Toward Improving the Understanding of Traffic Network Effects of Commercial Airports

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ABSTRACT
Modern airports are the economic equivalents of small cities and have substantial impacts on the surrounding transportation network. This paper evaluates existing methodologies for traffic estimation for these unique land uses in the context of travel demand modeling and in particular trip generation analysis. Document review includes the Institute of Transportation Engineers (ITE) Trip Generation Manual and "Special Generator" reports from many municipalities. Case studies from several large hub airports and smaller regional airports are used to develop an understanding of current conditions. Comparisons to predicted values are used to determine the forecasting accuracy. Mode splits at major airports are examined to determine if alternative modes are being promoted effectively. In addition to travelers, airports employ significant numbers of employees and this paper investigates their characteristics regarding mode choice, trip end locations, and time of day travel. The durations spent at the airport are analyzed to determine the proportions of trips that are for pick up or drop off and those that park. Large numbers of trips are generated at airports, and the effects on local streets are evaluated. Conclusions about the existing methodologies and recommendations for future adjustments are made.

BACKGROUND

Airports play vital roles in all major cities economies by providing connections to other places, fostering the sharing of knowledge and skills. With thousands of jobs on site and moving millions of people every year they are constant centers of activity as people arrive and depart. Within the U.S., airports are deeply integrated into cities, often surrounded by businesses or communities. The access roads that connect them with the local transportation network are typically multilane highways clogged with traffic for many hours a day. Transit connections are present either through a rail line or local bus networks. However, the volumes of transit riders and vehicles are underreported and the prediction methodology is limited. This paper seeks to clarify the understanding of airport trip generation and mode shares.

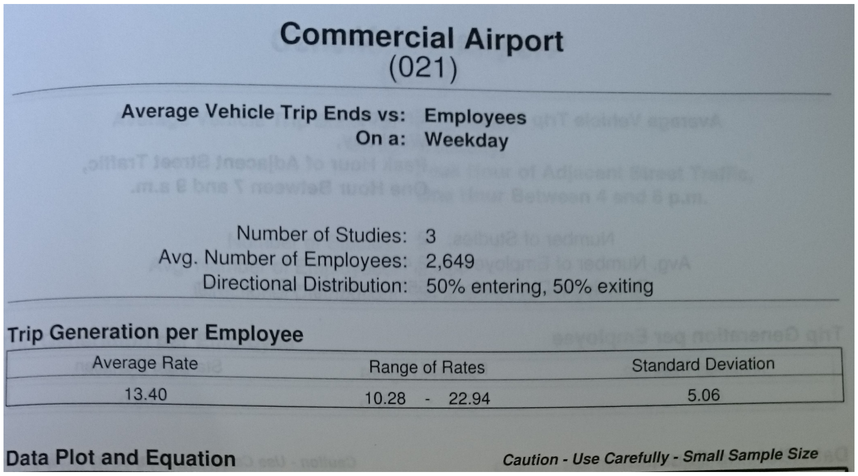
TRAVEL DEMAND MANAGEMENT

Current Practice and Methodology

Airports in the U.S. were mostly established in the 1940s-1950s and have been expanding ever since. Because of their enormous size requirements, particular topography required, and high costs, new airports are not constructed often. Their origins mean they were established without travel demand modeling, such as the four-step model. The lack of new airport construction provides little incentive for studies to determine trip volumes and generation rates. Most municipalities and airport operators deal with traffic by adding physical capacity expansion incrementally. When new terminals or gates are added at airports the supplementary action usually involves widening of access roads or lengthening of curb fronts (1). Access roads are often lengthened through loops to prevent traffic build up from spilling onto local streets. These expansions have resulted in many airports having convoluted and confusing ground access systems.

The methodology for airport trip generation is limited in both volume and supporting evidence. The Institute of Transportation Engineers Trip Generation Manual is a primary source for trip generation values. The manual considers the number of employees, average number of flights, and number of commercial flights as possible independent variables tied to the final trip generation (2). A representative example of the trip generation rates from Trip Generation Manual is shown in Figure 1.

The ITE Trip Generation Manual provides an average rate for vehicle trips but does not offer a fitted curve equation. There are only three studies recorded and this is inadequate to find a fitted curve for commercial airport trip generation or produce accurate results. Some independent variables in the ITE Trip Generation Manual only have two studies, further reducing accuracy. In addition, the studies underpinning the rates are from the 1970s at San Francisco International Airport or 1983 at an unspecified Southern California airport. This data is outdated and does not consider forces of deregulation increasing air passengers or the increase in transit connectivity present at modern airports.


