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SYNTHESIS OF LITERATURE AND APPLICATION TO TEXAS AIRPORTS

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16. Abstract

Air transportation plays a vital role in the Texas economy. Air passenger/cargo traffic is projected to continue to increase considerably at many of the state's large airports. Ground access to airports is an important function that must be provided for at the regional level as well as in the immediate vicinity of the facility itself. Congestion problems affecting airport access are in some instances reaching unacceptable proportions; there are also concerns regarding the negative impacts such congestion is having on air quality and other environmental considerations. Accordingly, these issues require concerted action to meet project needs.

To address the above challenges and current gaps, this project will take a comprehensive look at the landside access issues associated with the major airports in the state. It will seek to improve on existing planning procedures and processes to meet the unique needs of airport traffic demand, for both people and goods. To be effective, planning for airport ground access must be multimodal and intermodal, consider both operational, regulatory and capital-intensive infrastructure provision issues, consider multiple levels of scale/resolution, and recognize the unique dynamic aspects of air traffic demand, i.e., its temporal patterns.

This report presents an overview and synthesis of the literature reviewed under the first task. The research team concludes that the motivation and the need for the ground access study is high and that existing approaches and documents are insufficient to meet the needs for strategic ground access planning of major airports in Texas.

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TO TEXAS AIRPORTS

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EXECUTIVE SUMMARY

Air transportation plays a vital role in the Texas economy. Air passenger and air cargo traffic is projected to continue to increase considerably at many of the State's large airports. Ground access to airports is an important function that must be provided at the regional level as well as in the immediate vicinity of the facility itself. Congestion problems affecting airport access are in some instances reaching unacceptable proportions, with negative impacts on air quality and other environmental considerations. Accordingly, these issues require concerted action to meet project needs.

To address the above challenges and current gaps, this project adopts a comprehensive look at the land side access issues associated with the major airports in the State. It seeks to improve on existing planning procedures and processes to meet the unique needs of airport traffic demand, for both people and goods. To be effective, planning for airport ground access must be multimodal and intermodal, consider both operational, regulatory and capital- intensive infrastructure provision issues, consider multiple levels of scale/resolution, and recognize the unique dynamic aspects of air traffic demand, i.e. its temporal patterns. It must also carefully consider the potential of emerging ITS technologies in the airport environment.

This report summarizes the findings of the literature review and synthesis performed in the first task of the project. The review indicates that available procedures and guidelines are of a very general and generic nature and are insufficient to address the strategic and tactical planning needs of major airport systems in their proper regional context. The FAA's *Intermodal Ground Access to Airports: A Planning Guide* provides useful information and a good introduction to the scope and nature of the issues likely to be encountered at airports. However, it does not present specific operational tools that could be applied to specific situations and specific airports.

The report concludes that the major airports in Texas present unique access challenges that require intervention beyond the generalities of the *Planning Guide*, or any other available reference. The scope of these issues makes them inseparable from those of general transportation accessibility issues in the entire region of the airport. The scale and magnitude of these problems are likely to increase with continuing growth in airport-related traffic and activities. Institutional factors, involving cooperation and communication among several governmental and quasi-governmental entities, play a substantial role in ensuring an effective planning process that provides for the needs of air passenger and freight travel in the overall mobility of the region.

The review and synthesis conducted in the first project task further reinforces the motivation and the need for this work and validates the basic premises of the work plan developed to address the research objectives.

CHAPTER 1
OVERVIEW OF PROBLEM AND APPROACH

Air transportation plays a vital role in the Texas economy. Air passengers and air cargo traffic are projected to continue to increase considerably at many of the state's large airports. Ground access to airports is an important function that must be provided at the regional level as well as in the immediate vicinity of the facility itself. Congestion problems affecting airport access are in some instances reaching unacceptable proportions, with negative impacts on air quality and other environmental considerations, and hence require concerted action to meet projected needs.

To address the above challenges and current gaps, this project takes a comprehensive look at the landside access issues associated with the major airports in Texas. It seeks to improve on existing planning procedures and processes to meet the unique needs of airport traffic demand, for both people and goods. Using as a starting point the process outlined in the Federal Aviation Administration's (FAA) *Intermodal Ground Access to Airports: A Planning Guide,* the research expands the set of solution options by including success stories at other airports around the country and customizes a state-of-the-art methodological approach for Texas airports. As part of the process of proposing and testing alternative solution strategies, the project also reviews current plans and studies formulated by the airports' planning departments as well as the respective metropolitan planning organizations (MPOs) and assesses these against an evaluation framework that recognizes the above factors. The results of this research will provide the Texas Department of Transportation (TxDOT), airport authorities, and other concerned entities with short- and long-term strategies for addressing landside access issues.

One concern at the outset of the project was the extent to which existing procedures, particularly the above-noted *Planning Guide,* provided sufficient information to meet the access planning needs of airport authorities and affected local, regional, and state entities. Two observations were made at the proposal preparation stage. First, the emphasis of the *Planning Guide* is principally on access considerations in the immediate vicinity of airports; it is rather limited and generic in terms of strategic network-level and regional access issues. Second, Texas airports, especially those in large metropolitan

areas, present certain unique features that would not be adequately addressed in a generic document such as the *Planning Guide*. The review performed under the first project task, along with the discussions held with various airport officials and other experts in this community, has confirmed these observations, providing at the same time justification for the intended focus of the current effort.

This report presents an overview of the literature reviewed under the first task and the project team's recommendations regarding a need for and focus of subsequent tasks of the current research. The literature review in Chapter 2 consists of two main parts: first, an overview of selected papers and reports, followed by a more detailed discussion of the *Planning Guide*. Chapter 3 discusses applicability to Texas airports and implications for the present research effort. To expand on the literature review of Chapter 2, a description of relevant Web sites is provided in Appendix A. An annotated bibliography is provided in Appendix B to better reflect the depth and breadth of the review conducted to date for the project.

CHAPTER 2
LITERATURE REVIEW

A literature search produced several journal articles and/or papers relating to ground access that detailed specific airport efforts, proposed HOV solutions, or expanded upon the *Planning Guide*. However, none of these articles covered the specific issues related to Texas airports, nor did the articles present a systematic process that could solve ground access problems. A comprehensive annotated bibliography is included in Appendix B. Only selected general articles are highlighted in this chapter, along with a review of the *Planing Guide* contents.

Highlights of Selected Articles

Analysis of New Orleans Airport Ground Transportation System (Mundy, 1980) details the steps taken by the New Orleans airport authority in developing the ground transportation system. Significantly, Mundy addressed this problem as a facilities *management* issue as opposed to a facility *design* problem. The article reiterates known generalities, e.g., emphasizing the importance of establishing clear objectives for the project. The congestion problems of interest to that airport include a poorly designed roadway access system, lack of parking spaces, and curb prioritization issues. The principal solution to the problems discussed in the paper was the addition of HOV lanes for public transportation.

Effects of Road Access Pricing at the Los Angeles Airport: A Case Study (Lampe, 1993) describes the airport access charge imposed on commercial vehicles at that airport. After evaluating available technologies and systems, LAX moved, in 1989, to install a state-of-art automatic vehicle identification (AVI) system to reduce traffic congestion and, at the same time, maximize revenues collected from ground transportation operation. The AVI system consists of electronic tags and readers. Since implementing the AVI, LAX claims that there has been a 20% reduction in congestion compared to the previous system.

Ground Access to Singapore Changai Airport (Fan, 1990) emphasizes an understanding of the traffic characteristics and utilization of access facilities. The

feasibility of applying typical ground access planning parameters recommended for Western airports to Changai Airport is also investigated. Peak traffic levels are found to be manageable. The curbside is the critical link of the access system, but congestion in peak periods does not last very long at present. Although the two public car parks together provide sufficient parking, the closer-in car park is always full in the evening while the less expensive car park is usually half empty, though it is only 825 ft (250 m) farther. This situation suggests that convenience is more important than cost to most users.

