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METHODOLOGY FOR EVALUATING AIRPORT ACCESS CONGESTION MITIGATION STRATEGIES

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16. Abstract

Methodology for evaluating airport access congestion mitigation strategies, based on Chapter 4 of Research Report 1849-3, *Assessment of Intermodal Strategies for Airport Access*. The methodology is intended to assist planners from TxDOT, airport authorities, and Metropolitan Planning Organizations (MPOs) in developing short and long-term strategies to address airport landside access issues.

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Methodology for Evaluating Airport Access Congestion Mitigation Strategies

INTRODUCTION

The methodology presented here is based on the information provided in Chapter 4 of Research Report 1849-3, *Assessment of Intermodal Strategies for Airport Access*. The methodology is intended to assist planners from TxDOT, airport authorities, and Metropolitan Planning Organizations (MPOs) in developing short and long term strategies to address airport landside access issues. The methodology considers key elements that have direct and indirect implications on airport access. These include the formulation of individual preferences influencing the demand for access, as well as the local and regional impacts of airport access congestion.

Evaluation of congestion management strategies for airport landside access cannot be made using standard planning tools. Specifically, these tools are static in nature, and hence inappropriate for problems where temporal patterns of airport access are essential. Thus, the evaluation methodology must be sensitive to the peaking and other temporal characteristics of the demand. Furthermore, the methodology must consider an intermodal perspective. Taking into account these special requirements, the following steps provide a conceptual framework of the processes that determine the demand and associated service levels for airport landside access.

STEP 1: Develop an Understanding of the User Decisions about Mode Choices

In order to develop an evaluation methodology, it is first necessary to understand user decision processes and their effects on access demand, as well as overall network congestion in the immediate vicinity, and in the regional context of the airport.

Environmental factors, users' attitudes and perceptions, as well as individual and trip characteristics contribute to the formation of individual preferences. These preferences, in conjunction with information accumulated through experience or acquired from other sources, result in a set of decisions made by the individual, which in turn lead to demand for services (*Ref 1*). Figure 1 illustrates these interactions.