Commercial Airport
(021)

Average Vehicle Trip Ends vs: Employees
On a: Weekday

Number of Studies: 3
Avg. Number of Employees: 2,649
Directional Distribution: 50% entering, 50% exiting

Trip Generation per Employee

Average Rate	Range of Rates	Standard Deviation
13.40	10.28 - 22.94	5.06

Data Plot and Equation — Caution - Use Carefully - Small Sample Size

FIGURE 1 Example of Trip Generation Manual rates.

Some agencies provide their own estimates of aviation trip generation. Those with their own rates consider either the number of employees, daily flights, or annual operations as the independent variable. The annual operations refer to the number of take-offs and landings occurring at each airport. The agencies with their own estimates and the formula are listed in Table 1.

TABLE 1 Agency Trip Generation Formulas

Agency	Formula
Michigan State (3)	(104.73 * Annual Operations) / 365
Florida Department of Transportation (3)	24 * Employees
National Association of City Transportation Officials (4)	11.8 * Employees
San Diego (5)	100 * Commercial Flights

A survey of 23 large Metropolitan Planning Organizations (MPOs) showed that approximately 65% used a special generator formula to determine the number of air passenger trips. The remainder treated air passenger trips as either home based non-work trips or non-home based non-work trips. Of the same MPOs, only six treated employees with a special sub generator model. The remainder treated employee trips as journey to work trips or did not model the trips. However most of these models treat the airport as a single TAZ and do not take into account the unique characteristics of airports. This simplifies the process but causes inaccuracy when modeling, particularly for airport employees, who are often are parked offsite or working in various facilities around the airfield. Different access roads could be required to reach each zone causing the model to misrepresent trips. Furthermore airport employees are often parked off site and brought in by shuttle meaning their vehicle trips affect a different zone than their employment suggests (6). Airport employees have shift times different than typical workers causing high traffic at different times than the model would suggest.

Data and Test Results

To test the validity of trip generation estimates, reported vehicle trips volumes and factors were tested against various models. The paper included the number of employees, number of operations, and actual vehicle counts were provided for twenty airports ranging in size between 1.5 and 40 million annual passengers (7). The airports were a diverse mix from across the nation including strong origin-destination airports, such as Las Vegas, regional hubs, such as Seattle, international gateways, such as Miami, and a range of others. Each airports independent variable data was used with all of the trip generation formulas to generate expected vehicle trip values. For the ITE Trip Generation Manual two formulas were evaluated using both employee numbers and average flights per day. The results are shown in Figure 2.

