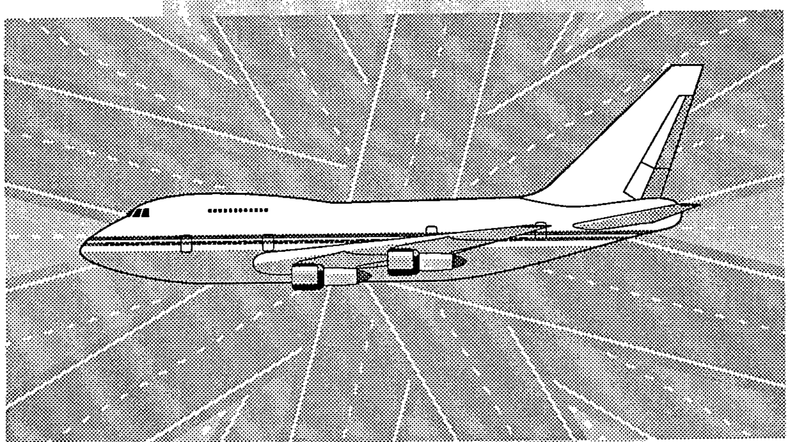
FINAL REPORT

EVALUATING IMPROVEMENTS IN LANDSIDE ACCESS FOR AIRPORTS

PB99-113276



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Standard Title Page - Report on Federally Funded Project

1. Report No. FHWA/VTRC 99-R7	PB99-113276	3. Recipient's Catalog No.
4. Title and Subtitle Evaluating Improvements in Landside Access for Airports		5. Report Date October 1998
		6. Performing Organization Code
7. Author(s) Lester A. Hoel and Heather Wishart Shriner		8. Performing Organization Report No. VTRC 99-R7
9. Performing Organization and Address Virginia Transportation Research Council 530 Edgemont Road Charlottesville, VA 22903		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. SPR 5750-040-940
12. Sponsoring Agencies' Name and Address Virginia Department of Transportation 1401 E. Broad Street Richmond, VA 23219	FHWA 1504 Santa Rosa Road Richmond, VA 23239	13. Type of Report and Period Covered Final Report
		14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

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Three conclusions were drawn. First, there is a lack of consistency in measuring airport access performance. Second, landside access to airports is a major concern at airports of all sizes, but there is no significant difference in reported access problems among large, medium, and small airports. Third, the methodology developed may be tailored to meet the needs of a specific airport.

The study recommends that the Virginia Department of Transportation and the Virginia Department of Aviation incorporate the evaluation methodology into the access fund appropriations process; encourage Virginia airports to adopt the methodology as a step in the mater plan process; and encourage nationwide use of the methodology by airport authorities, state departments of transportation, and the Federal Aviation Administration.

17 Key Words Airport access, evaluating landside access, performance measures, service characteristics, planning methodology, case study	18. Distribution Statement No restrictions. This document is available to the public through NTIS, Springfield, VA 22161.		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of Pages 83	22. Price

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(The opinions, findings, and conclusions expressed in this report are those of the authors and not necessarily those of the sponsoring agencies.)

Virginia Transportation Research Council
(A Cooperative Organization Sponsored Jointly by the
Virginia Department of Transportation and
The University of Virginia)

In Cooperation with the U.S. Department of Transportation
Federal Highway Administration

Charlottesville, Virginia

October 1998
VTRC 99-R7

ABSTRACT

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INTRODUCTION

Intermodal transportation involves moving passengers or freight between points of origin and destination using two or more modes. For freight transport, the interchange between modes is typically a port or terminal, where ships discharge cargo for further delivery by truck or rail. For passenger transport, the interchange between modes is typically an airport, where passengers disembark from aircraft and continue their journey by some form of ground transport, typically automobile, bus, or rail.

The three elements of the intermodal transfer process are (1) the landside portion, which provides access to the terminal from the surrounding area; (2) the terminal portion, where freight or passengers are processed between the modes; and (3) the sea or airside portion, which provides access to the freight or passenger carrier (either a harbor channel or airside takeoff and landing facility).

To provide for a "seamless" transportation connection between modes, the three elements must work in harmony. That is, landside access, terminal flows, and the sea or airside facilities must be adequate to accommodate expected demands. Since the function and characteristics of each element are different, they can be separated for purposes of analysis and design. However, each element must be capable of serving anticipated demand with a consistent quality of service.

The main function of the landside access system is to provide service to airport passengers and visitors. Superimposed on this continuous activity is cargo transport and travel by employees who service the terminal and aircraft. The access system must furnish circulation, distribution, and storage of vehicles. With few exceptions, the available infrastructure is limited and new facilities are unlikely. As is the case with seaports, the challenge for planners is to operate existing facilities more efficiently and decrease demand.

Air transportation is important to Virginia, and providing quality landside access to its airports is a principal concern. Virginia has an extensive air transportation infrastructure. Nine airports serve the state with commercial air service to more than 600 worldwide destinations, offering complete general aviation services, including corporate jet facilities. Another 61 general aviation airports are licensed for public use. The close proximity and convenient location of Washington National make it important to air travel in Virginia. Washington National and Dulles International provide service to more than 30 million passengers annually. Both have recently completed major capital improvement programs.[1] Important airports also exist in large metropolitan areas, such as Richmond, Norfolk, and Roanoke.

PROBLEM STATEMENT

Past forecasts of air travel underestimated aviation demand and were narrow in scope, quickly causing airport and landside facilities to outgrow their capacity and become inadequate to serve demand.[2] Landside accessibility is a concern not only at larger airports; many smaller and medium-size airports are also affected because of changes in airline flight scheduling practices.[3] As the number of annual passengers continues to increase, ground travel between the airport and the adjacent city or suburbs is taking longer. For the majority of air passenger trips, the ground travel portion meets or exceeds the air portion, and at some airports, the lack of landside access capacity may limit the ability of the airport to process passengers and aircraft.[4] Further, the main advantage of air transport is speed, and its value is reduced if airport access time is excessive. Therefore, reducing the time it takes to access the airport is important to the air transport industry.[5]

Air transportation accounts for 17.1 percent of all intercity passenger miles, and when compared with non-automobile modes, it represents 90 percent of the total market (rail is 0.6% and bus is 1.2%).[6] This market segment is a significant portion of intercity "mass" transportation, and increased appeal of air travel through improved landside accessibility can further enhance the use of this mode.

Since most airport-related trips are by automobile, solutions to landside congestion have typically involved adding highway lanes, providing additional parking facilities, and increasing terminal curbsides. Environmental concerns combined with an inability to expand because of land constraints have provided the incentive for airport planners to examine other alternatives, such as transportation system management (TSM) strategies and public transportation. Examples are commercial vehicle per-trip fees, consolidation of courtesy vehicle services to reduce vehicle miles of travel, and police enforcement of curbside parking limits. Innovative public transportation services include the proposed extension of commuter rail to Dulles International Airport, the pedestrian walkway to the Metrorail station at Washington National Airport, and the Intermodal Transportation Center that will be completed as part of the expansion of Miami International Airport. Airport access mode choice reflects regional transportation patterns. Thus, public transportation to airports will not be extensively used if it is not an element of a regional network.

Although major airports usually are difficult to get into and out of, especially during rush hours, the extent of the problem is not known and good airport access and the access problem have yet to be defined.[7] The large scale of investments in terminal facilities has fueled concerns regarding the impacts of these investments and has required decision makers to endeavor to understand the tradeoffs between costs, air and ground transport efficiency, environmental quality, and community quality of life. Yet, there is no generally accepted definition of what constitutes adequate landside access.[8] Further, identifying the level of landside access performance that is provided to air passengers is not possible under current practices.

Although many access options exist, standardized evaluation practices are lacking that can compare the performance provided. An objective and consistent methodology is needed to evaluate existing conditions and determine the most appropriate option from a passenger perspective.

PURPOSE AND SCOPE

The purpose of this research is to describe the elements that comprise airport access and to develop a methodology for identifying and evaluating existing landside access performance and proposed improvements from a passenger perspective. The scope is limited to landside access service between approaches to the airport and the terminal entrance. Approaches refer to the major arterials, freeways, or rapid transit facilities that provide access to and from the airport. Parking, terminal curbside, and public transportation concerns are addressed as well. Passenger travel is the focus of this research. Employee, cargo, and urban traffic components are studied to determine their effect on passenger access.

METHODOLOGY

To accomplish the research objectives, the following tasks were completed:

1. Ascertain the landside access performance measures and access modes and investigate Virginia state and metropolitan transportation agencies to ascertain methods currently used to identify and evaluate airport ground access improvements on a statewide and regional level.

2. Conduct a national survey of airport authorities to determine the characteristics of airport access services provided.

3. Establish factors relevant to identifying and assessing proposed access improvements and develop an evaluation methodology.

4. Demonstrate the evaluation methodology by investigating landside access facilities at Richmond International Airport (RIC).

LANDSIDE ACCESS PERFORMANCE MEASURES, ACCESS MODES, AND EVALUATION PRACTICES

Performance Measures

Twelve performance measures have been identified as useful to the evaluation of any intermodal system.[9] Five relate to passenger concerns: cost, time, convenience, reliability, and quality of travel.

Cost

Access costs are incurred by passengers in private automobiles and those using public transportation modes. Private automobile costs are out-of-pocket expenses such as for parking and tolls. Public mode costs include fares and gratuities. Lower cost options are generally preferred, but, often, travelers are willing to pay more for modes that are faster and more reliable. Typical costs reflect the regional cost of living and, therefore, vary among airports.

Time

Trip time for the purpose of airport access evaluation is the total elapsed access time measured between approaches to the airport and the terminal entrance and vice versa. Traffic congestion, slow vehicles, transfers, and waiting time for vehicle arrival all contribute to delays that increase trip time. For public modes, a key element of trip time performance is waiting time. In general, perceived waiting time is twice actual time.[10] Trip time can also influence travel cost of for-hire modes when charges are based on elapsed time.

Reliability

In the context of airport access, *reliability* refers to the dependability of an access mode in guaranteeing a stated arrival time. Reliability is a measure of confidence that an access mode will adhere to its operating schedule. High-quality airport access requires timely, reliable service to ensure that passengers will not miss their flight. Typically, there is very little tolerance for delay. Passengers often minimize risk by leaving early for the airport, thus anticipating possible delays. Access improvements that increase reliability allow passengers to begin their trip closer to the scheduled departure time, thereby decreasing total trip time. Evaluating reliability requires considering the ground access network on which the service operates, including airport approaches and roadways, and may be performed by recording on-time performance or conducting field studies. However, passenger perception of reliability does not always reflect actual performance, and repeat experiences with high reliability may be necessary to allay concerns.[11]

Convenience

Convenience is the ease of travel associated with an access mode. Proximity of the mode to the trip origin or final destination affects convenience. A measure of convenience is walking distance. Passengers rate walking distance as important, especially when carrying baggage.[2] Convenience can be expressed as the number of level changes required, availability of baggage assistance, and location of pick-up or drop-off points relative to the airline counter or baggage claim area. Convenience is also the degree to which an access mode can adapt to meet the needs of passengers. Convenient access modes accommodate baggage, are handicap-accessible, have unlimited hours of operation, and serve a wide area beyond the airport.

Quality

Quality of travel is reflected by passenger satisfaction service factors such as number of transfers, number of stops, headways, provision of information, vehicle appearance, physical comfort, cleanliness, safety, and attentive service by employees. Some factors are similar to those for trip time and convenience. However, since passenger perception of service quality is important, it is evaluated separately.

Access Modes

Airport access modes may be classified into two categories: private and for-hire. The automobile is the primary private mode. For-hire modes include public transportation such as conventional bus or rail transit and paratransit such as taxicab, airport limousine, charter service, and hotel or rental car courtesy vehicle. Each mode has unique characteristics with regard to the performance elements described earlier. Table 1 shows the percentage of passengers using each access mode at selected airports and reflects the national tendency of automobile and taxicab as the principal access modes.[8]

Table 1. Landside Access Modes of Passengers at Selected Airports

Access Mode	Departing Passengers (%)			Arriving Passengers (%)		
	Miami	Denver	La Guardia	Miami	Denver	La Guardia
Private auto (including rental car)	53	70	34	67	78	35
Taxicab	22	14	46	18	10	35
Limousine	10	5	13	10	5	20
Bus	15	3	5	5	5	5
Other	0	9	2	0	3	5

Performance varies from one airport location and service provider to the next and depends on the access facilities provided, such as roads, parking lots, and terminal curbside. Private automobile and taxicab are the two most common airport access modes and generate the highest number of trips per passenger. Table 2 shows the number of landside access vehicle trips per air passenger trip for each access mode developed for Boston Logan International Airport but applicable to access at all airports.[12] These values account for the number of airport trips made and number of air passengers per vehicle. Modes that produce greater vehicle trips per air passenger trip contribute to congestion and delays on access facilities. Automobile pick-up/drop-off and taxicab are the two modes that require the most trips.

Table 2. Landside Access Vehicle Trips per Air Passenger Trip[12]

Mode	Vehicle Trips per Air Passenger Trip
Auto pick-up/drop-off	1.29
Taxicab	1.09
Auto park	0.74
Rental car	0.69
Airport limousine	0.33
Bus	0.10
Rapid transit	0

Private Modes

The dominant private access mode is the automobile. Private modes typically have the highest levels of convenience and quality and therefore capture the largest mode share. However, increased demand is placing constraints on the facilities these modes operate on, causing increased time and decreased reliability.

The private automobile mode includes rental cars, cars driven and parked by passengers, and cars dropping off air passengers at the airport and picking them up. Drop-off/pick-up private automobile trips place a greater demand on access facilities than other private modes since two round trips are made by the driver. This is in comparison to one round trip made by air passengers who drive themselves and park and by those who rent cars.

The private and on-demand characteristics of private automobile travel make it an attractive mode that most for-hire transportation modes cannot approach. The cost of service is typically seen as comprising only out-of-pocket expenses such as parking and toll costs. The perception of many drivers is that out-of-pocket costs for this mode are minimal. Automobile access time is usually competitive with or surpasses that of other modes. Convenience and quality are high, as the air passenger may leave and arrive at the airport when desired. The vehicle is comfortable and can easily accommodate luggage.

The high performance level of the private automobile is not easily matched by other modes. However, demand associated with private travel places constraints on facilities that are worsening with increased traffic volumes. Attempts have been made to reduce private automobile trips by a variety of methods, including increasing parking costs and improving public transportation performance.

For-Hire Modes

For-hire access modes include taxicab, airport limousine, charter service, bus, courtesy vehicle, rail, and other modes. Rental cars are not considered a for-hire mode since their operating characteristics and access demands are similar to those of the privately owned automobile.

Certain general performance characteristics apply to most for-hire modes. Public transportation costs are generally lower than automobile parking costs for longer air trips. However, trip time is usually longer than for private modes and multiple stops increase time further. Airport configuration affects trip time, as non-centralized airports necessitate more stops. If a public transportation access mode necessitates four or more stops at the airport, the service will not be used.[13] Most for-hire modes do not provide door-to-door service or baggage assistance and have limited hours of service and range. The result is poor convenience performance. Thus, quality is generally lower with for-hire modes than with private modes.

To attract ridership, public modes must provide convenience, reliability, and quality that competes with that of the private automobile. If high-quality public transportation is provided, access mode choice will shift from automobiles, thus reducing congestion and delay for all modes.

Taxicab

As shown in Table 2, the taxicab is the second most used airport access mode. Taxis can save passengers money if they offset parking costs. Time, reliability, convenience, and quality of taxicabs are similar to those of the private automobile. The impact of taxicabs on congestion on airport access roads may be minimized. Holding areas, dispatchers, permits to control the number of vehicles on airport property at a given time, and enforcement of curbside dwell time limits are strategies often used. These strategies result in decreased congestion at the terminal curbside. Requiring per-trip fees discourages vehicles from circling the terminal continuously to attract passengers.

Airport Limousine and Charter Services

Airport limousine and charter services are either provided on-demand or are pre-arranged. These services usually cost more than other public modes, but the trend in larger cities is for air passengers to pay higher fares for better quality, more direct services such as door-to-door shared rides.[14] Trip time and convenience are optimized by grouping passengers with similar destinations to maximize trip efficiency. Door-to-door shuttles in San Francisco capture 14 percent of airport access and provide an excellent example of a successful shared-ride service that is privately owned.[9]

Bus

Bus service may be incorporated as part of the metropolitan public transportation system, or dedicated express airport buses may be provided. Convenience, especially relating to baggage assistance, is a particular concern as transferring, boarding, and walking from the bus stop to the terminal are difficult with luggage.

Courtesy Vehicles

Courtesy vans and buses are often provided by hotels and rental car agencies to transport passengers to and from the airport. Performance is determined by the service provider. Excessive trips caused by courtesy vehicles that circle repeatedly to pick up passengers increase congestion and contribute to the overall airport access problem. The most frequently cited problem associated with courtesy vehicles is curbside congestion, especially lengthy waits at the curbside, parking in the wrong spaces, leaving vehicles unattended, and blocking traffic.[15] Agreements between businesses to consolidate courtesy service, per-trip fees imposed with each trip made around the airport, required on-demand service, holding areas, and dispatchers are alternatives to improve airport access with regard to courtesy vehicles.

Rail

Extension of rail service to the airport may be considered to address mobility issues in congested areas. High capital costs limit rail to larger airports.[16] Rail access is most successful at airports serving frequent travelers who carry little baggage, and where it provides travel time or reliability advantages over other modes because of severe traffic congestion.[12] U.S. airports with rail stops within walking distance of the terminal are Washington National, Atlanta Hartsfield, Boston Logan, Chicago O'Hare, Chicago Midway, and Philadelphia. Airports with shuttle service to a rail station are Cleveland Hopkins, Washington Dulles, Baltimore Washington, Oakland, San Francisco, Lambert St. Louis, Ft. Lauderdale/Hollywood, San Jose, and Burbank-Glendale-Pasadena.

Certain characteristics may improve passenger performance and increase use of rail where available. Direct, frequent service with minimum stops make travel time and convenience more competitive with the private automobile. A drop in ridership of 50 percent is expected to occur when passengers must switch trains and is greater if a transfer to bus is required. Off-airport or inconvenient rail stations detract from the benefits of rail access.[3] Conversely, rail stations can be positioned to be more convenient to passengers than other modes. For example, the rail station at the Frankfurt, Germany, airport is closer and easier to access from the baggage claim area than the parking garage. Other beneficial qualities are through or combined air/rail ticketing; baggage check at the rail station; and short, enclosed walking distances. Overnight parking at the rail station is necessary for most trips. Each of these characteristics improves convenience. Rail access that is fully integrated as part of an extensive regional transit system provides a more convenient service than a single dedicated line between one area (typically the central business district) and the airport.[12] Safety and security concerns that affect quality performance may be addressed through lighting, police presence, and aggressive vandalism countermeasures.

European airports with rail access realize higher rail mode shares than U.S. airports. Three elements of rail access were examined at seven European airports, and a direct correlation was found between the performance of these elements and mode share. These elements are quality of ground-air transfer at the airport, quality of in-vehicle characteristics such as speed and comfort, and availability of traveler assistance with baggage and other needs. Other factors such as differing European attitudes toward the private automobile and the existence of a nationwide rail system further explain the disparity between European and U.S. rail ridership. Integration of the rail system into an extensive national or regional system is a common feature of successful European rail access systems. In many cases of European airports, high ridership levels originate from regions other than the central business district, which is the market typically served by rail access systems in the United States.[14]

Other

Other public modes have been proposed for airport access. One example is the use of helicopters to shuttle air passengers between remote terminals and the airport. Some investigation has been made into these potential access modes, but thus far none has emerged as a promising means of carrying significant numbers of travelers to the airport.

Access Roads, Terminal Curbside, and Parking Areas

Performance of access modes is greatly affected by the access facilities on which they operate, since congestion and related delay increase time and decrease reliability. The planning process addresses current and future demand on access facilities. Access facilities are associated with a variety of operating characteristics, ranging from operations similar to freeway ramps and arterials on approaches and distribution networks, to urban street network behavior demonstrated by through traffic adjacent to the airport terminal and in parking lots. Many access facilities are becoming increasingly congested as volumes increase and capacity is reached or overcome. Land constraints and environmental concerns and regulations often restrict the expansion of access facilities. To optimize passenger performance measures of time and reliability, the objective must be to optimize efficiency of operations and facilities, in conjunction with exploring alternate access services.

Roadways

The airport access network includes highways and major roads adjacent to the airport approach, airport access roads, and circulation and distribution facilities. Airport access roads circulate traffic by connecting the off-airport highway system to terminal area access roads, which provide access to the principal functional areas.[4] Distribution facilities include terminal frontage roads and service roads.