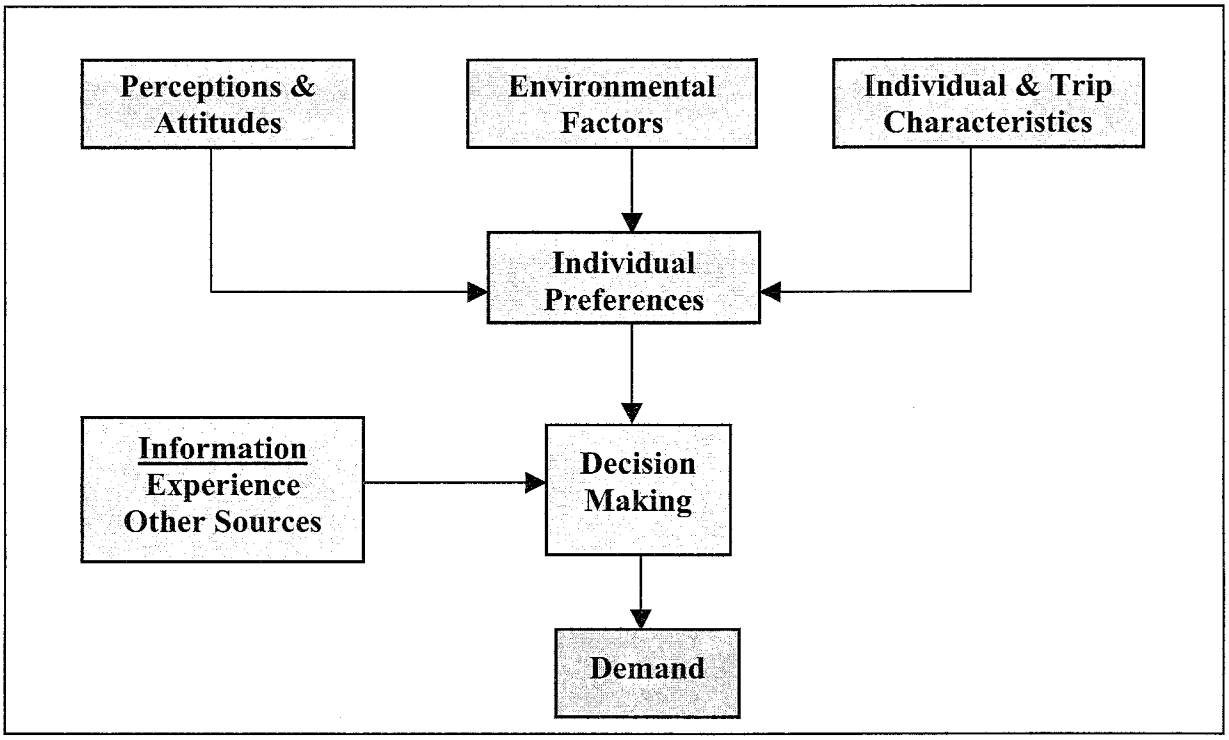

Figure 1 - Factors and characteristics leading to the demand for airport access

The choices made by users depend on ***individual (personal) and household characteristics***. Such characteristics include age and gender of the individual, and the number of workers in the household. In addition, ***trip characteristics*** such as time of day, parking location, airline, destination, and number of bags to be carried on the trip are expected to influence the choices made by the user (*Ref 2*). Examples of ***environmental factors*** include things like weather, aesthetics associated with a mode, security, etc.

The linkage between the ***attitudes and perceptions of a user*** and his or her behavior has long been addressed in psychology literature. Individual behavior is affected by intentions, which are in turn influenced by attitudes (*Ref 3*). For example, when an individual decides to embark on a trip, often the intention would be to participate in an activity. However, different users might have different beliefs and opinions regarding alternate modes of travel because they typically have their own perceptions of characteristics such as comfort, reliability, and convenience (*Ref 4*).

Together these factors: (1) perceptions and attitudes, (2) environmental factors, and (3) individual and trip characteristics, each help shape an individual's preferences towards travel.

Available information influences the choices users make. This information is either accumulated through experience or acquired from other sources. Traveler information systems can be of assistance in this regard. It is believed that accurate, timely, and understandable information can contribute to choices that are somewhat better, either for the individual traveler, society as a whole, or both (*Ref. 5*).

Travelers then can reasonably ***make decisions*** about mode, time, and their route based on personal preferences, and using the most current and reliable information available to them.

STEP 2: Identify Classes of Users and Their Attributes

In this section, the principal classes of airport based trip users are identified. Knowing the types of users is essential in order to conduct an effective analysis of airport-related travel.

Air passengers are not the only ones who make trips to and from airports. The airport population is diverse, and the access/egress system must serve the needs of disparate users, namely: air travelers, meeters and greeters, visitors, employees, air cargo personnel, and persons who supply services to the airport. The discussion hereafter considers: (1) air passenger market segments, (2) airport employees, and (3) air cargo.

Air Passenger Market Segments

Air passengers are primarily concerned about dependable travel times, especially as the times relate to flight arrivals and departures. Some of the passengers leave no margin for time delay in their trips to the airport and as such are referred to as *just-in-time* travelers (*Ref 6*). For most air travelers, missing a flight departure has severe consequences; missing a connecting flight and thus some lost time, or even some additional cost. Indeed, air travelers vary in their sensitivity to ground access costs. Those on business trips are less concerned about access costs than those on non business trips. For some passengers, such as those on leisure trips with low airfare tickets, the cost of ground access may represent a significant portion of the total travel costs.

For each group of air travelers, there tends to be a service or location attribute that dominates their ground access decisions. Typically, air passenger characterization occurs along two dimensions, residency status and trip purpose, which leads to four distinct market groups:

- resident business,
- resident non business,
- non resident business, and
- non resident non business.

A discussion of the characteristics of each market segment follows.

