Final Report to

FHWA

For

Traffic Analysis Framework Part IIA --

Establishing Multimodal Interregional Passenger Travel Origin Destination Data

Program Support for Highway Policy Analysis

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Section 1

Need for Long Distance Trip Tables

In 1995, the date of the last long distance passenger travel survey by the Federal government, U.S. households made over 1 billion personal trips to destinations within the United States and an additional 41 million trips to other countries, logging a total of 827 billion miles of travel, or about 25% of all person miles of travel in the nation[1]. This included a great deal of business and tourist travel, both major contributors to the national economy, as well as trips to visit family and friends and to engage in a variety of personal business activities. The costs and benefits of such long distance travel, when aggregated over the nation's traveling population, runs into many billions of dollars each year. Therefore, there is an economic and social imperative to support high levels of personal mobility for long distance travel nation-wide.

Trips made by U.S. residents on a daily basis for work, shopping, or recreation are fairly well understood and have been modeled for many years. On the other hand, non-freight long distance trips, which are made occasionally and for very different reasons, have not been the subject of much study until recently. While long-distance trips represent only a small portion of total daily trips in urban areas where most of the highway congestion occurs, they often carry a high economic value and by definition account for a disproportionate share of total regional VMT. However, with the passage of Intermodal Surface Transportation Efficiency Act (ISTEA) and its successors, and as multi-state and multi-regional transportation flows have assumed greater importance in planning and programming, the need for understanding and modeling long distance travel has become more acute.

While there have been a multitude of household surveys to describe, understand, and model everyday short distance trips, surveys describing long distance trips are very limited. This is due to the longer time frame needed to interview households and the vastly larger geographic reach that such surveys must encompass, as opposed to surveys used to support the development of MPO models.

Due to the nature of the available data and to maintain compatibility with air and rail data obtained directly from FHWA, the definition of an auto and bus trip is defined in two ways. First, and for the discussion of travel estimation in 2008 and 2040, we define a trip as a single round-trip, from an origin to a primary destination and back. These trips are unlinked trips and intermediate stops are not included in this discussion. Second, the trip tables that this study has produced are slightly different. They represent one-way trips, meaning that the trip to a primary destination represents one trip and the return trip represents a separate trip.

The rest of this report is organized as follows. Section 2 discusses the data sources used in the development of the trip tables. Sections 3 and 4 present the base and future year methodology. Section 5 discusses the conversion of auto person trips to vehicle trips and section 6 discusses the geography for data release. The report concludes with caveats for data usage and recommendations for future work.

[1] http://www.bts.gov/publications/1995_american_travel_survey/us_profile/entire.pdf

Section 2

Data Sources

2.1 Introduction

One of the key requirements to build the trip tables included the need to have a readily available data set to cover the entire nation for 2008. For long-distance bus trips and auto trips, necessitated blending contemporary data sources with older more complete sources. The most comprehensive publically available source of long-distance multimodal travel data is the 1995 American Travel Survey (ATS). The National Household Travel Survey (NHTS) provide more limited, but useful information for long-distance travel as well. These sources are still important for informing long-distance bus and auto estimates. For air and rail travel, more up to date and complete data are available. Air and rail long-distance passenger tables for 2008 were developed directly using data from the Federal Aviation Administration (FAA) and Amtrak. Other data sources, each with their advantages and disadvantages, were considered to build the auto and bus trip tables as will be explained later in this section.

Table 2-1 shows the long distance trips (100 miles or more) from the 1995 ATS and the 2001 and 2009 NHTS.

Table 2-1 Long Distance Trips from National Surveys

	CAR	AIR	BUS	RAIL	OTHER	TOTAL
	Expanded Trips (>100 MI) by Main Travel Mode					
1995 ATS	**1,627,716,000**	**322,330,000**	**40,890,000**	**9,988,000**	**1,714,000**	**2,002,638,000**
Modal Share	81.3%	16.1%	2.0%	0.5%	0.1%	100%
2001 NHTS	**2,336,093,693**	**193,289,524**	**55,443,050**	**21,144,317**	**11,155,783**	**2,617,126,367**
Modal Share	89.3%	7.4%	2.1%	0.8%	0.4%	100%
2008 NHTS	**3,205,130,326**	**201,646,048**	**43,234,705**	**16,886,134**	**41,565,117**	**3,508,462,329**
Modal Share	91.4%	5.7%	1.2%	0.5%	1.2%	100%
	Number of Sampled Trips (>100 MI) by Main Travel Mode					
1995 ATS	**449,009**	**83,336**	**10,238**	**2,477**	**916**	**545,974**
Modal Share	82.2%	15.3%	1.9%	0.5%	0.2%	100%
2001 NHTS	**40,333**	**3,347**	**933**	**392**	**160**	**45,165**
Modal Share	89.3%	7.4%	2.1%	0.9%	0.4%	100%
2008 NHTS	**9,847**	**661**	**183**	**28**	**143**	**10,862**
Modal Share	90.7%	6.1%	1.7%	0.3%	1.3%	100%

Source: 1995 ATS, 2001 NHTS, and 2009 NHTS

2.2 Auto and Bus Travel Estimates, 1995 American Travel Survey

For developing the 2008 long-distance auto passenger estimates, the 1995 ATS served as the primary data source for this study. For bus travel, the ATS was one of three data sources used in the travel estimations. The 1995 ATS collected information on the origin, destination, volume, and socio-economic characteristics of long-distance travelers in the United States. The survey was conducted for the Bureau of Transportation Statistics by the U.S. Bureau of the Census as a component of the Census of Transportation.

Approximately 80,000 households nationwide were randomly selected to participate in the survey. In most cases, one adult household member provided information for all household members. The survey consisted of four detailed interviews conducted approximately every three months from April 1995 to March 1996. These interviews were conducted primarily by telephone, with in-person interviews for some respondents who could not be reached by telephone.

The 1995 survey achieved an 85 percent response rate from those households that were eligible for interview.

The survey gathered demographic characteristics of all household members regardless of age and information about their trips of 100 miles or more, and back, taken during 1995. Trip characteristics included such items as the origin and destination of the trip, stops along the way and side trips from the destination, the principal means of transportation, the access and egress modes to airports, train and bus stations, and information about the travel party. Some basic travel and tourism information was also collected including the reason for the trip, number of nights spent away from home, and the type of lodging. Route distances of all trips were calculated by Oak Ridge National Laboratory.

Table 2-1 shows the distribution of person trips by mode. As shown in Table 2-1, three out of four long distance trips are made by personal automobile (car, pickup truck, or van). Commercial flights were the second most frequently used mode, accounting for 16.8 percent of the modal share.

The average one way trip distance covered by automobile (car, pickup truck, or van) is 279.7 miles and **Table 2-2** shows the summary of one way trip distance by automobile. **Figure 2-1** shows the distribution of trips graphically. As shown in Figure 2-1, 75 percent or more of trips are less than 300 miles.

Table 2-2 1995 ATS Weighted Person Trip Distance Summary

	One Way Distance (miles)
Minimum	0
1st Quartile	128.0
Median	179.0
Mean	277.8
3rd Quartile	288.0
Maximum	5,895.0

Source: 1995 ATS

Table 2-3 shows the distribution of automobile trips among the top 10 MSAs from the 1995 ATS data. As can be seen from the table, most of the trips take place between MSAs that are near each other; this is confirmed by the distribution shown in Table 2-3. The top 10 MSAs are located either along the eastern seaboard or in California and this is also not unexpected given the large populations in these areas. The top 10 MSA pairs account for ten percent of all long distance automobile trips. **Figure 2-2** shows the distribution of distances for the top 10 MSA pairs.

According to the 1995 ATS, travel by charter and schedule service bus travel accounted for roughly (2.1 %) of long-distance passenger travel in the United States, based on a sample size of over 10,000 recorded trip records. The team considered a variety of additional data sources and approaches for estimating long-distance bus travel.