Traffic congestion on any component of the airport access network decreases efficiency and in severe cases may prevent air passengers from making their flight on time. Some airport officials and planners feel that the largest source of congestion stems from the use of adjacent roads by urban commuters and non-airport traffic.[17] Ground access demand is determined by mode share, vehicle occupancy, circulation patterns, and the length of time the passenger arrives at the airport before a flight, or remains after arrival. Air trip characteristics, parking availability, extent of public transportation options, and availability of alternate check-in locations also influence ground access demand.[8]

Airport landside access components are designed in accordance with the *Highway Capacity Manual (HCM)*, but no level of service (LOS) criteria are universally recommended specifically for airport access components.[4] *HCM* evaluation standards may be used, but emphasis should be placed on the effects of driver unfamiliarity, common at airports, on safety and capacity.[8]

Improvements in traffic operations may increase facility efficiency and therefore improve passenger performance. Circulation patterns determined by airport and ground access configuration may be made more efficient. For example, a non-centralized airport with a single terminal frontage road may benefit from an improved design that provides direct access to each terminal that is not impeded by loading and unloading at other terminals. Driver familiarity and facility complexity affect traffic flow, and confused drivers unfamiliar with the access system are sometimes forced to make quick decisions that result in frequent merges, lane changes, and weaving. Most people travel by air infrequently, and unfamiliarity is a problem for many drivers. Improved configuration and increased presence of roadway directions may also alleviate traffic flow problems.

Terminal Curbside

The terminal curbside is where passengers load or unload luggage from vehicles and leave or enter the landside access system. Excess demand and inefficient operations create curbside congestion that can spill over onto the adjacent terminal frontage road. The terminal curbside is "the most significant specialized functional element of an airport."[18]

Particular characteristics determine operation and capacity of the terminal curbside. At some airports, additional islands are provided to increase area for loading and unloading. However, these islands require pedestrians to cross lanes of traffic to reach the terminal, thereby decreasing lane capacity and causing a potential safety hazard. Double and triple parking may result from long vehicle dwell times and large vehicles such as buses and luxury limousines that decrease curbside capacity. Available curbside area, pedestrian paths, passenger characteristics, vehicle mix and characteristics, and flight schedules affect capacity and determine demand peaks throughout the day.[8]

Flight arrivals tend to place a greater demand on terminal curbside than flight departures, because of a variety of factors. One of these is the simultaneous arrival at the curbside of many passengers from one flight, compared to the staggered arrival of departing passengers. The unpredictable nature of time required to retrieve baggage and reach the curbside prompts some drivers to dwell for longer periods while waiting for passengers, with many vehicles waiting at the curb at the same time.[12] Dwell times vary by type of vehicle, number of occupants, and amount of baggage. Management policy regarding dwell time and authorized vehicles also affects operations.

Curbside performance evaluation methods have been developed. One method, developed by Mandle, Whitlock, and LaMagna, determines overall curbside LOS based on the relationship between traffic volumes, service levels, and curb length.[8]

Alternatives for improving terminal curbside vary. Regulations that limit dwell time and restrict certain types of vehicles may benefit operations. Traffic management practices including signals, signs, and traffic policing can improve operations and encourage compliance with regulations. Terminal curbside may be reconfigured to increase curb space and maximize traffic flow. Opportunity for expansion depends upon the particular airport, but is generally limited by terminal size. Private automobiles are the largest source of curbside demand. Their impact may be reduced with increased availability of close-in parking, making terminal curbside stops unnecessary, or with off-airport terminals and increased public transportation.[8]

Parking Areas

Public parking areas include lots or garages where air passengers and visitors may store their private automobiles. Other parking areas, such as employee lots, taxicab holding areas, and air cargo shipping lots, are most often separated from public parking areas. As they do not affect public parking to a great extent, they are not treated in this discussion.

Public parking areas are usually divided into three categories. Short-term lots are intended to provide storage for airport visitors and pick-up/drop-off drivers. The high turnover rates of these lots create greater demand on the roadway system. High hourly rates are imposed to discourage use of these lots for longer periods of time. Long-term lots store automobiles for passengers who drive themselves to the airport. Reduced-rate or satellite parking is situated some distance from the airport terminal, and is typically provided at larger airports. Often called satellite or remote parking, shuttle buses or people mover systems are used to transport passengers to the terminal. These buses may also be used in large long-term lots.

Time required to find a parking space is the first determinant of parking area performance. The number of spaces required is greater than demand to prevent lost time and strain on airport roads caused by repeated circling while searching for a spot. Various indices have been developed to determine parking space capacity. For smaller airports, the Roads and Transport Association of Canada recommends 1.5 spaces per peak-hour passenger or 900 to 1,200 spaces per million annual enplaned passengers. The Federal Aviation Administration (FAA) recommends 1 space per 500 to 700 annual enplaned passengers.[8] Other methods may result in different recommendations. These estimation techniques exclude connecting passengers, who do not generally enter the landside access system.

Other factors influence performance. The time and distance required to walk or ride between the terminal and parking area add to passenger trip time. Trip time is also increased by long waits at fee collection booths while exiting the parking lot. If a long walk also involves carrying luggage or is not protected from the elements, passenger convenience will be affected. Some airports use 240 m (800 ft) as the maximum distance tolerated between the terminal and parking area without bus or other shuttle service to improve convenience.[8]

Different strategies may improve the performance of parking areas without building more spaces. The physical design may be adjusted to improve operations, especially at entrances and exits. Changeable message signs providing information can prevent circling in lots that are already filled to capacity. Pre-cashiering methods that involve pre-paying parking fees in the terminal or on foot may prevent long waits at collection booth exits.

Another option is to change parking pricing depending on the improvement objective. Parking lot demand is very sensitive to parking cost.[8] For example, increasing short-term fees may shift passengers to long-term or remote lots, and prevent overuse of short-term lots. However, adverse impacts must be investigated. The possibility exists that this action will increase demand at terminal curbside, as passengers first stop to unload luggage before parking in remote lots, or that long-term lot capacity may be surpassed. Changes to parking pricing have also been suggested as a way to decrease trips made to the airport. The option of significantly raising parking fees to encourage use of public transportation has been suggested to achieve this objective; however, this practice has the likely consequence of increasing drop-off trips, thereby causing adverse congestion and delay effects. Decreasing parking availability has also been suggested, but is not supported by airport management. Airports have little incentive to support alternatives that discourage automobile trips since the average airport receives one-third of its revenue in parking fees. Some airports have excess parking area, and would prefer more roads.[7]

Ground Transportation Centers

Ground transportation centers (GTC) have been proposed to promote the use of public transportation to airports. These facilities are intended to improve passenger performance for public modes by providing a convenient central pickup and drop-off location. Shifting more passengers to public transportation relieves demand on the roadway system that may translate into shorter travel times and decreased congestion. The facility may be located in the terminal, adjacent to airport property, or some distance away near a population center (called off-airport terminals). GTCs not located inside the terminal must be connected by an efficient shuttle service. Amenities such as on-site ticketing and baggage check and claim increase convenience and improve passenger performance. A successful GTC can improve the intermodal connection, ease airport congestion, improve transportation service, and lead to secondary benefits relating to quality of life and the environment.

From a passenger perspective, GTCs can have many benefits. To encourage patronage, parking rates may be lower than at the airport. Taxicab fares may be lower if the off-airport terminal is closer to population centers than the airport itself. In regions with several airports, passengers may return to a different airport than they departed from, increasing selection of flights and return times. GTCs may also benefit the airport by reducing parking requirements and increasing possible area for airport expansion. A workshop sponsored by the FAA and Institute of Transportation Studies at the University of California at Berkeley concluded that GTCs appear to offer the most favorable prospect for reduction of access trips at many airports. However, placement such that a significant market is served is required for benefits to be realized.[11] To be economically feasible, intermodal facilities must provide a high LOS in order to be competitive with the private automobile and attract sufficient levels of travelers.

Savings attributable to these benefits may in some cases cover implementation and operating costs. Despite this, funding problems arise since benefits rarely accrue to sponsoring agencies. Airports generally do not desire to fund any project that will decrease their parking revenue, even if access problems can be alleviated. Airlines do not anticipate any increased revenue from sponsoring a GTC, and have little incentive. Private operators want to maximize profit, and reduction of congestion and delay is of little concern.[11] However, with effective placement and high performance, successful GTC ventures are possible.

Variations of the GTC concept exist in coordination with some airports. A satellite station that serves the Orlando, Florida, airport makes it possible for baggage to be checked directly through to the off-airport site, located in a convenient destination area for travelers. When passengers do not have to worry about baggage until they reach their destination, public transportation is made more convenient and more popular to use. The Marin Airporter in Larkspur Landing, California, serves the San Francisco airport and is a private bus terminal built with private funds. Until security concerns made this impossible, airlines checked baggage through to the airport from the bus terminal. On-airport GTCs at Pittsburgh, Pennsylvania, and Atlanta, Georgia, are other examples of centralized ground transportation locations that provide a variety of access choices to the air passenger. Expansion plans at Miami International Airport include development of the Miami Intermodal Transportation Center, to include links to a seaport, a parking facility, an automated guideway transit system, commuter rail, and numerous transportation modes.

Evaluation Practices

Federal and Virginia transportation agencies were questioned to ascertain methods currently used to identify and evaluate airport ground access improvements on a federal, state, and airport level. The information served to guide the research project regarding airport access planning. Airport access improvements are locally initiated, and local agencies are responsible for project development. However, funding comes from a variety of sources and the review processes imposed by funding agencies affect the processes used to evaluate and justify improvements.

Federal Aviation Administration

The FAA requires airport sponsors requesting Airport Improvement Program discretionary funds to conduct project-level benefit-cost analysis (BCA) of some capacity-related airport projects. Capacity projects are defined as those projects that include new construction or reconstruction of airport infrastructure for the purpose of accommodating or facilitating airport traffic. Both airside and landside capacity projects are subject to BCA. BCA must be conducted for capacity projects that require $5 million or more in discretionary funds or for which a Letter of Intent is sought as confirmation of future FAA funding.[19]

The objectives of BCA are to allow the FAA to determine if adequate information is available indicating the need for and consequences of the proposed action, that potential benefits to society justify potential costs, and that the proposed action will maximize net benefits to society. BCA is intended to facilitate consistent and comparable analyses among proposed airport projects, and is a means of evaluating airport landside improvements on a federal, statewide, or local level.

The steps involved in the BCA process are (1) define project objectives; (2) specify assumptions about future airport conditions; (3) identify the base case (no investment scenario); (4) identify and screen all reasonable alternatives to meet objectives; (5) determine appropriate evaluation period; (6) establish reasonable level of effort for analysis; (7) identify, quantify, and evaluate benefits and costs of alternatives relative to base case; (8) measure impact of alternatives on airport usage; (9) compare benefits and costs of alternatives; (10) perform sensitivity analysis; and (11) make recommendations of best course of action. Step 7 includes examination of benefits and costs, regardless of the party that experiences them. Benefits are identified, and economic values are assigned. Costs are estimated, modeled, and applied. Externalities such as air emissions, noise, and delay, as well as hard-to-quantify benefits to passenger comfort and convenience, are included.[19]

In addition to the BCA process, the FAA employs a prioritization process. Airport improvement funding is prioritized based on factors such as airport size, importance of the project to airport capacity and performance of the airport, and significance of the airport and the project to the statewide and national system of airports.

Virginia Department of Aviation

The Virginia Department of Aviation (VDOA) reviews and funds locally sponsored airport improvement projects, but has no direct control over airport access systems. No evaluation guidelines exist, and no universal criteria must be met for funding to be approved. Rather, the VDOA analyzes studies performed locally by the airport sponsors. VDOA support is a prerequisite for FAA funding but is not required for funding approval by the Commonwealth Transportation Board or any other agency. Revenue-producing components of the access system, such as parking areas and taxicab oversight, are outside the eligibility of VDOA funding.

Virginia Department of Transportation

Airport access funding is included as a special program of the Industrial Access Roads Program of the Virginia Department of Transportation (VDOT). No evaluation guidelines exist, but particular criteria are required for funding. Similar to industrial projects, airport access projects begin outside the property line and end at the nearest adequate public road. Funds are limited to the actual construction and engineering of a road facility and may not be used for expenses such as right-of-way acquisition or adjustment of utilities. Additional limitations include the requirement that the airport is a licensed, public-use facility and that any one airport may not receive more than $450,000 in one year ($300,000 unmatched, $150,000 matched). The governing body of the county, city, or town must make the request for funds and commit to providing necessary right-of-way and utility adjustment. VDOA input is sought on the use and justification of airport access fund allocation. Prior evaluation of proposed improvements does not occur, and funds are allocated on a first-come, first-served basis. No prioritization process is employed to ensure funding of the most effective or necessary projects.

Airport Authorities

Analysis of landside access usually occurs as part of the master planning process that is conducted by each individual airport. Consultants hired to update the master plan generally follow the traditional four-step transportation planning process of trip generation, trip distribution, modal split, and trip assignment. In some cases, performance of individual components is measured using the methods that were introduced in the section entitled "Access Roads, Terminal Curbside, and Parking Areas." A criticism made by some planners is that airport activity forecasts can be overly ambitious, resulting in requests for unnecessary capacity improvements and possibly making improvement funds unavailable for more appropriate projects. Improvements are identified based on specific needs and objectives, and are evaluated for their impact on capacity, operations, the environment, and other areas, but performance provided to passengers is not determined in a thorough and consistent manner.

Local Government and Metropolitan Planning Organizations

Local governments and metropolitan planning organizations (MPOs) also maintain responsibility for landside access. Funding requirements, appropriations processes, and evaluation of improvements vary among jurisdictions. The Metropolitan Washington Council of Governments monitors time performance of landside access improvements after implementation. Every 5 to 7 years, a study is conducted of access times from various activity centers to

Washington Dulles Airport and Washington National Airport. Differences in access times are linked to probable causes and addressed.

NATIONAL SURVEY OF AIRPORTS

Access problems vary among airports depending upon attributes such as airport location and operating characteristics. Studying the existing characteristics of landside access at U.S. airports may aid in understanding the national access problem and in finding solutions. A survey of ground transportation management practices and regulations was published in 1986, and the Airports Council International-North America (ACI-NA) prepared a study of airport parking needs in 1994, but no surveys have been conducted to determine the overall performance of passenger access on a national level.[20, 21]

A questionnaire was developed to determine the characteristics of airport access services provided, existing access problems, and strategies employed to combat these problems nationwide. To develop the questionnaire, airport access literature was used to select relevant topics. Because of the complex nature of the subject matter, an extensive set of questions was posed. In the 1986 survey of airport management practices and regulations, an 81.4 percent response rate was achieved, thus suggesting that given the importance placed on ground transportation, we could expect a similarly robust return rate.[20]

An airport sample was determined from the *1994 Primary Airport Enplanement Activity Summary*, which is published by the FAA and lists the annual number of passenger enplanements at every primary airport under FAA jurisdiction.[21] Since landside access concerns may vary depending on the amount of airport traffic, the sample of airports was classified by size to determine if access limitations are dependent upon airport size. The enplanement activity summary was organized by airport size using the Airport Operations Council International's classifications for large airports (1% or more of total annual enplanements at airports under FAA jurisdiction), medium-size airports (0.25% to 1%), and small airports (less than 0.25%). Airports were also distinguished between hub (0.05% or more) and non-hub (10,000 enplanements to 0.05% of total annual enplanements).

Key contacts associated with landside access or airport operations of U.S. airports were identified from a list of members of the American Association of Airport Executives. A copy of the questionnaire was sent to representatives of every large and medium-size airport in the enplanement activity summary (29 large airports and 38 medium-size airports). Every small airport with more than 500,000 annual enplanements was included in the survey (34 airports). Ten (30%) small hub airports were selected at random. Thus, 111 surveys were mailed. Non-hub airports were excluded from the survey because of the limited access traffic they generate. The questionnaire is shown in Appendix A.

The questionnaire was mailed to airport officials in August 1996. A second wave of questionnaires was mailed in November 1996, using the same list of contacts. Seventy percent of airport officials responded. Of the large airports contacted, 66 percent completed surveys. Seventy-nine percent of the medium-size airports responded, and 66 percent of the small airports responded.

The following sections discuss the survey responses. Analysis of variance (ANOVA) results are presented in Appendix B. Percentages are based on the number of responses received for that question. Responses to the survey are based on the best information available to airport officials. Although airport authorities collect some of the data requested in the questionnaire, other data are not collected. For example, data on access mode availability and operating characteristics are generally known, but the percentage of passengers using these modes is rarely measured. Thus, airport officials estimate certain responses based on experience with their facility. Subjective responses provide useful information on how airport access performance is perceived.

Overall Rating of Landside Access Problems

ANOVA results indicate no significant difference in reported overall access performance by airport size at a 95 percent confidence level. Figure 1 presents the responses. Seventy-four percent of managers at all airports perceive that landside access problems exist to some degree. Eighty-four percent of large airports, 84 percent of medium-size airports, and 65 percent of small airports agree.

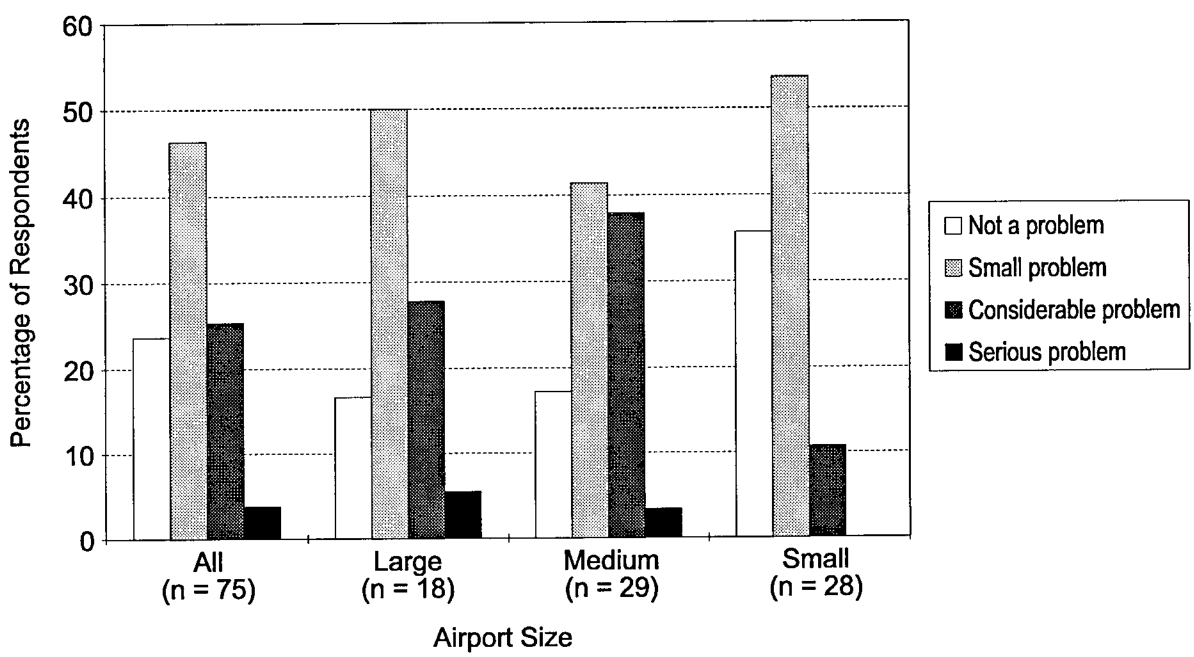


Figure 1. Overall Rating of Landside Access Problems

Landside Access Problems

ANOVA results indicated no significant difference in reported access problem severity by airport size at a 95 percent confidence level. Table 3 shows the extent to which specific landside access issues are viewed as problems. Figure 2 depicts the reported access problem severity.