Lessons for Rail Access to Airports (Kivett, 1996) summarizes the key planning, design, and operational issues — vis-à-vis rail access — that must be addressed in the ongoing expansion of existing airports, as well as in the development of new airports, around the world. The focus is on those airports for which rail access (i.e., an effort to link the city center of a major metropolitan area with its airport) is under consideration or is in the formative stages of implementation.

Automated Guideway Transit to Provide Access to New York City Airports (Tambi and Griebenow, 1993) describes the New York Port Authority's efforts in addressing airport access issues in a multi-faceted manner. In addition to reviewing several transit system management measures, the Aviation Department is examining several access improvements, one of which would involve connecting the existing rail systems, both commuter and subway, with the airports. This connection would be achieved with the construction of an Automated Guideway Transit (AGT) system linking the airports to major transportation transfer facilities.

Improvements to Airports Ground Access and Behavior of Multiple Airport System: BART Extension to San Francisco International Airport (Monteriro and Hansen, 1996) presents a case study of an extension of a Bay Area Rapid Transit rail link into the San Francisco International Airport (SFO). Two choice models were developed. One is a nested logit model in which the airport choice decision occurs at the higher level and the mode choice decision at the lower level; the other is a multinomial logit model. The results indicated that improvements to SFO ground access would modestly strengthen SFO as the dominant airport in the San Francisco Bay Area, and that most of the diversion of passengers would be from Oakland Airport.

Planning for Intermodal Access at American Airports (Shapiro, 1996) briefly describes the contents of the *Planning Guide,* some of the relationships that were developed, how they were derived, and their importance to airport access planning. Shortly after the passage of the ISTEA legislation, the Federal Highway Administration and Aviation Administration recognized that very limited guidance was available for airport operators and MPOs to use for planning intermodal access to airports in the U.S. The *Planning Guide* was developed as a result. This *Guide* is designed to provide guidance to states, metropolitan planning organizations, and airport operators regarding the types of analyses that should be performed when planning airport access.

Relationship between Airport Activity and Ground Transportation Needs (Shapiro and Katzman, 1998) also presents highlights from the *Planning Guide*. The article provides detailed discussion of vehicle trip relationships and airport trip generation, curbside configurations, parking requirements, and mode access to U.S. airports. The article identifies topics that the *Guide* does not cover and the areas that need to be explored further.

Several articles dealing with *rail access* and *access mode choice* considerations were reviewed (a discussion is included in Appendix B). The review was not confined to domestic airports offering rail access, but also included international facilities, where rail and transit usage for airport access is considerably higher. One conclusion drawn from this review is that success (in rail and transit usage) at international airports is not readily transferable to domestic airports. However, an alternative that does not appear to have received sufficient attention at U.S. airports, yet possesses several desirable attributes and much potential, is the use of off-airport check-in facilities in conjunction with privileged transit access. Such configurations and facilities merit further study in light of not only the potential of recent communication technologies on the supply side, but also the advances in methods to better study related behavioral aspects of travelers.

Intermodal Ground Access to Airports: A Planning Guide

This guide is designed to provide policy guidance, rules of thumb, data, and analytical techniques related to airport access. It has been prepared to help airport operators, local governments, metropolitan planning organizations (MPOs), consultants,

and others identify airport access problems, find alternative solutions, and evaluate their effectiveness. The guide focuses on providing passengers access to commercial airports from primary origins or destinations. It deals with off-airport roads, transit, and high occupancy vehicle (HOV) facilities up to the airport boundary and on-airport roads, parking circulation elements, transit, and curb facilities up to terminal entrance.

Off-airport and some airport access plans and programs must frequently be coordinated with other regional transportation plans and programs and must be consistent with regional and state plans and programs, such as long-range transportation plans, regional plans, and state air quality plans.

A technical approach to airport ground access planning provides a framework for this planning guide. Chapter 2 describes airport access problems, the roles of state and local agencies, and the relationship between airport access and the Clean Air Act. Chapter 3 discusses the development of performance measures and their relationship to goals and objectives. Chapter 4 details the types of data that may be collected to quantify performance measures and determine access patterns and demand. It also describes techniques for obtaining needed data and provides specific guidance for conducting passenger origin-destination surveys. Chapter 5 provides an overview of how to estimate existing and future airport access patterns and demands and how to identify potential deficiencies. Chapter 6 describes alternative access improvements, including HOV options, intermodal facilities, and improvements to airport infrastructure, such as access roads, parking facilities, and terminal curbside. Chapter 7 describes how to evaluate alternative improvements, while Chapter 8 describes how to implement such improvements.

Chapter 2: A brief overview of the proposed airport ground access planning process is presented. This overview establishes a seven-step planning process, each step relating to succeeding chapters in this guide. The seven steps of the process can be summarized as follows:

1. Define the problem.
2. Given the understanding of the policy issue, establish performance measures to be used in the program of monitoring and evaluation.
3. Collect data needed to support the application of the performance measures.

4. Understand existing and future conditions and performance of the system.
5. Develop candidate strategies and actions.
6. Assess effectiveness of alternative strategies and actions and select cost-effective actions.
7. Implement, monitor, and gather feedback using the established performance measures.

The above steps are rather generic in nature and are standard fare in introductory planning textbooks. As such, they are not likely to meet specific needs of an airport authority or related agency. A review is presented of the various legal, regulatory, and institutional considerations in the initial development of a work plan for an airport ground access planning process. It is stressed that public transit system service ground access to the airport, preferably the airport terminal area, should be considered. Easy direct access to terminal buildings, as well as baggage transport and security, is essential in efforts to encourage substantial passenger use.

The FAA documents make clear that airport ground access is an important part of the airport's master planning and design responsibilities and, at the same time, must function within the context of the regional transportation system and the policies of government agencies typically unrelated to an airport's operation. A primary purpose of this guide is to document the nature of the planning process and to aid practitioners in building partnerships between on- and off-airport planning and activities. However, practical tools and strategies to achieve such coordination and integration operationally remain outside the scope of this chapter and of this document.

Chapter 3: The planning process mandated by ISTEA stipulates that monitoring and evaluation should be established early in the cycle. Chapter 3 has been prepared to help local planners and administrators develop goals, objectives, and performance measurements that are relevant to the needs of the local community. Efforts at developing performance measures in Oregon and Boston are summarized. The *Planning Guide* also includes a proposed basic list of areas for performance evaluation by those just starting the process of ISTEA-based planning for airport access improvements.

In regions having significant Clean Air attainment problems (e.g., Dallas, Houston, Austin, and San Antonio), planners must expect to use a full calculation of

regional VMT change as a principal performance measure for the evaluation of projects, strategies, and actions under consideration. The techniques available to obtain data related to different airport ground access goals, objectives, and performance measures are detailed in the *Planning Guide*. Airport access could include a base-year inventory consisting of surveys of physical and operational characteristics of intermodal facilities and systems based on performance measures.

It is important at this juncture to emphasize that both the science and the art of performance measurement in a specialized field, such as airport access, are in their infancy.

There are three principal factors to be considered in the selection of survey techniques: (1) the type of study being conducted, which controls the types of information and levels of accuracy required; (2) activity level at the airport under study, which is measured by the size of the population or subgroups (such as air passengers transit riders) to be surveyed; and (3) the configuration or spatial arrangement of activities of the airport and region under study.

Chapter 4: This chapter describes techniques available to obtain data related to different airport ground access goals, objectives, and performance measures. The usual steps followed in the development of an airport access survey are:

1. Define study objectives.
2. Identify data requirements.
3. Select survey strategy.
4. Select data collection techniques.
5. Prepare survey specifications and conduct survey.
6. Summarize post-survey findings.