Figure 2-1 1995 ATS Weighted Person Trip Distance Distribution

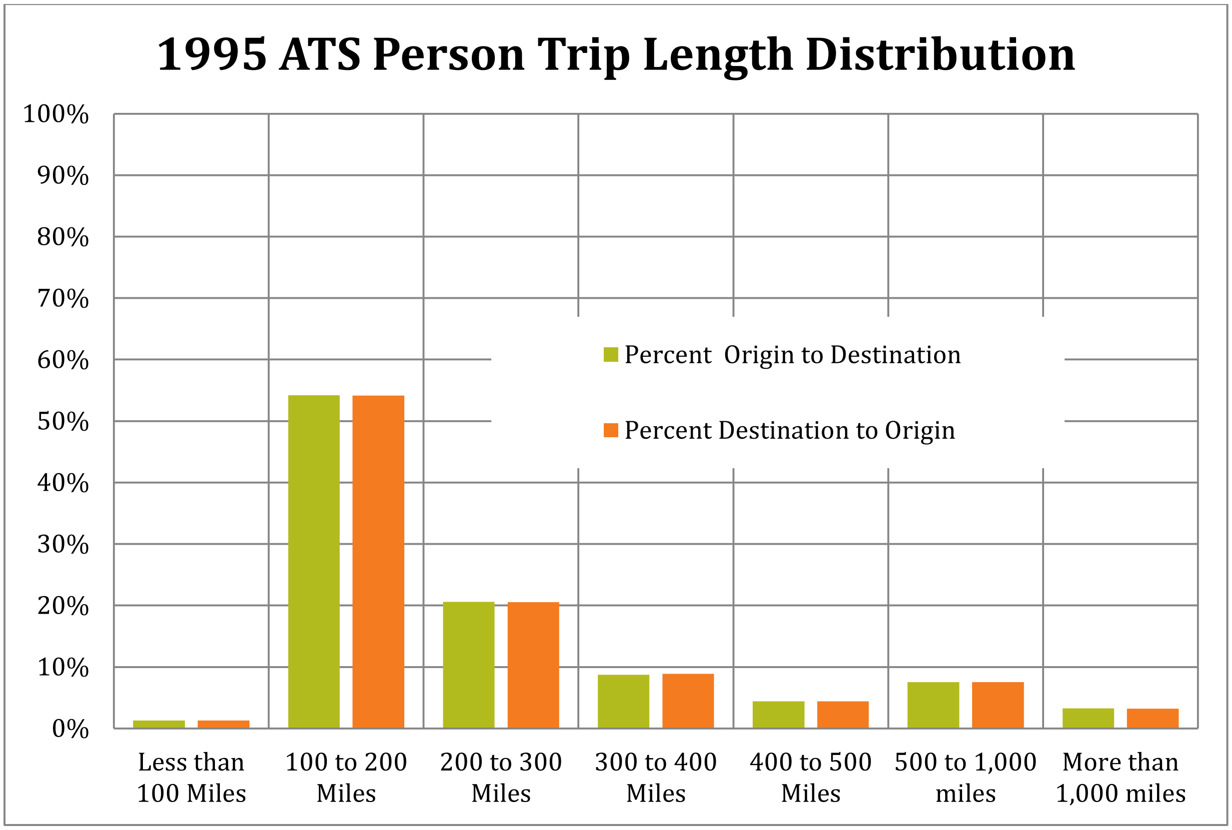
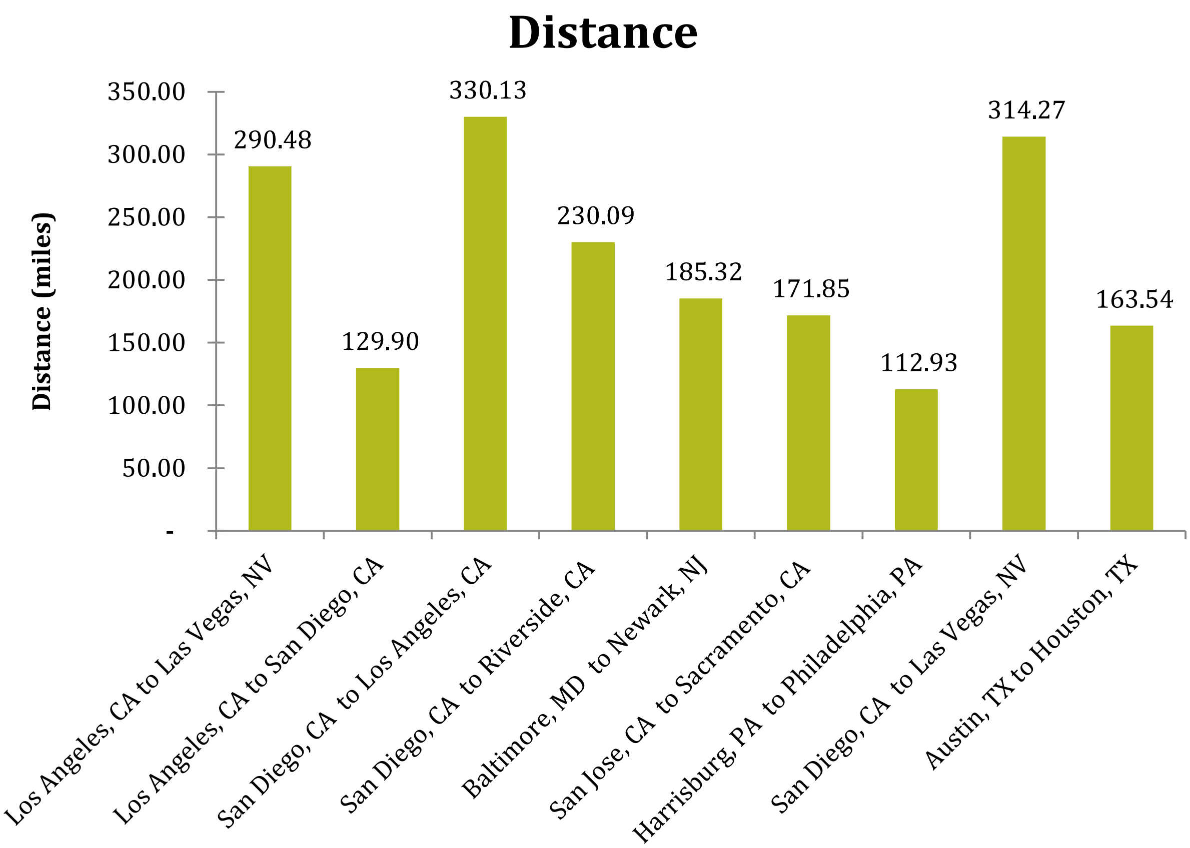


Table 2-3 Top MSA Pairs from 1995 ATS Data

MSAOD	Origin MSA	Destination MSA	Frequency	Percent	Cumulative Percent
4480_4120	Los Angeles-Long Beach, CA PMSA	Las Vegas, NV MSA	4,265,379	1.7%	1.7%
4480_7320	Los Angeles-Long Beach, CA PMSA	San Diego, CA MSA	3,681,424	1.5%	3.2%
7320_4480	San Diego, CA MSA	Los Angeles-Long Beach, CA PMSA	3,051,580	1.2%	4.5%
7320_6780	San Diego, CA MSA	Riverside-San Bernardino, CA PMSA	2,103,736	0.9%	5.4%
720_5640	Baltimore, MD PMSA	Newark, NJ PMSA	1,915,894	0.8%	6.9%
7400_6920	San Jose, CA PMSA	Sacramento, CA PMSA	1,837,798	0.8%	7.7%
3240_6160	Harrisburg-Carlisle, PA MSA	Philadelphia, Pa-NJ PMSA	1,691,491	0.7%	8.4%
7320_4120	San Diego, CA MSA	Las Vegas, NV MSA	1,657,553	0.7%	9.0%
640_3360	Austin-San Marcos, TX MSA	Houston, TX PMSA	1,400,878	0.6%	9.6%

Figure 2-2 Distribution of One way Automobile Distances for the Top Ten MSA Pairs (1995 ATS)



2.2.1 Comparisons to the 2001 NHTS

The 2001 NHTS was the last major survey across the country dedicated to understanding long-distance passenger travel patterns. Given that the 1995 ATS data is being used as an important source of data for the 2008 auto and bus travel estimates, it is important to understand the trends in the travel patterns from some of the more recent data available. Therefore, the team compared the 2001 NHTS results to the 1995 survey to ensure that the travel patterns were consistent. **Figures 2-3**, **2-4**, and **2-5** show comparisons between the 1995 ATS and 2001 NHTS data in terms of modal choices, trip length distribution, and trip purposes.

Figure 2-3 shows that in both the ATS and the NHTS, most (at least four out of five) long distance trips took place by personal vehicle. The ATS shows a large share of bus trips and this has dropped quite a bit in 2001, whereas air travel has a larger share in 2001 compared to 1995. The NHTS shows a higher auto mode share, in part due to its definition of a long-distance trip as travel greater than 50 miles in length, a large proportion of which is captured by auto.

Figure 2-4 shows the trip length distributions from 100 miles and above between the NHTS and ATS data. The 2001 NHTS considered any trip above 50 miles as a long distance trip whereas the 1995 ATS considered any trip above 100 miles as a long distance trip. In order to be consistent and make meaningful comparisons, the trip length distribution was recalculated after dropping the less than 100 miles categories from the NHTS and ATS. As can be seen in the figure, the distributions between the two surveys are quite consistent with the NHTS showing a slightly larger distribution of trips within 200 miles.

Figure 2-5 shows the comparisons between the 1995 ATS and the 2001 NHTS across trip purposes. Again, in order to compare it in a meaningful manner, the 12 purposes in the 1995 ATS were reclassified into the four NHTS purposes as follows:

- Business – Business
- Combined Business/Pleasure – Business
- Convention, Conference, Or Seminar – Business
- School-Related Activity – Personal Business
- Visit Relatives or Friends – Pleasure
- Rest Or Relaxation – Pleasure
- Sightseeing, Or To Visit A Historic Or Scenic Attraction – Pleasure
- Outdoor Recreation (Sports, Hunting, Fishing, Boating, Camping, Etc.) – Pleasure