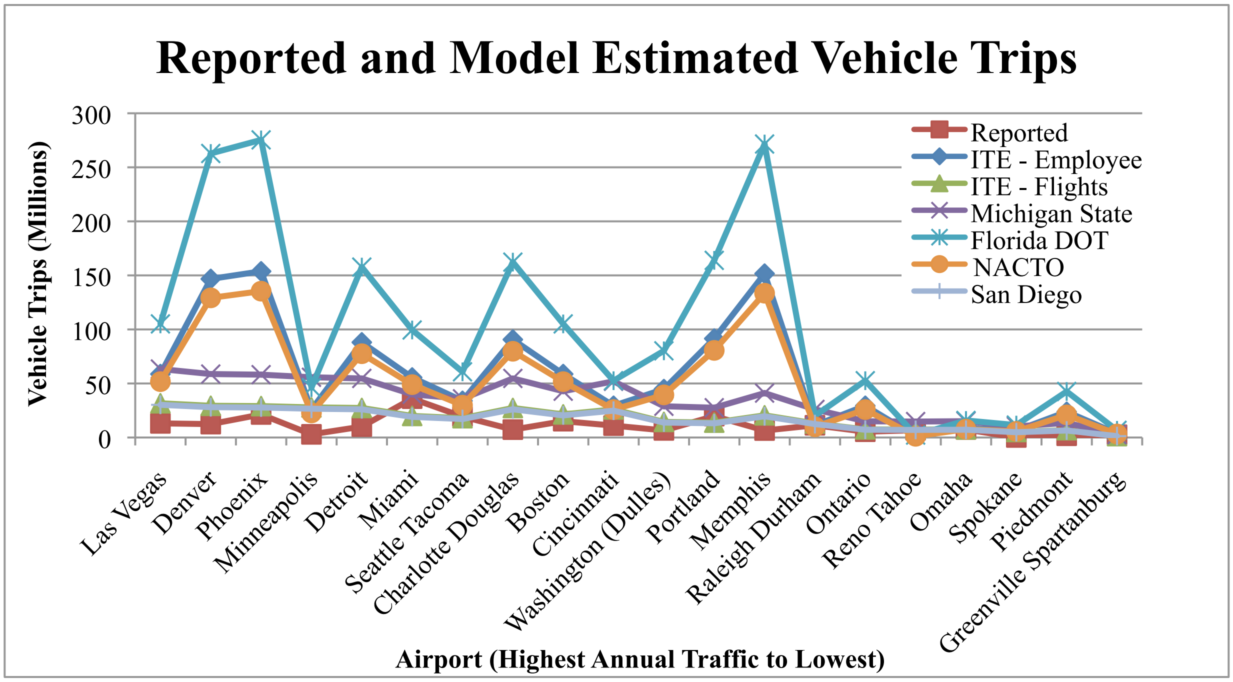


FIGURE 2 Reported and Estimated Vehicle Trips

The estimates produced by the models varied widely and overestimated the vehicle trips by large margins. For some airports and models the error could be more than 200 million vehicle trips for an airport reporting less than 25 million recorded annual trips. To understand the accuracy the two visually closest models, ITE Trip Generation Manual using flights and San Diego were plotted against the reported vehicle volumes in Figure 3. Without the values produced by some models the disparities between the reported values and closest models are more pronounced. The smallest difference between a model and the reported values is 1% but the large majority of the data points have a 20% difference or more.

The key distinction about the results is that the two closest models utilized flight information as the independent variable while the most inaccurate models used employee numbers. A closer analysis of the data shows that the reported employee numbers varied significantly even between airports of similar sizes. This may stems from differences in counting employees. Some airports will count all those that work on site and others will only count those who are directly employed by the operating agency. In addition the number of employees may not directly correspond to the number of flights. For example, the airport in Memphis is the main cargo airport of Federal Express and has large numbers of employees to handle the cargo, but relatively few flights. This misleads the employee-based models, which count the cargo employees who are not contributing to serving passengers.

NOTABLE CHARACTERISTICS OF AIRPORTS

Mode Split

Within the United States airports are generally served primarily by roadway access but are increasingly connected into transit networks. This is providing transit with a higher portion of the mode share in recent years. An ACRP report with data from 2005 showed the 27 airports with the highest transit utilization (6). The graph can be seen in Figure 4.