Three broad types of surveys and studies are typically conducted: traffic, passenger, and special purpose. At larger airports, a mixed survey strategy is recommended, one in which air passengers, airport employees, and users of the primary visitor modes (e.g., short-term parking facilities and regularly scheduled bus and rapid transit services) are sampled. The concepts and procedures discussed in this chapter are again quite general and are insufficient for application to a specific context, especially to

major airport systems having unique characteristics, such as those in Dallas-Fort Worth and Houston.

Chapter 5: This chapter provides an overview of concepts underlying the approaches to estimating existing use and future demands for airport access facilities. Airports generate large volumes of traffic and serve several different markets (e.g., passengers, employees, and visitors).

The inventory phase involves collecting and analyzing available data (e.g., roadway plans; previous studies; available traffic data; airline passenger, airport cargo, airport employee, and vehicle survey data; and passenger forecasts). Forecasts of future airport access patterns and travel demands are required to plan and assess the adequacy of future airport and regional transportation facilities. To analyze the demand for ground transportation facilities, such as roadways, parking lots, and curbsides, it is first necessary to determine the "design period" that best represents the demand condition for which a facility should be planned. Beyond conveying a broad general understanding of the underlying concepts, the *Planning Guide* is of limited usefulness on this topic. Actual challenges in application and implementation to specific contexts are not within the scope of the presentation.

Chapter 6: Alternatives for Improving Airport Access. This chapter presents alternative types of airport access improvements and provides examples. Each airport could use either capital improvements, such as adding highway or rail transit links, or operational improvements, such as improved bus or shuttle service. The chapter suggests six different alternatives to consider:

1. Access roads
2. Parking
3. Terminal curbside facilities
4. Rubber-tired and rail transit options
5. Intermodal facilities
6. Demand management techniques, such as TDM strategies and application of ITS technology

The chapter presents a fairly extensive catalogue of measures under each of these improvement categories. This catalogue reflects existing best practice and is a useful reference guide to a rich toolbox of principally operational improvements. The extent of the measures catalogued is illustrated below by a listing of options corresponding to the access roads element.

Three areas of discussion of access roads are included: off-airport, near-airport, and on-airport. These are discussed in turn below.

Access Roads Off Airport

Three principal standard practice references are mentioned.

1. *Manual on Uniform Traffic Control Devices 1* — Standard green airport sign.
2. *ITE — Airport Roadway Guide Signs, A Proposed Recommended Practice 3* offers the following: All major roads intersecting the airport feeder roads with a 10–25 mile radius of the airport should carry the airport message as an integral part of its highway designation signs.
3. FHWA — *National Highway System, The Backbone of America's Intermodal Transportation Network 4* — Most airports have adequate access but face increasing problems of peak-hour congestion. The NHS will provide resources to improve existing access routes to tomorrow's airports. The NHS will enable plans for airport expansion and the required ground access to be much more closely integrated. The NHS, passed in Congress November 1995, included roads that served a total of 143 airports.

Needs related to emergency vehicle access to and from airports must not be overlooked in the regional planning context. EMS and Fire shortest routes and alternate routes mitigate impediments and bottlenecks and minimize response times.

- *Geometric Design Alternatives for Improving Capacity to Off-Airport Roads*
  - Widening highways for provide additional travel lanes
  - Constructing medians and median dividers
  - Extending left-turn storage lanes
  - Constructing additional turn lanes
  - Widening paved shoulders
  - Implementing minor geometric improvements

- Straightening sharp horizontal curves
- Lengthening short crest and sag vertical curves
- Realigning skewed intersections
- Reducing grade differentials at intersections

- *Traffic Operations Alternatives*
  - Improvement in traffic signal operations on arterial roads that lead to airports
  - Improvements in traffic surveillance systems
  - Implementation of traffic management centers
  - Implementation of improved traffic information dissemination systems

Access Roads Near Airports

NCHRP and ITE — *Traffic and Transportation Planning Handbook 6* — Airports are among the largest metropolitan trip generators, but their measurable impacts on the highway network are within a few miles of the airport. Localized impact can be quite severe. Far greater attention should be devoted to capacity of roads in the immediate vicinity of airports.

- *Geometric Design Alternatives*
  - Same as those listed for off-airport access roads
  - Construction of new direct access roadways
  - Controlled-access roadways dependent upon passenger demand
  - Exclusive express lanes such as those at Dulles Airport
- *Traffic Operation Alternatives*
  - Same as those listed for off-airport access roads
  - Highway advisory radio
  - Changeable message signs

On-Airport Roads Excluding Terminal Curbside Areas

There are many different vehicle destinations on the airport property.

- *Airport Users*
  - Passengers:
    - Local residents — business and nonbusiness travel
    - Nonresidents — business and nonbusiness travel

- Meeters and greeters, visitors, spectators
- Employees and others:
  - Airport employees
  - Airline employees and air crew
  - FAA employees
  - Employees of tenants of the airport
  - Non-airport employees working at airport
  - Non-airport employees delivering goods and services
  - Customers of airport and other services

- *Airport Circulation*
  - Components of airport landside circulation:
    - Airport roads
    - Terminal curb areas
    - Public parking facilities
    - Restricted access parking areas
    - Public transportation and rental car areas
  - Classification of airport roads:
    - Primary airport access roads
    - Terminal area access roads
    - Recirculation roads
    - Terminal frontage roads
    - Service roads (general and restricted use)
  - Typical airport circulation systems:
    - Centralized — Single building or continuous series of buildings — ORD, SFO, LAX, ATL, DCA, FLL
    - Decentralized — Divided terminal building (by airline or arriving/departing PAX) — Orlando, Jacksonville, Cincinnati
    - Segmented — Terminal access roads funnel traffic to separate terminal facilities — JFK, Kansas City
    - Unitized — Centrally located roadway to series of terminals — DFW, George Bush

- *Principles for Design and Operation of Airport Roads*
  - Sufficient length to permit smooth channeling of traffic
  - Ample space between no more than two route choices
  - Minimum four lanes adjacent to terminal curb
  - Separate service-related and passenger-related traffic
  - Large airports — grade separation between arriving and departing passengers
  - Circulation in front of terminal — one-way counterclockwise — right-side loading
  - Separate traffic streams early with adequate signing to avoid confusion
  - Needs of the pedestrian should be considered:
    - Separate pedestrians and vehicular traffic
    - Establish pedestrian/bicycle networks
    - Consider special provisions for bicycles
    - Maximize safety at pedestrian crossings
    - Minimize the number of at-grade crossing points
  - Traffic signal control justified only under MUTCD
  - Design of airport roadway system includes provisions for:
    - Satellite parking areas
    - Access to on-airport intermodal stations including transit
    - Rental car areas
    - Safety considerations for parking access points
    - Taxi and public transportation staging and parking areas
- *Roadway Designs to Accommodate Taxis*
  - Geometric design alternatives
    - Roadway network
    - Interchanges
    - At-grade intersections
    - Driveways and other access points
  - Traffic operations alternatives
    - Improved signage to avoid confusion

- Improve pavement marking and delineation
- One-way CCW traffic

o Transportation enhancement alternatives
- Provide covered walkways
- Improve marking and lighting of pedestrian routes
- Install or improve bus stop shelters
- Improve visibility of shuttle stop signs
- Install bicycle racks
- Improve pedestrian and bicycle trails

o Management of Traffic during Construction

What the* Planning Guide *Does Not Cover

While this *Guide* provides a good single-source starting point for the key concepts associated with providing access to airports, its scope and level of coverage make it insufficient for the complex access needs of major airports seeking to meet their strategic regional and international roles. Its generic nature does not allow engineers and planners to address the complex web of factors and considerations associated with major airport access provision in a large urban area. Consequently, the need for additional work related to this subject is quite evident. Key areas that require additional development include a need to:

- gather more data on airport travel characteristics, such as the number of ground access trips related to origination, employees, and cargo activity at different airports;
- gather data on the number of passengers traveling in each vehicle that enters an airport (vehicle occupancy);
- collect and publish more information on peaking characteristics at different types of airports;
- develop guidance comparable to the *Guide* for planning freight access to airports; and
- develop better access-related planning tools and models, especially in order to address the airport's role in the context of its metropolitan area's strategic mobility needs.