Figure 2-3 ATS and NHTS Mode Distribution

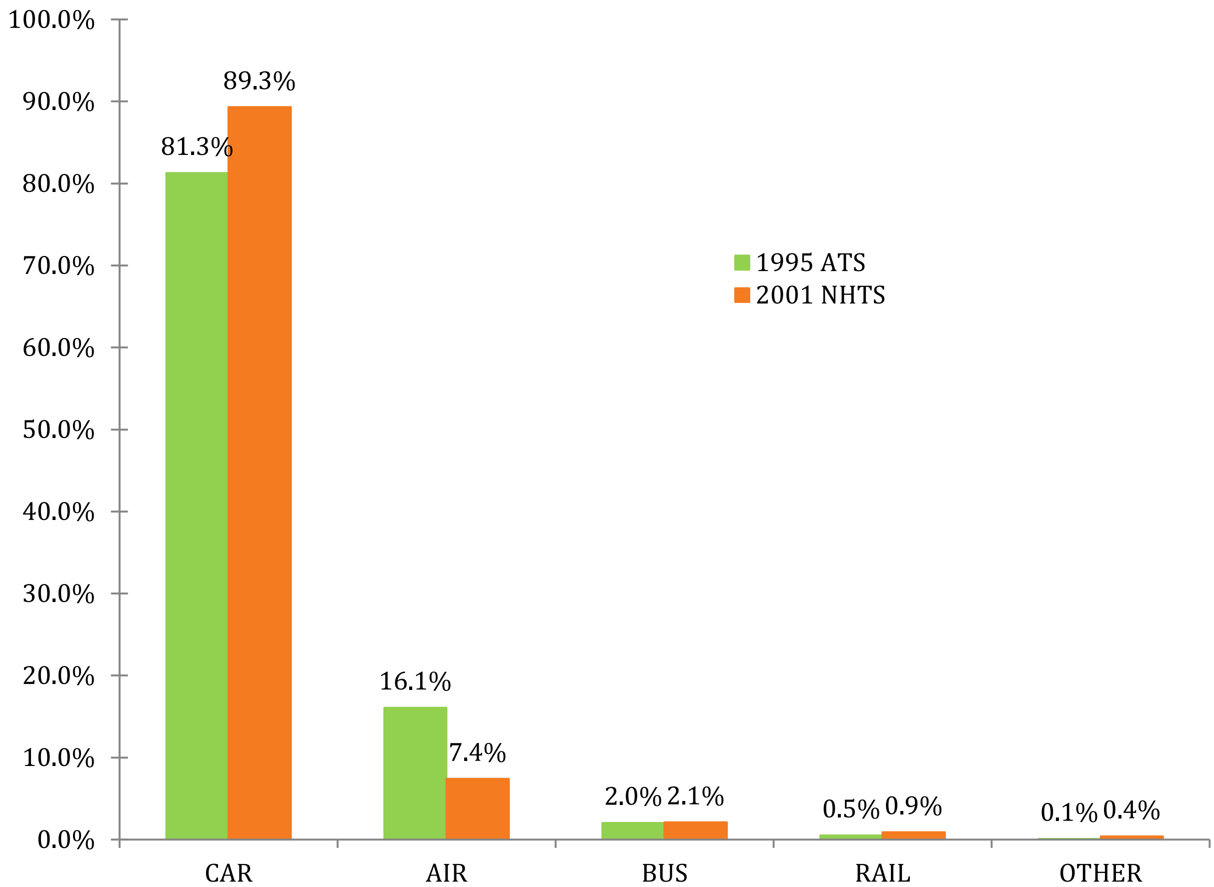


Figure 2-4 1995 ATS and 2001 NHTS Trip Length Distribution

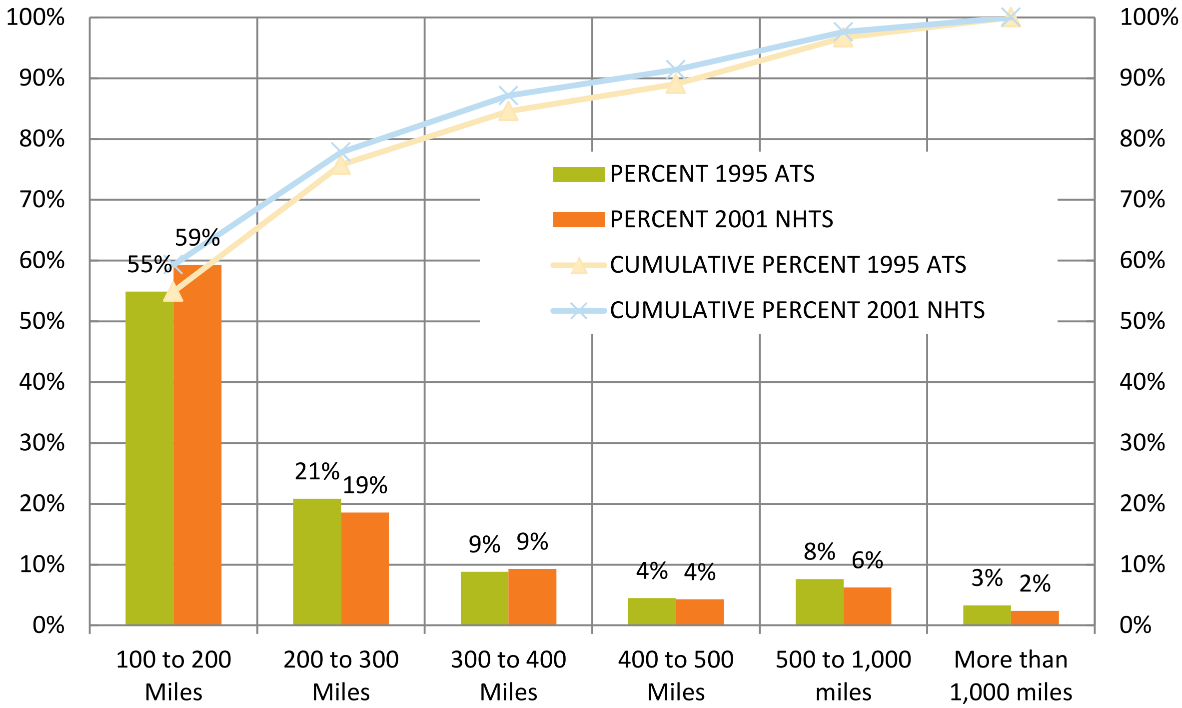
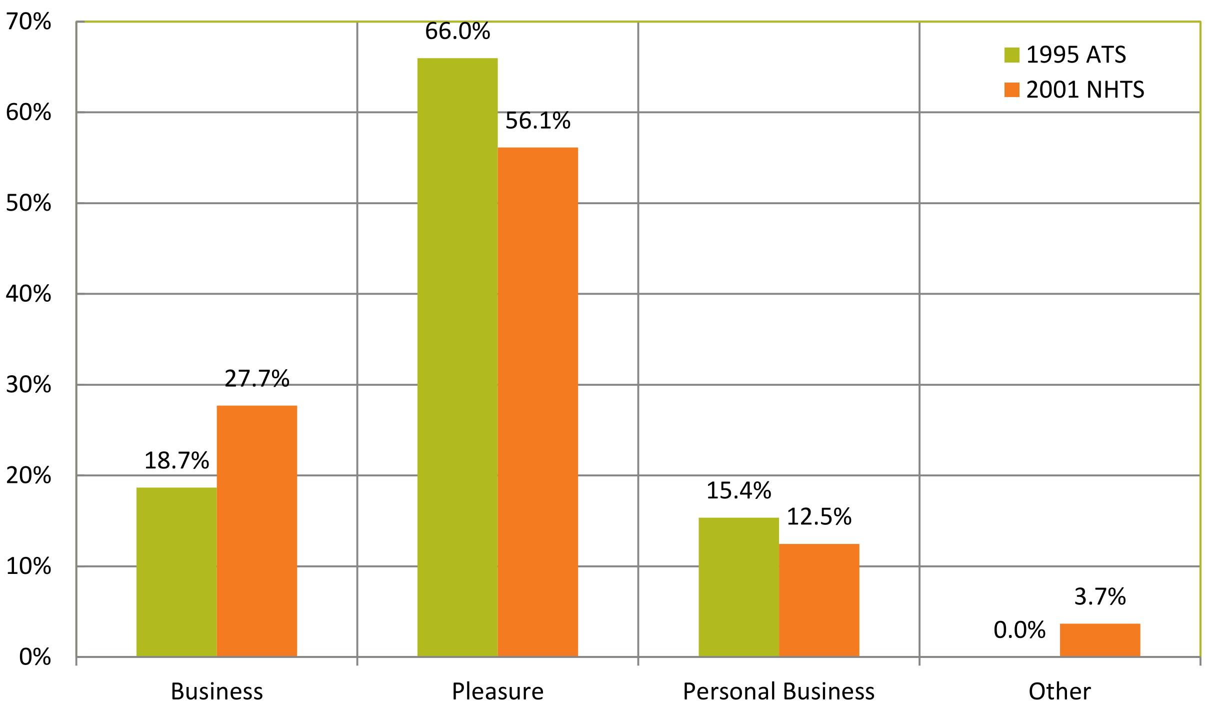


Figure 2-5 1995 ATS and 2001 NHTS Trip Purpose Comparison



- Entertainment (Attend The Theater Or Sports Event, Etc.) – Pleasure
- Shopping – Pleasure

- Personal, Family, Or Medical (Wedding, Funeral, Health Treatment, Etc.) – Personal Business
- Other Reason – Other

There are similar trends between the ATS and NHTS in terms of trip purpose distribution. As can be seen from Figure 2-5, most of the trips by auto are for reasons of pleasure. This is not surprising given that most business travel beyond 250 to 300 miles is accomplished by air and auto trips are typically less than 300 miles as shown in Figure 2-4.

These comparisons of the ATS and NHTS data show that in terms of trip purposes and trip length distributions, there is consistency in travel patterns and this offers a measure of reassurance when using the 1995 ATS data to estimate 2008 travel.

2.2.2 Other Data Sources, Auto and Bus

The other data sources that were considered for the development of the auto and bus tables were:

- **DK Schifflet Panel Survey.** DK Schifflet maintains a database of about 40,000 households which it uses to track long-distance travel patterns for business and leisure travel. While this information is used primarily by the hospitality industry for marketing purposes, it has a potential subsidiary value as a source of long-distance travel pattern data. The project team was able to review and assess data at the level of the census division from this source.

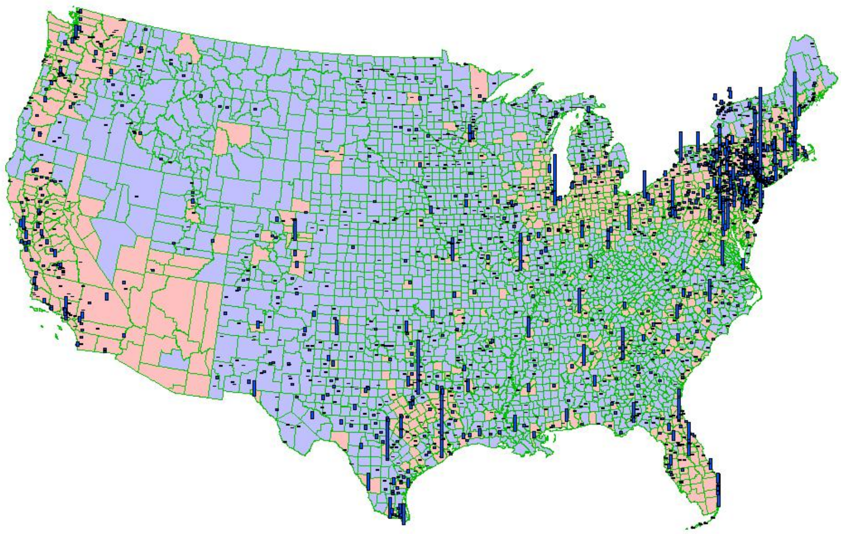
- **2001 National Household Travel Survey.** The 2001 National Household Travel Survey captured about 40,300 auto and 940 bus trip records as long-distance trips, less than 1/10th the number captured by the 1995 American Travel Survey.

- **2008 American Bus Association (ABA) Motorcoach Survey.** The American Bus Association survey provides information about total demand, supply and bus operator characteristics for a large majority of charter and scheduled service bus providers in the United States. While the survey does not provide information about long-distance origin/destination travel patterns, it does provide information about ridership characteristics that helped to assess the stability of the socio-economic information relative to trip-making derived from the American Travel Survey.