Table 3. Percentage of Airports Reporting Landside Access Problems

Terminal curbside congestion: departures	96
Terminal curbside congestion: arrivals	96
Unfamiliar drivers weaving or causing backups	77
Long-term lots filled to capacity	71
Fare collection backups	68
Airport access road congestion	67
Short-term lots filled to capacity	64
Pedestrians causing safety concerns	63
Cars continuously circling to find a closer spot	58
Highway access ramp congestion	47
Pedestrians causing traffic backups	45
Satellite lots filled to capacity	45

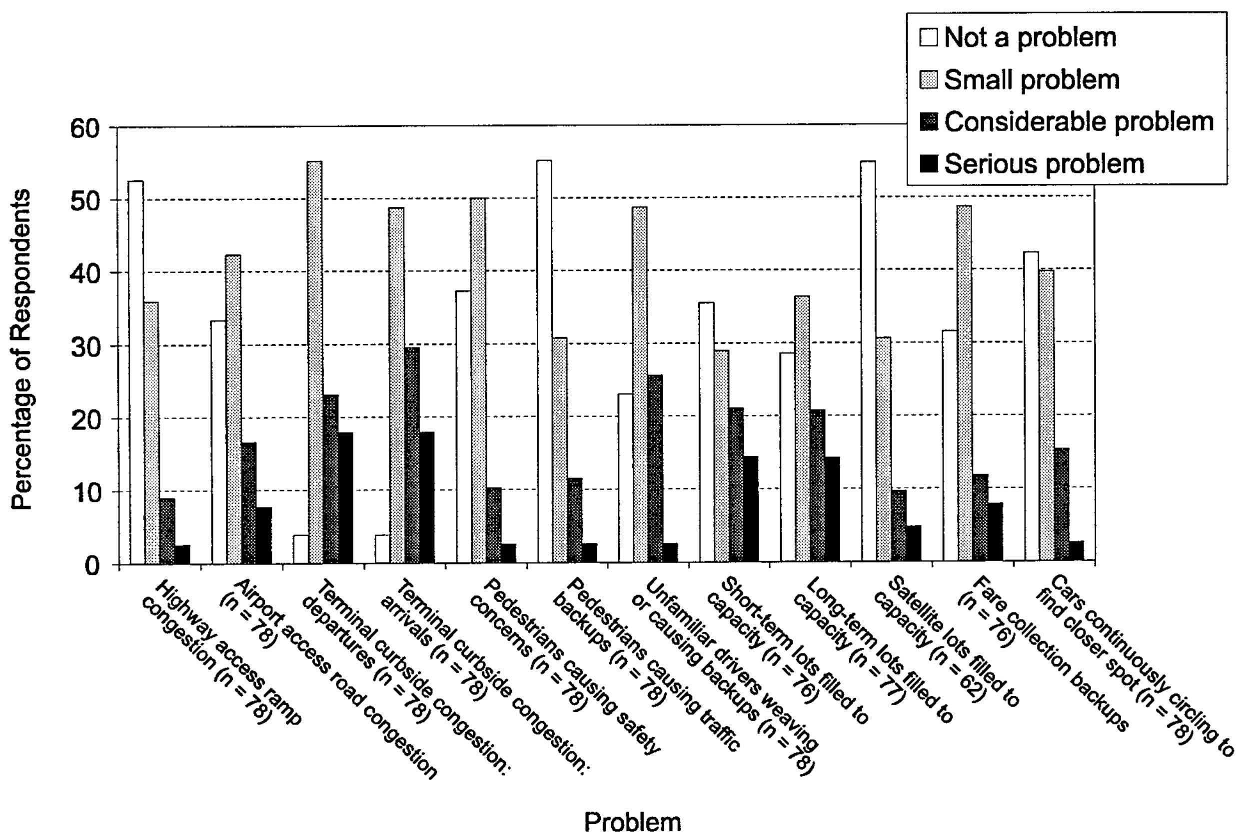


Figure 2. Severity of Landside Access Problem

As can be seen in Table 3, each limitation was perceived to pose a problem by at least 45 percent of the airports. The most commonly reported problem was terminal curbside congestion, which was viewed as a problem at 96 percent of airports surveyed. As shown in Figure 2, 41 percent of airports reported a considerable or serious problem with curbside congestion at departures, and 47 percent reported a considerable or serious problem with curbside congestion at arrivals. Other problems reported by the majority of airports were drivers unfamiliar with the airport weaving or causing backups, long-term parking lots filled to capacity, fare collection backups, airport access road congestion, short-term parking lots filled to capacity, pedestrians causing safety concerns, and cars continuously circling the airport system. The problems least rated were highway access ramp congestion, pedestrians causing traffic backups, and satellite parking lots filled to capacity.

In the ACI-NA study, congestion at airports was reported as follows: off-airport access roadway congestion was reported by 79 percent of large airports, 63 percent of medium-size airports, and 41 percent of small airports; on-airport roadway congestion was reported by 68 percent of large airports, 69 percent of medium-size airports, and 34 percent of small airports; and airport curbside congestion was reported by 89 percent of large airports, 92 percent of medium-size airports, and 72 percent of small airports.[21]

Public Transportation Availability

The percentage of airports with rail, bus, and airport limousine services available are presented in Table 4. ANOVA results indicated a significant difference in public transportation availability among large, medium-size, and small airports at a 95 percent confidence level. Most airports are served by bus. All of the large airports, 63 percent of medium-size airports, and 59 percent of small airports have bus service. Airport limousine service is also widely available. Eighty-four percent of large airports, 63 percent of medium-size airports, and 48 percent of small airports are served by airport limousine. As expected, a greater percentage of large airports have rail service than do medium-size or small airports. Twenty-six percent of large airports have rail service, compared to 17 percent of medium-size airports and no small airports. However, not all of these airports are directly served by rail, and shuttle services are required at some airports.

Table 4. Public Transportation Availability at Airports (%)

Mode	All Airports n = 78	Large n = 19	Medium n = 30	Small n =29
Bus	71	100	63	59
Airport limousine	62	84	63	48
Rail	13	26	17	0

Trip Reduction Methods

The respondents were asked to select which, if any, of the following methods they have employed to reduce the number of access trips: promotion of public transportation, imposition of a fee for each trip around the airport (per-trip fees), change of parking rates, methods aimed at reducing employee trips, or other methods. The method of changing parking rates includes such practices as raising rates in short-term lots and lowering rates in long-term lots to discourage drop-off trips. ANOVA results indicated a significant difference in trip reduction method usage among large, medium-size, and small airports at a 95 percent confidence level. The only exception was the category of *other,* which did not vary considerably by airport size. Table 5 shows the results.

Table 5. Percentage of Airports Employing Trip Reduction Methods

Method	Large n = 19	Medium n = 30	Small n = 29
No action taken	63	63	93
Promote public transportation	26	27	3
Per-trip fees	16	33	0
Change parking rates	16	27	3
Employee methods	32	17	0
Other	11	0	3

Thirty-seven percent of large airports, 37 percent of medium-size airports, and only 7 percent of small airports have employed a trip reduction method. Some airports have employed more than one. The most commonly used practices at large airports focus on reducing employee-induced trips and promoting public transportation (32% and 26% of large airports, respectively). The most widely used methods at medium-size airports are implementation of per-trip fees (33%), promotion of public transportation (27%), and changing parking fee structure (27%).

Taxicab and Courtesy Vehicle Problems

The survey requested that various possible access problems related to taxicabs and courtesy vehicles be rated according to a scale of *not a problem, small problem, considerable problem,* and *serious problem.* ANOVA results indicate a significant difference in problem severity reported by large, medium-size, and small airports at a 95 percent confidence level for three of the identified problems: courtesy vehicles continuously circle, number of courtesy vehicles on airport property exceeds demand, and taxicabs continuously circle. Responses for three other identified problems were not significantly different by airport size. Results are presented in Table 6. Reported severity is presented for large airports in Figure 3, medium-size airports in Figure 4, and small airports in Figure 5.

Table 6. Percentage of Airports Reporting Taxicab and Courtesy Vehicle Problems

Problem	All Airports n = 77	Large n = 18	Medium n = 30	Small n = 29
Taxicabs: Number on Airport Exceeds Demand	56	61	53	55
Courtesy Vehicles: Double Parking at Curbfront	53	50	67	41
Courtesy Vehicles: Continuous Circling	40*	56	50	21
Taxicabs: Double Parking at Curbfront	32	33	23	41
Courtesy Vehicles: Number on Airport Exceeds Demand	32*	44	48	7
Taxicabs: Continuous Circling	18*	28	10	21

* Severity of problem is significantly different among large, medium, and small airports.

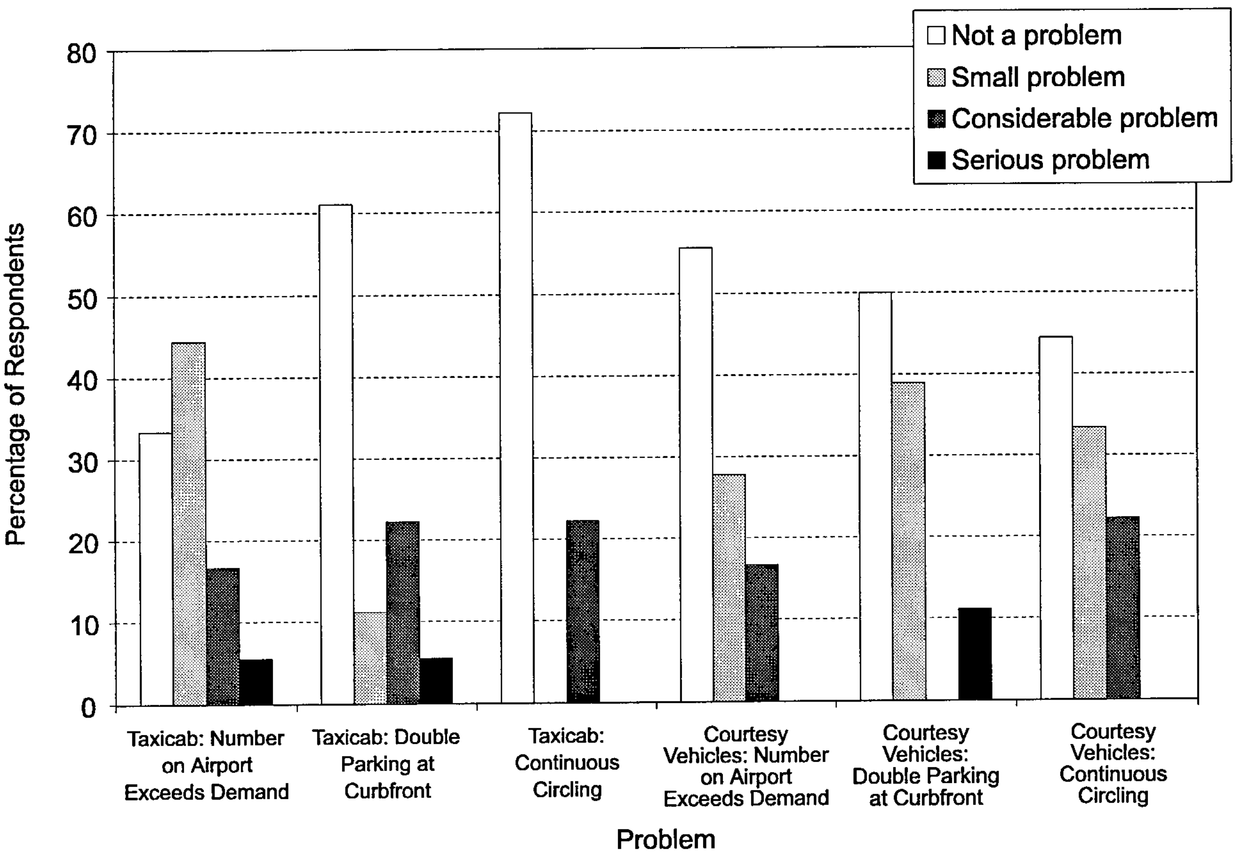


Figure 3. Severity of Taxicab and Courtesy Vehicle Problems at Large Airports

The most commonly reported problem was excessive numbers of taxicabs on airport property (56% of airports to some degree, 19% to a considerable or serious degree). Courtesy vehicles double parking at the terminal curbside was second (53% to some degree, 14% to a considerable or serious degree).

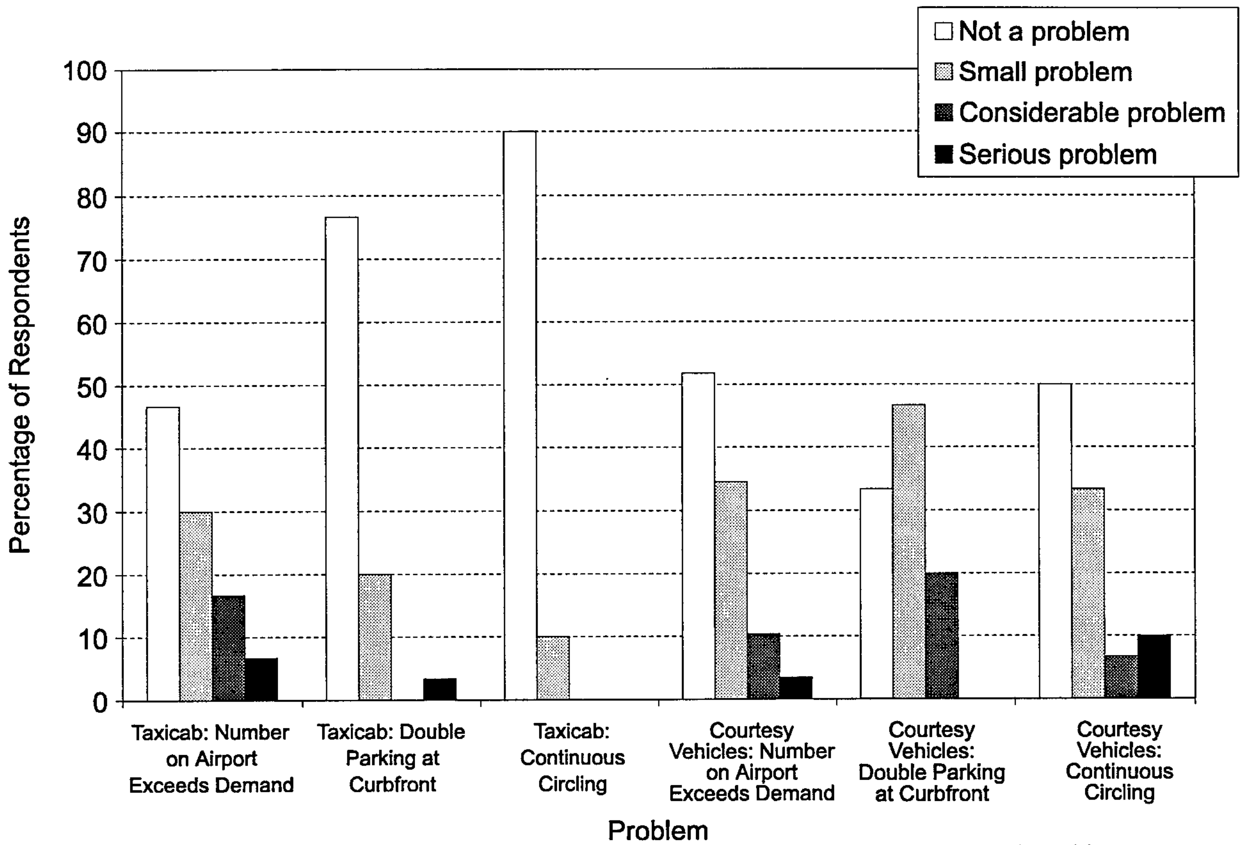


Figure 4. Severity of Taxicab and Courtesy Vehicle Problems at Medium Airports

Continuous circling of courtesy vehicles, excessive numbers of courtesy vehicles, and continuous circling of taxicabs were statistically different by airport size but not consistently more or less severe. Problems with courtesy vehicles regarding circling and excessive numbers were perceived to be more severe at large and medium-size airports than at small airports. Managers at 22 percent of large airports and 17 percent of medium-size airports reported a considerable or serious problem with courtesy vehicle circling compared to 3 percent at small airports. Managers at 17 percent of large airports and 14 percent of medium-size airports reported a considerable or serious problem with excessive numbers of courtesy vehicles compared to 3 percent at small airports. However, problems with taxicabs circling were perceived to be more severe at large and small airports than at medium-size airports. Managers at 22 percent of large airports and 7 percent of small airports reported a considerable or serious problem with taxicabs circling compared to no medium-size airport.

Control of Taxicabs and Courtesy Vehicles

The survey requested information on control of the number of taxicabs and courtesy vehicles permitted on airport property. ANOVA results indicated no difference in taxicab and courtesy vehicle control by airport size at a 95 percent confidence level. All airports reported use of designated holding areas where taxicabs and other vehicles

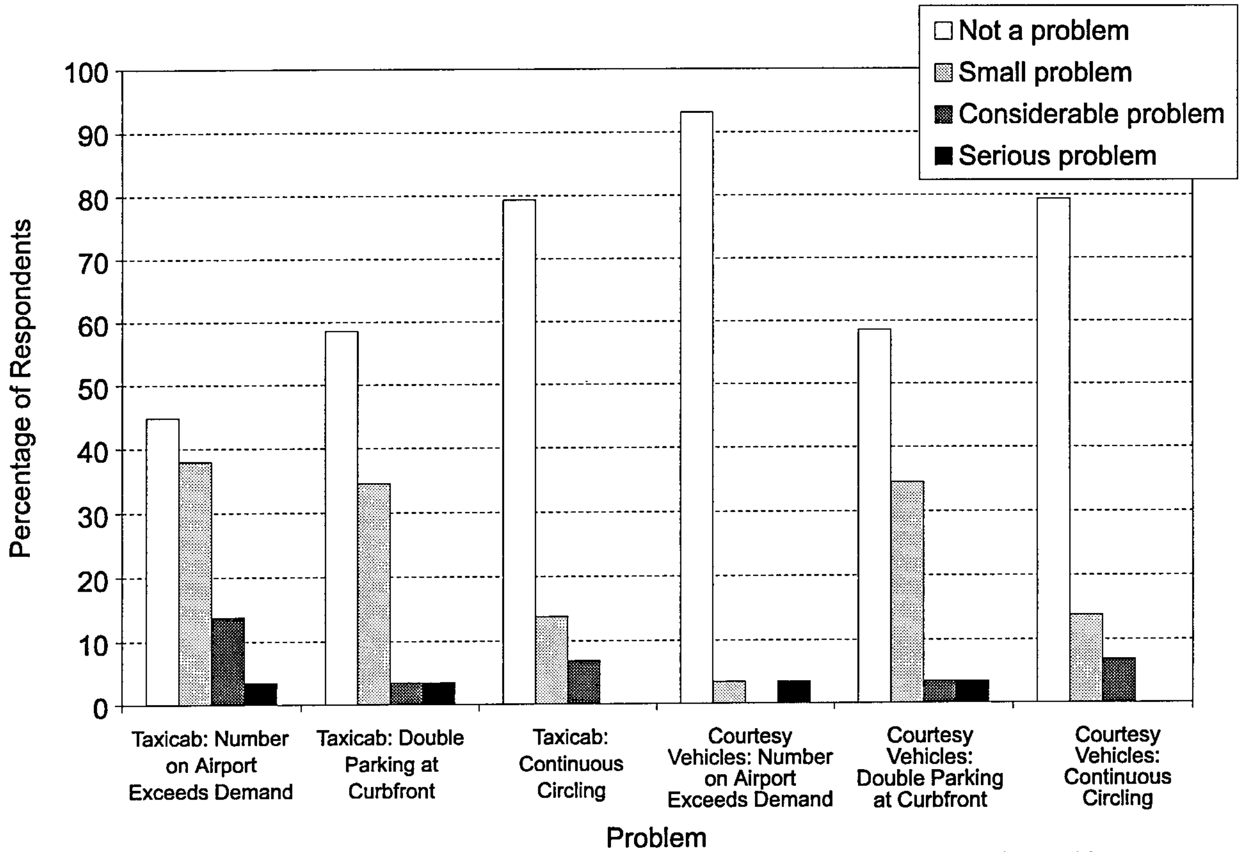


Figure 5. Severity of Problems with Taxicabs and Courtesy Vehicles at Small Airports

are required to wait until needed. Eighty-one percent of all airport managers reported control of the number of taxicabs and 64 percent reported control of the number of courtesy vehicles on airport property. Control of taxicabs and courtesy vehicles was achieved through permits, contracts, starters/dispatchers, or other methods.

Airport Access Performance

The questionnaire requested ratings of access mode performance in the areas of passenger cost, convenience, trip time, safety, flexibility, quality/comfort, and reliability on a scale of *excellent, good, fair,* or *poor.* Although airport authorities have general opinions of access mode performance, they do not share the same perspective as air passengers. However, a national survey of airport users was impractical for this research, and responses from airport authorities are, therefore, presented with the caution that a similar survey of air passengers might offer different results. Responses are depicted in Figures 6 through 11.