CHAPTER 3
APPLICABILITY TO TEXAS AIRPORTS

This chapter briefly discusses the applicability of ground access planning at four of the major airports in Texas. The main point of this discussion is that each airport is unique and has its own individual access issues. Therefore, the general planning rules and guidelines for airport access espoused in the FHWA *Intermodal Airport Access Planning Guide* do not necessarily precisely fit, nor entirely meet, the requirements and special characteristics of these airports. The two largest and busiest of these airports, DFW and Bush Intercontinental, maintain large planning staffs augmented by consultants hired under contract. The two midsize airports, Austin and San Antonio, have very small planning staffs. Other airports that have need of airport access planning include Alliance Airport, Corpus Christi Airport, and El Paso International Airport. However, as a generalization, these airports and others like them probably do not maintain a sizable full-time planning staff. Therefore, their ground access planning would be addressed only during the preparation of the airport master plan.

1. Dallas/Fort Worth International Airport

DFW International Airport is administered by the Dallas/Fort Worth International Airport Board, an agency created by Texas legislation with board members from the two member cities. Unlike most Texas airports, which are administered by city departments of aviation, DFW airport is run by a professional airport staff reporting to the airport board. Given the airport's large size, this is an effective way to organize and respond to the needs of the airport. With its more than 18,000 acres, DFW is the second largest airport in the U.S., as measured in terms of land area. With more than 2,500 aircraft operations a day, it is either the second or third busiest airport in the U.S., depending on how the actual measurement of annual aircraft operations is made.

DFW has one unique ground access problem that does not appear to be found at any other airport. Because of its large acreage and key location between the high employment growth area of north Dallas and the high residential growth area of south Fort Worth, DFW is ideal for a major transportation artery between the two areas. In addition, the airport layout, with its central multilane divided thoroughfare oriented

north-south, attracts a large number of commuter vehicles that do not intend to use the airport but merely pass through as a means of obtaining the shortest-time commute. Anecdotal evidence reported by the airport staff has indicated that during rush hour, the waiting queue to enter the airport parking gate can exceed 20 minutes with all lanes open. As further evidence, DFW reported in the ACI airport parking survey that 16 million vehicles exited their parking facility toll booths in 1996, compared to 17 million origin and destination passengers. These figures are very high compared with those for other airports for the same year; for example, Chicago's O'Hare had 4 million vehicles exiting parking for 27 million O&D passengers.

To attempt to mitigate this problem by curbing the demand, the airport recently instituted a new parking rate of $2 for parking times between 0 and 8 minutes. The toll remains "no charge" for times between 9 and 30 minutes. The purpose is not to become a toll road authority but to reduce demand for the primary access roadway by charging a pass-through toll for drivers having no intention of stopping at the airport. It will be interesting to see what effect the new pricing schedule has on the demand for the ground access roadway.

DFW is also currently studying the feasibility of adding light rail access to the airport using the Dallas Area Rapid Transit (DART) authority system. Because of the high number of airport employees and the need to replace the existing rubber-tired people mover system within the airport, this project will most likely proceed to implementation. This project will probably be decided by the airport authority and DART directly without much, if any, input from either TxDOT or the local metropolitan planning organization (MPO).

One problem that was identified by DFW Airport was the lack of communication and coordination between DFW Airport and TxDOT on the placement of signage off-airport. Although there exists an MPO (NCTCOG), as well as TxDOT district offices in both Dallas and Fort Worth, communication between DFW Airport and these offices both for long-range access planning and short-range coordination on closures appears to be less than optimal for all entities concerned.

One of the other problem areas at DFW, a problem that is also shared with Houston, is mitigation of air pollution problems. Houston is in severe nonattainment, and

Dallas is expecting to reach severe nonattainment levels in the near future. The severe nonattainment designation by EPA will have considerable influence on the nature and extent of the ground access planning that is expected to take place, and on the types of access alternatives that must be considered. The airport needs to coordinate its actions with those ongoing at the regional level to reduce low-occupancy private automobile trips in order to reduce air pollution levels.

Houston George Bush Intercontinental Airport

The City of Houston Division of Aviation administers three airports in the Houston metropolitan area: George Bush Intercontinental, William P. Hobby, and Ellington Field. George Bush Intercontinental is a large hub airport with a large O&D passenger demand. Compared to cities with similar population, Houston has a small transit program, one that consists primarily of conventional bus service coupled with aggressive construction of high-occupancy vehicle facilities along freeways.

The typical ground travel times to George Bush Intercontinental could be problematic from some parts of the city during certain times of the day. It appears that Houston traffic is at times so bad that commuter flights are being flown from Hobby and Ellington to George Bush Intercontinental Airport, thereby providing intracity air shuttle service. The Houston Aviation Division has professional airport planners on its staff to handle the projected growth in passenger numbers; additional Houston information will be obtained for subsequent tasks of this project.

San Antonio International Airport

Ground access problems for San Antonio International Airport, which is located at the intersection of US 281 and IH-410, are relatively minor except for the crowded exit ramps from a very busy Loop 410. San Antonio is a medium-sized airport with about 7 million annual passengers, nearly all of whom are O&D. San Antonio has no plans for rail access but does provide some bus service to the airport.

Both Austin and San Antonio share a common problem in that they are likely to be designated as nonattainment for ozone as soon as 3 years of data have been collected under the new ozone limits. Accordingly, ground access plans that help reduce ozone will be looked at more closely at these two airports.

Both Austin and San Antonio have MPO organizations that work closely with the city planners. Both airports are administered by city departments of aviation, though the full-time planning staffs are relatively small. They both have the advantage of being able to draw upon traffic engineers from the city staff. Both airports have the good fortune to have ground access by state-maintained divided highways directly outside their gates. However, this also means that each airport needs to communicate with TxDOT district offices for maintenance, signage, or improvements.

Although Austin and San Antonio airports are very similar in size and passengers, there are some problems unique to each. San Antonio has a higher percentage of international travel, and particularly international cargo, with two foreign trade zones on the airport. International cargo is of high importance to the airport.

Continued growth at San Antonio International Airport is likely to be a problem for its current site. The terminal complex has grown to twenty-eight gates in two terminal buildings; in addition, parking space is relatively scarce. Growth in ground transportation to the airport will be one of the biggest problems at the airport, given that the site has exceeded its original design for ground access. The very limited acreage between Loop 410 and the airport will make ground access a major problem in efforts to accommodate passenger growth.

Austin Bergstrom International Airport

Like San Antonio Airport, Austin Bergstrom International Airport (ABIA) is a medium-sized facility, one having about 6 million annual passengers (nearly all O&D) and twenty-six aircraft gates. Moreover, like San Antonio, Austin will soon become designated as a city in nonattainment for ozone. However, even with the similarities, there are different ground access planning issues associated with the Austin facility.

Unlike San Antonio, Austin allowed the general aviation reliever airport in town to close. However, Austin has an advantage (although some might argue an inconvenience) in that general aviation has a separate ground access point to the airport.