- **2010 and 2011 ABA Member Origin Destination Surveys.** In 2010 and 2011, the American Bus Association polled its members about their annual ridership by service type and city pairs. Roughly ten percent of respondents completed the survey and this, together with the Motorcoach survey, provided important information that enabled the team to estimates the total number of bus travelers and the distribution of travel by service.

- **Russell's National Motor Coach Guide.** Russell's Motor Coach Guide offers a paper catalogue that assembles the bus schedules produced by many of the nation's major intercity bus operators in a single resource. To assess the utility of the data, the intercity schedules were extracted from the guide and matched to mapping coordinates. The vertical bars in **Figure 2-6** below correspond to the number of times a city or town appears in a bus schedule, as a proxy of service supply. Information such as this can be used to build forecasts of bus demand that incorporate supply characteristics.

Figure 2-6 Estimated Frequency of Intercity Bus Service, 2008



Source: Russell's Motor Coach Guide, 2008 and CDM Smith

- **Curbside and Chinatown Bus Service data.** In 2008, curbside bus services, which provide direct services between major cities, were beginning to capture a significant share of the bus travel market, but the services were limited compared to the expansion that the industry has seen between then and 2015. Descriptions of the curbside services have been published in various research reports, and provide an indication of the demand for travel at the level of cities and city pairs.

- **Statewide Household Travel Survey**. The California and Ohio statewide travel survey contain useful information about long-distance auto trips that were used to help validate the 2008 auto person trip estimates. However, both surveys contain negligible numbers of bus trips and were not useful sources of information for estimating bus travel and not considered for auto either due to the restricted nature of their geographies.

- **2011 Federal Motor Carrier Safety Administration (FMCSA)**. FMCSA maintains a database of companies that offer charter and regularly-scheduled bus service. The company information includes number of vehicles and headquarters location. Mileage and other information about long-distance origin/destination travel are not available from the database.

- **National Park Visitor Data**. The National Park Service, visitors and conventions bureaus and other public and private organizations collect survey information that tracks the number of visitors for a particular attraction or region, as well as their mode of arrival and place of origin. **Table 2-4** shows the visitors arriving by bus and auto based on surveys in following parks:

  - Yosemite, Grand Canyon, Shenandoah, Colonial National Historical Park (NHP) (provided mode and resident state information)

  - Smoky Mountain, Boston NHP, Congaree (provided resident state information)

Table 2-4 Share of Long Distance and Auto NPS Visitors

Park	2008 Visitors	LD Trips Share	Auto Share
Colonial NHP	3,332,039	94.4%	76%
Grand Canyon	4,425,314	95.5%	61%
Congaree NHP	104,913	46.2%	100%
Shenandoah	1,075,878	77.1%	90%
Smoky Mountain	9,044,010	89.4%	N/A
Boston NHP	2,232,495	95.5%	N/A
Yosemite	3,066,580	65%	74%
Weighted Share		**87.9%**	**71.5%**

Source: National Park Service (NPS) Visitor Surveys, 2002-2011

- **Cross Border Data.** The Bureau of Transportation Statistics (BTS) Border Crossing/Entry Data provides summary statistics for incoming crossings at the U.S.-Canadian and the U.S.-Mexican border at the port level. Data are available for trucks, trains, containers, buses, personal vehicles, passengers, and pedestrians. Border crossing data are collected at border ports by U.S. Customs and Border Protection. The data reflect the number of vehicles, containers, passengers or pedestrians entering the United States. Customs and Border Protection does not collect comparable data on outbound crossings.

- **US Census 2008 Population Estimate Data.** The U.S. Census Bureau Population Estimates Program annually produces population estimates based upon the last decennial census for general purpose governmental units (ie., Nation, state, county). Each year, the Census Bureau calculates the estimates in the time series for previously released years using the most up-to-date demographic components of change and legal boundaries available.

- **Bureau of Labor Statistics (BLS) Quarterly Census of Employment and Wages (QCEW).** The QCEW program publishes a quarterly count of employment and wages reported by employers covering 98 percent of U.S. jobs, available at the county, MSA, state and national levels by industry. The QCEW program produces a comprehensive tabulation of employment and wage information for workers covered by State unemployment insurance (UI) laws and Federal workers covered by the Unemployment Compensation for Federal Employees (UCFE) program. Publicly available files include data on the number of establishments, monthly employment, and quarterly wages, by NAICS industry, by county, by ownership sector, for the entire United States. These data are aggregated to annual levels, to higher industry levels (NAICS industry groups, sectors, and supersectors), and to higher geographic levels (national, State, and Metropolitan Statistical Area (MSA)). The QCEW program serves as a near census of monthly employment and quarterly wage information by 6-digit NAICS industry at the national, State, and county levels. At the national level, the QCEW program publishes employment and wage data for nearly every NAICS industry. At the State and area level, the QCEW program publishes employment and wage data down to the 6-digit NAICS industry level, if disclosure restrictions are met.

In selecting the data sources to use for the long-distance auto and bus passenger flows, the team considered the project resources available as well as the quality and comprehensiveness of the available data. The team decided to use the American Travel Survey as the primary source of travel data, for auto travel because it is the only comprehensive public source of national origin-destination data. For the bus travel estimates, the team used the ATS to estimate a destination choice model to establish the state level origin-destination patterns, augmented by:

1. ABA survey data, which provided control totals to be distributed by the destination choice model, and
2. Russell's guidebook and published research about curbside services, to inform the distribution of bus travel from the states to counties.

The team has also augmented the ATS with visitor survey and border crossing data, to create a reasonable profile of long distance auto and bus travel in the Continental U.S.

2.3 Air

2.3.1 Overview

The 2008 air person trip origin-destination table (2008 air OD table) was developed by blending three primary sources of data: two national datasets, Airline Origin and Destination Survey Data (DB1B) and T-100 data, that describe air passenger trips between airports, and a collection of airport specific and regional airport ground access surveys that describe air passenger trips from trip origins (e.g. homes, offices, hotels) to airports and from airports to trip destinations. The combination of trip origin to airport, airport to airport, and airport to trip destination describes a complete air passenger trip from origin to destination. The 2008 air OD table was prepared using a spatial resolution of county to county movements and then aggregated to larger spatial units, referred to here as TAF zones, which are groups of counties.

2.3.2 Air Data Sources

2.3.2.1 Airline Origin and Destination Survey Data (DB1B)

The DB1B is a 10% sampling of itineraries flown on all domestic certificated route carriers with a few exceptions for helicopter carriers, intra-Alaska carriers and domestic carriers who only operate aircraft with 60 or fewer seats[2]. This data is collected by the Office of Airline Information (OAI) of the Bureau of Transportation Statistics (BTS). Data for domestic itineraries (the entire trip involves only domestic airports) are publicly available and can be obtained directly from the BTS website in different levels of aggregation. Itineraries involving international airports are permanently restricted but can be requested directly from the BTS with the submission of a special request form. Access to international itineraries was requested and received for the development of the 2008 air OD table and the data share a similar structure to the domestic data. At the most disaggregate form, the DB1B data provide coupon-level details for all sampled itineraries like carrier, number of passengers, fare class, lay-over or transfer airports, and flight distance. For 2008, the publicly available data includes 11,910,099 itineraries representing 34,458,578 coupons and 25,491,934 passengers, while the complete data that includes international itineraries is comprised of 16,098,148 itineraries, 49,739,103 coupons, and 31,125,909 passengers.

[2] Small carriers (those operating only domestic flights with 60 or fewer seats) are divided into two groups: If the small carrier is acting as a sub carrier, operating a flight on behalf of a carrier that is required to report, then the entire itinerary is reported for that trip by the reporting carrier. If the small carrier is operating a scheduled service on their own behalf then those trips are not reported. This requirement reduces the proportion of flights on small aircraft that are not captured in the DB1B sample.

The survey sampling is an on-going effort with data being made available via the BTS website on a quarterly basis. To be included in the sample, the assigned serial number for the itinerary must end with the digit 0. All other itineraries are excluded from the survey. The resulting sample frame includes every passenger trip that includes some movement on certificated air carriers required to report.

An example itinerary included in the DB1B data can be found in Table 2-7. This itinerary represents a round-trip made by three passengers traveling on a group ticket from Asheville Regional Airport (AVL) in North Carolina to Ted Stevens Anchorage International Airport (ANC) in Alaska. Each direction of the trip had two layover stops – Douglas Airport (CLT) in Charlotte, NC and McCarran International (LAS) in Las Vegas. The Break value of X indicates the directional OD break in the itinerary. The ticket carrier for this series of flights was US Airways. The first leg was operated by PSA Airlines (Operating Carrier 16). The last leg of the return trip from CLT to AVL was operated by a non-reporting operating carrier as indicated by Type = D. The fare class of X corresponds to restricted coach.

Table 2-5 Share of Long Distance and Auto NPS Visitors: Example Itinerary from the Airline Origin and Destination Survey

COUPON	ORIGIN	DEST	BREAK	TYPE	TICKET CARRIER	OPERATING CARRIER	REPORTING CARRIER	NUMBER PASSENGERS	FARE CLASS
1	AVL	CLT		A	US	16	16	3	X
2	CLT	LAS		A	US	US	16	3	X
3	LAS	ANC	X	A	US	US	16	3	X
4	ANC	LAS		A	US	US	16	3	X
5	LAS	CLT		A	US	US	16	3	X
6	CLT	AVL	X	D	US	17	16	3	X

The intermediate stops represent additional detail that was not necessary for the development of the OD table, which just required the origin and destination for each itinerary. The concept of a “trip segment” was used to summarize the DB1B data into origin-destination pairs by combining the coupon information and the break column. A trip segment is defined by combining the origin airport for the minimum coupon with the destination airport for the minimum coupon with an “X” in the “Break” column. This provides the origin and destination airports for each value of “X” and each itinerary and is thus repeated for all itineraries in the dataset. In the example above, the origin airport (AVL) from coupon one is combined with the destination airport (ANC) for coupon three. This process would be repeated starting at coupon four’s origin airport (ANC) and coupon six’s destination airport (AVL). **Table 2-6** represents the results of this data summary process for the example itinerary Table 2-5.