Resident business travelers are typically the most frequent users of the airport facility, and thus develop patterns of access behavior based on repeated trips to the airport. They are likely to know the most efficient and reliable means of transport to and from the airport. Usually their air trips are short in duration, and such travelers carry little if any luggage compared to non business travelers. While some of these characteristics might make their travel profile favorable for public transportation options, their sensitivity to access time reliability makes them cautious about using public means of transportation. Finally, such passengers are more likely to be traveling to and from the airport at peak arrival and departure times (*Ref 6*).

Resident non business travelers typically depart from home, travel in large parties, have an appreciable amount of luggage, and have longer stays than resident business travelers. While they may not travel as often as business travelers, they are expected to have some level of information about access to the airport, and may have developed a preferred method of getting there. Depending on the characteristics of their travels, resident non business air passengers will likely be dropped off or picked up at the airport by friends or family, or park in reduced-rate parking facilities. Finally, such travelers are candidates for public transportation access to an airport if the location at which they access the system is convenient and located somewhere between their origin point and the route they would normally take to the airport (*Ref 6*).

Non resident business travelers are usually either destined for a place of business or a hotel and begin their trips to the airport from the same location. Such places tend to be located in city centers, close to regional attractions or the airport, or in proximity to regional highways. They usually require the kind of flexibility in choice provided by a rental car or taxi. However, they could be users of public transportation when such transportation means are expedient and the trip does not involve multiple stops and transfers (*Ref 6*).

Non resident non business travelers are usually the least informed and most unfamiliar with the access options available at a given airport. Because such passengers may be unfamiliar with the access options available, they will use the most readily available, such as taxicabs or shared-ride, door-to-door vans, and thus are unlikely to use public transportation (*Ref 6*).

Airport Employee Market Segments

Employee trips to and from an airport are not similar to those generated by other types of office or industrial employment. Such employees have non standard work hours because operations at the airport need to be maintained on a 24-hour basis. A study conducted at Boston Logan Airport estimated that only 60% of all employees commute on an average weekday, and between 30% and 40% of the employees work on Saturdays and Sundays. Moreover, only 25% of weekday employees arrive between 6:00 a.m. and 10:00 a.m., which is the normal a.m. peak period (*Ref 7*). Flight crews arrive when they are needed for flights and often will not leave the airport until several days later, while non flight crew employees may work on shifts. However, airport employees (airport, airlines, and related businesses) have other characteristics, such as regular travel patterns and familiarity with alternatives, that make their behavior similar to that of regular commuters, and thus amenable to service by conventional transit services (*Ref 6*).

Airport employees are concerned about dependable travel time, particularly when they must report to work. The 24-hour operation of an airport makes the service hours of any access service very important, because some airport employees must commute at hours not typically covered by regional transit services. In some cases, one leg of the trip might occur within typical commuting hours, while the other leg may be outside those hours, thereby precluding use of public transportation. Airport employees are naturally concerned about the cost of using an access mode because of the repetitive nature of their travel. Airport employees are also concerned about the service frequency (*Ref 6*).

Air Cargo Operations

Air cargo operations generate employee and delivery trips (e.g., trucks, vans, and other vehicles that transport cargo to and from the airport). There is no commonly accepted trip generation rate for air cargo delivery that applies to all airports, because airlines and airport operators typically report cargo in terms of annual or monthly tons of cargo. Moreover, cargo-handling methods may vary widely and may affect the number of access trips. For example, overnight package services or courier services (such as Federal Express or United Parcel Service) usually assemble large volumes of cargo at off-airport locations and use a few large trucks to transport this cargo to and from their airport terminals. Freight forwarders or agents, who operate at off-airport locations near most international gateways, use similar procedures. On the other hand, a much larger number of access trips per ton of cargo are generated by the small package delivery services operated by air carriers, e.g., Delta Dash (*Ref 7*).

Concluding Remarks About Classes of Airport Users

Airport users differ in their characteristics and behavior. It is important to understand these differences in order to properly evaluate congestion at the airport and develop strategies for mitigation.