Austin Bergstrom does not fit the mold of other Texas airports because it is essentially the only new medium-sized commercial service airport constructed in the U.S. in the last 20 years. The airport was built upon the site of Bergstrom Air Force Base after

the base's closure. Significant planning and resources were devoted to planning ground access to the airport. A complete ground access study was performed, although costs were kept to a minimum because the airport already had two grade-separated freeway entrances to the old Bergstrom Air Force Base. The study concluded that ground access times to the airport would not be a problem because the peak-hour traffic loads were less than those occurring when the base was an active military installation. Subsequent tasks in the present study should include a review of the depth of the traffic study performed for the 1993 airport master plan.

Because Austin Bergstrom was a new facility, planning included reserving space near the terminal for future light rail access to the airport. Nonetheless, the planners did not believe that there would be sufficient demand to justify a light rail access system to the airport.

An important issue for ground access planning at Austin Bergstrom is coordination and planning with TxDOT. Because of the lead times, TxDOT had programmed a new highway leading from north Austin to an earlier proposed airport site in Manor. However, in 1993 the city voted to discontinue plans for the Manor site and to rebuild on the Bergstrom site. With different timelines for planning and construction, major improvements to US 71 (the main access to the airport) were scheduled for construction after the airport opened, with such improvements then continuing for another 2 years. The lead times to schedule and program major infrastructure improvements are far longer than the public realizes. Enhanced procedures for coordination between airport, city, MPO, and TxDOT deserve study for potential improvement.

Implications for Present Study

As noted at the end of the previous chapter, and as highlighted in the discussion in this chapter, both the state of the art and the state of the practice pertaining to ground access planning for major airports are lacking. The review of literature indicated that procedures and guidelines currently available are of a very generic nature and are insufficient to address the strategic and tactical planning needs of major airport systems in their proper regional context. The *Planning Guide*, discussed in some detail in the

previous chapter, provides useful information and a good introduction to the scope and nature of the issues likely to be encountered at airports. However, it does not present specific operational tools that could be applied to specific situations and to specific airports. From a methodological standpoint, considerable advances have taken place in the analysis of the demand for access and in procedures for the design and evaluation of intermodal network-level alternatives. The *Planning Guide* does not provide a methodology; it presents concepts, all useful, but insufficient for the operational planning needs of actual airports.

Also highlighted in the discussion of this chapter is the fact that the major airports in Texas present unique access challenges that require intervention beyond the generalities of the *Planning Guide* or any other available reference. The nature of these issues is such that their scope is not separable from those of general transportation accessibility issues within the entire region of the airport. Airports like DFW have become major growth poles and hubs of economic activity in their respective regions. This role will continue to increase in tandem with the growing importance of convenient air travel for both passengers and goods in the much-touted New Economy, which is so critical to the future economic well being of the state. Institutional factors, involving cooperation and communication among several governmental and quasi-governmental entities, play a considerable role in ensuring an effective planning process that provides for the needs of air passenger and freight travel in the overall mobility of the region.

The conclusion of this review, conducted as an initial task of a 3-year project, is to confirm the objectives and tasks laid out in the original research proposal. The review and synthesis to date have further reinforced the motivation and the need for this work and has validated the basic premises of the work plan developed to address the research objectives.

APPENDIX A

RELATED WEB SITES

www.dfwairport.com/planning/transportation.htm

Summary

The site describes the future ground transportation plans for DFW airport. Currently, mass transit options are available via express and local service to the airport. However, future phases include a commuter rail service, a people-mover system, an automated parking fee collection system, a park-and-ride facility, and possible roadway improvements.

www.ci.houston.tx.us/departme/aviation/iah.html

Summary

This site presents general information for Houston travelers. Houston currently has metro bus service located in several terminals throughout the airport. IAH offers special membership rates for IAH-Sure Park members. Members are guaranteed a parking space once they pay for membership.

www.ci.houston.tx.us/departme/aviation/hou.html

Summary

Services available at William P. Hobby airport do not differ much from those provided at the Bush Intercontinental Airport; that is, metro bus service is also available in addition to other ground transportation options, such as the Airport Express. Moreover, the various parking options existing at HOU are presented.

www.ci.sat.tx.us/aviation/index.html

Summary

San Antonio travelers are provided with sufficient information on the easiest way to get to the airport from various activity centers in San Antonio and its vicinity. In addition, information about various ground transportation options is available, such as city bus service. Finally, San Antonio International Airport has several parking options, which are categorized as short term, long term, and shuttle.

www.ci.austin.tx.us/newairport/default.html

Summary

Available on this Web page is a complete description of Capital Metro bus service to the airport. Moreover, maps pertaining to best route options to and from the airport are also available via a direct link.

APPENDIX B

ANNOTATED BIBLIOGRAPHY

The articles and reports summarized in this annotated bibliography are grouped into five main categories:

1. At-Airport Issues
2. Demand Side
3. Entire Airport System
4. Network
5. Rail Access

1. At-Airport Issues

Adams, G., and Jackson, R. "Improving Ground Access to LAX." *Traffic Congestion and Traffic Safety in the 21st Century*. June 8–11, 1997. pp. 160–166.

Summary

Comprehensive master planning is well underway for major improvements to the Los Angeles International Airport (LAX). The implemented master plan is expected to accommodate a significant increase in annual air passengers, as well as the associated increase in ground access travel demand. With realization of the master plan improvements still at least a decade in the future, it was recognized that measures must be taken in the short term to address existing vehicular traffic congestion and to accommodate increased travel demands into the 21st century. Barton-Aschman Associates, Inc., was retained by the Los Angeles Department of Airports (LADOA) to help in identifying ground access problems and in formulating solutions. This paper describes one of several congestion problems studied and the solutions being implemented, including consideration of an on-airport traffic management center that may be installed in the old control tower.

Nakazawa, K. "Look Back on First Year's Actual Result of Access Railway for New Tokyo International Airport." *Japanese Railway Engineering*. No. 125. September 1993. pp. 23–26.

Summary

Opened in May 1978, New Tokyo International Airport at Narita City served approximately 6 million annual passengers in the first year. By 1990 the number of annual passengers had grown to approximately 20 million, of which 95 percent were international travelers. The rate of growth of air cargo at the airport places it among the world leaders; indeed, the Narita Airport is the most important port in Japan for trade

exchange with foreign nations. The access railway to the airport is an important part of the airport operation.

Lacomber, A. "Ground Access to Airports: Prospects from Intermodalism." *Transportation Quarterly*. Vol. 48. No. 4. pp. 381–392.

Summary

This paper examines the question of airport ground access in view of the requirements and goals of the CAAA and ISTEA. The regulatory, funding, and institutional constraints of intermodal approaches to the ground access problem are considered. Some of the new opportunities for cooperation between airports and transportation planners with respect to ground access solutions are integrated.

2. Demand Side

Blackhall, J., Brackenbury, S., and Ramsey, M. "London Luton Airport New Access Road: A Successful Construction Partnership." *Proceedings of the Institution of Civil Engineers: Transport*. Vol. 29. No. 4. November 1998. pp. 207–217.

Summary

Studies to assess the growth in future passenger traffic at London Luton Airport have forecast that the current (1994) traffic of about 2 million passengers per year will increase to 20 million passengers per year by 2015. In view of this future expansion, London Luton Airport Limited has formulated a long-term development strategy that includes innovative integrated and sustainable transport links. The new access road is an important part of this development strategy. This paper describes the various stages of the new access road construction, from its inception and planning through final completion; it outlines how the informal partnering process, instigated after tender award, helped to ensure the project's successful conclusion.

Cunningham, L., and Gerlach, J. "Transportation Agencies' Experiences with Decision Support Systems for Airport Ground Access Planning." *Transportation*. Vol. 25. No. 1. Feb. 1998. pp. 37–53.