Table 2-6 OD representation of example itinerary

ORIGIN	DEST	NUMBER PASSENGERS	TRIP SEGMENT
AVL	ANC	3	1
ANC	AVL	3	2

By default, every itinerary has at least one trip segment and may have more depending on the number of coupons and directional stops included for each itinerary. The greatest number of segments for an itinerary included in the DB1B data for 2008 is 16.

Since the DB1B data contains mostly complete round-trip itineraries, passenger flights can be segmented into outbound versus inbound trips. For a given airport, the distribution of origin counties for outbound travelers (typically residents of the region the airport is located in) can be much different than the distribution of destinations for inbound travelers (typically visitors to the region that the airport is located in). These distributions depend on population, employment and area tourist attractions. Accounting for the difference between outbound and inbound trips has a meaningful impact on the assignment of origin/destination counties in a complete trip table. The differences between resident and visitor trip distributions are discussed below in the discussion of ground access survey data.

2.3.2.2 T-100 Data

The T-100 data provide monthly traffic for each operating carrier for each market in which the carrier operates. Unlike the DB1B data, the T-100 data is not sampled and represents a full enumeration of the population. All carriers with operating revenue greater than $20 million and who conduct flights where one or both of the ends of a flight are inside the domestic U.S. are required to submit monthly segment and traffic data to the Department of Transportation. U.S. federal law requires participation so the T-100 data has a very small level of non-response.

There are two forms of the data: market data and segment data. The difference between the two types of data is that, in the market data, a passenger is “enplaned” and is counted only once as long as he/she remains on the same flight number, but in the segment data, a passenger is "transported" and is counted for each leg of the trip.

Table 2-7 provides an example of the level of detail that is provided in the T-100 segment data. In 2008, PSA Airlines performed 1061 flights (out of 1075 scheduled) between Asheville (AVL) and Charlotte (CLT), North Carolina on their Canadair RJ-200er Aircraft. This corresponds to a total of 38,405 passengers and 8,351 lbs of freight moving between AVL and CLT. In total, the T-100 segment data represents 669,742,968 passenger flights on 360,315 flight segments.

Table 2-7 T-100 Segment Data for PSA Airlines, Inc. for Flights between AVL and CLT on the Canadair RJ-200er Aircraft

MONTH	SCHEDULED DEPARTURES	DEPARTURES PERFORMED	SEATS	PASSENGERS	FREIGHT	MAIL	AIRCRAFT TYPE
1	84	81	4050	2586	252	0	629
2	66	65	3250	2327	700	0	629
3	72	71	3550	2741	1211	0	629
4	70	68	3400	2604	1402	0	629
5	71	71	3550	2598	275	990	629

6	62	61	3050	1978	0	0	629
7	65	64	3200	1940	592	0	629
8	62	62	3100	1884	300	0	629
9	119	118	5900	3949	902	0	629
10	130	130	6500	5178	200	0	629
11	148	146	7300	5425	590	0	629
12	126	124	6200	5195	1927	0	629

Table 2-8 provides a similar example of the level of detail that is provided in the T-100 market data. In 2008, PSA Airlines transported 42,555 market passengers and 7,777 lbs of freight between Asheville (AVL) and Charlotte (CLT), North Carolina. Unlike the segment data, aircraft type and the number of departures are not available at the market level; therefore, the example includes flights operated using both Canadair RJ-200er Aircraft and other equipment. In total, the T-100 market data represents 653,822,858 passengers traveling in 262,595 flight markets.

Table 2-8 T-100 Market Data for PSA Airlines, Inc. for Flights between AVL and CLT

MONTH	PASSENGERS	FREIGHT	MAIL
1	2461	252	0
2	2263	700	0
3	2741	632	0
4	2569	1402	0
5	2693	275	990
6	1977	0	0
7	1858	592	0
8	1884	300	0
9	5721	902	0
10	7204	200	0
11	5785	590	0
12	5399	1932	0

T-100 (U.S. Carriers) and T-100f (Foreign Carriers) segment and market data is available from January 1990 to the current date. Public access to international data for U.S. and foreign air carriers is restricted for a period of six months from the data date, except that a U.S. carrier's foreign-to-foreign airport data are restricted for three years. Like the DB1B, a special request form can be submitted to the BTS for access to restricted data from foreign carriers, but for the 2008 base year being used for the air OD table, the international data is already included in the publically-available T-100 data.

The primary limitation of the T-100 data is that it only represents either segment flows from point to point in the case of the segment data, or travel within a market connected by flights on a particular flight number in the case of the market data. It does not describe the complete flow of passengers between an origin airport and final destination airport where those passengers make a connection that involves a change of flight number. However, the T-100 data is still a useful source of control totals for segment and market flows; it was used to verify the expansion of the DB1B data and to augment certain markets missed by the DB1B data, as discussed in the completing and adjusting airport to airport OD data section below.

2.3.2.3 Ground Access Survey Data

Airport ground access surveys detail the origins of airport access trips. They are typically carried out by airport authorities, regional planning authorities (such as MPOs), or regional consortiums of these two types of agency, for future airport planning purposes. They do not follow a prescribed format but do generally collect similar types of data, such as trip origin location to some level of specificity, mode of travel to the airport, trip purpose, whether the air traveler is resident in the airport's region, and demographic data describing the air traveler. **Table 2-9** summarizes the ground access surveys obtained to support the development of the air OD table. It shows the airports covered within each survey along with the survey years and sample sizes.

The ground access surveys that were obtained cover 15 of the 40 largest airports (in terms of enplanements) in the country, and are representative of approximately 151 million of the 344 million departing passengers (44%) from the 40 largest airports.

Table 2-9 Ground access survey metadata

SURVEY	YEAR	AIRPORT(S)	SAMPLE SIZE
Greater Orlando Aviation Authority study	2009	MCO	502
San Diego survey	2007	SAN	801
Washington-Baltimore Regional Air Passenger survey	2005	IAD	5,750
		BWI	5,831
		DCA	4,677
FAA Regional Air Service Demand study	2005	JFK	5,106
		LGA	4,282
		EWR	4,480
		SWF	1,100
		HPN	1,100
		ISP	1,100
		ABE	1,208
		ACY	1,143
		TTN	98
Los Angeles International Airport passenger survey	2006	LAX	16,023
Ontario International Airport passenger survey	2001	ONT	3,395
New England airports survey	2004	BOS	5,461
		BDL	3,740
		PVD	2,748
		PWM	1,096
		MHT	2,956
		BTV	1,151
		BGR	883
		BED	65
		HVN	336
		PSM	83
Chicago Airport Express study	2003	ORD	4,382
		MDW	2,407
MTC Airline Passenger survey	2002	SFO	3,630
		OAK	2,364
		SJC	2,722
Total			**88,213**

The surveys obtained provide good coverage of the Northeast, including the New York, New England, and the Washington-Baltimore regions. The Southwest and California are well represented with airport surveys from the San Francisco bay area, Los Angeles, and San Diego regions, but surveys were not obtained for Phoenix and Las Vegas. In the Midwest, the Chicago region airports are covered, but surveys were not obtained in other major metropolitan areas such as Detroit and Minneapolis-St. Paul.

Other regions for which no surveys were obtained are the Pacific Northwest region (Seattle and Portland areas) and the south (other than Orlando), where several major airports such as Miami, Atlanta, Houston, and Dallas-Ft. Worth are not represented. The development of models to estimate the ground access trip distributions around airports where no survey data were available is discussed in Section 3.3.1.4 below.

2.4 Rail

2.4.1 Overview

The 2008 rail person trip origin-destination table (2008 rail OD table) was created using a similar approach to the 2008 air OD table, by blending data on station to station trips provided by Amtrak with data and models of station access trip distributions. The 2008 rail OD table reports rail passenger trips on the Amtrak system and was prepared using a spatial resolution of county to county movements and then aggregated to larger spatial units, referred to here as TAF zones, which are groups of counties.

2.4.2 Data Sources

Current rail travel in the U.S. is a combination of commuter rail in metropolitan areas such as New York and Chicago, and intercity travel on services operated by Amtrak. Commuter rail trips are generally too short to be considered long-distance trips and therefore the 2008 rail OD table was developed using only Amtrak data. There are no publicly available OD datasets from Amtrak, the operator of long distance rail services in the United States. Boarding and alighting data are published by Amtrak in state level factsheets. Each factsheet provides the total boardings and alightings for each station in the state. While these data do not link origins to destinations, they do provide publicly available information on station level demand for 2008. However, to support the development of the rail OD table, Amtrak agreed to provide access to their station to station data under a confidentiality agreement. These data link origins to destinations for trips on a particular Amtrak route but do not provide transfer information for trips that involve travel on more than one Amtrak route.

FRA provided access to ridership data processed by the California DOT describing the number of passengers on each of the California Thruway Bus services. In order to ride on these bus services, the trip must be connecting to or from an Amtrak rail trip, and so the data were used to distribute more accurately the origin and destination of rail trips in California.

The California High Speed Rail Authority (CHSRA) conducted significant survey work of existing rail travelers as part of the development of demand forecasts for proposed high speed rail services in California. Access to these survey data was obtained and used to describe the access trip length distributions for existing rail trips on the Amtrak system.

Section 3

Base Year Trip Table Development

This paragraph is formatted in the "LFT Body" style, which serves as the basic formatting for standard narrative text.

3.1 Auto Trips

3.1.1 Trip Generation

The auto trip generation is done for two purposes

- Business.
- Non Business.

Table 3-1 shows the ATS trip purposes categorized into these two purposes.

Table 3-1 Trip Purposes for Trip Table Development

ATS Trip Purpose	TAF Trip Purpose
Business	Business
Combined Business/Pleasure	Business
Convention, Conference, Or Seminar	Business
School-Related Activity	Non Business
Visit Relatives Or Friends	Non Business
Rest Or Relaxation	Non Business
Sightseeing, Or To Visit A Historic Or Scenic Attraction	Non Business
Outdoor Recreation (Sports, Hunting, Fishing, Boating, Camping, Etc.)	Non Business
Entertainment (Attend The Theater Or Sports Event, Etc.)	Non Business
Shopping	Non Business
Personal, Family, Or Medical (Wedding, Funeral, Health Treatment, Etc.)	Non Business
Other Reason	Non Business

Some considerations that the project team considered when looking developing the trip generation equations were:

- The least number of input data items needed;
- Input data items are readily available; and
- Statistically valid.