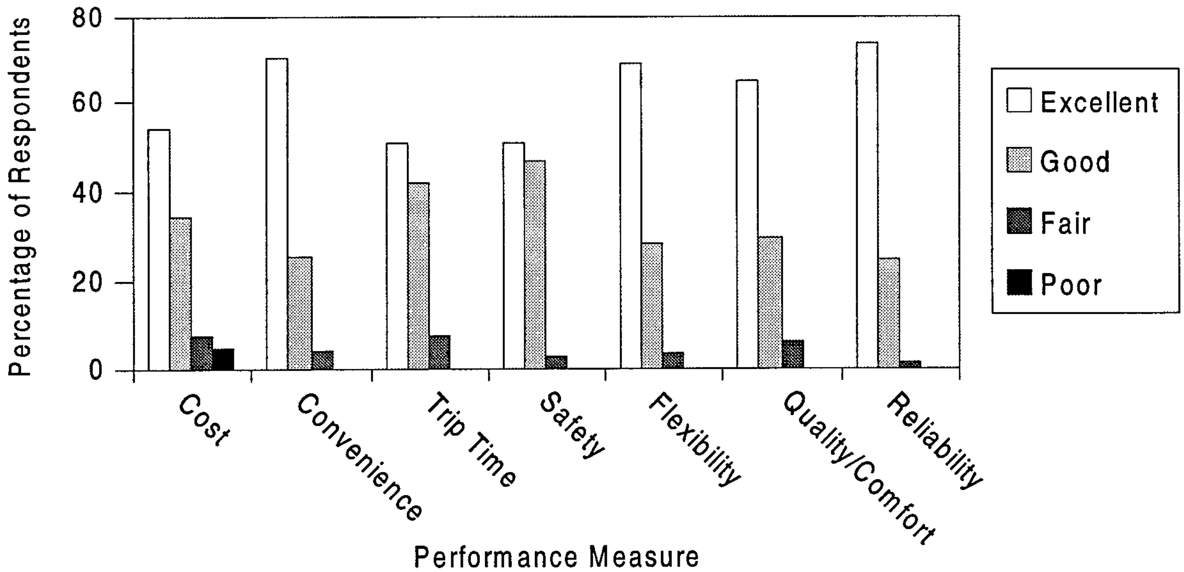


Figure 6. Passenger Performance of Private Auto at All Airports

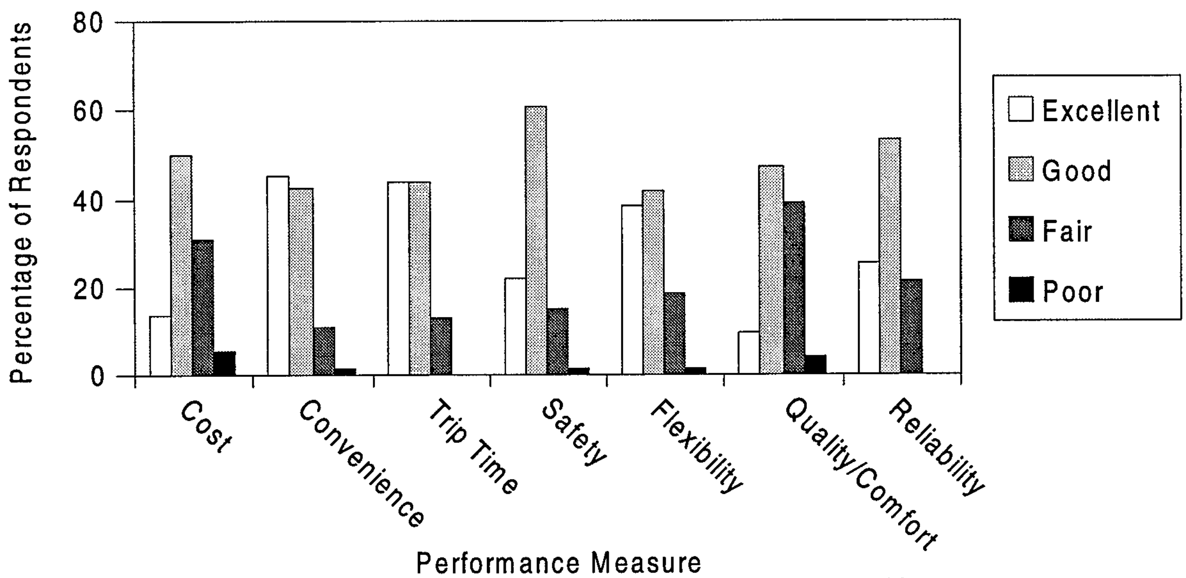


Figure 7. Passenger Performance of Taxicabs at All Airports

Private Automobile

The private automobile was associated with excellent or good performance in each size category by managers at the majority of airports. As shown in Figure 6, the highest scoring performance measure was reliability. Ninety-nine percent of airport managers perceived that reliability is excellent or good. Safety and flexibility were rated excellent or good at 97 percent of airports. The lowest scoring performance measure was cost. However, 88 percent of respondents perceived cost to be excellent or good.

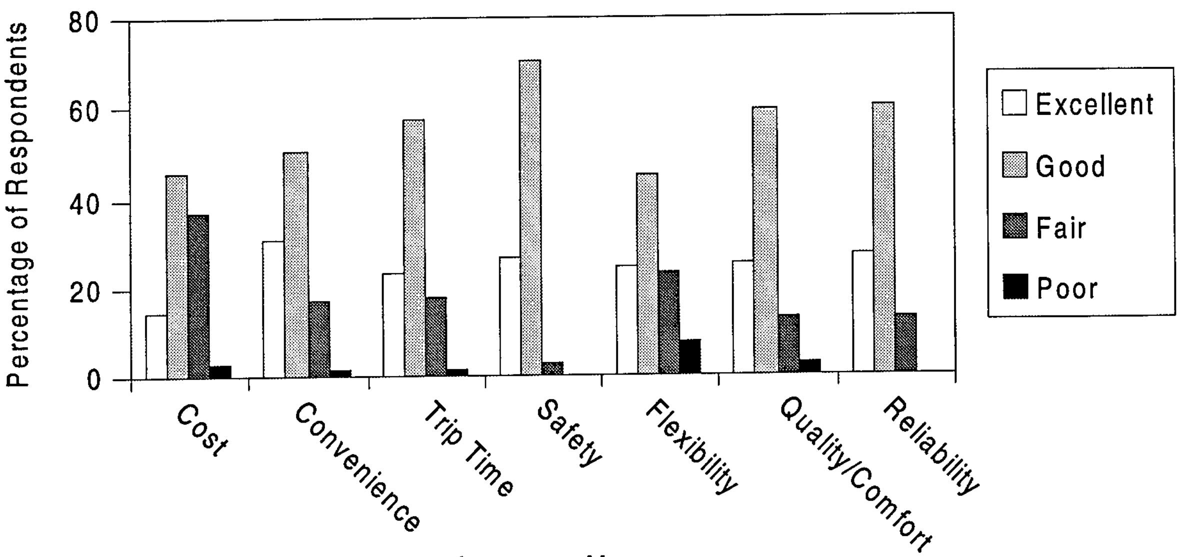


Figure 8. Passenger Performance of Airport Limo and Charter at All Airports

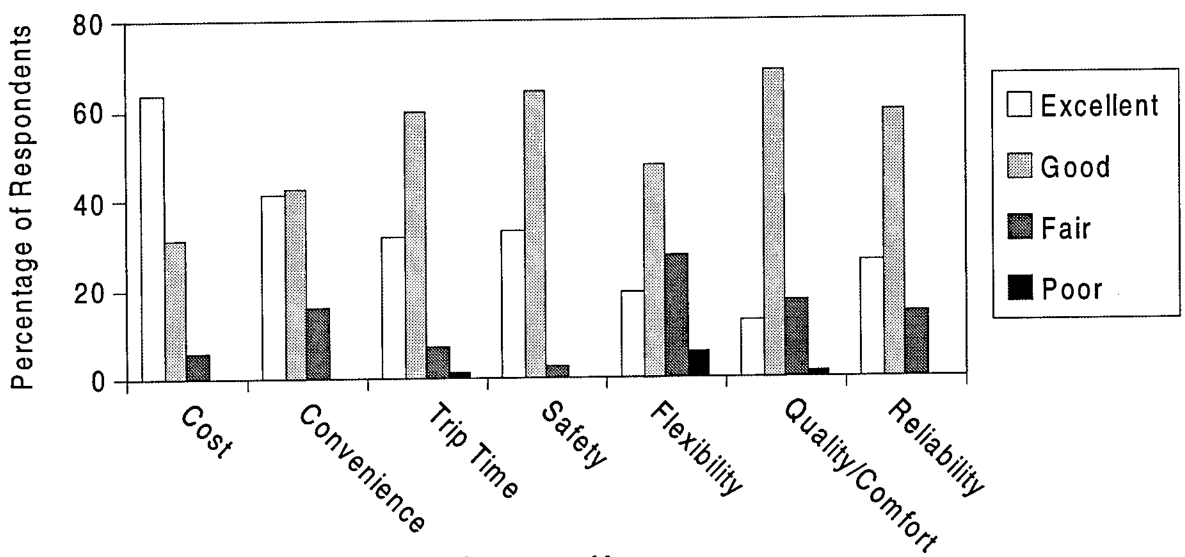


Figure 9. Passenger Performance of Courtesy Vehicle at All Airports

Taxicab

Taxicabs also received high performance ratings by airport managers, with the majority indicating excellent or good performance. However, ratings were lower than those for private automobile. As shown in Figure 7, the highest scoring performance measure was convenience, which was rated as good or excellent at 87 percent of airports. Cost and quality/comfort were the lowest rated performance measures but were rated excellent or good at 64 and 57 percent of airports, respectively.

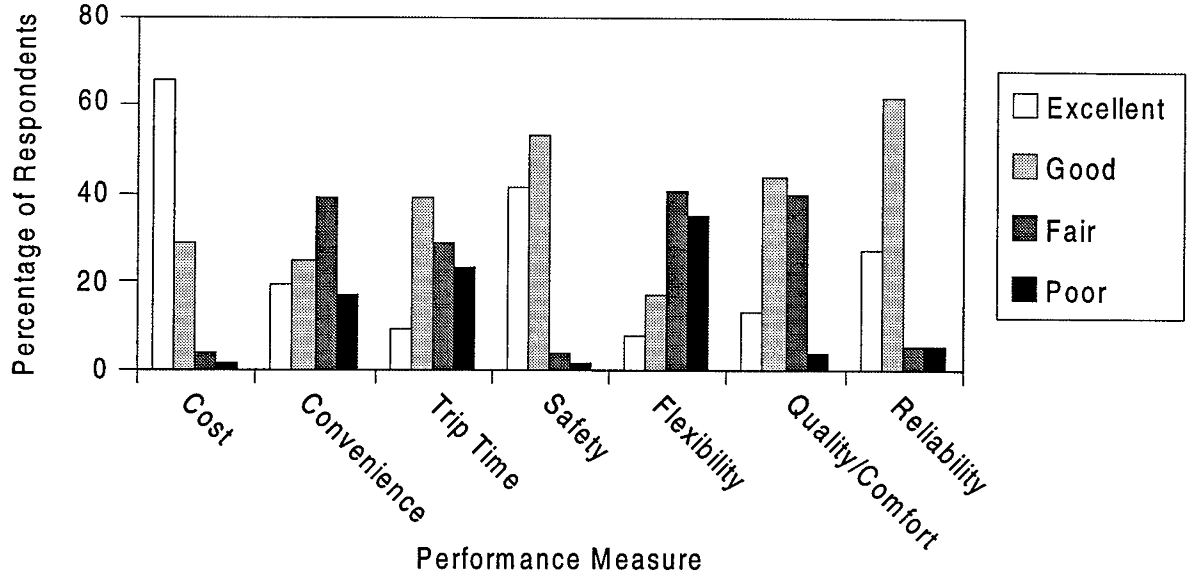


Figure 10. Passenger Performance of Bus at All Airports

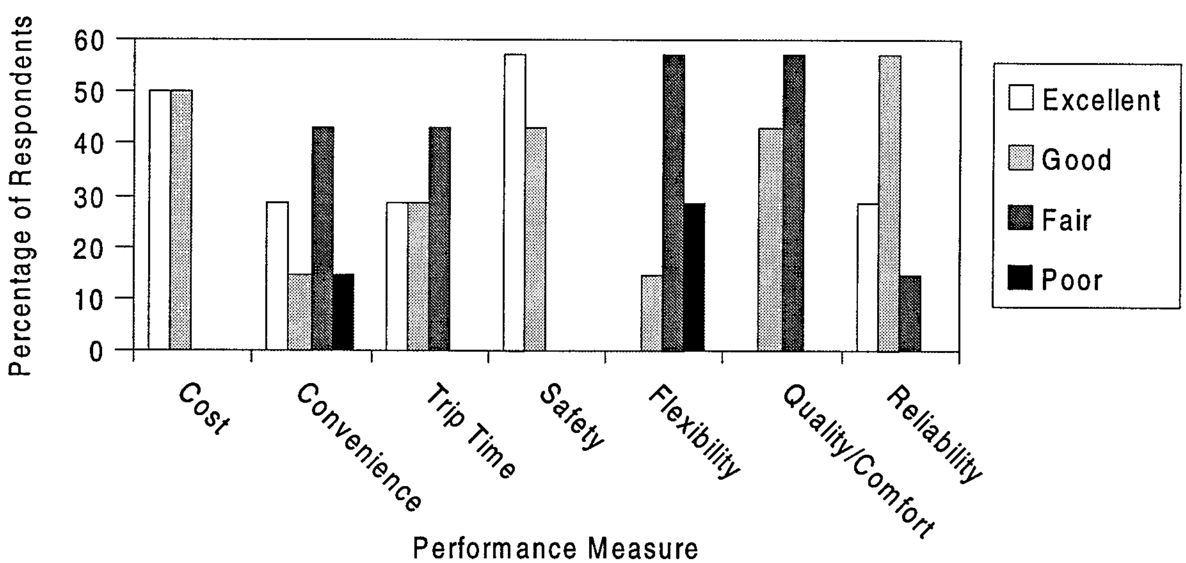


Figure 11. Passenger Performance of Rail at All Airports

Airport Limousine and Charter

Airport limousines and charters received good ratings at most airports, with considerable responses of fair performance in cost and flexibility. As shown in Figure 8, the highest rated performance measure was safety, with 97 percent of airports reporting safety as good or excellent. Sixty percent of respondents rated cost as good or excellent, which was the lowest rated performance measure for airport limousines and charters.

Courtesy Vehicle

As shown in Figure 9, courtesy vehicles were rated highly in all categories, with excellent or good performance. Safety was the highest rated performance measure. Ninety-seven percent of all airport managers reported safety as excellent or good. Cost and trip time were also highly rated. Flexibility was the lowest rated performance measure, but 67 percent rated performance as excellent or good.

Bus

Low fares gave busses a very high cost rating, with lower performance in other areas. As shown in Figure 10, 94 percent of respondents rated cost as excellent or good. Safety was the highest rated performance measure, with 95 percent reporting excellent or good performance. Flexibility was the lowest rated, with 25 percent reporting excellent or good performance. Convenience and quality/comfort were also rated low.

Rail

Nine responding airports are served by rail, but only seven answered this part of the questionnaire. Of those airports with rail access, cost and safety were rated highly. As shown in Figure 11, both were reported to be excellent or good. Flexibility was the lowest rated performance measure, with only 14 percent reporting excellent or good performance. Convenience and quality/comfort also had significant numbers of fair or poor responses.

Summary

Results of the national survey indicate that landside access concerns are perceived to pose a significant problem for many airports. All of the landside access problems included in the questionnaire were rated as a problem at more than 45 percent of airports. Terminal curbside congestion was the most pressing problem, but drivers unfamiliar with the access system and parking lot capacity also have a large impact on the access performance. ANOVA results indicated no significant difference in problem severity among large, medium-size, and small airports at a 95 percent level of confidence.

Most airports are served by public transportation, and public transportation availability differs among large, medium-size, and small airports. Large airports are better served by public transportation. However, very little is known about its effectiveness and use.

Few methods have been implemented to reduce passenger car, taxicab, or courtesy vehicle trips. Use of trip reduction methods differs by airport size classification, and a greater percentage of large and medium-size airports take steps to reduce trips than do small airports.

Holding areas and controls on the number of vehicles allowed on airport property have worked to resolve problems with taxicabs and courtesy vehicles. However, enforcement is required to minimize the number of taxicabs on airport property and double-parked courtesy vehicles.

Performance ratings highlight the strengths and limitations of access modes, as reported by airport managers. A similar survey of airport users might produce different results. Strengths indicate attributes that other modes must compete against to improve performance, and weaknesses suggest areas requiring improvement. The private automobile provides a high level of performance, especially with regard to reliability, flexibility, and safety. Convenience is the main strength of the taxicab. Taxicab cost and quality/comfort are the lowest rated performance measures but are still rated highly at the majority of airports. Airport limousines and charters are perceived to be safe. Cost was the lowest rated measure for these modes but was rated excellent or good at 60 percent of airports. Strengths of courtesy vehicles are safety, trip time, and cost. Courtesy vehicle flexibility was rated as a weakness, but the nature of courtesy vehicle service is such that a very limited market is served. Cost and safety are strengths of bus service, but performance in flexibility, convenience, and trip time is deficient. Where rail service exists, strengths include cost and safety, yet limitations exist with regard to flexibility, convenience, and quality/comfort.

Potential areas of improvement emerge based on the identified strengths and limitations. Reduced fares would improve taxicab and airport limousine passenger performance but must be weighed against the desirability of increased taxicab use and related increased congestion. Taxicab quality and comfort could also be improved. Altering schedules to match local access patterns would improve flexibility, convenience, and trip time for bus service. Improving connections to rail and easing rail access would improve passenger flexibility and convenience. Quality and comfort on bus and rail could be improved by through ticketing and baggage assistance. Improvement of the performance measures identified as deficient can improve passenger landside access performance.

EVALUATION METHODOLOGY

Methods of studying various aspects of air transport have been proposed, but no consistent methodology exists to quantitatively analyze the efficiency of airport landside access facilities or identify and evaluate proposed improvements. A Transportation Research Board (TRB) committee presented a study process for the analysis of airport airside capacity, which may be used as a model for evaluation of other air transport components.[23] Participants in a TRB Intermodal Surface Transportation Efficiency Act (ISTEA) and Intermodal Planning Conference identified basic desired elements of any intermodal management system.[9] Baker and Wilmotte developed a broad plan for analysis of airport access that focused on the social and economic impacts of access problems and solutions.[5] Finally, the Federal Highway Administration/FAA *Airport Access Planning Guide* proposed a seven-step process for airport ground access planning.[12] However, a process for evaluating access and quantifying passenger performance does not exist.

The evaluation methodology we used in this study follows the standard procedure of any systems study, in particular, the eight steps of the ISTEA planning cycle shown in Figure 12. Application of these steps to airport access problems is the unique contribution of this study. This methodology is broad in scope, and specific analysis should be tailored to individual needs to match the characteristics of a particular airport. Appendix C provides an abbreviated guide to the methodology.

Step 1: Define the Problem

Before evaluation of an airport access system may commence, the main problems affecting landside access must be addressed and clearly defined. Identification of the specific access problems is the necessary first step so that data collection, performance analysis, and proposal of improvements may be efficiently and thoroughly completed. Goals and objectives should also be determined. The landside access questionnaire used in this study provides a base for problem definition and should be completed by airport officials in the beginning of the study process.

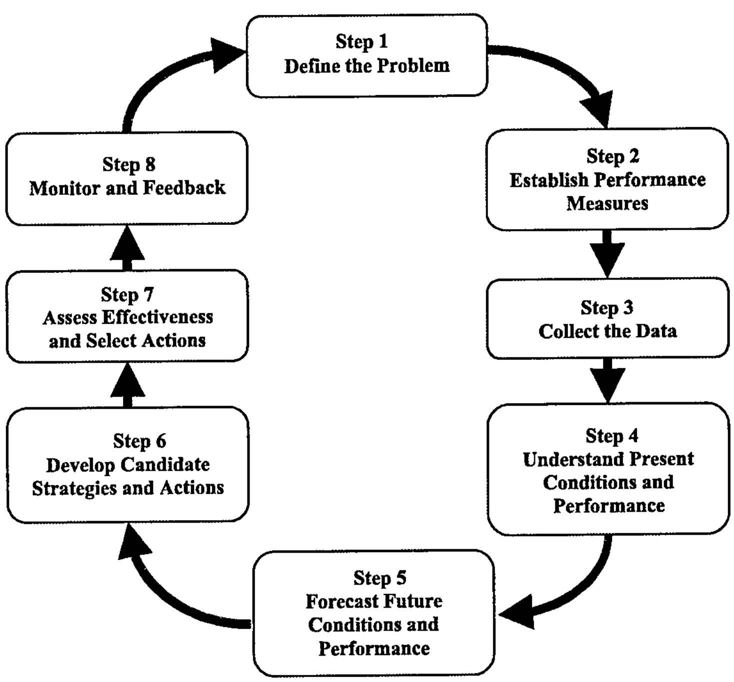


Figure 12. Eight Steps of the ISTEA Planning Cycle

Step 2: Establish Performance Measures

Once the problems have been identified, performance measures are established based on goals or objectives. Although landside accessibility has become a major concern for airports of all sizes, there is no generally accepted definition of what constitutes adequate ground access.[8] Efforts to define applicable goals and objectives exist on the state level by the Oregon Intermodal Management System and on the facility level by Boston-Logan Airport.[12] McKelvey described key elements of the ground access system, as well as factors considered in the evaluation of alternatives.[4] However, clearly defined performance measures are necessary to determine the service provided to passengers by components of the landside access system and to evaluate proposed improvements.

Emphasis on a particular aspect of performance depends on the characteristics of the airport, and views vary among passengers, airport and airline management, and the neighboring community. Passengers typically focus on cost, time, reliability, convenience, and quality. Management generally stresses operating and implementation costs, whereas community members emphasize environmental, noise, and traffic concerns. An overall LOS for the entire system is not practical because of the disparity among these groups. However, the goal of intermodal planning is to provide the highest overall LOS obtained from a balance of these passenger, management, and community performance. Therefore, a consistent methodology for measuring passenger performance is needed.

The performance measures previously introduced are a guide to those that may be used in airport access planning to determine current performance and to evaluate potential improvements. These recommended performance measures are cost, time, reliability, convenience, and quality. However, the specific performance measurement criteria within these categories are location and problem specific. Certain situations may warrant investigation of a particular performance characteristic, and needs and resources may preclude the necessity of others. Table 7 includes commonly used performance measurement criteria within the performance measures of cost, time, reliability, convenience, and quality.