In addition to the attributes of the users, it is important to identify their travel patterns. The next step following section presents the distribution of the origins and destinations of airport users in general and air travelers in particular.

STEP 3: Assess Geographic Distribution of Ground Access Trips

Trip patterns for airport access trips can be separated into on-airport circulation patterns and off-airport trip distribution. The former depends on trip purpose and airport design, while the latter also depends on trip purpose but it is more dependent on regional growth patterns and off-airport facilities that serve the airport. Table 1 describes the factors that affect trip distribution patterns for the on-airport and off-airport portions of an airport access trip (*Ref 7*).

Table 1 Factors influencing distribution patterns of airport access trips

Type of Access Trip	Passenger	Employee	Visitor	Air Cargo
On-Airport	Proportion of passengers using curbside and parking facilities.	Location of employee parking and transit facilities.	Curbside and parking availability.	Location of air cargo facilities and cargo vehicle entrances to airport.
Off-Airport	Place of residence and employment, tourist attractions, and available access routes and services.	Place of residence and available access routes and services.	Regional demographics and available access routes and services.	Location of air cargo handling agents and clients, warehouses, and industrial facilities.

Source: Ref. 7

Off-airport travel patterns for commercial and private vehicles are often based on the locations of regional population and employment, tourist attractions, hotels, off-airport parking, and rental car facilities. Knowing the distribution of air passenger and employee trip origins is critical to the planning of any successful public transportation service to an airport because passengers from these origins represent a candidate market for the planned service. One important consideration of ground access traveler origins is whether the location is a place of residence (a home-based trip) or one of the many non residential locations (non home-based trips). For home-based trips, the traveler can use the private vehicle as a mode of travel; however, that mode is typically not available for non home based trips (*Ref 6*).

Non home based origins of airport ground access trips are likely to be concentrated in city centers, business locations, and areas with well-known attractions for visitors. Ground access trip origins of most large U.S. airports are distributed over a wide region (*Ref 6*).

STEP 4: Determine the Temporal Characteristics of Airport Demand

The level of demand accommodated by ground transportation facilities at airports varies by season, day of the week, and hour of the day. An understanding of the temporal nature of this demand is helpful for airport landside management strategies.

Months of the Year Variations

The demand for airport services varies by month during the course of a year. For example, during peak holiday travel months, such as November and December, airport parking facility use and landside congestion usually increase compared to off-peak periods. A similar demand pattern is observed during July and August, when vacation travel activity is high. At airports located in states with warm weather resort destinations, such as Florida and Arizona, the peak month may occur during April (*Ref 7*). Figure 2, shows an example of seasonal variations in demand for airport services at Dallas/Fort Worth International Airport (DFW) Airport.