Using these considerations, The project team used American Community Survey (ACS) data and data from Energy Information Agency (EIA) to try different linear regression specifications including presence of children in Household, income, and gas prices. However, these specifications did not yield logical or significant results. Therefore, the project team developed linear regression specifications based on employment and population. The Production and Attraction equations by trip purpose are shown in equations 1 to 4.

In order to ensure that the full ATS dataset was used, the project team estimated the trip generation at the state level.

- Business Trip Productions = 0.47692 x Census Population (R^2 = 0.90) … (1)
- Non Business Trip Productions = 2.19893 x Census Population (R^2 = 0.95) … (2)
- Business Trip Attractions = 1.09773 x QCEW Employment (R^2 = 0.89) … (3)
- Non Business Trip Attractions = 6.573 x QCEW Leisure & Hospitality and Service Providing industry Employment (R^2 = 0.91) (4)

Figures 3-1 to **3-4** show a scatterplot of observed Vs. predicted values and indicate that the regression estimates have good predictive capabilities.

Figure 3-1 Scatterplot of Observed Vs. Predicted (Business Productions)

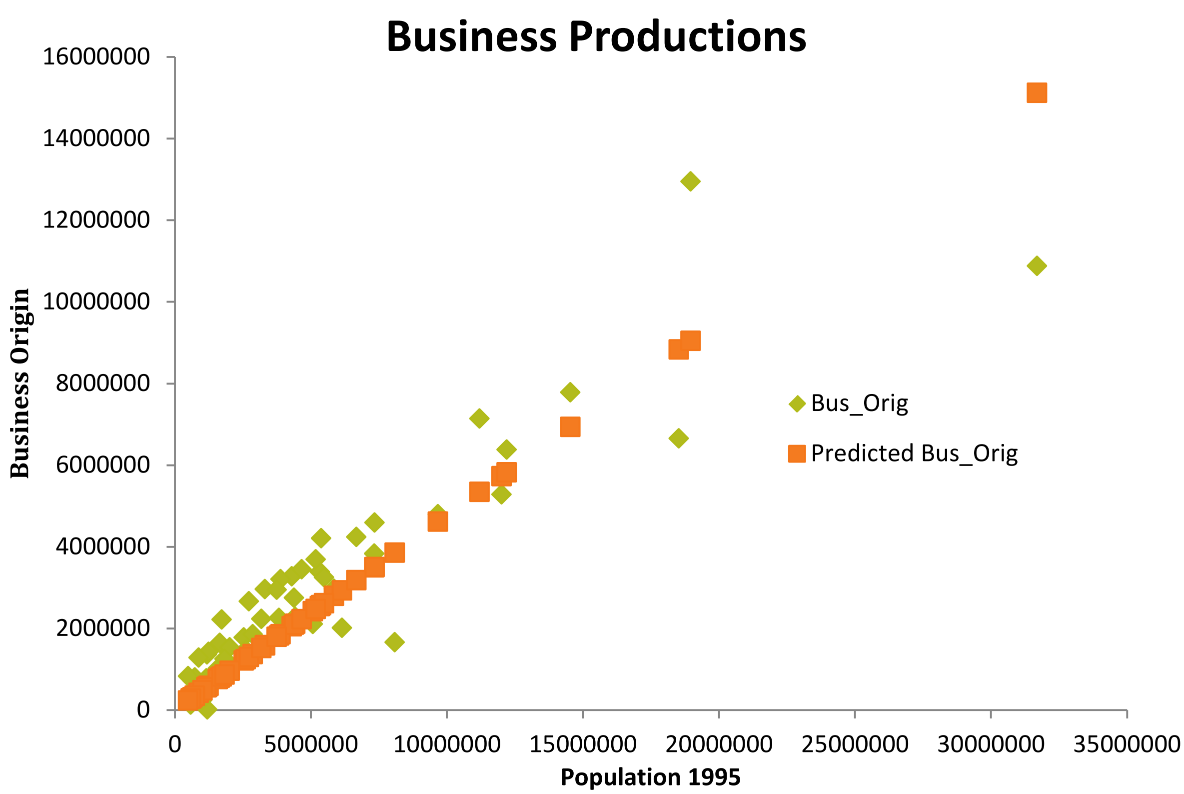


Figure 3-2 Scatterplot of Observed Vs. Predicted (Business Attractions)

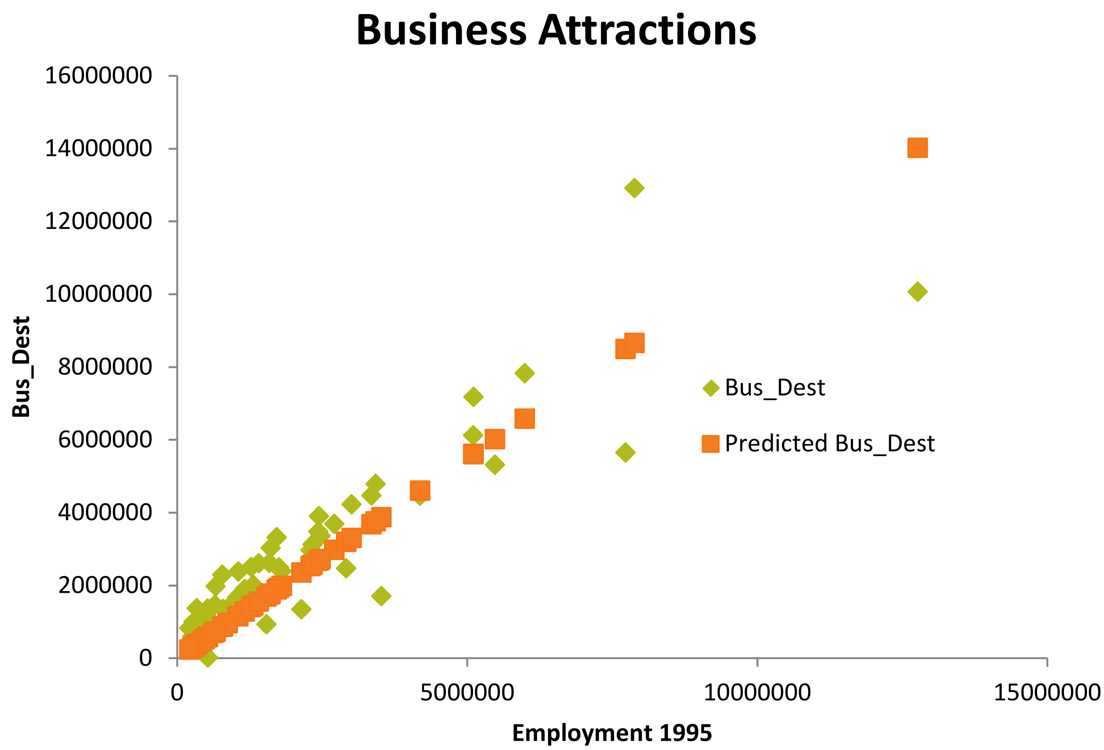


Figure 3-3 Scatterplot of Observed Vs. Predicted (Non Business Productions)

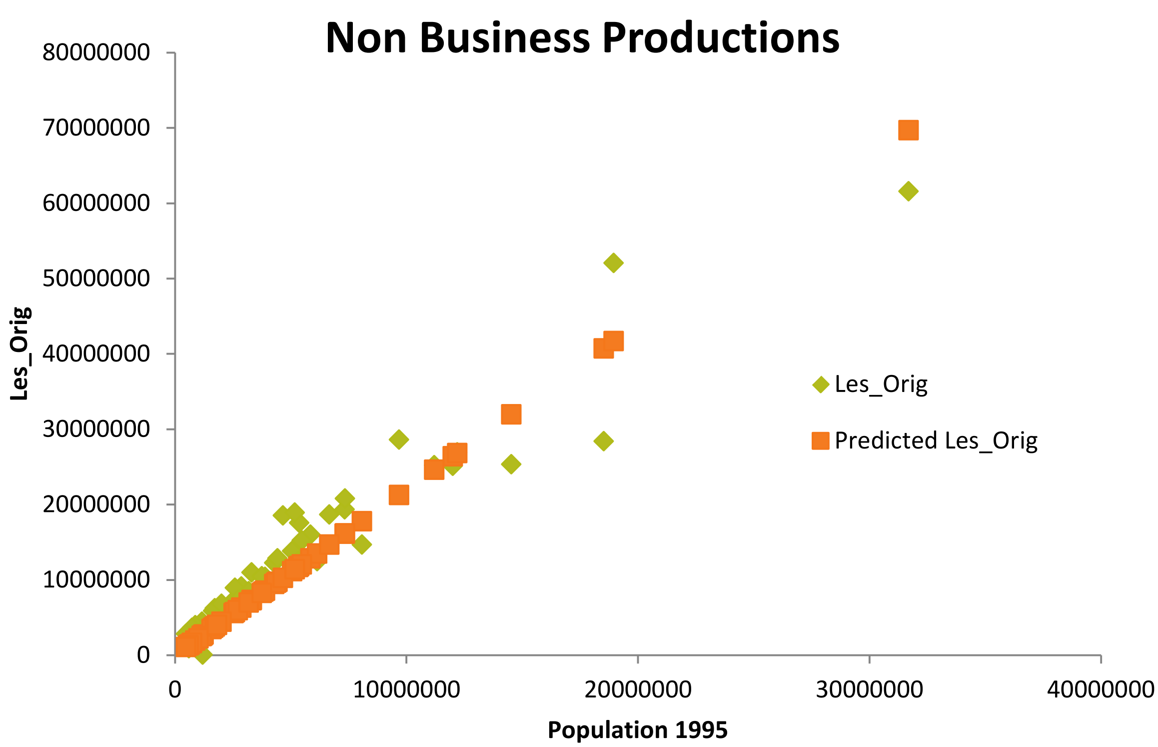
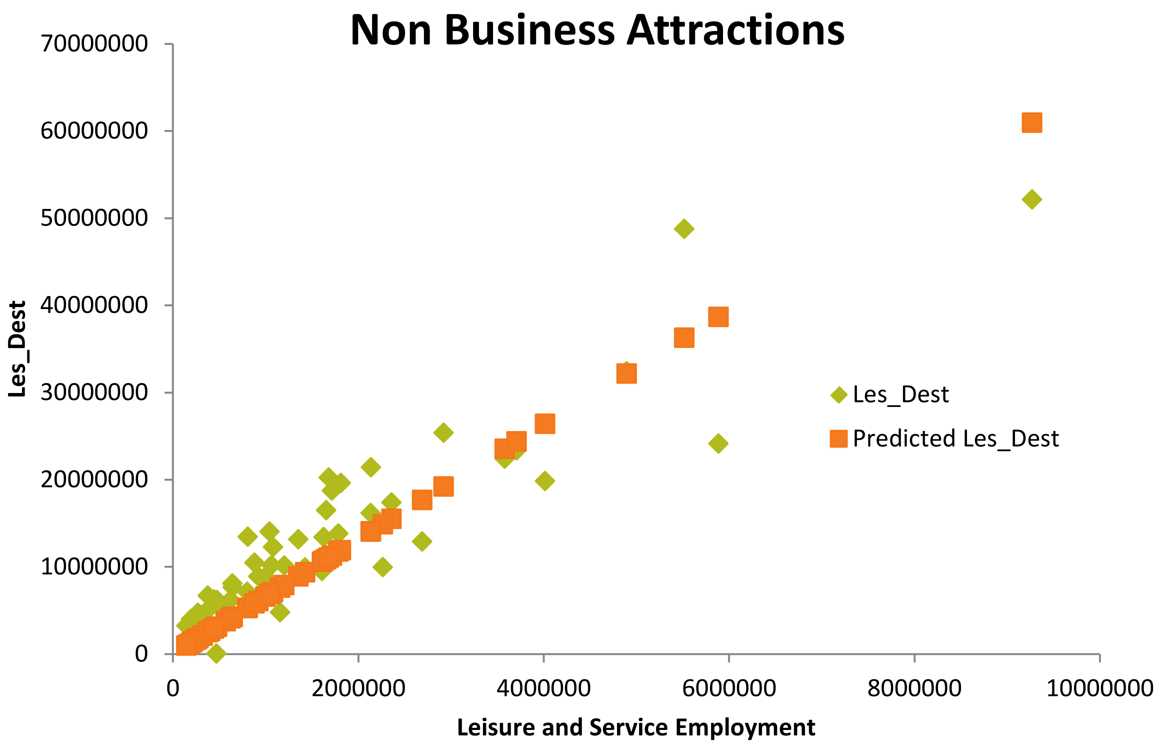