Summary

A field investigation was conducted that looked into the ways that transportation agencies use quantitative and qualitative information for making strategic decisions regarding airport ground access. The value of this information was analyzed for planning airport ground access improvements at seven major international airport sites. The major finding of the research is that quantitative modeling for strategic decision support is very difficult, costly, and time consuming. While modelers are confident that the models are accurate and reliable, executives generally lack confidence in the results. Transportation

officials believe that the information supplied is flawed by a number of defects that minimize its value for strategic decision makers.

Higgins, T. Z. "California Airports: Ground Access Vehicle Trips, Emissions, and Emission Reduction Strategies." *23rd Air Transport Conference*, June 22–24, 1994. pp. 102–106.

Summary

The paper discusses the volume of trips and emissions associated with ground access vehicles traveling to and from California airports, and potential ways to reduce these emissions. It provides a method for estimating the volume of ground access vehicle trips at airports and associated emissions based on annual passenger volumes, a commonly recorded and reported airport statistic. At the same time, the report provides the best information available on the current volume of airport access vehicle trips, as well as the range of VMTs and speeds associated with trips. An example is provided to show how to calculate emissions from vehicle trips based on VMT, speeds, and emission factors or particular air basins. Finally, the paper investigates the potential of several employee and passenger strategies aimed at reducing trips and emissions.

Monteriro, A., and Hansen, M. "Improvements to Airport Ground Access and Behavior of Multiple Airport System: BART Extension to San Francisco International Airport." *Transportation Research Record 1562,* November 1996. pp. 38–47.

Summary

Metropolitan regions having more than one major airport — multiple airport systems (MASs) — are important to the U.S. air transport system because of the large number of passengers they serve. Airport ground access factors strongly influence the allocation of traffic in MASs. The effects of improvements to airport ground access (by nonautomobile modes) on airport use in an MAS are analyzed. A case study of an extension of a Bay Area Rapid Transit rail link into the San Francisco International Airport (SFO) is presented. Two airport choice models were developed. One is a nested logit model in which the airport choice decision occurs at the higher level and the mode choice decision at the lower level; the other is a multinomial logit model. The results indicated that improvements to SFO ground access would modestly strengthen SFO as the dominant airport in the San Francisco Bay Area, and that most of the diversion of passengers would be from Oakland Airport.

3. Entire Airport System

Ellis, G. "Airport Ground Access — The Missing Link." *National Conference Publication-Institution of Engineers*. Vol. 1. No. 93. September 13–15, 1993. pp. 249–253.

Summary

From the perspective of a city's overall transport network, a major airport's trip generation is usually second only to that of the city's central business district. All major Australian airports are currently dependent on road-based ground transport modes, with private auto being used to carry out greater than 75% of all trips. The task of providing for the total ground access trip is generally shared between authorities that often differ in their primary operative objectives. Innovative ground transport planning will be required to effectively provide for this demand into the future. Measures such as the introduction of additional modes (especially rail), economic methods (such as road or parking use charges), or the decentralization of the centers of demand by the introduction of off-airport terminals will all become more prevalent in the future. Timely ground transport planning, enabled by cooperation between airport and external ground transport infrastructure authorities, will be necessary if Australian airports are to operate optimally into the future.

Fabian, L. "Rationalizing Airport Ground Access." *Transportation Quarterly*. Vol. 47. No. 4. October 1993. pp. 473–482.

Summary

Airports have evolved into expansive intermodal transportation complexes that attract significant surrounding off-airport development and ground traffic. Landside traffic generates more airborne pollutants than airside activities. Together, airside and landside air pollution have caused many airports to be identified as environmental "hot spots." This article focuses on landside opportunities to reduce ground access traffic and the resulting pollution through the use of automated people movers and personal rapid transit systems.

Gosling, G. "Analysis of Changes in Airport Ground Access Mode Use." *Proceedings — International Air Transportation Conference*. June 5–7, 1996.

Summary

Increasing concern over the impacts of airport-generated traffic on the surrounding street and highway system, as well as the emissions generated by those vehicle trips, is forcing airports to pay more attention to strategies to reduce or mitigate ground access traffic. However, airport ground access traffic covers many different types of trips, and few airports currently have effective systems to collect and integrate the information to effectively manage this system. The introduction of automated vehicle

identification systems at a growing number of airports has created a significant data resource, one that is largely used only for revenue accounting. This paper presents the results of a comprehensive analysis of ground-access mode use patterns at seven California airports over a 2-year period that integrated information from a wide range of sources at each airport. It was found that use of the different modes varied significantly throughout the year, even after allowing for changes in air traffic volumes. The fact that air passenger surveys are typically conducted only for short periods of time at infrequent intervals could lead to significant errors if these data are used to predict airport ground access traffic. The paper explores the factors that contribute to these fluctuations and discusses how a more comprehensive integration of existing data could greatly improve the ability of airports to predict short-term changes in demand for different modes and longer-term impacts of ground access management strategies.

Shapiro, P. "Planning for Intermodal Access at American Airports." *International Air Transportation Conference*. June 5–7, 1996.

Summary

Shortly after the passage of the ISTEA legislation, the Federal Highway Administration and the Federal Aviation Administration recognized that there was very little guidance available for airport operators and MPOs to use for planning intermodal access to airports in the U.S. As a result, the *Airport Access Planning Guide* is being developed. The *Guide* is designed to provide guidance to states, metropolitan planning organizations, and airport operators on the types of analyses that should be performed when planning airport access. It describes the airport access planning process and the procedures for performing analyses. During the development of the *Guide,* relationships were developed between the level of originating passengers at American airports and the characteristics of airport access and landside facilities. The types of characteristics that were related to origination passengers include public parking terminal curbside design and mode of access. This paper describes the contents of the *Guide,* as well as some of the relationships that were developed, how these relationships were derived, and their importance to airport access planning.

Lampe, A. "Effects of Road Access Pricing at the Los Angeles Airport: A Case Study." *ITE Journal*. Vol. 63. No. 12. December 1993. pp. 22–24.

Summary

Los Angeles International Airport (LAX) is one of the busiest airports in the world in terms of numbers of airplane passengers served and the size of the ground transportation necessary to serve those passengers. When LAX imposed an airport access charge for commercial vehicles, it was based on an honor system. But LAX officials were concerned that the system was not adequate. They needed a more effective system for reporting the commercial vehicle airport appearances and for assessing related charges. After evaluating available technologies and systems, LAX moved in 1989 to install a

state-of-the-art automatic vehicle identification (AVI) system to reduce traffic congestion and, at the same time, maximize revenues collected from its ground transportation operation. The system installation was completed in September 1990. The AVI system consists of electronic tags and readers. The tags, sometimes called transponders, are mounted in or on the registered vehicles. Each tag is programmed with its own unique identifier. The reader system includes a radio frequency transceiver, an antenna, digital logic, and computer-based software that are all connected to antennas placed at strategic locations. Since implementation of the AVI system, revenue collection has increased more than 250% and congestion has been reduced by 20%, compared to the honor system previously used by the airport.

4. Network

Bergener, J., and Javid, M. "Planning and Analysis of Airport Access using GIS: SLCIA Example." *International Air Transportation Conference*. June 5–7, 1996.

Summary

Geographic information systems have been used in many transportation engineering applications with varying degrees of success. At the present time, however, there are few cases of GIS being used for the sole purpose of airport access planning. This paper discusses ways in which GIS can meet the unique needs of airport planners and managers with respect to airport access planning.

Fan, H. "Ground Access to Singapore Changai Airport." *Journal of Advanced Transportation*. Vol. 24. No.1. Spring 1990. pp. 9–30.