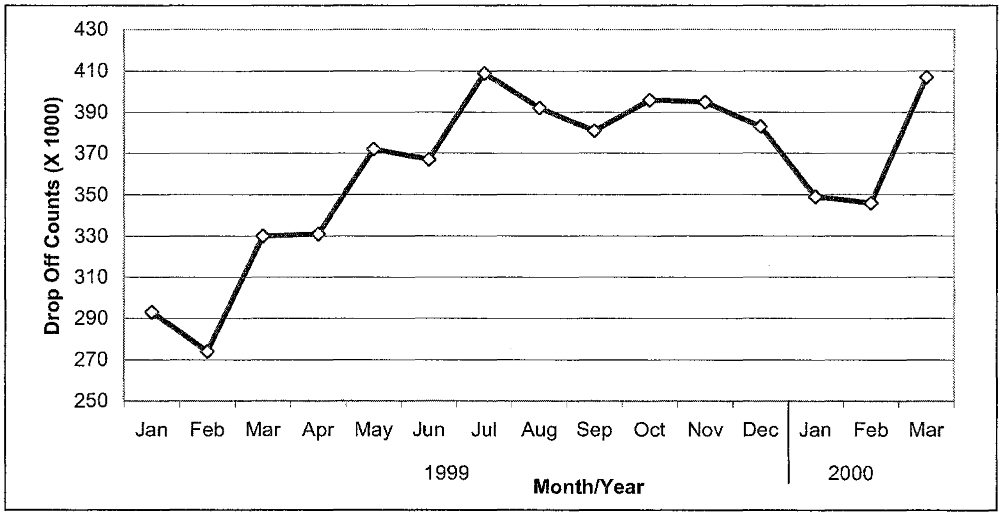

Figure 2 - Seasonal variations in drop-offs at DFW International Airport

Days of the Week Variation

In addition to the seasonal variations in airport demand, facility demands vary by day of the week. For example, peak roadway traffic volumes may occur early or late in the week as business travelers begin or end their trips. As such, the demand for long-term parking facilities may be greatest during the middle of the week (e.g., Wednesday) when most business travelers are away. On the other hand, at airports with a high number of non business or leisure travelers, peak demands may occur on weekend days (*Ref 7*). Figure 3, shows the daily variations in the number of drop-offs at DFW Airport.

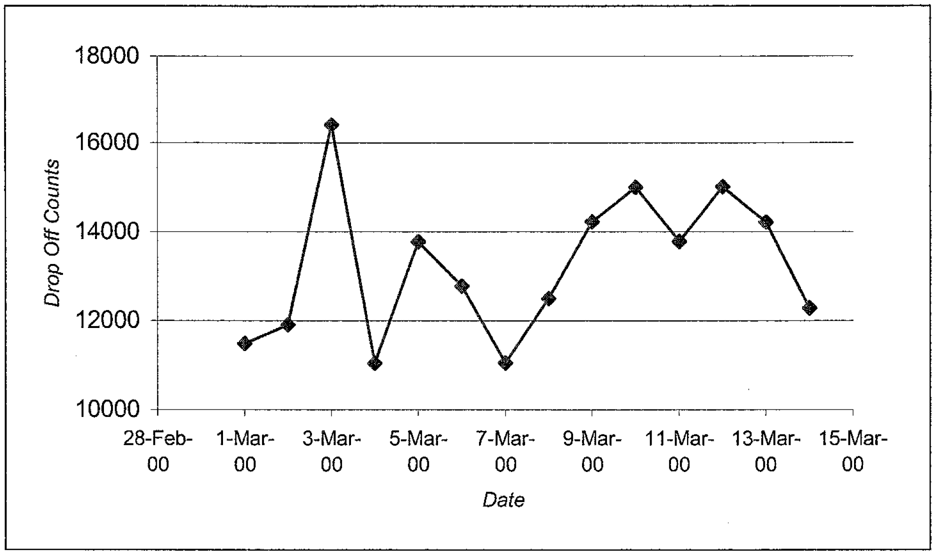

Figure 3 - Daily variations in drop-offs at DFW International Airport

<u>Time of Day Variation</u>

Finally, facility demands vary by time of day and type of traffic accommodated by the facility. At large airports, separate roadways and curbsides are often provided to accommodate different passenger activities (e.g., enplaning versus deplaning passengers, international versus domestic passengers). Each of these facilities must be designed to accommodate the activity occurring at that facility during the design period (*Ref 7*). An example of hourly variations in demand at DFW airport is shown in Figure 4.