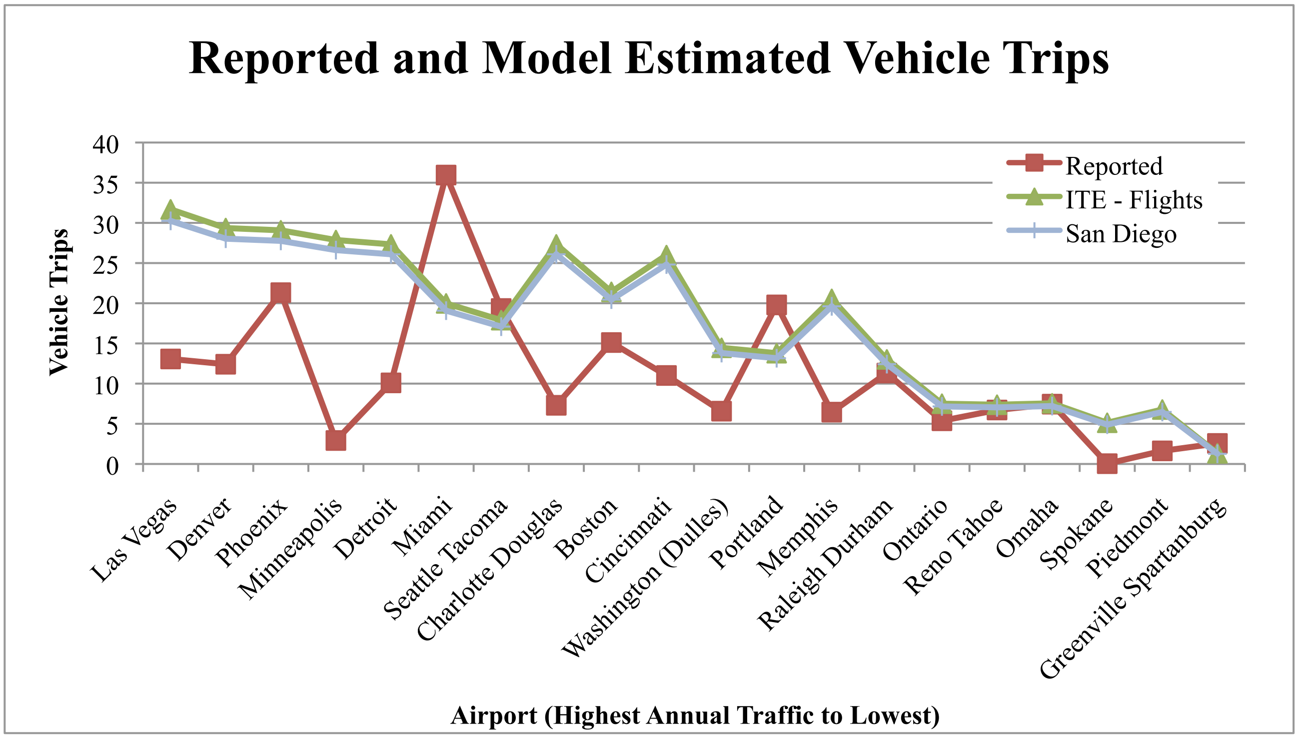


FIGURE 3 Reported and Estimated Vehicle Trips for Selected Models

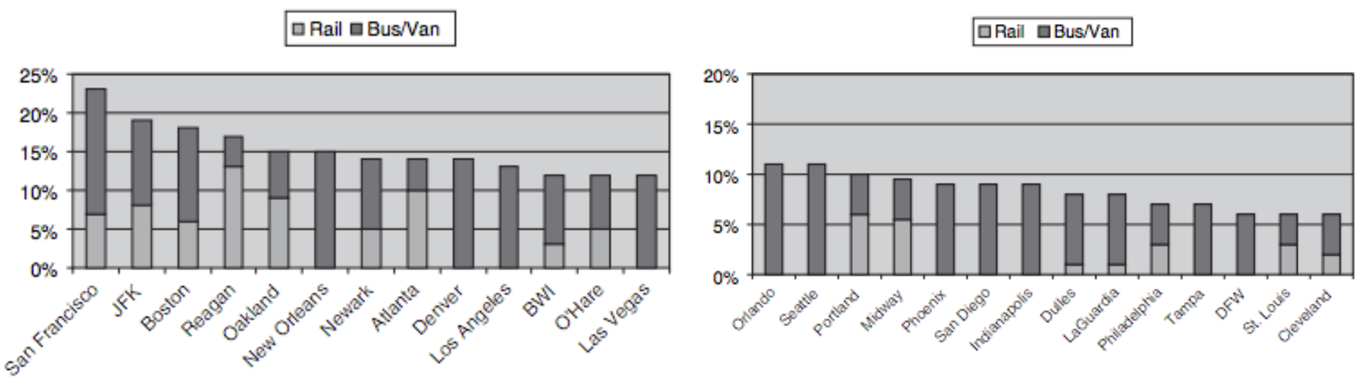


FIGURE 4 Transit Ridership at Major Airports (8)

A mode split case study is Seattle-Tacoma International Airport as it has vehicle access, multiple bus routes, and a recently completed light rail line. Two separate transit agencies provide five different bus routes that stop at SeaTac Airport. Sound Transit provides two regional buses and the light rail line. King County Metro has two standard bus routes, 156 and 180, and one Rapid Ride bus, the A Line, serving SeaTac Airport. The light rail was completed in 2009 and runs directly to the downtown core of Seattle, in the middle of hotels, high-rise housing, shopping, and a convention center.