Summary

This paper analyzes the ground access system at Singapore Changai Airport. The emphasis is on understanding traffic characteristics and utilization of access facilities. The feasibility of applying to Changai Airport typical ground access planning parameters recommended for western airports is also investigated. Peak traffic levels are found to be manageable. The curbside is the critical link of the access system, but congestion in peak periods does not last very long at present. Although the two public car parks together provide enough parking spaces, the closer-in car park is always full in the evening, while the cheaper car park is usually half empty even though it is only 825 ft (250 m) farther. This situation suggests convenience is more important than cost to most users.

Kivett, H. "Lessons for Rail Access to Airports." *International Air Transportation Conference*. June 5–7, 1996. pp. 96–105.

Summary

This paper summarizes the key planning, design, and operational issues that must be addressed in the ongoing expansion of existing airports, as well as development of

new airports around the world, in conjunction with rail access consideration. The focus is on those airports considering rail access or that are in the formative stages of implementation that will link the city center of a major metropolitan area with its airport.

Ndoh, N., and Ashford, N. "Evaluation of Airport Access Level of Service." *Transportation Research Record 1423,* October 1993. pp. 34–39.

Summary

Research in level-of-service evaluation to airport access using psychometric techniques is discussed. The raison d'etre of the methodology is to provide scale values of level of service and to then use the scales developed to investigate the effects of level of service on mode choice. The method was applied to a case study of access at a London airport. Results are presented in terms of passengers' satisfaction with various access attributes. The scale deduced for access information indicates the need for better distribution of access information to air passengers.

Tambi, J., and Griebenow, Bob. "Automated Guideway Transit to Provide Access to New York City Airports." *4th International Conference on Automated People Movers*. March 18–20, 1993. pp. 460–469.

Summary

The Port Authority of New York and New Jersey is currently addressing the issue of airport access in a multi-faceted manner. Besides looking at several transit system management measures, the Aviation Department is examining several access improvements, one of which would connect the existing rail systems, both commuter and subway, with the airports. This connection would be achieved with the construction of an automated guideway transit (AGT) system linking the airports to major transportation transfer facilities.

5. Rail Access

Mandalapu, S., and Sproule, W. "Airport Ground Access: Rail Transit Alternatives." *Transportation Research Record 1503*, 1995.

Summary

This paper provides comparative evaluation of various schemes of rail access to airports. These schemes are studied for three types of travel scenarios:

- More business passengers
- Equal number of business passengers and vacationers
- More vacationers

Three schemes are studied for their relative desirability for each of the three scenarios:

1. Dedicated service between airport and city center and, thus, an express non-stop service (airport station would be located in the terminal building).
2. Extension of an existing fixed rail-line to the airport (airport station would be located in the terminal building).
3. Airport station on a rail-line near the airport. A bus service or automated people mover (APM) would link the station with the airport.

Results provide respective levels (volume of passengers) at which each might become attractive. The attractiveness of any of the options increases with increasing demand and depends on the composition of the demand (e.g., business versus nonbusiness travelers).

The influence of baggage check-in facilities at stations is also studied. It is shown to be a key element in the selection of any access mode.

Idmerand, J. P. W., and Idber, C. H. "Effects of Rail Stations at Airports in Europe." *79th Annual Meeting of the Transportation Research Record*, Washington, D.C., January 2000.

Summary

This paper provides a discussion of rail stations at European airports, and how well these stations are operating, as measured by a benefit/cost ratio for each system. The history of several rail systems in Europe is presented. Service often started with (rail) shuttle service between the airport and the city center. This service was first adopted by the Brussels airport, which operated a rail-link for the World Exhibition in 1958. Airports subsequently became better integrated in the overall regional rail network: Representing as they did a major station along the suburban and national railway networks, the airports enabled service of long-distance trains, such as those operating in Amsterdam, Frankfurt, Geneva, and Zurich. In 1994, airports fully integrated into the national high-speed rail systems were put into operation (e.g., CDG2 in Paris and Lyon Satolas).

The airports studied and a classification of the type of rail service provided are shown in the table below.

Type of Link	Classical	High Speed Rail (HSR)
City Center to Airport	Brussels	Oslo Gardermoen
	London Heathrow	
	London Stansted	
	Newcastle	
	Paris CDG	
	Paris Orly	
	Milan Malpensa	
	Madrid	
	Stuttgart	
	Munich	
Suburban and Inter Regional Rail System at Airport	Amsterdam	Paris CDG
	Geneva	Lyon Satolas
	Zurich	Frankfurt
	London Gatwick	
	Birmingham	
	Frankfurt	
Airport to Airport	Zurich to Geneva	Paris CDG to Lyon Satols

Idmerand, J. P. W., Idber, C. H., Effects or Rail Stations at Airports in Europe. 79th Annual meeting of the Transportation Research Board, Washington, D.C., January 2000.

A description of the rail systems in seven European cities is summarized in the table below:

City	Airport	Dist. from city center	Rail descriptors	Passengers served	Departures	Coverage
Zurich	Zurich Kloten (ZRH)	11 km (North)	6 km long, mostly underground. (Double track)	9 Mi. pass/year	More than 290 trains per day	Most of suburban Zurich and the nationwide network of the Swiss Federal Railways plus destinations abroad such as Milan.
Geneva	Geneva Cointin (GVA)	4 km Northwest	6 km long double track.	2 Mi. pass/year	86 trains per day	Most of the Swiss Federal Railway network and destinations abroad such as Milan.
Stuttgart	Stuttgart Echterdingen (STR)	14 km South	20 Km long from the main station to the airport.	1.5 Mi. pass/year	72 trains on a weekday and 39 on weekends	
Frankfurt	Frankfurt Rhein/Main (FRA)	11 km Southwest	11 km long	5 Mi. pass/year	176 trains per day on average	

City	Airport	Dist. from city center	Rail descriptors	Passengers served	Departures	Coverage
Brussels	Brussels Zaventem (BRU)	12 km Northeast	18 km from main station to the airport	3 Mi. pass/year		
Paris	Charles de Gaulle (CDG2)	26 km North East	Rail station CDG2 under airport terminal 2. Direct connection with RER "B." Operates RER every 8 min. 18 pairs of TGVs on a workday since June 1996.			1.3 Mi pass/year
Paris	Orly (ORY)	14 km South	Rapid suburb "C" line underground through the city of Paris is operated as "Orlyrail" with a bus service to the terminals. New System: Since October 1991 "ORLYVAL" has been an automatic rail system linking both airport terminals to the RER "B" station on Antony. It is a double track that is 7.3 km long with double cab trains operating every 8 min.			2 Mi pass/year

The major conclusions reached are:

- For hub (major) airports, the effects are positive (except BRU and ORY).
- While airport size is effective, also effective in deciding whether a system is justifiable or not are access distance to the airport by rail, time travel, and fare savings.
- Effects on other public transportation systems (e.g., taxis and parking operators) are negative.

Mandle, P., Mansel, D., and Coogan, M. "Use of Public Transportation by Airport Passengers." *79th Annual Meeting of the Transportation Research Board*, Washington, D.C., January 2000.

Summary

This paper compares airports in the U.S. with those in Europe in terms of access by public transportation in its various forms. Only eight airports in the U.S. have direct rail access (stations within the airport or within walking distance of the terminal). The percentage of rail usage by passengers at these airports varies from a low of 3% to a high of 14%. Direct rail access is available at more than sixteen cities in Europe and Asia. The percentage of rail usage is as high as 30% at airports in Oslo (Gardemoen), Tokyo (Narita), Geneva, Zurich, and Munich. A combination of shuttle bus service and rail stations is available at eleven airports in the U.S.