Following the national survey, performance is evaluated on a four-point scale of *excellent* (strong positive impact on access performance; may attract passengers), *good* (above average; beneficial access performance), *fair* (provides the minimum performance necessary to maintain operations), and *poor* (strong negative impact on access performance; may detract passengers). *Excellent* and p*oor* indicate characteristics of access performance that are significant enough to cause passenger mode shift. Performance ratings are based on the data collected and account for a comparison between modes. The issues of subjectivity and perception prevent definitive assignments from being made for all airports. For example, it is not possible to assign a dollar amount to *excellent, good, fair,* and *poor* cost performance for use at all airports. Rather, the determination of performance within the four-point scale must account for characteristics

Table 7. Commonly Used Performance Measures

Cost Dollars per passenger trip ($/trip)
Time Comparison between modes; OR: Total one-way trip time/base case travel time (min/min) Waiting time (min)
Reliability Reputation of reliability; OR: Percentage of vehicle arrivals with less than 4 min. deviation from schedule (%)
Convenience Total walking distance with baggage (m) Total walking distance without baggage (m) Total number of level changes when walking (#) Availability and extent of baggage assistance (yes/no; location available) Availability of baggage storage areas on vehicles (yes/no) Handicap-accessible (yes/no) Radius of service provided from the airport (km) Hours of operation
Quality Number of transfers required (#) Number of stops between embarkation and destination (#) Service frequency or headway (# departures/hour) Total time for stops and transfers (min) Adequacy of information and directions(E/G/A/P) Maintenance of vehicles (E/G/A/P) Degree of physical comfort (E/G/A/P) Degree of protection from the elements (E/G/A/P) Friendly, helpful service (E/G/A/P) Adequacy of lighting, security patrols, and level of safety (E/G/A/P)

such as performance of other modes, regional trends, and airport location. The four-point scale is used to encourage definitive positive and negative responses, which is not possible with three- or five-point scales. Further, access performance cannot easily be distinguished between more than a few points and therefore is not well suited to a larger scale.

Step 3: Collect the Data

An overview of the airport landside access system and airport operations is the first step in data collection. The majority of basic data requirements may be obtained through a study of the airport's master plan and any access plans. The purpose of this aspect of data collection is to compile existing data; repeating the efforts of the master plan and previous work should be avoided.

Table 8. Basic Data Requirements and Sources

Data Requirement	Data Source
Inventory of access components: Airport access components Terminal access components Parking areas Layout of airport access system	Master Plan, Facility visits
Airport Activity: Number of enplanements per year Percentage of passengers transferring Air cargo activity Other operations Flight distribution peak periods	Master Plan, FAA enplanement data
Traffic Demand: Local traffic demand and access directional distribution	Access plans, DOT data, Traffic counts
User characteristics: Passenger profile: trip purpose, duration, resident vs. visitor, income, party size, etc. Percentage access distribution between passengers, visitors, and employees Impact of employee and air cargo activity on access system	Master Plan, Access plans, Airport operators, Passenger surveys
For-hire service characteristics: Availability by time, day, and area Mode choice distribution	Access plans, For-hire schedules and routes, mode operators
Anticipated changes in land use	Master Plan, Airport operators, MPO

An understanding of the characteristics of a particular airport is established with the data in Table 8. An inventory of all access components and the layout of the airport access system may be obtained from the master plan and through facility visits. Data on airport activity, including enplanements, percentage of passenger transfers, air cargo activity, other operations, and flight distribution, are also required. Local traffic demand and access directional distribution should be understood. Origins and destinations of passengers and other user characteristics are useful information and, if cost and time permit, may be valuable. User characteristics that pertain to an access study include trip purpose, trip duration, whether the passenger is a local resident or visitor to the region, income, and party size. The distribution of access vehicles among passengers, visitors, and employees and the impact of employee and air cargo activity on the access system should be investigated. The characteristics of for-hire transportation modes, including hours of operation, service area, and mode choice distribution, are also important. Finally, anticipated changes in land use should be researched to identify potential impacts on airport access in the future.

The determination and evaluation of existing conditions require extensive data collection, but much money and effort will be wasted if the search is not tailored to the problem being addressed. The entire access system should be considered, but planners must concentrate on those components essential to the problem solution. Much data may be collected during site visits and through interviews with mode operators; examples are parking fees, number of parking spaces available, and for-hire mode fares. Depending on the focus of the analysis, evaluation of specific performance measures may require additional data, which are listed in Table 9.

Table 9. Additional Data Requirements and Sources

Performance Measure	Data Requirement	Data Source
Cost	1. Toll costs 2. Parking rates 3. For-hire mode fares 5. Service gratuities	1. Facility inventory 2. Facility inventory 3. Mode inventory 5. Passenger surveys
Time	1. Total one-way trip time 2. Base case travel time 3. % waiting time of total trip time	1. Passenger surveys, Mode operators 2. Mode observation 3. Mode observation
Reliability	1. Mode arrival patterns 2. Mode vehicle breakdown history	1. Mode observation 2. Mode operators
Convenience	1. Walking distances 2. Number of level changes 3. Mode characteristics	1. Airport plans, Facility visits 2. Airport plans, Facility visits 3. Mode operators
Quality	1. Mode characteristics	1. Mode operators, Mode observation

Step 4: Understand Present Conditions and Performance

The data provide insight on the existing landside access situation. Possible explanations for the problem(s) defined in Step 1 may be identified. Using the data, access system performance is evaluated on a four-point scale according to each performance measure. This step provides the current landside access picture, so that future conditions and potential improvements may later be determined. The following tasks should be accomplished for each component of the landside access system:

1. Establish present conditions and describe current situation.

2. Identify possible reasons for the problem(s) defined in Step 1. Capacity, demand, terminal configuration, intersection and road geometry, and other factors may contribute to the problems identified.

3. Evaluate modes by performance measure using the data collected in Step 3. Using Table 7 is recommended for the completion of this task. Evaluation methods of specific access components such as roads and terminal curbside that were previously introduced may be used.

Step 5: Forecast Future Conditions and Performance

Predictions of future conditions and demand provide a window to the problems and performance issues that may arise. Estimated growth rates are used to forecast future demands on the access system. Airport master plans are usually a good source of information for this purpose. Possible land use changes and development are also identified, especially with regard to airport expansion and improvement. Future system performance is forecast by evaluating modes based on the predicted demand. The performance of existing modes under forecast demand allows identification of future problems and areas that may require improvement. These tasks should be completed:

1. Forecast future conditions and access mode growth.

2. Forecast future access demand.

3. Evaluate existing modes by performance measure based on forecast demand.

4. Predict future problems and performance issues.

Step 6: Develop Candidate Strategies and Actions

Suitable strategies for improving landside access performance must be specific to the airport and its landside problem(s). There is no general solution that can improve every situation. Rather, results from the preceding five steps must shape the proposed improvements to ensure maximum success.

Access improvements may be grouped into three categories: TSM, transportation demand management (TDM), and physical improvements. TSM works within the existing transportation infrastructure to provide enhanced service. Examples of TSM improvements are expanded bus service area, increased rail service frequency, and increased signing on airport access roads. TDM is a similar strategy that also works with existing facilities and services but strives to reduce the capacity required by decreasing traffic demand. High-occupancy vehicle incentive programs, employee trip reduction methods, and penalties for continuously circling around the airport are TDM strategies. Physical improvements require extensive construction of roadways, terminals, or access systems and include extension of rail service, lane widening, and curbside expansion.

Aspects of some proposed improvements may fall into more than one category. For example, the primary benefits of a transit TSM strategy of increasing rail service frequency relate to time, convenience, and quality. However, improvements in these elements may have the secondary roadway TDM objective of increasing rail ridership, thereby decreasing automobile traffic and reducing congestion and delay. It is therefore important to evaluate alternatives fully before determining which action to take. The best strategies often include improvements to a variety of performance measures.

Candidate strategies must follow the goals, objectives, and characteristics of the specific airport, but several improvement strategies are commonly used. The access improvements listed in Table 10 are not appropriate in every situation and are not inclusive. However, they provide a good starting point from which candidate strategies may develop.

Step 7: Assess Effectiveness and Select Actions

Of the strategies identified as possible actions, each must be evaluated for feasibility and potential effectiveness. In many cases, the first check of feasibility will be cost of implementation. Other initial checks of feasibility include land, legal, environmental, or social constraints that may render a strategy impossible.

Each alternative must also be evaluated for effectiveness. Based on current and predicted conditions and demand, each strategy is evaluated according to the performance measures, and the improvement in service is estimated. Other performance measures may be developed based on goals or objectives outlined during problem definition. For example, strategies developed to address curbside congestion may be subjected to the additional performance measures of percent reduction in average curbside dwell time or percent reduction in curbside demand. Strategies are prioritized, and those strategies that perform better and more significantly improve service are more likely to be implemented. However, feasibility constraints, and cost in particular, will play a large part in the prioritization of candidate strategies. The optimal action that is selected will be one that significantly improves service performance within a reasonable implementation cost and with acceptable environmental and social impacts. The following tasks must be accomplished for each alternative as part of Step 7:

1. Assess feasibility: economic, land, legal, environmental, or social constraints.
2. Evaluate the effectiveness of alternatives, and estimate impact of service changes.
3. Estimate improvement to performance (Table 7, used in Step 4, can also be used in this task).
4. Prioritize strategies.
5. Select optimal action.

The results of Step 7 will essentially be a "report card" of performance for each potential improvement.

Table 10. Commonly Used Airport Access Improvement Strategies

Strategy	Purpose	Primary Performance Measures Affected	Secondary Performance Measures Affected
Transportation System Management (TSM)			
Increase frequency of bus or rail service	Improve service to current customers and promote use of HOV modes	Time Convenience Quality	Reduced access trips affect: Time Reliability
Increase radius of bus service	Improve service to current customers and promote use of HOV modes	Convenience	Reduced access trips affect: Time Reliability
Improve/increase signing on access roads	Improve service on access roads and prevent weaving and missed exits by unfamiliar drivers	Time Reliability Quality	
Various physical improvements to for-hire access modes: cleanliness, number of stops, safety, physical comfort, etc.	Improve service to current customers and promote use of HOV modes	Convenience Quality	Reduced access trips affect: Time Reliability
Various service improvements to for-hire modes: number of stops, baggage assistance, etc.	Improve service to current customers and promote use of HOV modes	Convenience Quality	Reduced access trips affect: Time Reliability
Transportation Demand Management (TDM)			
Implement curbside management policies	Reduce dwell time at terminal curbside to decrease congestion and delay	Time Reliability Quality	
Implement entrance/exit or per-trip fees	Discourage vehicles from continuously circling the airport	Cost	Reduced access trips affect: Time Reliability
Alter parking prices	Depends on objective: discourage pick-up/drop-off trips or promote HOV modes	Cost	Reduced access trips affect: Time Reliability
Subsidize HOV modes	Promote HOV modes	Cost	Reduced access trips affect: Time Reliability

Strategy	Purpose	Primary Performance Measures Affected	Secondary Performance Measures Affected
Preferential parking, preferential pick-up/drop-off locations, or other incentives for HOV modes	Promote HOV modes	Time Convenience	Reduced access trips affect: Time Reliability
Physical Improvements			
Build centralized ground transportation center	Improve service to current customers and promote HOV modes	Convenience Quality	Reduced access trips affect: Time Reliability
Build off-airport ground transportation center	Reduce traffic at airport and promote shift to HOV modes	Convenience Quality	Reduced access trips affect: Time Reliability
Expand existing roads and ramps or build new ones	Reduce congestion on existing routes	Time Reliability Convenience Quality	
Build airport access roads for exclusive use by airport traffic	Reduce congestion on alternate routes; decrease impact of non-airport traffic and associated peaks	Time Reliability Convenience Quality	
Build more parking lots	Add storage capacity; reduce time spent searching for a parking space	Time Reliability	
Expand terminal curbside	Reduce congestion at curbside; improve circulation on adjacent airport roads	Time Reliability Quality	
Introduce/extend rail service	Reduce congestion on access roads; provide more airport access options	Time Convenience	Reduced access trips affects: Time Reliability
Install people movers or moving sidewalks between mode drop-off and airline check-in	Improve and promote HOV modes	Time Reliability Convenience	Reduced access trips affect: Time Reliability

Step 8: Monitor and Feedback

Implementation of the optimal strategy is not the final step. The system must be assessed to determine the effectiveness of improvements and to ensure that estimated conditions were sufficiently accurate for landside access to perform adequately. Careful evaluation of the system and its improvements will aid future projects, as well as those at other airports. In addition, monitoring assists planners in anticipating and planning for future needs.

ACCESS EVALUATION OF RICHMOND INTERNATIONAL AIRPORT

RIC serves the Richmond metropolitan area and central and southeastern Virginia. RIC was selected for this case study for several reasons: (1) it is at the threshold of a medium-size facility and access congestion is increasing; (2) future passenger and air cargo are expected to affect landside capacity further; (3) the airport is centrally located in a state capital and thus provides convenient service to many major destinations; (4) VDOT's Transportation Planning Division indicated a preference for RIC; (5) since RIC had been updating its master plan, recent data were available; and (6) the relative size of the facility is such that an analysis could be performed using available resources.

Step 1: Define the Problem

The main operational problems, needs, goals, and objectives of access to RIC were identified through informal interviews with transportation agencies and providers and through site visits and observation. In addition, the survey response received from RIC officials provided an excellent base on which to build problem definition efforts. Interviews were conducted with representatives of the Capital Region Airport Commission (CRAC), City of Richmond, Richmond Regional Planning District Commission, VDOA, Greater Richmond Transit Company, Groome Transportation, and James River Bus Line.

Four problems are described in greater detail here: (1) traffic congestion on airport approaches, (2) limited public transportation options, (3) limited curbside capacity, and (4) inadequate directional information. Parking was recently addressed with the construction and opening of two parking structures.

1. *Traffic congestion on airport approaches.* The problem of traffic congestion on access roads has four elements:

    - *Lack of direct access from I-295 and I-64.* Access from the interstate requires exiting onto local roads. The distance between the I-295 exits and the airport entrance is approximately 4.4 km (3.5 mi), and the distance between the I-64 exit and the entrance is approximately 0.8 km (0.5 mi). Traffic volumes on local roads are increasing and causing delays.

- *Traffic queues at the exit ramp of I-64 during peak periods.* South Airport Drive provides access to destinations other than RIC. During the morning and evening peak periods, traffic on the local roads backs up. The two closely spaced traffic signals on South Airport Drive directly outside the airport property are not coordinated, causing traffic queues at the exit ramp of I-64.

- *Increasing traffic volumes and congestion on approaches.* Increasing traffic volumes and congestion on approaches may be partially attributed to recent development along South Airport Drive, Williamsburg Road, and Hunstman Road that has attracted greater volumes of non-airport traffic. This congestion results in additional delays for airport-bound traffic.

- *Conflicts between passenger and cargo traffic.* Passengers travel the same route as cargo traffic. Conflicts between passenger and cargo traffic occur along South Airport Drive, where drivers of passenger cars who are unfamiliar with the access system make quick lane changes to get into the desired lane while through truck traffic continues to air cargo areas. The difference between passenger and cargo operating characteristics can cause conflicts and is a safety concern.

2. *Limited public transportation options.* RIC is served by seven buses daily as part of the South Laburnum local route, which covers approximately 24 km (15 mi). The morning bus route begins in downtown Richmond and ends at the Fair Oaks Park 'N' Ride, and the afternoon bus follows the reverse route. The bus service area is increased by connections to two other bus routes: the Seven Pines route and the Fair Oaks Express. However, connections are inconvenient and necessitate long waits between buses. The bus stop that serves the airport is located 147 m (490 ft) from arrivals and 240 m (800 ft) from departures. This location is inconvenient and discourages transit use.

3. *Limited curbside capacity.* Projected growth in enplanements at RIC will place restrictive demand on an already strained terminal curbside. Curbside analysis indicates a curb length deficiency with existing enplanement levels, and this shortage will become more severe with increased airport use. Limited curbside capacity necessitates double- and triple-parking, resulting in delay and unsafe conditions for pedestrians.

4. *Inadequate directional information.* The signs providing directions to passengers are inadequate to allow drivers to make decisions regarding how to get to the terminal or parking lots. These signs are low and located on the side of the road, thus restricting sight distance. Information about parking availability is shown on changeable message signs. However, decision sight distance is inadequate, resulting in excessive weaving.

Step 2: Establish Performance Measures

Performance measures that were previously described and tabulated in Table 7 were used to evaluate improvement alternatives.

Step 3: Collect the Data

An overview of the airport landside access system and airport operations was compiled to understand the characteristics of RIC. Collection of performance measure data was tailored to support investigation of the problems and needs identified in Step 1.

Most of the basic data were available in the RIC draft *Master Plan Update*[25] and the access plan, *Traffic and Ground Transportation Analysis.*[26] Data were also furnished by CRAC. Performance measure data were collected directly at the airport during two site visits.

The *Master Plan Update* and *Traffic and Ground Transportation Analysis* included an inventory and layout of the roadways and parking system. Data on the location of for-hire modes were collected during site visits. Enplanement levels were collected from the FAA. Other airport activity data, such as percentage of passengers transferring to another flight and air cargo activity, were provided in the *Master Plan Update* or by CRAC. *Traffic and Ground Transportation Analysis* included data on traffic demand. Information on user characteristics, including passenger profile and the impact of nonpassenger traffic, was mainly obtained through interviews with CRAC officials. However, few quantitative data are actually collected. The service characteristics of for-hire modes were determined through bus schedules, information provided by Groome Transportation, and conversations with transportation agencies. Much of these data came from conversations with Groome Transportation and taxi drivers. The *Master Plan Update*, CRAC officials, and other transportation agencies advised the researchers on anticipated changes in land use.

Access mode costs were collected through published bus, taxi, and limousine fares. Parking rates are published by the airport. Exact access times, averages, and variances would not provide much insight into access performance since access times vary with conditions and passenger perception is a large influence. Access times were therefore estimated through bus schedules, conversations with transportation providers, and site visits. Sample times required for a typical passenger to find a parking spot, wait and ride the parking shuttle, and reach the terminal were measured during peak periods to provide a base comparison. Reputations of reliability were obtained through interviews with transportation agencies.

Data on convenience were collected during site visits, including measurement of walking distances using a rolling counter. Interviews with Groome Transportation and taxi drivers also provided information on access convenience regarding baggage assistance, handicap-accessibility, radius of service from the airport, and hours of operation. Data on access quality relating to the number of transfers, number of stops, service frequency, and total time for stops were obtained through interviews with transportation providers. Subjective performance measures relating to quality, such as adequacy of information and directions, maintenance of vehicles, degree of physical comfort, degree of protection from the elements, and friendly, helpful service, were investigated during site visits. Comparisons were made between modes. Information regarding lighting, security patrols, and safety was obtained through interviews with CRAC officials and security guards.

Step 4: Understand Present Conditions and Performance

The data were compiled and analyzed to understand present access conditions and performance. Data on access components, airport activity, traffic volumes, user characteristics, for-hire service characteristics, and anticipated changes in land use provide an overview of the access situation at RIC. More specific data on cost, time, reliability, convenience, and quality are used to understand present performance.

Understanding Present Conditions

Understanding present conditions requires a description of airport activity, an inventory of access components, information on traffic demands, user characteristics, for-hire service characteristics, and anticipated changes in land use.

Description of Airport Activity

RIC handled 1,066,411 enplanements in 1995.[22] Almost all passenger traffic is leaving or destined for RIC, with a negligible percentage of passenger transfers. A number of other services are supported in addition to commercial airline service. Domestic and international air cargo service is provided by DHL Express, United Parcel Service, Federal Express, Emory, Airborne Express, Burlington Air Express, Baltimore Air Transport, and the U.S. Postal Service. General aviation, corporate aviation, and Virginia Air and Army National Guard are also present.

Accepted planning practices dictate construction of an access system to meet projected design day traffic volumes. The RIC design day is determined as 3.3 percent of design month enplanements. The design month (month of peak enplanements) at RIC has historically been 9.4 percent of annual enplanements. The month identified as the design month varies from year to year, and therefore no particular month may be expected to be the peak month. Four daily flight peak time periods were identified in the access plan based on a review of airline schedules. These time periods are the early morning peak (6:30 to 7:29 A.M.), the midmorning peak (9:00 to 9:59 A.M.), the afternoon peak (4:45 to 5:44 P.M.), and the evening peak (8:30 to 9:29 P.M.)[26] Passengers are instructed by the airlines to check in at least 1 hour before the flight; thus peak periods for the purposes of landside access evaluation are expected to begin 1 hour before these flight peak periods.

Inventory of Airport Access Components

RIC is situated to the east of the City of Richmond in Henrico County. The airport is approximately 7.5 miles east/southeast of the Richmond central business district. A number of arterial roadways and interstate highways provide access between RIC, the City of Richmond, and the surrounding region. Access from the east and west is provided by I-64 and Williamsburg Road (U.S. Highway 60). The most direct access from the north is provided via I-95 to I-295, with airport access provided from I-295 via the I-64 interchange to South Airport Drive (Route 156 South) or the interchange with U.S. Highway 60 (Williamsburg Road). Access from the south is provided by I-295 or by northbound I-95 to I-64. Access in the immediate vicinity of RIC is provided by local roads, including U.S. Highway 60 (Williamsburg Road), South Laburnum Avenue, and Charles City Road, which provides more direct access to cargo terminals. Figure 13 shows the major access facilities and the location of RIC. Figure 14 shows the local roads in the vicinity of RIC.

Most passengers access the airport by private automobile. Rental car agencies are located adjacent to the terminal. Taxicab, airport limousine, charter services, courtesy vehicles, and bus are also available. Approximately 35,000 taxicab trips are made per year, and approximately 70,000 passengers use Groome Transportation each year. Bus ridership is low. No further data are available on passenger mode split. Rail access is not provided.