Finding the mode split for passengers at SeaTac Airport ridership numbers for all of the transit services. Using Sound Transit's 2015 Service Improvement Plan ridership numbers and King County Metro's provided monthly data, daily transit ridership volumes were determined (9) (10). Vehicle volumes were estimated airport growth rates and previous volumes. Passenger vehicles, shuttles, or taxis account for a significant majority of the trips made with an 80% overall trip share. The light rail accounted for another 10% of trips making it equal to all of the bus services provided. Compared to the transit share indicated in 2005, before the light rail, the percentage of transit users has roughly doubled. The light rail serves as a direct, fast connection to a densely packed and extremely popular portion of the city and brought in large numbers of new riders when completed. In the United States many airports make significant money from parking fees at the airport and try to encourage travelers to park at the airport and pay. This creates a disincentive for them to encourage transit use and slows the integration of high capacity transit service.

Employee Characteristics
Airport employees are different from typical workers and these characteristics have effects on the surrounding transportation network. As mentioned they work non-traditional shifts due to the 24 hours nature of airports. Large numbers of employees arrive very early in the morning and again around the mid afternoon. They also often park off site in dedicated airport employee parking lots or in local neighborhoods creating traffic on side streets (11). Employees comprise a high proportion of transit riders to the airports, particularly on bus lines serving more outlying communities. Employers may offer discounted or free transit passes inducing demand on the bus routes. Transit agencies reference the large numbers of employee ridership in documentation for the continued serving of the airport by bus routes (9).

Despite travelling to different locations around the airport than air travelers, employees can have larger impacts on the transportation network. At strong origin-destination airports, where most travelers do not connect to other flights, the ratio of average employees to daily passengers originating in that city is around 0.5 employees per passenger. Cities of this nature tend to be resort or vacation destinations such as Tampa or Las Vegas. Large hubs, where many passengers travel through but few originate, have different ratios that range from 0.9 to 1.55 employees per daily originating passengers (3). Examples include San Francisco International or Dallas/Fort Worth International. At hub airports large volumes of passengers are handled, requiring large numbers of employees, but relatively few are using the ground access system. Employees contribute a larger share of the trips, in some cases outnumbering the passenger trips. This effect can exacerbate the other unusual travel times and locations effects from employees.

Trip Duration and Frequency
Air passenger trips to airports tend to be highly divergent in the length of time spent at the airport. The most common air passenger access modes are either drop off and pick up or parking at the airport garages. Those parking are typically in the parking garage for multiple days creating flows one directional flows on common business travel days such as Monday and Friday. However, pick up and drop off trips have a short few minute duration between arriving and departing. This type of trip also creates two vehicle trips for every drop off. Older studies showed that 1.29 vehicles trips were created for every passenger using the pick up and drop off method, due to higher occupancies (8). This creates problems for airports and surrounding networks if the AM or PM peak is primarily composed of pick up and drop off air travelers. Estimates of this traffic indicate that 30% of air travelers get to the airport using this method (12). With the rise of car-sharing applications the issue may worsen as more travelers elect to use it. At many airports car-sharing drivers are allowed to drop off passengers but not pick them up. This creates two trips for every drop off similar to the existing pick up and drop off scenario. If permitted to pick up, many drivers circle through the airport access roads creating congestion.

CONCLUSIONS AND RECOMMENDATIONS
Trip generation models are under developed for airports and their ground access systems. Current methods rely on limited older studies while the industry has changed and developed. Many models rely on the number of employees at the airport but drastically overestimate the number of trips. Better models rely on the number of flights; however, these still usually have an error of 20% or more. Verifying proper numbers for both flights and number of airport employees is important to increase accuracy. Proper use of the trip generation models is not widespread in MPOs due to the unusual characteristics of airports and their employees.

Transit access to airports is currently underutilized as a mode of access with the best connected airports having only 20% of trips through buses or rail. Access through transit is increasing rapidly with new projects such as Seattle's Link Light Rail. Buses often serve more employees than air passengers justifying the continuation of bus routes, especially at unusual hours such as the early morning. At some hub airports trips made by employees can outnumber those of passengers and models should take into account the shift times and trip end locations, such as employee parking. Pick up and drop off trips by autos are especially hard on the surrounding road network due to the effective doubling of vehicles as each access creates a trip one direction and then immediately back. Car sharing and the legal restrictions surrounding it could exacerbate the problems.

For the most accuracy models with flight numbers should be used, or employee based models should verify that all employees working on the airport grounds are included. New models could be calibrated to relate to the numbers of airline employees specifically to ensure concessions or cargo operations do not affect the model accuracy regarding air travelers. Transit should be more deeply integrated into airports through buses for employees and high capacity routes to tourist or business destinations.

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