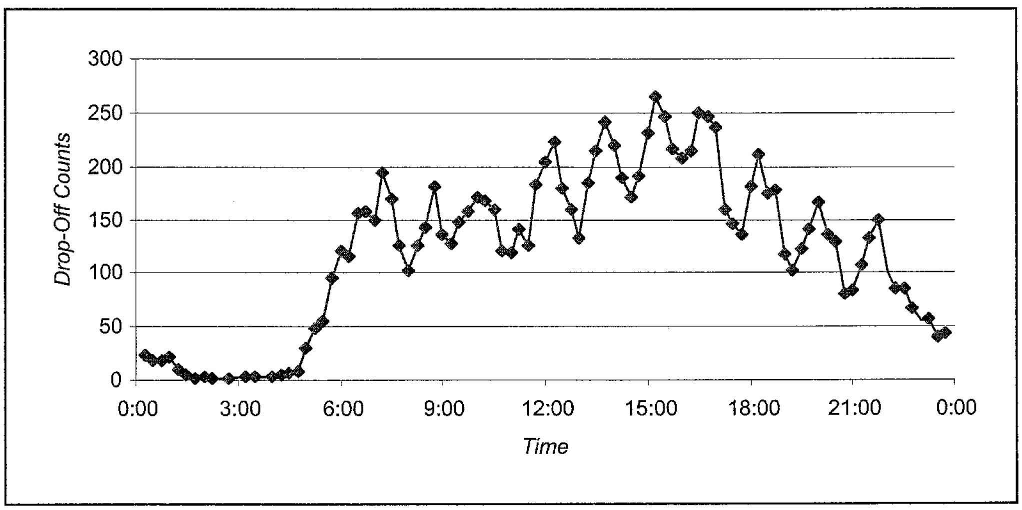

Figure 4 - Hourly variations in drop-offs at DFW International Airport

Step 5: Conduct a Network Assessment of Airport Access Scenarios

In the U.S., rail or light rail access to airports is available at a few airports. Providing alternative ground access options to the airport would relieve congestion on roadways leading to and in front of the terminals. Therefore, it is necessary to test how various elements interact in sharing use of the roadway system and its interfaces with the airport system and available modes. This will allow for diagnosis and identification of the types of problems, their causes, and hence possible short and long-term strategies to alleviate them. To this end, a simulation-based approach to the dynamic assignment problem in an intermodal network with an emphasis on airport access should be used to study airport congestion at the network level.

The simulation tool used in this research is DYNASMART-IP, a state-of-the-art dynamic network analysis and evaluation tool conceived and developed at the University of Texas at Austin. DYNASMART-IP models the evolution of traffic flows in a traffic network, which result from the travel decisions of individual travelers. The model is also capable of representing travel decisions of travelers seeking to fulfill a chain of activities at different locations in a network over a given planning horizon.

Methodological Structure of DYNASMART-IP

The model represents several modal networks through a single integrated multidimensional network. Associated with each link are two state vectors for each time interval, respectively representing the number of vehicles of each class on the link, and the associated cost incurred by each class in traversing that link (when the link is entered during the specified time interval). There is no restriction on the number and types of vehicle classes that may be considered in the model. Typical classes of relevance to the study of intermodal networks include autos, trucks, and various types of transit modes. They may also include high-occupancy vehicles HOVs. The associated cost vector provides the principal mechanism for designating certain links for particular classes. For example, a very high cost for a single occupant auto on a certain link, coupled with the actual travel time for an HOV, could indicate a special HOV facility. Similarly, a transit network may be represented to allow both exclusive (e.g., underground rail) or shared right-of-way (e.g., buses). Transfer penalties at major transfer nodes in the network are explicitly modeled. For each traveler, the waiting time until the arrival of the next vehicle that serves the chosen transit line and the parking cost at the park-and-ride facility are considered when evaluating the different travel options.

The model captures explicitly the dynamic interactions between mode choice and traffic assignment in addition to the resulting evolution of the network conditions. It determines the time-dependent assignment of individual trips to the different mode routes in the network, including the corresponding arc flows and transit vehicles loading.

Model Components

The vehicular traffic flow simulation logic in DYNASMART has been adapted for the research to better represent interactions between transit vehicles and autos. Figure 5 illustrates the framework and components of the model, which are explained next.