Inventory of Terminal Access Components

South Airport Drive provides internal airport circulation. Terminal Drive provides access to the terminal. A number of local roads that connect with South Airport Drive provide access to other airport buildings such as the Virginia Aviation Museum, rental car return, corporate flight departments, and air cargo terminals. None of the South Airport Drive intersections located on RIC property is signalized. Figure 15 shows terminal area circulation.

Inventory of Parking Areas

Passenger parking is provided adjacent to the terminal and at three remote (satellite) parking lots with shuttle service. One of these remote lots is privately owned and operated and is located off airport property. Valet parking is also available. A recommendation made by a September 1993 parking study was to build two parking structures adjacent to the terminal; the first of these structures was in operation and the second was opened to the public during this study. It is anticipated that both satellite parking lots will be closed to avoid high shuttle service costs, since capacity will not be needed now that the garages are open.[25] Discounts for passengers using Pay-On-Foot (designated pay stations located in the terminal and parking deck) and Automated Vehicle Identification (accounts that make use of a vehicle transponder) will be implemented in the future. The existing Pay-On-Foot collection machines allow passengers to save time by paying parking fees in advance. Table 11 summarizes characteristics of the existing and near-future passenger parking facilities.

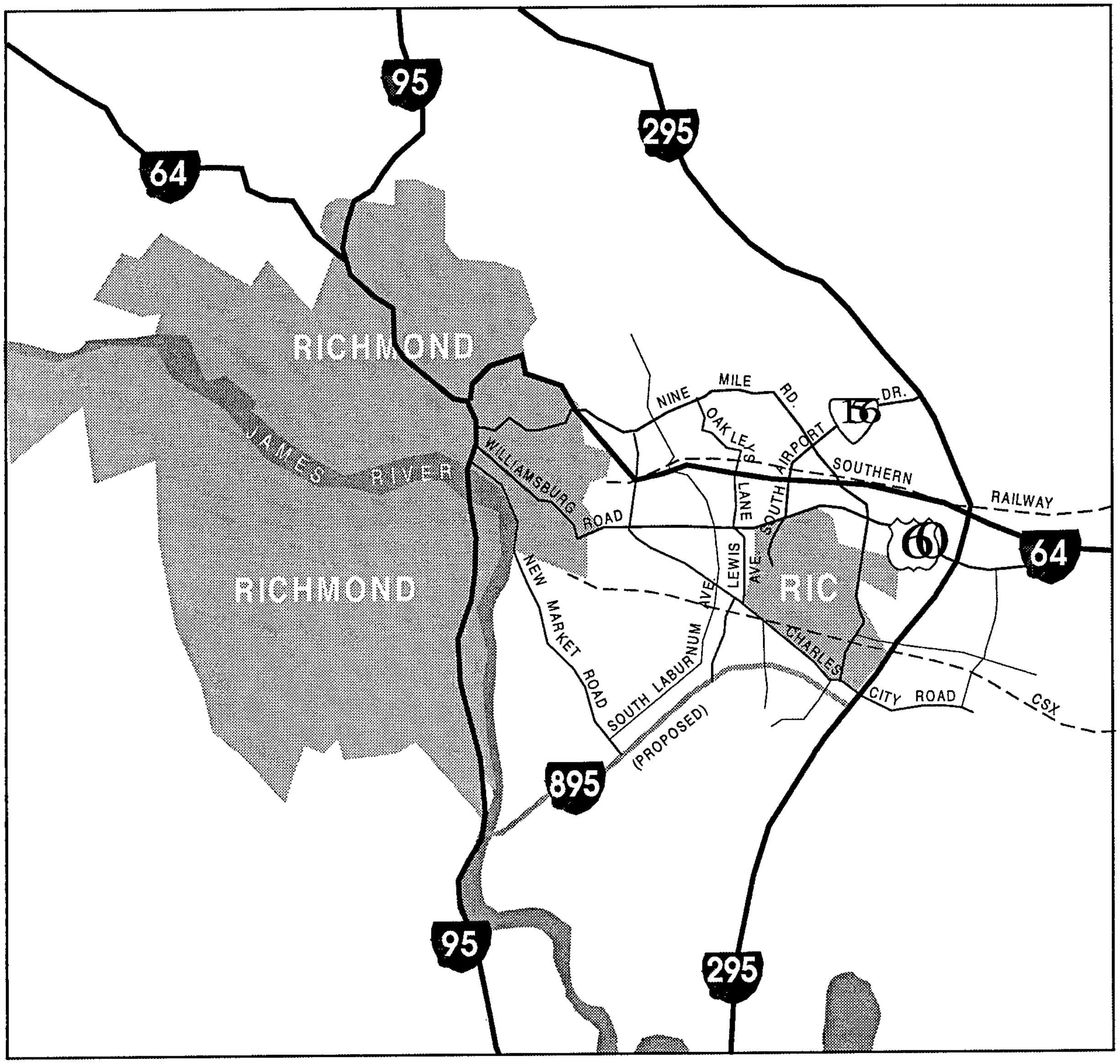


Figure 13. Regional Access to RIC

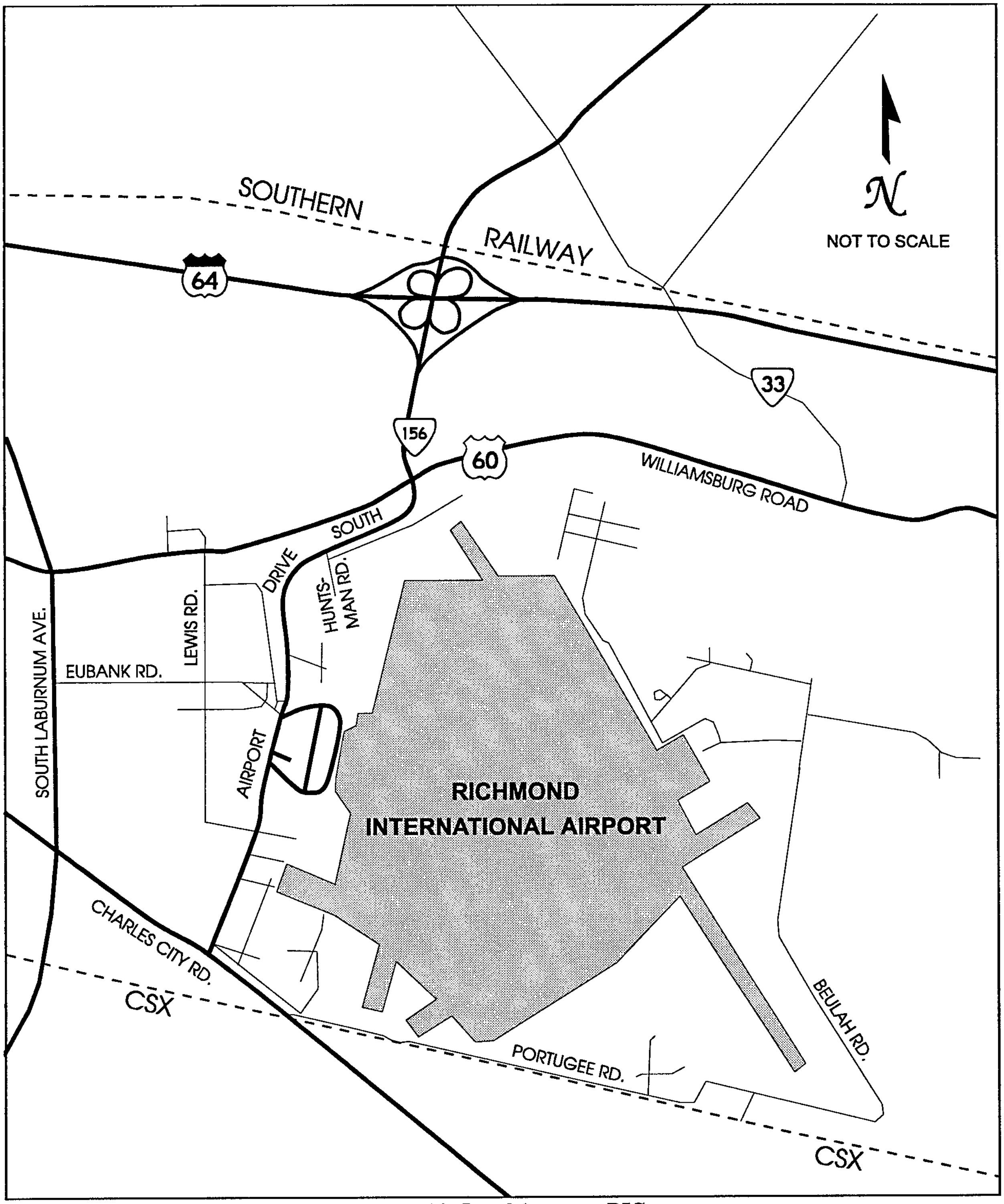
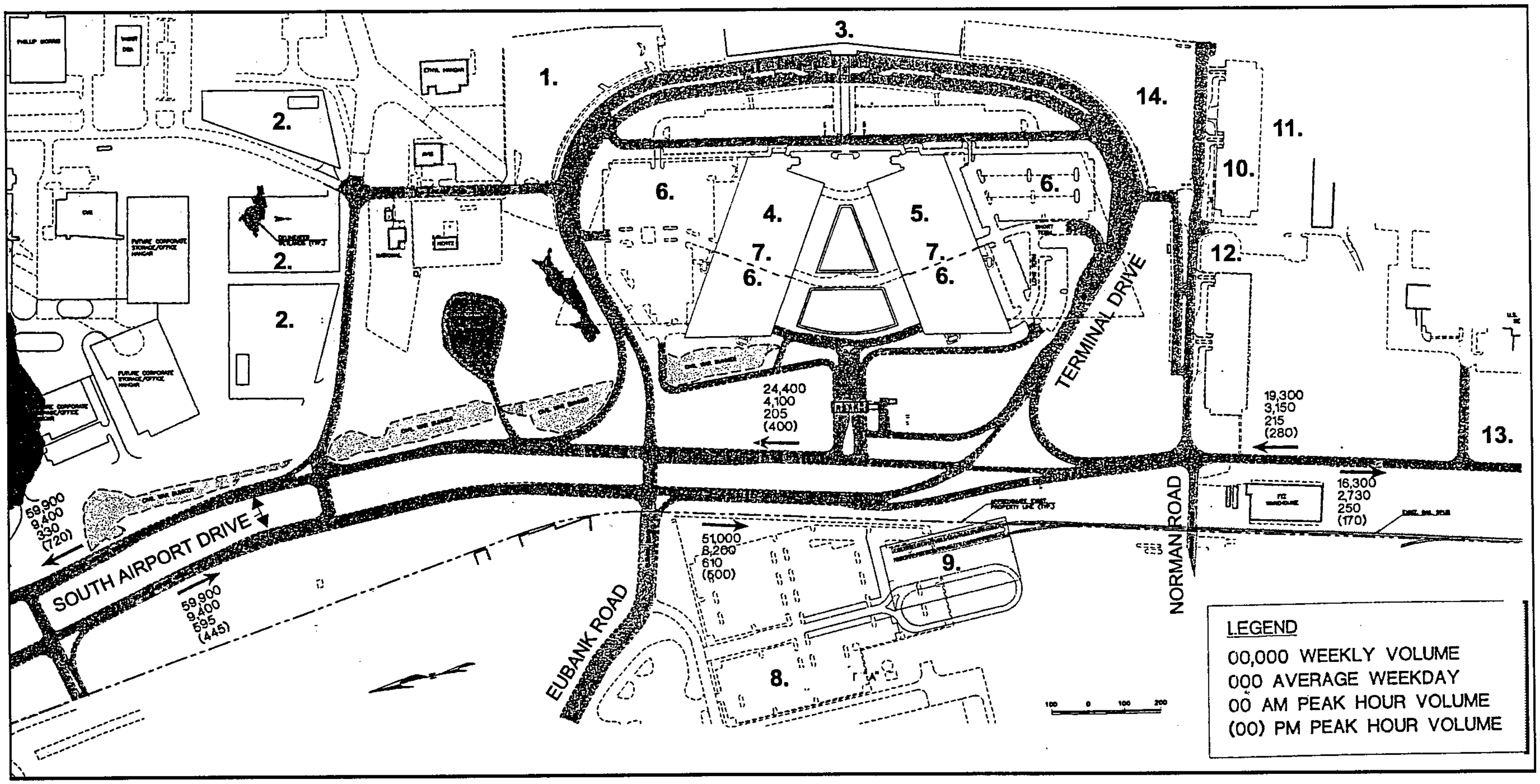


Figure 14. Local Access to RIC



1. Existing rental car ready lot
2. Future rental car service
3. Existing terminal
4. Parking garage "A"
5. Parking garage "B"
6. Short term parking
7. Long term parking
8. Satellite parking lot "A"
9. Future transit rail station (year 2010)
10. Employee parking
11. Air cargo
12. Cab holding area
13. Satellite parking lot "B"
14. Express parking

Figure 15. Terminal Access with Traffic Volumes

Table 11. Passenger Parking Facilities at RIC

Location	Capacity	Cost
Terminal Parking Area: Short-Term/Hourly	346 short-term lot spaces (including metered curbside spaces)	$2/hour; $14/day
Terminal Parking Area: Long-Term/Garage	3,000	$3/hour; $9/day
Express Lot	275	$2/hour; $8/day
Satellite "A" Parking Lot	780	$1/hour; $6/day
Satellite "B" Parking Lot	650	$1/hour; $5/day
Valet Parking	45	$15 first day, $1.50/hour ($10 max) after 24 hours
Rental Car Ready Lot	249	
Employee Lot	328	
Aero-Park Off-Airport Parking Lot	Not Available	$7.50/day

Traffic Demands

As part of RIC's access planning process, weeklong traffic counts were conducted along South Airport Drive on airport property from May 17, 1996, to May 24, 1996. Turning movements were also recorded. Figure 15 includes traffic volumes recorded on South Airport Drive. Table 12 presents directional distribution of vehicles accessing the airport property. Complete results of these counts are available in *Traffic and Ground Transportation Analysis.*[26] Results of these traffic counts and turning movements indicate that the majority of terminal traffic accesses from and egresses to the North via South Airport Drive, which provides access to I-64. High traffic volumes on Federal Drive are likely attributable to the employee parking lot and taxicab holding area located along this road. Traffic along Clarkson Road is likely attributed to the aviation buildings and rental car agencies on this road.

Table 12. Directional Distribution of Existing Traffic Volumes Accessing RIC

Route	Percentage
South Airport Drive (Route 156)-Southbound	51
Williamsburg Road (Route 60)-Westbound	6
Williamsburg Road (Route 60)-Eastbound	5
Eubanks Road	11
Norman Road	4
Charles City Road-Westbound	6
Charles City Road-Eastbound	17
Total	100

Analysis conducted on the airport property as part of the master plan update indicates LOS B for northbound South Airport Drive and LOS A for southbound South Airport Drive and Lewis Road. Terminal curbside analysis indicates an existing deficiency in curb space based on 1996 enplanement levels. Based on the FAA recommendation of 1 space per 500 to 700 annual enplaned passengers, RIC currently requires between 1,523 and 2,133 parking spaces (based on

1995 data of 1,066,411 enplanements). With the completion of the second parking garage, the existing capacity includes approximately 5,096 passenger parking spaces, which exceeds FAA recommendations. The garages incorporate long-term, short-term, and rental car parking.

User Characteristics

Certain user characteristics affect airport access requirements and mode choice. Seventy percent of RIC passengers are business travelers, and 30 percent travel for pleasure. The average household income is $55,000. The average size of a party traveling together is 1.6 passengers. However, higher vehicle occupancy rates on access roads are assumed since meeters, greeters, and airport visitors are not included in this figure.

For-hire Service Characteristics: Taxicabs

Any taxicab is permitted to drop off passengers at the airport. Taxicabs wishing to pick up passengers are required to hold a contract with CRAC. Fifteen taxicab companies hold CRAC contracts, which represent 40 vehicles. The $1-per-trip fee is usually taken out of the driver's tip. Drivers indicated that time required to pay the per-trip fee was nominal and that the system works well. Taxicab service is provided on demand. Three taxicabs are permitted to queue outside the terminal arrivals door, and as each taxicab departs, the driver rings a bell to the holding area to signal the next cab to the terminal. The holding area has a capacity of about 30 taxicabs. Taxicab service is provided from 5 A.M. until the last flight of the day at approximately midnight. Because of the long wait for passengers and the per-trip fee, drivers are often reluctant to accept short trips. However, airport contracts require that all trips be accepted regardless of length, and this policy is enforced.

For-hire Service Characteristics: Airport Limousine and Charter Services

Airport limousine service is provided under airport contract by Groome Transportation. On-demand service is provided, but to maximize the number of riders per vehicle, drivers wait until most passengers have left the terminal arrivals area before beginning a trip. To reduce trip time, trips are arranged such that no more than three stops are made. Groome operates 22 hours a day; service is not provided between 1 and 3 A.M. Baggage assistance and storage are provided, and one vehicle is equipped with a handicap lift. Groome vehicles are not subject to the per-trip fee. Approximately 350 to 400 passengers use Groome Transportation per day.

Charter service is provided by several private bus companies and is prearranged by interested groups. Charter bus services that have a contract with CRAC must pay a $4 per-trip fee ($2 for mini-buses), and buses not under contract must pay an $8 per-trip fee ($4 for mini-buses).

For-hire Service Characteristics: Bus

Bus service is provided by Greater Richmond Transit Company Monday through Friday with no holiday service. Four buses provide service between RIC and downtown Richmond in the morning on 30-minute headways. Three buses provide the same service in the afternoon on 30- to 42-minute headways. Transfers increase the available service area. From downtown Richmond to RIC, the trip takes approximately 35 minutes. All routes are wheelchair accessible except for one route in the morning and one in the afternoon. The bus stop is located on the outer loop of the terminal access road, far from other access modes and transportation providers, and necessitates a long walk to the terminal.

For-hire Service Characteristics: Courtesy Vehicles

Several area hotels and one off-airport rental car agency provide courtesy vehicles for their customers. Courtesy services are provided on-demand, and vehicles are not usually filled to capacity. Several hotels provide their own vehicles, and other hotels have a contract with Groome Transportation to bill fares directly to the hotel. Those hotels that provide their own vehicles and are located far from RIC necessitate a wait of up to 30 minutes.

Anticipated Changes in Land Use

The *Master Plan Update*[25] forecasts significant growth in air travel demand at RIC. To accommodate this growth, four airside development alternatives were investigated, with one recommended alternative. Four land use alternatives were also developed to handle the additional aircraft and enplanements and include terminal, air cargo, maintenance, and other service building expansions. Based on land use alternatives, three terminal alternatives were identified to specify terminal expansion within the description of the chosen land use alternative. Once approved and funded, these land use changes will occur over a 35-year period. Since the *Master Plan Update* is currently under review, it is presently impossible to specify exactly what land-use development will occur and how it will affect landside access.

Several studies are currently underway that affect landside access to RIC. One feasibility study is investigating need, potential market, legislative and institutional barriers, and alternative scenarios for an intermodal transportation facility at RIC. This study, entitled *Richmond International Airport Intermodal Transportation Facility*, includes planning and conceptual development of a freight and passenger transfer facility for air, rail, truck, and other modes and will be conducted over the next 3 to 5 years. The proposed facility would link all forms of transportation in a unified, interconnected transportation system to provide for enhanced mobility, intermodal efficiency, and effectiveness for the movement of passengers and goods associated with RIC.[27] Increased freight traffic is a possible result of this facility, which would likely affect passenger access. Renovation of the downtown Main Street Station is also being considered to include shuttle service and eventual rail service to RIC.

Another study is the *I-64/I-895 Direct Airport Access Road Corridor Feasibility Study*, which was initiated during this research to investigate the development of an intermodal freeway and direct link to improve access between RIC, I-64, and the proposed I-895. I-895 is a planned tollway link between I-295 and I-95. The purpose of this study is to identify alternative alignments, determine right-of-way requirements and impediments, perform environmental reviews to identify general environmental conditions and potential environmental difficulties, and determine estimated project design and construction costs.[28]

The I-64 Major Investment Study (MIS) and CSX Corridor MIS are two other ongoing studies that address mobility issues and identify potential transportation improvements in the region, including access to RIC. Outcomes from these studies may affect land use and landside access to RIC in the future.

Understanding Present Performance

Understanding present performance requires a more specific description of cost, time, reliability, convenience, and quality. Access performance data are tabulated in Table 13.

Cost

There are no toll roads in the immediate vicinity of RIC. Automobiles are not charged to enter the airport, but for-hire modes under contract are assessed a $1 per-trip access fee for cars and sedans, $2 for mini-buses, and $4 for buses. Transportation providers not under contract pay $1 for cars and sedans, $4 for mini-buses, and $8 for buses. Automobile parking rates are shown in Table 11.