Figure 3-4 Scatterplot of Observed Vs. Predicted (Non Business Attractions)



3.1.2 Distribution

The balanced productions were then estimated distributed using a destination choice model and the multinomial logit formulation for each trip purpose is shown in equations 5 and 6. The trips are distributed from zone *i* to zone *j* based on the share of zone *i* among all possible zones in the choice set.

- $Business_j$ = 0. 536*(LN($Households_i$) + 2*LN($Employment_j$)) -2.81*LN($Distance_{ij}$) … (5)
- Non $Business_j$ = 0.584*(LN($Households_i$)+2*LN($Employment_j$)) - 2.47*LN($Distance_{ij}$) … (6)

Figure 3-5 shows the multinomial formulation of how trips are distributed from zone *i* to zone *j*.

Figure 3-5 Multinomial Logit form for Trip Distribution

$$BusinessTrips_{ij} = BusinessProductions_i \frac{exp(Business_j)}{\sum_{j' \in Zones} exp(Business_{j'})}$$

$$NonBusinessTrips_{ij} = NonBusinessProductions_i \frac{exp(NonBusiness_j)}{\sum_{j' \in Zones} exp(NonBusiness_{j'})}$$

3.1.3 Special Generators

For the national parks, border trips, and places such as Las Vegas and Orlando which attract a large portion of visitors which are not necessarily captured by the ATS, data from the national parks service (NPS), BTS for cross border inbound trips, visitors bureau from Las Vegas and Orlando are allocated to their production/attraction zones based on the non-business trip distribution equation 6.

The trips are then finally allocated to the Counties and the resulting productions and attractions are shown in **Figures 3-6** to **3-9**.