A discussion of the potential for rail service in the U.S. is presented. For example, ridership is greater overseas (Europe and Asia) mainly because cities in those continents have greater reliance on rail as a dominant means of public transportation. The authors believe that there is a "ceiling" on the market share that could be attracted by rail in particular and public transportation in general for airport access in the U.S. They estimate

this "ceiling" at about 10 to 15%. The higher ceiling on public transportation usage in Europe and Asia (estimated at about 30%) can be attributed to the fact that these cities have extensive network coverage, more limited highway access, higher regional densities, and greater use of rail as a feeder service.

The characteristics that need to be available to have a successful rail system are, in their order of importance:

1. Proportion of airline passengers with trip ends in downtown.
2. Characteristics of the passenger market (e.g., whether traveling alone or not, amount of luggage, familiarity with the regional transit system).
3. Regional travel time.
4. Ability to walk between station and destination.
5. Extensive regional coverage.
6. At-airport travel time: Passengers using rail would like to minimize the time required to travel from the station to their gate.
7. Frequency of service and associated waiting time.
8. Availability of parking at non-airport stations.

Finally, the authors conclude that few U.S. cities, if any, possess these success characteristics.

Mansel, D., and Mandle, P. Review of Off-Airport Passenger Check-in Facilities (Satellite Terminals). *79th Annual Meeting of the Transportation Research Record*, Washington, D.C., January 2000.

Summary

The concept of off-airport check-in facilities is presented. Satellite terminals would be linked to the airport via some mode of high occupancy transport. It is believed that such a facility would relieve airport users from major sources of delay, namely, delays on access roads, insufficient parking, having to carry baggage on and off transport facilities, delays at airline ticket counters, and crowded gate areas. Both domestic and international case studies of satellite terminals are presented, with Zurich considered to provide the most elaborate such system. Key challenges to ensure a successful system include:

- Security Requirements: It is required that all airports and airlines adapt and implement the approved FAA Security Program (mainly addressing passenger and baggage screening).
- Close-out times: There is a minimum preflight time available to passengers arriving at the satellite terminal for transporting luggage after being checked in to the airport; in addition, passengers must account for travel time between the station and airport.

- Difficulty Providing Baggage Claim: For example, with such a system who would be liable for lost or damaged baggage? In addition to customer service issues, such as if a passenger is unexpectedly met by a friend or relative, currently there is no way to stop checked baggage from going to the satellite terminal.
- Travel Time Advantages: The mode of travel between the terminal and the airport must provide reliable and reduced travel times as compared to private auto to be attractive (e.g., if bus can make use of HOV lanes or bus preemption at traffic signals it would become highly competitive).
- Availability of Parking.
- Airline Industry Cooperation and Support.

Schank and Wilson. "Airport Access Via Rail: What Works and What Doesn't." *79th Annual Meeting of the Transportation Research Record*, Washington, D.C., January 2000.

Summary

This paper tackles the issue of rail links as they relate to domestic airports. Characteristics of airport rail links that affect rail modal share are discussed. Key factors that might affect the performance of an airport rail link are presented in the following table:

Fixed Factors	Design Factors
Location of the airport relative to the city	Speed and reliability relative to other access modes
Productions and attractions along link	Location of airport train terminal
Local cultural factors	Transit fare(s)
Airport characteristics	Parking rates
Ease and availability of connections	
State of local transit	

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Airport rail link performance for major airports in the U.S. is summarized in the following table, in order of decreasing rail mode share.

Airport	Fare	Time to CBD			Rail peak	Km to	Parking Rates		Terminal	Speed	Mode
		Rail	Auto	Diff	Headway	CBD	Short	Long	in Airport	(km/hr)	Share
DCA	$1.10	17	10	7	3	7	$4.00	$8.00	Yes	26	9.0%
MDW	$1.50	29	19	10	7	18	$3.00	$10.00	Yes	37	8.1%
ATL	$1.50	21	10	11	8	14	$1.00	$5.00	Yes	41	6.0%
BOS	$0.85	14	8	6	4	5	$4.00	$12.00	No	21	5.7%
STL	$3.00	39	30	9	7	16	$1.50	$5.00	Yes	25	5.0%
OAK	$3.10	30	14	16	10	13	$2.00	$8.00	No	26	4.1%
OAK-to SF	$4.75	40	29	11	10	30	$2.00	$8.00	No	46	4.1%
ORD	$1.50	44	21	23	7	29	$3.00	$8.50	Yes	40	3.9%
CLE	$1.50	34	20	14	12	16	$3.00	$11.00	Yes	28	3.0%
PHL	$5.00	42	17	25	30	11	$5.00	$6.50	Yes	16	2.0%
JFK	$1.50	65	25	40	10	26	$4.00	$6.00	No	24	1.7%
BWI-to DC	$6.00	73	38	35	45	48	$4.00	$6.00	No	40	1.0%
MIA	$3.25	75	12	63	60	11	$3.00	$10.00	No	9	1.0%
SJC	$1.10	29	5	24	10	3	$1.50	$10.00	No	7	1.0%
BWI-to Balt	$1.35	40	15	25	30	13	$4.00	$6.00	Yes	19	n/a

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Schank and Wilson's analysis found that only two factors exhibit a direct correlation with mode shares: rail link travel time and rail/auto time difference. The table below lists airports by increasing rail link travel time to the central city, illustrating that the mode share decreases with increasing rail travel time

Airport	Time to Center	Km to Center	Speed (Km/hr)	Mode Share
DCA	14	5	21	5.7%
MDW	17	7	26	9.0%
ATL	21	14	41	6.0%
BOS	29	18	37	8.1%
STL	29	3	7	1.0%
OAK	30	13	26	4.1%
OAK-to SF	34	16	28	3.0%
ORD	39	16	25	5.0%
CLE	40	30	46	4.1%
PHL	40	13	19	n/a
JFK	42	11	16	2.0%
BWI-to DC	44	29	40	3.9%

Airport	Time to Center	Km to Center	Speed (Km/hr)	Mode Share
MIA	65	26	24	1.7%
SJC	73	48	40	1.0%
BWI-to Balt	75	11	9	1.0%

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A similar table was prepared for the access time differential between rail and auto travel times. The table also illustrates that modal share decreases as the difference between rail and auto travel times increases.

Airport	Rail	Auto	Difference between Rail & Auto	Mode Share
DCA	14	8	6	5.7%
MDW	17	10	7	9.0%
ATL	39	30	9	50%
BOS	29	19	10	8.1%
STL	21	10	11	6.0%
OAK	40	29	11	4.1%
OAK-to SF	34	20	14	3.0%
ORD	30	14	16	4.1%
CLE	44	21	23	3.9%
PHL	29	5	24	1.0%
JFK	40	15	25	n/a
BWI-to DC	42	17	25	2.0%
MIA	73	38	35	1.0%
SJC	65	25	40	1.7%
BWI-to Balt	75	12	63	1.0%

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The following observations were reached on the basis of the authors' analysis of the data:

a) As the rail/auto travel time difference increases the rail mode share is likely to significantly decrease and vice versa.
b) Airports operating off-airport rail stations are likely to attain lower rail mode shares.
c) The more elaborate the airport rail link is, the more likely it is to attract more passengers. As a matter of fact most U.S. airport rail links do not serve the metropolitan areas efficiently and thus are incapable of attracting a large modal share.

d) Airports that serve a large number of long-haul trips are most likely going to suffer from low rail mode shares.
e) A high market of low-cost carriers at an airport is likely to increase rail mode share.
f) Airports that have proximity to the downtown area and other major activity centers are likely to capture higher rail mode shares.
g) A service frequency that is incompatible with passenger demand is likely to result in an airport losing its rail mode share.
h) An airport rail link that is part of a modern well-designed rail system is likely to increase the rail mode share.
i) Airport rail links that are dedicated to serving only the central business district are likely to have low mode shares.
j) Airport workers are more likely than airport passengers to use airport rail links.

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