Automobiles incur operating costs. Taxicab fares are $1.50 for the first 0.32 km (0.2 mi) and $.30 for each additional 0.32 km. Additional charges are waiting time, $.30 per minute; additional passengers, $1 per additional passenger over age 5; and evening service, $1 per trip between 9 P.M. and 6 A.M. Airport limousine fares are charged according to a zone system, with single, one-way fares ranging from $6.25 for local trips to $72.00 for Fort Pickett, the most distant zone. Group discounts are available. Charter service fares are individually arranged, usually as part of a group travel package. Bus fares are based on payment method (prepaid versus cash) and range from $1.00 to $1.25 for local service and from $1.35 to $1.60 for service between the city and county. Senior citizen, disabled, and student discounts are available. Courtesy vehicle service is included as part of another service cost, such as a hotel or rental car rate.

Gratuities are individually determined by passengers and typically given to drivers of taxicabs, airport limousines, and courtesy vehicles. Gratuities are usually in the range of several dollars.

Table 13. Landside Access Component Performance at RIC

Performance Measure	Private Auto: Driven	Private Auto: Drop Off	Taxi	Airport Limo/ Charter	Bus	Courtesy Vehicle
Cost						
Dollars per passenger trip	G	E	F	G	E	E
Time						
Time comparison between modes	E	E	E	E	F	G
Waiting time	E	E	E	G	P	F
Reliability						
Reputation of reliability	E	E	G	G	G	G
Convenience						
Total walking distance with baggage	G	E	E	E	P	E
Total walking distance without baggage	E	E	E	E	E	E
Total number of level changes when walking	E	E	E	E	E	E
Availability and extent of baggage assistance	G	G	E	E	P	G
Availability of baggage storage area on vehicles	E	E	E	E	F	E
Handicap accessible	E	E	E	E	G	G
Radius of service provided from airport	E	E	E	G	F	F
Hours of operation	E	E	E	E	P	E
Quality						
Number of transfers required	E	E	E	E	F	E
Number of stops required	E	E	E	G	G	E
Service frequency or headway	E	E	E	E	P	E
Total time for stops and transfers	E	E	E	G	G	E
Adequacy of information and directions	P	P	G	G	F	G
Maintenance of vehicles	N/A	N/A	G	G	G	G
Degree of physical comfort	E	E	G	G	G	G
Degree of protection from the elements	G	E	G	G	G	G
Friendly, helpful service	N/A	N/A	G	G	G	G
Adequacy of lighting, security, and level of safety	E	E	E	E	E	E

E = excellent, G = good, F = fair, P = poor.

Time

Once the passengers are on RIC property, travel times for departing passengers to reach the terminal are similar. The centralized terminal configuration allows for one stop for all drop-off passengers, even with for-hire vehicles shared by passengers flying with different airlines. Passengers who park their private automobiles must take the time to park and walk to the terminal. One-day sample parking times were measured during the morning departure peak period on Wednesday, August 13, 1997, to get an idea of parking time. Parking times were reasonable, with less than 5 minutes required for all parking areas. Walking time is associated with parking in the garage and short-term lot and with the bus. For passengers parking in the satellite lots, waiting time for the shuttle to arrive can be up to 10 minutes, with time en route to the terminal lasting up to 8 minutes. The time for taxicabs and courtesy vehicles to pay per-trip fees is negligible. Considering their proximity to the terminal, these modes enjoy a slight time advantage over other modes that must park.

Travel times vary by mode for arriving passengers. During peak periods, the time required to pay automobile parking is greater if a queue forms at the collection booths. However, the easily accessible collection machines inside the airport terminal and in some garage locations make it possible to avoid this delay. One-day sample payment times were measured during the morning arrival peak period on Wednesday, August 13, 1997, and no wait was experienced. Sufficient taxicabs are generally available to prevent any waiting time. Airport limousines may take around 15 minutes for rides to be arranged and all passengers to leave the arrivals area. Waiting times for courtesy vehicles may be up to 30 minutes. Waiting time for bus varies depending on the time of flight arrival, as service is provided only during certain hours.

Reliability

Based on the interviews conducted with transportation-related agencies, all modes have good reputations regarding reliability. Private automobiles have the highest reliability performance since passengers have the ability to control departure times. The Groome Transportation contract includes a requirement for a maximum 10-minute wait once a ride is requested. Several bus arrivals were observed on Wednesday, August 13, 1997. Each arrival was on schedule.

Convenience

Approximate walking distances for each access mode were measured and are provided in Table 14. These distances are approximated from the furthest possible location and may be shorter depending on the actual parking space. Most walking distances are acceptable, but walking distance to the bus is poor given the common tolerance of 240 m (800 ft). Longer walking distances to and from the parking garages are acceptable because the garages are within sight of the terminal and a shorter walk may be perceived. In addition, these are maximum distances, and most walks are slightly shorter. No level changes are required since elevators

Table 14. Approximate Walking Distances at RIC

Location	Distance to Arrivals	Distance to Departures
Short-term parking	218 m (725 ft)	218 m (725 ft)
Garage parking	350 m (1165 ft)	350 m (1165 ft)
Satellite A	60 m (200 ft)	60 m (200 ft)
Satellite B	60 m (200 ft)	60 m (200 ft)
Taxicab	15 m (50 ft)	51 m (170 ft)
Airport limousines/charters	15 m (50 ft)	21 m (70 ft)
Courtesy vehicles	15 m (50 ft)	15 m (50 ft)
Bus	240 m (800 ft)	147 m (490 ft)

service the parking garages. Unless a stop is made at the terminal to discharge luggage before parking, each of these walking distances necessitates passengers to carry baggage.

Quality

Data regarding quality were collected during two site visits. Some performance measures that describe quality were estimated or described to meet the objective of describing the overall passenger performance without undergoing extensive yet unnecessary field studies.

The number of transfers and stops, and the time they require, is associated only with airport limousine and bus. The actual time varies but must be accounted for in evaluating the overall passenger performance and mode choice. Private automobile, taxicab, airport limousine and charters, and courtesy vehicles provide on-demand service. Buses stop twice per hour during operating hours.

One of the problems identified in Step 1 was the lack of adequate information on parking availability and directions to terminals and parking lots. Private automobiles are directed to satellite lots when the garage is full by means of changeable message signs located off the shoulder of South Airport Drive. However, this information is not prominently displayed and is provided too close to the terminal area to allow sufficient time for decision making. Directions to terminals and lots are also not prominently displayed. These inadequacies cause quick lane changes and create a safety concern since through truck traffic is also present. No information on traffic conditions is provided upon approaching the airport or upon exiting the airport. These problems of inadequate information affect private automobiles to a much greater extent than other modes, since for-hire service providers are more familiar with the airport configuration and operation.

Maintenance of vehicles affects reliability and passengers' perception of service quality and is important with for-hire modes. Maintenance of taxicabs, airport limousines, charter services, buses, and courtesy vehicles is generally sufficient. Maintenance of private automobiles depends on the driver.

The degree of physical comfort provided also affects for-hire modes. This is a subjective performance measure, but no for-hire mode presently equals the private automobile with respect to physical comfort.

The degree of protection from the elements affects those passengers who incur a walking distance, especially when carrying baggage. Passengers who park their automobile must walk to the terminal or the shuttle bus stop. Shuttle bus stops are covered, and a covered walkway spans most of the walk from the garage to the terminal. Passengers dropped off at the terminal curbside may quickly enter the terminal building without much exposure to the elements. Airport limousines, charter services, and courtesy vehicles also necessitate little time outdoors, as walking distances to the terminal are short. The long walk to the bus stop is covered along the terminal building, but the remainder of the walk to the stop is uncovered, as is the stop itself.

Friendly and helpful service affects the quality of for-hire modes. Each mode performed sufficiently in this area. At airports where customer satisfaction is a primary concern, or where numerous complaints are filed, more in-depth study of service quality may be warranted.

The parking garages were designed with safety in mind and have adequately lit glass-enclosed stairwells and elevators that are visible from the exterior. Satellite lots are lit and staffed by fare collection attendants. Routine safety patrols are conducted by airport police and parking lot employees. For-hire modes service the terminal area, which is well lit and policed by foot and vehicle patrols. Few incidents of thefts are reported in the parking lot, parking garage, and terminal areas, and reports of assaults are virtually nonexistent.

Step 5: Forecast Future Conditions and Performance

Year 2020 aviation demand forecasts were completed for RIC as part of the *Master Plan Update.*[25] Based on the forecast growth in enplanements, changes in airport access activity and demand were projected. Three possible levels of future demand were developed that account for aviation growth and potential impacts relating to economic development, technological changes, competing modes of transportation, and infrastructure improvements such as the planned I-895.

Future access capacity analysis was conducted to evaluate existing infrastructure based on forecast demand and to predict future problems and performance issues. Analysis resulted in the conclusion that the roadway infrastructure could handle year 2020 traffic levels with additional capacity for growth, but that significant shortages in terminal curbside would occur by 2000.[25] The new parking structures are anticipated to provide sufficient long- and short-term parking capacity through the year 2010. A discussion of the forecast methodology is beyond the scope of this project, and interested readers are directed to the *Master Plan Update*[25] and *Traffic and Ground Transportation Analysis*[26] for more information.

South Airport Drive and Lewis Road were assessed in the *Master Plan Update* according to *HCM* standards. The LOS of each road was determined using projected traffic volumes generated through the four-step process of trip generation, trip distribution, mode split, and traffic assignment. This process was influenced by forecasts of aviation and other local development. Northbound South Airport Drive is projected to degrade to LOS C by 2005 and to LOS F by 2015. Southbound South Airport Drive is expected to operate at LOS A until 2015. Lewis Road is expected to remain at LOS A until at least 2030.[25]

Terminal curbside analysis was also conducted as part of the access plan. Curbside dwell times were measured over a 4-day period to determine average dwell times. In addition, curb length requirements were forecast using the method introduced in the section on terminal curbsides and based on forecast enplanement levels. According to this method, an existing deficiency in curb space was apparent, and significant shortages will occur by 2000. Table 15 summarizes the findings of the access plan based on a desired curbside LOS between B and C.[26]

Table 15. Terminal Curb Length Footage Requirements at RIC[26]

Location	Year			
	1996	2000	2010	2020
Existing				
Departure	250	250	250	250
Arrival	250	250	250	250
Commercial	190	190	190	190
Total	690	690	690	690
Requirement				
Departure	235	383	553	703
Arrival	288	445	623	801
Commercial	282	445	633	810
Total	805	1,273	1,809	2,314
Deficiency				
Departure	0	133	303	453
Arrival	38	195	373	551
Commercial	92	255	443	620
Total	130	583	1,119	1,624
Notes: This analysis excludes long-term curb parking of 22 minutes and beyond. The requirement service level set for this table is between service levels B and C. It is assumed that commercial vehicles, while curb parking, will require 35% of total curb parking estimates.				

Step 6: Develop Candidate Strategies and Actions

Candidate strategies and actions were developed based on the access problems identified in Step 1, as well as the data collected in Step 3, the present condition performance studied in Step 4, and future conditions forecast in Step 5. Candidate strategies were developed to address the identified access problems within the categories of TSM strategies, TDM strategies, and physical improvements. These strategies are summarized in Table 16.

Transportation System Management Strategies

Several access problems may be alleviated through TSM strategies that improve operations using existing infrastructure. Six TSM strategies were developed for RIC.

1. Optimize Signal Timing. The problem with traffic queuing at the exit ramp of I-64 during peak periods may be addressed in an investigation of the signal timing at the intersections of South Airport Drive with Audubon Drive and Williamsburg Road. These signals should be studied and coordinated to reduce the impact of traffic exiting from I-64.

2. Place Signals on South Airport Drive. Placing signals at certain intersections was recommended in *Traffic and Ground Transportation Analysis*[26] as a result of the forecast conditions and performance. A traffic signal will be warranted by 2010 at the intersection of South Airport Drive and Huntsman Road because of traffic accessing the Virginia Air Museum. Other signals may become necessary depending on the impact caused by I-895. Signalization on

Table 16. Candidate Strategies and Actions at RIC

Strategy	Purpose	Primary Performance Measures Affected	Secondary Performance Measures Affected
Transportation System Management (TSM)			
Optimize Signal Timing	Minimize traffic queues at the exit ramp of I-64	Time, quality	Reduced delays affect cost, reliability
Signalization on South Airport Drive	Alleviate problems of increasing traffic volumes and congestion on approaches	Time, quality	Reduced delays affect cost, reliability
	Increase and improve public transportation options	Time, convenience, quality	Reduced access trips affect time, reliability
Move Bus Stop	Improve public transportation options	Time, convenience, quality	Reduced access trips affect time, reliability
Increase Enforcement of Curbside Policies	Improve terminal curbside operations	Time, reliability, convenience, quality	
Improve Access Information and Directions	Improve service on access roads and prevent weaving and missed exits by unfamiliar drivers	Time, quality	Reduced delays affect cost, reliability
Physical Improvements			
Provide Direct Interstate Access	Alleviate problems associated with lack of direct interstate access	Time, quality	Reduced delays affect cost, reliability
Roadway Improvements	Accommodate increasing traffic volumes and congestion; reduce conflicts	Time, quality	Reduced delays affect cost, reliability

South Airport Drive is intended to alleviate the problem of increasing traffic volumes and congestion on approaches.

3. Improve Bus Service. The access issue of limited public transportation options may be addressed through performance improvements to the existing bus service. One possible action is to increase airport limousine service between RIC and the Fair Oaks Park 'N' Ride bus stop or other bus stops. The Fair Oaks Park 'N' Ride stop is served by eight Greater Richmond Transit Company buses daily, which cover other areas of the region. Improving the connection between other bus stops and RIC would increase public transportation options and performance by covering a broader time period and larger area. This could be accomplished by installing courtesy telephones with direct links to Groome Transportation at the bus stop and by increasing awareness of the service through publicity. Another possible improvement is to increase the frequency of bus service to RIC. However, ridership levels are currently low, even during the morning peak period, and there is not much indication that increasing service frequency would be warranted by increased ridership.

4. Move the Bus Stop. The inconvenient location for bus loading may be improved by moving the bus stop to the area currently used by charter buses. Moving the bus stop to a location closer to the terminal will increase bus convenience and awareness of the availability of bus as an airport access option. Charter bus service is infrequent, and the use of the charter bus area by public buses should not pose a problem.

5. Increase Enforcement of Curbside Policies. Terminal curbside operations may be improved through increased enforcement of dwell time limits and policies regarding double and triple parking. Physical improvements will likely be necessary in the future, but increased enforcement would improve curbside operations and make better use of available capacity in the interim before the curbside is expanded.

6. Improve Access Information and Directions. Information on parking availability and directions to the terminal and lots may be more adequately provided in several ways. First, information should be provided immediately at the entrance to the airport property to increase decision sight distance and allow sufficient time for drivers to make decisions and realize where they need to go. Second, the information should be placed on larger, more prominent signs. Future improvements such as real-time traffic advisory information provided in the baggage-claim area of the terminal or on the airport approaches may become feasible when enplanements or congestion significantly increases. Improving access information and directions would also help to reduce passenger-cargo traffic conflicts by decreasing the effects of unfamiliar drivers.

Transportation Demand Management Strategies

No specific TDM strategies were developed, but two of the strategies considered may have the secondary benefit of decreasing transportation demand through increased public transportation use and improved traffic operations. The TSM strategies of improved bus service may draw more riders and moving the bus stop location closer to the terminal may increase awareness, also increasing ridership.

Physical Improvement Strategies

Some physical improvements will become necessary to accommodate growth in passenger enplanements and local traffic. Two were developed for RIC:

1. Provide Direct Interstate Access. Direct interstate access is being studied in the I-64/I-895 Direct Airport Access Road Corridor Feasibility Study, which will not be completed for several years. Several alignments are being studied to address the problems posed by the lack of direct interstate access, including congestion and delay. One alignment recommended in the Master Plan Update includes extension of South Airport Drive to an interchange with the proposed I-895.[25]

2. Make Roadway Improvements. The problem of increasing traffic volumes and congestion on approaches may be alleviated through a combination of roadway improvements. As a result of the traffic studies based on forecast conditions and performance, initial infrastructure improvements were recommended in the access plan.[26] Roadway improvements were recommended to accommodate year 2020 volumes with excess capacity for growth. The only major roadway improvements recommended were the widening of South Airport Drive between Fox Road and Charles City Road and improvements to the intersection of South Airport Drive and Williamsburg Road. These are preliminary recommendations, and further studies are necessary to determine alignment and feasibility. Roadway improvements may also help to reduce conflicts between passenger and cargo traffic. However, passenger traffic still must make lane changes and will tend to move slower than cargo traffic, so the provision of a separate entrance for truck traffic might be beneficial. Another possible strategy is a truck-only lane to accommodate through-cargo traffic.

Other preliminary recommendations were made in the *Master Plan Update* that have not yet been investigated, including improvements to South Airport Drive and a multilevel terminal and frontage roadway system. In addition, several transportation studies are currently underway. These studies are the *Richmond International Airport Intermodal Transportation Facility Study*, the I-64 MIS, and the CSX Corridor. These recommendations and studies may result in action taken to improve airport access.

The *Master Plan Update* makes recommendations for South Airport Drive beyond those recommended in the access plan based on traffic studies. One such recommendation is for grade separation at the intersection of South Airport Drive and Terminal Drive. This recommendation was made to reduce conflicts between passenger traffic accessing the airport terminal and northbound traffic using Airport Drive from Charles City Road and the cargo areas. Another roadway improvement recommended in the *Master Plan Update* is movement of the intersection of South Airport Drive and Eubank Road further north to the existing intersection of Clarkson Road and South Airport Drive. This new location would provide sufficient land to permit widening of the crossing and dedicated turn and acceleration lanes. The *Master Plan Update* also includes a recommendation for grade separation at South Airport Drive and Williamsburg Road.[25] These recommendations are preliminary and have not yet been investigated for need or feasibility.

Terminal curbside LOS analysis was conducted in the access plan, resulting in the conclusion that significant shortages of curbside area will occur by 2000. Recommendations for a multilevel terminal and frontage roadway system were made to deal with this problem. Minimum curbside requirements were recommended, but further studies and design have not yet been conducted.[26]

If the *Richmond International Airport Intermodal Transportation Facility Study* results in construction of an intermodal facility, greater traffic volumes can be accommodated and congestion can be alleviated if sufficient passengers are attracted to mass transit for a portion of the access trip. Further, construction of an intermodal facility and renovation of the downtown Main Street Station with shuttle service are possible methods of handling increasing traffic volumes by diverting access trips to public transportation. The access issue of limited public transportation options may also be addressed. These strategies could improve the intermodal connection for users of public transportation and provide more options than the bus currently provides. However, the impact of an intermodal facility on passenger access attributable to increased freight traffic volumes must considered.

Completion of the I-64 MIS and CSX Corridor MIS may result in recommendations for other physical improvements. Although these studies do not focus on RIC, their outcomes may affect access. Highway and rail connections are possible results of these two studies.

Step 7: Assess Effectiveness and Select Actions

Prior to selection and implementation, the strategies identified as possible actions must be evaluated for feasibility and effectiveness. Land, legal, environmental, or social issues must be investigated for their impact on feasibility. A full feasibility and effectiveness evaluation and the selection of priorities for each strategy are beyond the scope of this demonstration of the methodology. In practice, the selection of the optimal strategy would be based on a detailed assessment of effectiveness and feasibility.

Transportation System Management Strategies

The six proposed TSM strategies do not appear to have any major feasibility constraints, but further studies are required for some improvements. These strategies are intended to improve access performance in a variety of areas with minimum investment.

1. Optimize Signal Timing. No feasibility constraints are expected for the study and optimization of the signals at the intersections of South Airport Drive and Audubon Drive and Williamsburg Road. Improved performance for all modes in time and quality are expected, including trip time, access road LOS, and safety.

2. Place Signals on South Airport Drive. Placing signals on South Airport Drive at Huntsman Road should not meet any significant feasibility constraints. The quality of all modes should improve in access road LOS and safety.

3. Improve Bus Service. Improved bus service through improved connections with bus stops appears to be feasible, but it is not known whether this service is necessary or would be used. Surveys should be conducted to determine potential ridership, or a trial period accompanied by publicity for the service could take place. Bus performance would improve in trip time, since travelers could take a bus closer to their flight time, and convenience, in radius of service and hours of operation. However, service quality would be affected somewhat as a result of the transfer between bus and shuttle.

4. Move the Bus Stop. Moving the bus stop closer to the main terminal entrance would increase convenience for bus passengers. Total walking distance, both with and without baggage, would be decreased. Protection from the elements, a performance measure of quality, would be improved since passengers could easily reach the covered walkway that leads to the terminal entrance. Moving the bus stop appears to be feasible, since charter bus operations are currently low and traffic operations on the outer loop of the frontage road would not be significantly affected.

5. Increase Enforcement of Curbside Policies. Increased enforcement of curbside dwell time limits and policies would improve time and quality performance. Trip time could be decreased, since fewer vehicles would be blocked by double- or triple-parked vehicles. The LOS of access roads would also improve for all access modes since vehicles loading and unloading would not interrupt the flow of traffic on the frontage road to as great an extent. No feasibility constraints are expected with increased enforcement, and cost would be limited to labor.

6. Improve Access Information and Directions. Adequacy of information and directions is a performance measure of quality. Trip time for private automobiles may also be reduced if passengers can avoid wrong turns and reach their desired location more quickly, and safety may be increased for all modes because of decreased weaving and lane changes. Providing information immediately upon entering the airport property, and using larger, more prominent signs is feasible without significant cost.