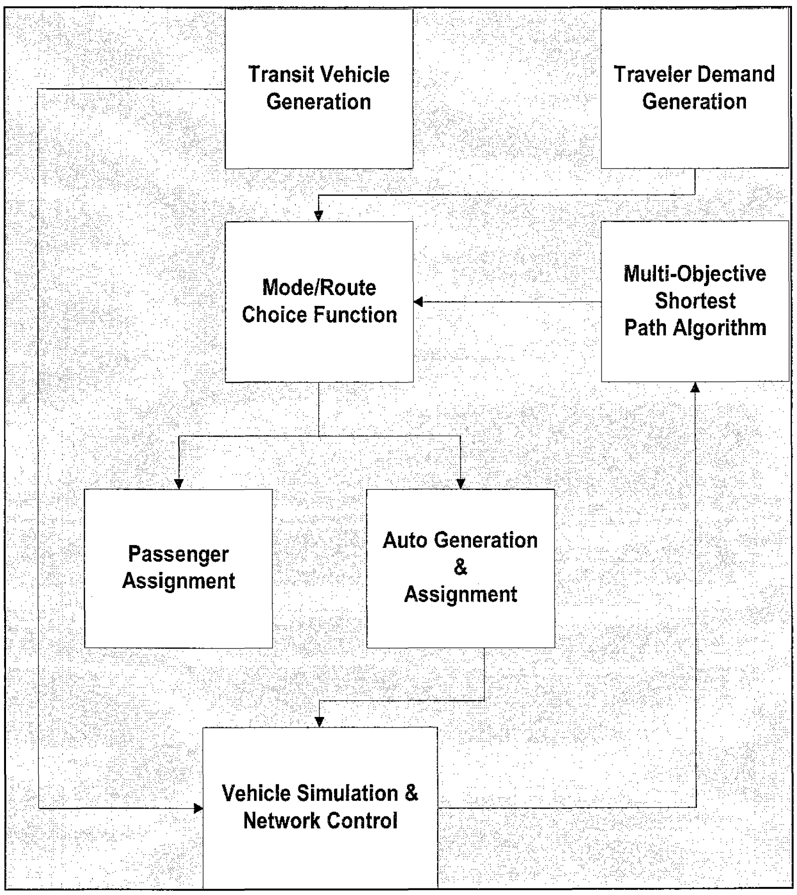

Figure 5 - DYNASMART modeling framework

Trip Generation - As noted, the model can accept as demand input a file listing the population of travelers, their attributes and travel plans (including origins, destinations, time of departure), and mode choice, if known. However, a more likely way of applying the model is to **generate travelers** on the basis of prespecified time-dependent Origin-Destination (OD) zonal demands. Each generated traveler is assigned a set of attributes, which include his or her trip starting time, generation link, final destination, and a distinct identification number. A binary indicator variable is also assigned to each traveler to denote car ownership status. In parallel, **transit vehicles are generated** according to a predetermined timetable and follow predetermined routes. Prevailing travel times on each link are estimated using the vehicle simulation component, which moves vehicles, capturing the interaction between autos and transit vehicles as described later. The model also estimates other measures that may be used by travelers as criteria to evaluate the different mode-route options, including travel distances, parking cost, highway tolls, transit fares, out-of-vehicle time, and number of transfers along the route.

Mode/Route Choice- A mode-route decision module is activated at fixed intervals to provide travelers with a superior set of mode-route options. The activation interval (usually in the range of 3 to 5 minutes) is set such that the variation in network conditions is captured, while retaining desirable computational performance for the procedure. The route-mode decision module consists of a **multiobjective shortest path algorithm** designed for large-scale intermodal transportation networks, which is described separately. This multiobjective shortest path algorithm generates a set of superior paths in terms of the set (or a suitable subset) of attributes listed above. Considering a diverse set of travelers' behavioral rules, as well as different levels of information availability and response, travelers evaluate the different mode-route options and choose a preferred one. These behavior rules and response mechanisms are implemented through a behavior component within the model as described in a subsequent section.

Each option represents an initial plan that a traveler follows (unless he or she receives enroute real-time information of a better plan) to reach his or her final destination. This plan describes the used mode(s) and the route to be followed including any transfer node(s) along this route. Based on the available options, a traveler may choose a *pure* mode or a combination of modes to reach his or her final destination.

Assignment - If a traveler chooses private car for the whole trip or part of it, a car is generated and moved into the network with a starting time equal to its driver's starting time. Each newly generated vehicle is assigned an ID number that is unique to this vehicle. Vehicles are then moved in the network subject to the prevailing traffic conditions until they reach their final destinations or the next transfer node along the prespecified route (in the case of an intermodal trip).