Transportation Demand Management Strategies

Strategies with secondary TDM benefits can improve quality performance. Decreased demands on access roads and the terminal curbside would improve LOS for all modes.

Physical Improvement Strategies

The two physical improvement strategies are intended to improve access performance through increased capacity. Although performance improvements can be great, feasibility constraints are significant. Each strategy must be investigated through extensive feasibility studies, and several are currently underway. Environmental, legal, and economic constraints are likely.

1. Provide Direct Interstate Access. The I-64/I-895 Direct Airport Access Road Corridor Feasibility Study will address the feasibility of direct interstate access and the benefits of various alignments. It is too early in the study to speculate on feasibility. Depending on the alignment selected, direct interstate access can improve access time, reliability, and quality. Trip time may be decreased for all modes because of decreased congestion, and reliability of on-time arrival may therefore be improved. Quality would be improved through improved LOS of access roads.

2. Improve Roadway. The roadway improvements to South Airport Drive recommended in the Master Plan Update and Traffic and Ground Transportation Analysis must be investigated for land, legal, environmental, or social constraints, and the design alignment must be determined. These improvements would likely improve passenger performance for all access modes regarding trip time and quality in access road LOS and safety. The feasibility of a separate entrance or lane for cargo traffic would need to be studied if the separation of passenger and cargo traffic were deemed necessary.

The feasibility of other physical improvement strategies under consideration will be determined in current and future transportation studies. The feasibility of an intermodal facility is being investigated in the ongoing *Richmond International Airport Intermodal Transportation Facility Study*. The City of Richmond is investigating the feasibility of renovation of the downtown Main Street Station with feeder service to RIC. These strategies intend to increase convenience performance for public modes, particularly bus service. If ridership increases significantly, increased service frequency and express service to RIC may be warranted, and quality could also be improved.

The feasibility and design of a multilevel terminal and frontage roadway system have not yet been studied to deal with the significant shortages of curbside area that are expected by 2000. An effective design could improve time and quality performance for all modes. The intent of an expanded terminal curbside is reduced trip time and improved LOS on access roads. The feasibility of physical improvements recommended in the I-64 MIS and CSX Corridor MIS will be determined in these studies.

Step 8: Monitor and Feedback

Upon implementation of a selected strategy, monitoring the action and collecting feedback would be appropriate. In practice, the system would be assessed to determine the effectiveness of improvements after implementation. More specific performance measures could be used to assess performance improvement, for example, reduction in curbside demand and in the number of queuing vehicles on the I-64 exit ramp. Actual conditions would also be evaluated to ensure that estimated conditions were sufficiently accurate for landside access to perform adequately. This careful evaluation of the system and its improvements would aid future projects and assist planners in anticipating and planning for future needs.

CONCLUSIONS

- *No standard methodology exists to measure performance of airport access facilities or evaluate improvements.* In Virginia, improvements are funded on a first-come basis, with little effort to study potential benefits or compare projects. One result of this lack of pre-implementation research is a shortage of access improvement funds.

- *Landside access to airports is a major concern at airports of all sizes, and no direct correlation exists between the reported severity of access problems and airport size.*

- *The access evaluation methodology developed in this study may be tailored to meet the needs of a particular airport.* The methodology is flexible, making it possible to concentrate on specific access needs or accommodate limited resources. It provides a means of consistently evaluating airport landside access performance from the passengers' perspective.

RECOMMENDATIONS

1. *Incorporate the evaluation methodology into the appropriations process for access funds.* This would provide a more effective means of justifying funding based on need and expected benefits and a more equitable means of allocating limited resources among projects. Since funding is provided on the state level by VDOA and through VDOT's Industrial Access Roads Program, both VDOA and VDOT should consider adopting the methodology as a funding prerequisite. Local governments involved in airport access projects should be encouraged to adopt the methodology as a funding requirement to standardize the funding process further.

2. *Encourage Virginia airports to adopt the evaluation methodology as a step in the master plan process.* The evaluation methodology developed as part of this research corresponds to existing airport planning. Many of the data requirements are similar to those used in the master plan. To increase efficiency and consistency, airport authorities should require that the access evaluation methodology be employed as part of master plan efforts. This will ensure that airport landside access receives sufficient analysis during the planning process and will help to prevent the necessity of further data collection at a later time.

3. *Encourage nationwide use of the access evaluation methodology by airport authorities, state departments of transportation, and the FAA.* Widespread use of the evaluation methodology would provide a means of comparing landside access performance and the most effective improvement efforts among different airports. This technology transfer would also encourage further refinement of the methodology and demonstrations of effective use. This research should be shared with the appropriate parties to educate them on the evaluation methodology that was developed and encourage their support.

RECOMMENDATIONS FOR FURTHER RESEARCH

- *Determine the effectiveness of the methodology at airports of various sizes and characteristics around Virginia and the United States.* Although the methodology is flexible in its requirements and is anticipated to accommodate airports of any size, it is possible that it is more effective when used at airports of certain size, in particular regions, or with certain characteristics. A study of this type might also result in further refinement of the methodology as well as indicate the costs and resources required for assessments of varying scales.

- *Develop an expanded methodology to study the entire passenger trip, as mode choice is determined based on influences present off the airport property.* Development of similar methodologies to evaluate freight access performance, environmental performance, and facility performance would provide a complete package of airport access methodologies that could further benefit the evaluation of airport access performance and improvements.

- *Develop a thorough and consistent data collection practice to increase technology transfer in airport access planning.* Development of a data collection system would further the understanding of access improvement effectiveness and could assist airport management in determining the most appropriate solutions.

- *Determine the effect of airport location on access performance.* Expanding the questionnaire to include distance from the central business district would permit analysis and comparison of access characteristics and performance based on this factor. In addition, a survey of airport users regarding access mode performance would be valuable. Airport authorities have a good feel for the services provided but do not share the customer-oriented perspective that airport users can provide.

- *Determine how these interactions can be minimized and passenger/freight movements coordinated to improve the intermodal connection at airports.* At many airports with significant cargo operations, little attention is given to the adverse effects of and interaction between freight and passenger access. Operators of motor carriers and private automobiles react differently at airports, based on their degree of familiarity and trip purpose. These differences may cause conflicts and problems with traffic flow.

- *Study trip reduction methods and introduction or expansion of public transportation service, including a survey of their use, case studies of successes and failures, and guidelines for implementation.*

- *Determine the best means of handling the problems of terminal curbside congestion and drivers unfamiliar with the access system, commonly cited problems.* Terminal curbsides are often expanded to increase capacity, but there is much room for improvement in terminal curbside operations through policy, enforcement, and intelligent transportation systems. Similarly, problems associated with unfamiliar drivers may be alleviated with more effective signs, directions, real-time data, and access configuration. Research into new technologies and systems management intended to solve these problems could go a long way in improving airport access performance with a minimum of additional capacity.

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APPENDIX A

AIRPORT SURVEY QUESTIONNAIRE

Questionnaire

LANDSIDE ACCESS FOR AIRPORTS

November 1996

The Virginia Transportation Research Council and the University of Virginia are conducting a study of improvements in landside access for airports. In order to determine the practical experiences of U.S. airports, we would appreciate it if you could respond to this questionnaire and answer the questions with regard to your airport's experiences. Thank you very much for your help.

Airport Information

1. Who is in charge of ground transportation landside administration?
   Name: ______________________________
   Title: ______________________________
   Telephone Number: ______________________________
2. What organization or authority governs landside access facilities on your airport's property?
   Name: ______________________________
   Address: ______________________________
   ____
3. How many annual enplanements does your airport handle? ______________
4. What percentage of your passengers are making connections or transfers? ________%

Ground Access Limitations

1. Please score your opinion of the severity of the following problems as they relate to your airport by circling the appropriate number.

	Not a Problem	Small Problem	Considerable Problem	Serious Problem
Roadways:				
highway access ramp congestion	1	2	3	4
airport access road congestion	1	2	3	4
terminal curbfront congestion: departures	1	2	3	4
terminal curbfront congestion: arrivals	1	2	3	4
Human factors:				
pedestrians causing safety concerns	1	2	3	4
pedestrians causing traffic backups	1	2	3	4
unfamiliar drivers weaving or causing backups	1	2	3	4
Parking factors:				
short-term lots filled to capacity	1	2	3	4
long-term lots filled to capacity	1	2	3	4
satellite lots filled to capacity	1	2	3	4
fare collection backups	1	2	3	4
cars continuously circling to find a closer spot	1	2	3	4
Please rate the ground access problem overall	1	2	3	4

2. Please specify the number of spaces and price charged for each type of parking, if available:

	Short-term parking	Long-term parking	Satellite parking
Number of spaces			
Price charged ($ per time period)			

3. What mode of transportation is used to transport passengers from satellite lots to the terminal?

____

4. Have any recent changes or improvements been made to ground access? ___ Yes ___ No
If yes, what were these changes, when were they made, and how effective were they? Please explain.

____
____
____

Public Transportation Availability and Usage

1. Is rail available for transportation between the airport and surrounding population?
_____ Yes _____ No (If No, go to question 2)
   a) Is baggage assistance provided to passengers traveling by rail? ___ Yes ___ No
   b) What is the time between train departures? ______________________
   c) Is there a rail stop on the airport property? _____ Yes _____ No
      If no, is transportation available between the rail stop and the airport? What mode is provided?

____

   d) What percentage or total number of passengers use the rail system? __________
      What percentage or total number of airport employees? ______________
      Please explain reasons for usage rate. ______________________________________

____
____

2. Is bus service available for transportation between the airport and surrounding population?
_____ Yes _____ No (If No, go to question 3)
   a) Is baggage assistance provided to passengers traveling by bus? ___ Yes ___ No
   b) What is the time between bus departures? ______________________
   c) Is there a bus stop on the airport property? _____ Yes _____ No
      If no, is transportation available between the bus stop and the airport? What mode is provided?

____

   d) What percentage or total number of passengers use the bus system? __________
   What percentage or total number of airport employees? ______________
   Please explain reasons for usage rate. ______________________________________

____
____

3. Is door-to-door shared ride service available (shared vans or limos)?
_____ Yes _____ No (If No, go to question 4)
   a) What is the time between departures? ______________________
   b) What percentage or total number of passengers use shared rides? __________
   Please explain reasons for usage rate. ______________________________________

____
____

4. Have any recent changes or improvements been made to public transportation modes? __ Yes __ No
If yes, what were these changes, when were they made, and how effective were they? Please explain.

____
____

5. Have steps been taken to reduce the number of vehicle miles of travel (VMT) to the airport?

____ Yes ____ No (If No, go to next section: Courtesy Vehicles and Taxicabs)

a) What steps have been taken? (check all that apply)

_____ Promote use of public transportation by:

___ providing special air/bus or air/rail combination fares

___ providing baggage assistance on public transportation modes

___ advertising and providing information about public transportation options

___ other (please specify): ________________________________

_____ Change parking rates

___ raise short-term parking rates

___ raise long-term parking rates

___ lower satellite parking rates

___ other (please specify): ________________________________

_____ Impose per-trip fees on taxis, courtesy vehicles, and/or limos

_____ Employee VMT reduction methods (incentives, rail discounts, etc.)

_____ Other (please (specify): ________________________________

b) How effective have these steps been in reducing the number of passenger vehicle miles traveled to the airport? Please explain. ________________________________

____

Courtesy Vehicles and Taxicabs

1. Please score your opinion of the severity of the following problems as they relate to taxicabs and courtesy vehicles (hotel, rental car, etc.) at your airport.

	Not a Problem	Small Problem	Considerable Problem	Serious Problem
Taxicabs:				
number on airport property often exceeds demand	1	2	3	4
double parking at terminal curb	1	2	3	4
continuous circling around airport	1	2	3	4
Courtesy vehicles:				
number on airport property often exceeds demand	1	2	3	4
double parking at terminal curb	1	2	3	4
continuous circling around airport	1	2	3	4

2. Is there a designated holding area/staging area for taxis? _____ Yes _____ No

buses? _____ Yes _____ No

courtesy vehicles?_____ Yes _____ No

3. Does the airport control the number of taxis and/or courtesy vehicles allowed?

_____ Yes _____ No (If No, go to next section: Airport Access Performance)

a) _____ Taxis controlled by

___ permits

___ contracts

___ starters/dispatchers

___ other (please specify): ________________________________

b) _____ Hotel courtesy vehicles controlled by: ____________________

c) _____ Rental car/parking lot courtesy vehicles controlled by: ____________

Airport Access Performance

How well do these access modes perform at your airport? Please score your opinion of the level of service they provide in the following categories with 1 = Excellent 2 = Good 3 = Fair 4 = Poor

Access Service / Mode Category	Example:	Private Auto	Taxicab	Limousines/ Vans/ Charters	Courtesy Vehicles	Bus	Rail
PASSENGER MEASURES							
cost of service/ cost of travel	1 (excellent)						
Convenience	1						
trip time	4 (poor)						
Safety	2 (good)						
Flexibility	4						
quality/comfort	3 (fair)						
Reliability	2						
public awareness/ acceptance	3						
FACILITY MEASURES							
Environmental impact	4						
energy use and efficiency	4						
Capacity	1						
opportunity for expansion	2						

Conclusion

Is there any other important issue pertaining to airport access that has not been addressed? Please feel free to use this page or call Heather Wishart at (804) 293-1997.

____

____

Your name: ___________________________________

Title: ___________________________________

Address:____

____

Phone number:____

Would you like a copy of the final report? _____ Yes _____ No

Thank you very much for your time and assistance in completing this survey. Your responses are invaluable to us. Please return the completed survey by February 17, 1997, to:

Heather Wishart
Virginia Transportation Research Council
530 Edgemont Road
Charlottesville, VA 22905
(804) 293-1997
Fax: (804) 293-1990

APPENDIX B

NATIONAL SURVEY OF AIRPORTS: ANOVA RESULTS

Overall Rating of Landside Access Problems

Landside Access Category	Level of Significance
Overall rating of landside access	0.362

Landside Access Problems

Landside Access Category	Level of Significance
Highway access ramp congestion	0.843
Airport access road congestion	0.063
Terminal curbfront congestion: departures	0.149
Terminal curbfront congestion: arrivals	0.145
Pedestrians causing safety concerns	0.764
Pedestrians causing traffic backups	0.151
Unfamiliar drivers weaving or causing backups	0.704
Short-term lots filled to capacity	0.297
Long-term lots filled to capacity	0.597
Satellite lots filled to capacity	0.079
Fare collection backups	0.744
Cars continuously circling to find a closer spot	0.290

Public Transportation Availability

Public Transportation Mode	Level of Significance
Rail	0.020
Bus	0.004
Airport Limousine	0.041

Trip Reduction Methods

Trip Reduction Method	Level of Significance
No action taken	0.036
Promote public transportation	0.047
Per-trip fees	0.002
Change parking rates	0.007
Employee methods	0.178
Other	0.013

Taxicab and Courtesy Vehicle Problems

Mode	Level of Significance
Taxicabs: number on airport exceeds demand	0.785
Courtesy vehicles: double parking at curbfront	0.279
Courtesy vehicles: continuous circling	0.033
Taxicabs: double parking at curbfront	0.191
Courtesy vehicles: number on airport exceeds demand	0.035
Taxicabs: continuous circling	0.008

Control of Taxicabs and Courtesy Vehicles

Method	Level of Significance
Taxicab holding area	0 (100% of all airports)
Control number of taxicabs	0.905
Bus holding area	0.361
Courtesy vehicle holding area	0.006
Control number of courtesy vehicles	0.813

APPENDIX C

GUIDE TO EVALUATION METHODOLOGY

This appendix provides a step-by-step guide to the landside access evaluation methodology. The methodology is flexible. It is designed to accommodate airports of all sizes and evaluations that range in detail from general to specific. Because of the variances in airport size and depth of study, it is impractical to present definitive cost and time estimates for the entire evaluation process. However, broad estimates of time required for each step are provided based on experience with the methodology demonstration on Richmond International Airport. Other studies may require more or less time. It is recommended that the methodology be employed during the Master Plan process, to most efficiently conduct Master Plan and evaluation efforts simultaneously, and since those individuals working on the Master Plan are likely to be most familiar with the operations of the airport.

Step 1: Define the Problem

Estimated Time: 1 month

1. Identify problems of landside access that impact passenger performance (lead to lost time, missed flights, passenger complaints, etc.)
2. Define and describe problems.

Useful sources:

- Interviews with airport authorities
- Interviews with transportation agencies and providers (taxi drivers, bus drivers, parking attendants, MPOs, etc.)
- Passenger complaints
- Passenger surveys
- Site visits and observations

Step 2: Establish Performance Measures

Estimated time: 2 weeks

Based on problems defined in Step 1, identify the performance measures that are most important to passenger performance. Recommended performance measures include (E/G/F/P refers to ratings of Excellent, Good, Fair, or Poor):

1. Cost: Dollars per passenger trip ($)
2. Time: Comparison of trip time between transportation modes; or the ratio of trip time for each mode to the trip time of the fastest mode (E/G/F/P); Waiting time (min)
3. Reliability: Reputation of reliability; or percentage of vehicle arrivals with less than 4 min. deviation from schedule (E/G/F/P or %)
4. Convenience
    - Total walking distance with baggage (m)
    - Total walking distance without baggage (m)
    - Total number of level changes when walking (no.)
    - Availability and extent of baggage assistance (yes/no; location available)
    - Availability of baggage storage areas on vehicles (yes/no)
    - Handicap-accessible (yes/no)

- Radius of service provided from the airport (km)
- Hours of operation

5. Quality
    - Number of transfers required (no.)
    - Number of stops between embarkation and destination (no.)
    - Service frequency or headway (no. departures/hour)
    - Total time for stops and transfers (min)
    - Adequacy of information and directions (E/G/F/P)
    - Maintenance of vehicles (E/G/F/P)
    - Degree of physical comfort (E/G/F/P)
    - Degree of protection from the elements (E/G/F/P)
    - Friendly, helpful service (E/G/F/P)
    - Adequacy of lighting, security patrols, and level of safety (E/G/F/P)

Useful sources: Use the problems identified in Step 1 to determine common areas of complaints, and select performance measures based on these.

Step 3: Collect the Data

Estimated time: 1.5 months

1. Compile existing data for an overview of the airport landside access system and operations
    - Inventory of access components:
        — Airport access components
        — Terminal access components
        — Parking areas
    - Layout of airport access system
    - Airport Activity:
        — Number of enplanements per year
        — Percentage of passengers transferring
        — Air cargo activity
        — Other operations
        — Flight distribution peak periods
    - Traffic Demand: Local traffic demand and access directional distribution
    - User characteristics:
        — Passenger profile: trip purpose, duration, resident vs. visitor, income, party size, etc.
        — Percentage access distribution between passengers, visitors, and employees
        — Impact of employee and air cargo activity on access system
    - For-hire-service characteristics:
        — Availability by time, day, and area
        — Mode choice distribution
    - Anticipated changes in land use
2. Based on problems defined in Step 1 and performance measures established in Step 2, collect specific data related to performance measures:
    - Cost: Toll costs, parking rates, for-hire mode fares, service gratuities, etc.

- Time: Total one-way trip time, base case travel time, percent waiting time of total trip time, etc.
- Reliability: Mode arrival patterns, mode vehicle breakdown history, etc.
- Convenience: Walking distances, number of level changes, mode characteristics, etc.
- Quality: Mode characteristics

Useful sources:

- Master Plan
- Access Plan
- Site visits and observation
- FAA enplanement data
- Department of Transportation data
- Traffic counts
- Interviews with airport authorities
- Passenger surveys
- Schedules of for-hire transportation modes
- Interviews with transportation agencies and providers (taxi drivers, bus drivers, parking attendants, MPOs, etc.)

Step 4: Understand Present Conditions and Performance

Estimated Time: 1.5 months

For each component of the landside access system:

1. Establish present conditions and describe current situation
2. Identify possible reasons for the problem(s) defined in Step 1
3. Evaluate modes by performance measure using the data collected in Step 3 (Table 7 is recommended for this task)

Step 5: Forecast Future Conditions and Performance

Estimated time: 1 month

1. Forecast future conditions and access mode growth
2. Forecast future access demand
3. Evaluate existing modes by performance measure based on forecast demand
4. Predict future problems and performance issues

Useful sources:

- Master Plans
- Regional plans
- Requests for zoning changes and plans for land use changes and development

Step 6: Develop Candidate Strategies and Actions

Estimated time: 2 weeks

Develop strategies to address the problems identified in Step 1 and the present and future performance identified in Steps 4 and 5

Step 7: Assess Effectiveness and Select Actions

Estimated time: 2 months

1. Assess feasibility: economic, land, legal, environmental, or social constraints

Note: in many cases, feasibility studies will be underway or initiated that require months or years to complete. These feasibility studies are consulted and may be recommended in this step, but are not considered as a part of the methodology.

2. Evaluate effectiveness of alternatives; estimate impact of service changes
3. Estimate improvement to performance (Table 7 can also be used for this task)
4. Prioritize strategies
5. Select optimal action

Step 8: Monitor and Feedback

Estimated time: Ongoing

1. Assess the system to determine the effectiveness of improvements and ensure that estimated conditions were accurate
2. Use information in this step to aid future projects and those at other airports
3. Anticipate and plan for future needs