If a traveler chooses a transit mode, he or she is assigned to a transit line so the destination of this passenger is a node along the route followed by the bus line. If no single line is found or if the passenger is not satisfied with the available single line, the passenger is assigned to a path composed of two lines with one transfer node; therefore, the destination of the passenger is a node along the route followed by the second bus. If no two lines are found, the search is continued for three lines with two transfers. It is assumed that no passenger would be willing to incur more than two transfers in his or her trip. Thus, if no path with a maximum of two transfers is available, the trip is determined as infeasible. Given the passenger's origin node, the nearest transit stop along the first line in the passenger's path is determined, and he or she waits until the arrival of the next vehicle that serves that transit line. When a transit vehicle arrives at a certain stop, all passengers waiting for a vehicle serving this specific line board this vehicle (subject to capacity constraints) and head towards either their final destination or the next transfer node along their route.

Vehicle Simulation and Network Control - Upon the arrival of a vehicle (private car or transit vehicle) to a certain destination node, this destination is compared to the final destinations of the travelers on board. If it matches the final destination of a traveler, the current time is recorded for this traveler as his or her arrival time. If the times and/or destinations are different, the traveler transfers to the next transit line in his or her plan. The nearest stop is again determined and the traveler waits for his or her next transit vehicle. The time difference between arrival at the transfer node and boarding of the next line is calculated as the waiting time at the current transfer node for this traveler. This process is continued until all vehicles reach their final respective destinations. If a traveler misses the initially assigned transit vehicle because of late arrival or because the vehicle does not have enough space, the model allows the traveler to replan his or her trip. The available options are regenerated for this traveler, who makes a selection according to the decision process subsequently described.

Other Modes Specific to Airport Access

Off-airport terminals can be tested as a potential long-term solution for alleviating congestion in the test network. Direct rail service can be modeled from the off-airport location to the airport. The high-speed rail is modeled in DYNASMART in a similar manner to an exclusive HOV lane with appropriately specified high-speed transit.

Other Forms of a Network Assessment Model

The DYNASMART model assumes a stochastically diverse set of travelers with different relevant choice criteria and response mechanisms to externally supplied information. The model framework allows implementation of different mode-route choice models that might adequately represent the traveler's behavior. The implemented model could be deterministic or stochastic and could be based on compensatory or non compensatory choice rules. Deterministic models assume availability of perfect information for travelers and that travelers choose the best alternative based on the available information. Stochastic models (e.g., logit form or probit form) on the other hand, take into consideration that information might not be perfect and that travelers may have different perceptions to the supplied information. For the experiments presented in this paper, travelers are assumed to evaluate the different available alternatives either at the start of or along (in case of enroute information availability) their trip based on a deterministic utility function. The multiobjective k-shortest path algorithm with k=3 is used to generate the different attributes for the nondominated paths from every node to every destination. This function combines all the attributes in one generalized cost measure. Travelers evaluate the generalized cost of the different alternatives and choose the one with minimum generalized cost.

SUMMARY

The methodology presented herein provided information about the processes that determine demand and associated service levels for the airport landside access. It is divided into five steps:

1. Develop an Understanding the User Decisions about Mode Choices

2. Identify Classes of Users and Their Attributes
3. Assess Geographic Distribution of Ground Access Trips
4. Determine the Temporal Characteristics of Airport Demand
5. Conduct a Network Assessment of Airport Access Scenarios

Users considered in the analysis of airport-related travel were divided into three principal classes: air passengers, airport employees, and air cargo. Two trip patterns for airport access were discussed: on-airport circulation and off-airport distribution. Moreover, sample variations for airport access by season, day of the week, and hour of the day were presented.

The network simulation-assignment methodology considers different travel modes such as private cars, buses, metro/subway, and HOVs. The model captures the interaction between mode choice and traffic assignment assuming a stochastically diverse set of travelers in terms of their relevant choice criteria.

This methodology serves as the basis for subsequent mode choice model development and network-level scenario development.

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