Figure 3-6 2008 Business Productions

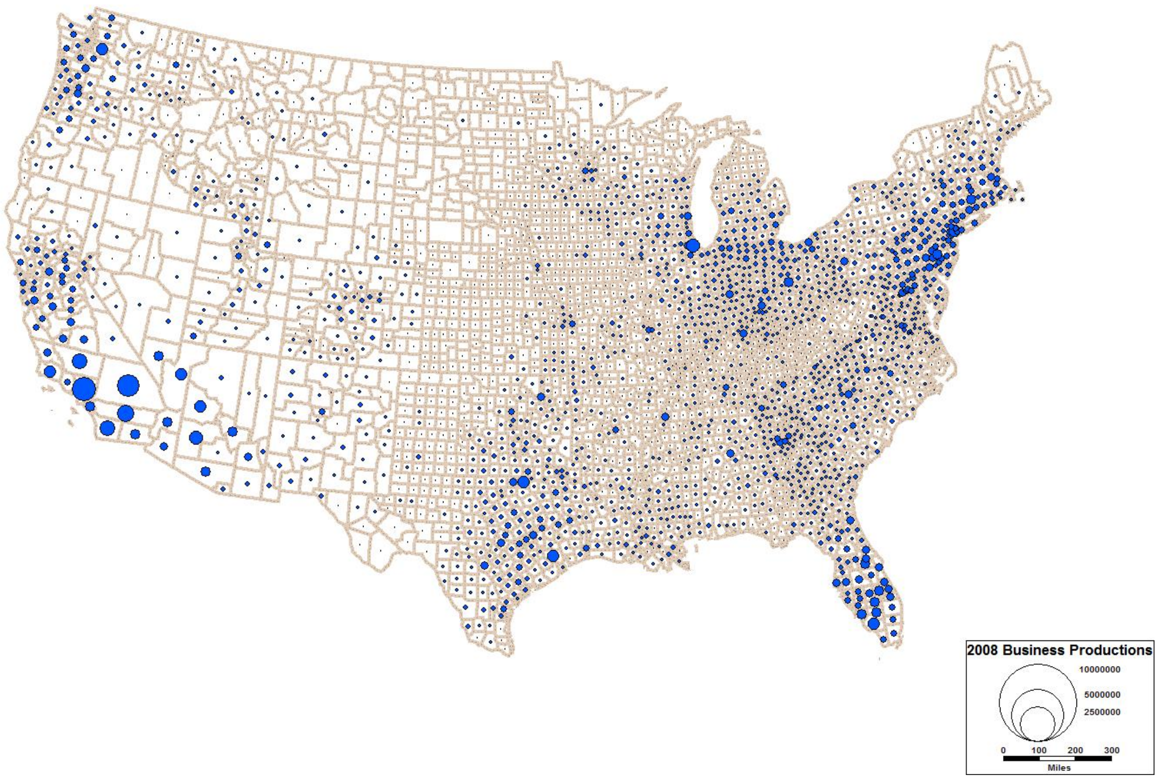


Figure 3-7 2008 Business Attractions

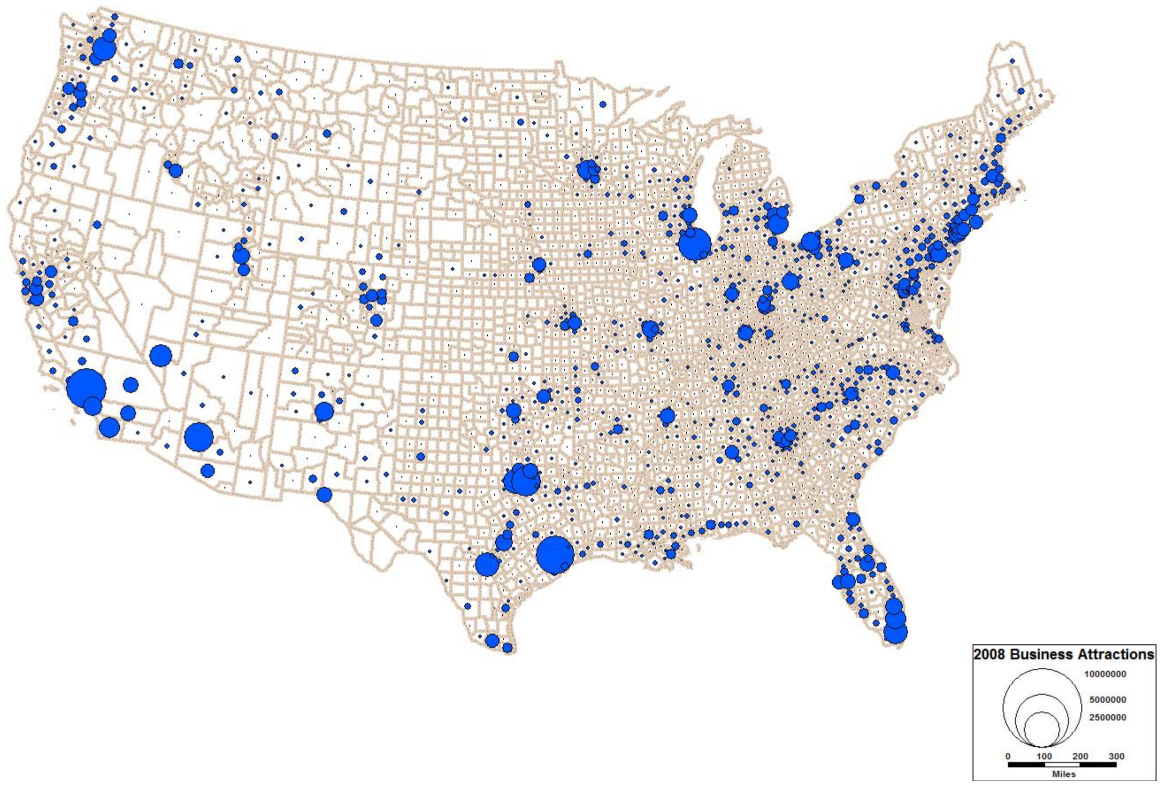


Figure 3-8 2008 Non-Business Productions

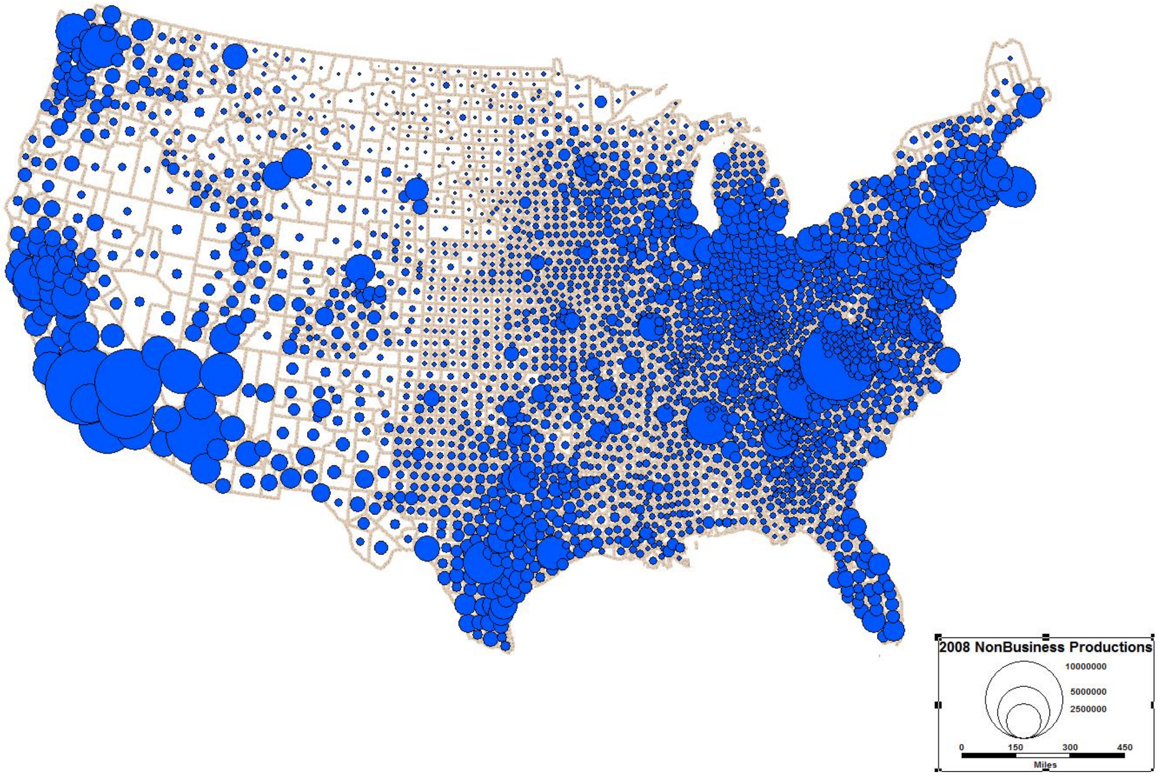
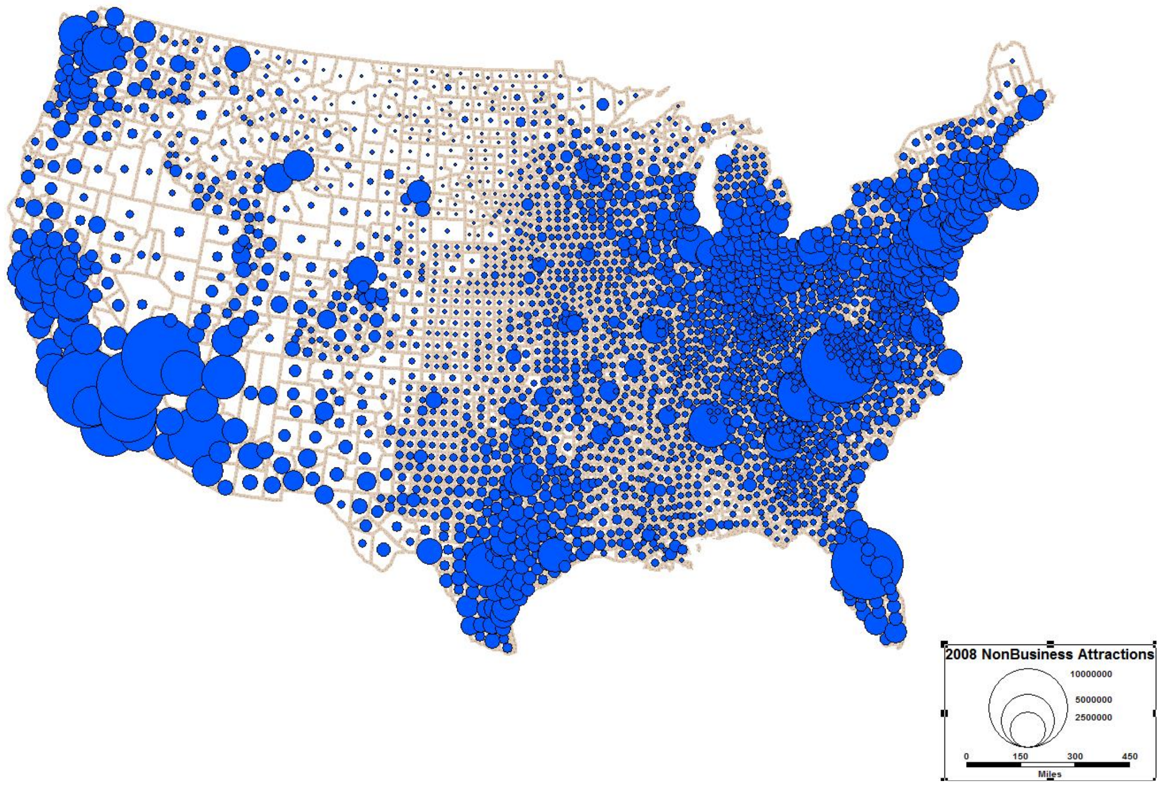


Figure 3-9 2008 Non-Business Attractions



3.1.4 Results and Validation

Table 3-2 shows the results of the trip table and **Table 3-3** compares the trip length distribution to data from the 2002-2003 Ohio Long Distance survey and 2011 (calibrated to 2008) California High Speed Rail Survey.

Table 3-2 Estimated Auto Passenger Trips

Parameter	Auto
1995 ATS	813,858,000
2008 Estimate	1,225,711,728
Auto Share 1995	81.3%
Auto Share 2008	82.2%
Total Growth (1995 to 2008)	50%
Annual Total Growth (1995 to 2008)	3.2%

Table 3-3 Trip Length Frequency Comparison

Distance Bin	Estimated 2008 Auto	1995 ATS Auto	2002/2003 Ohio Long Distance Survey	2008/2011 California Long Distance Survey
100 to 200 miles	52.6%	54.9%	59.7%	59.3%
200 to 300 miles	18.8%	20.8%	15.2%	13.9%
300 to 400 miles	10.1%	8.9%	9.7%	19.6%
400 to 500 miles	6.2%	4.5%	5.5%	6.4%
500 to 600 miles	4.3%	2.8%	3.6%	0.7%
600 to 700 miles	3.1%	1.8%	1.9%	0.1%
700 to 800 miles	2.2%	1.3%	1.8%	0.0%
800 to 900 miles	1.6%	1.0%	1.1%	0.0%
900 to 1000 miles	1.2%	0.7%	0.7%	0.0%
More than 1000 miles	2.6%	3.3%	0.8%	0.0%

3.1.5 Results and Validation

The project team procured 2008 business and leisure industry travel survey data at the level of the census region from DK Shifflet data to compare the auto estimates produced by the project team. Overall, the Shifflet data show 30% more business trips than are produced by the project team estimates; the largest single regional difference occurs in the West (55%). By contrast a comparison of the two sources for non-business trips show a much closer match. Nationally, there is virtually no difference between the two sources in non-business trips. A more detailed comparison of the two sets of estimates revealed that there were significant differences in the ATS and Shifflet surveys' designs and implementation that made direct comparisons difficult. Ultimately, the team did not alter the estimates based on the panel survey data. **Tables 3-4** and **3-5** shows the Business and Non Business Comparisons stratified by Census Division.

Table 3-4 Business Trips Comparison

Census Division	DK Shifflet	CDM Smith	Difference
New England	6,010,000	5,949,287	1%
Mid Atlantic	20,060,000	14,552,374	38%
East North Central	35,370,000	25,414,718	39%
West North Central	24,170,000	16,098,283	50%
South Atlantic	44,290,000	35,858,608	24%
East South Central	17,160,000	15,073,426	14%
West South Central	29,930,000	26,723,142	12%
Mountain	23,920,000	16,298,333	47%
Pacific	43,510,000	19,258,774	126%
Total	244,420,000	175,226,945	39%

Table 3-5 Non Business Trips Comparison

Census Division	DK Shifflet	CDM Smith	Difference
New England	32,240,000	38,789,265	-17%
Mid Atlantic	86,720,000	88,530,119	-2%
East North Central	110,630,000	140,720,308	-21%
West North Central	69,460,000	99,869,327	-30%
South Atlantic	164,850,000	192,864,956	-15%
East South Central	52,000,000	78,456,958	-34%
West South Central	84,280,000	153,279,768	-45%
Mountain	87,090,000	110,895,184	-21%
Pacific	134,000,000	147,078,898	-9%
Total	821,270,000	1,050,484,783	-22%

3.2 Bus Trips

The team developed an estimate of 2008 bus trip ends using data provided from the ABA's analysis of its motorcoach census, augmented by a special survey of its membership to support this estimation effort. To estimate travel patterns from the survey, the team estimated a state-level trip distribution model, and the city-level service frequency data provided a guide and a validation tool for distributing trips to the counties.

Specifically, the long-distance bus trip estimation consisted of:

- Developing an estimate of national ridership using source data from the ABA
- Converting the national estimate to state level productions, using a trip generation model
- Adding special generator trips to account for popular visitor destinations

- Allocating the productions to state OD pairs, using a destination choice model
- Allocating the state flows to county flows, using 2008 service level data and county level socio-economic data.

Each of these is described in turn below.

3.2.1 National Estimate of Long-Distance Passenger Bus Trips

The ABA conducts a regular census of its membership and gathers information such as the types of services offered, size of the carriers' operations and passenger characteristics. Based on this information and additional information collected outside of the census, the team assembled a global estimate of passenger trips for 2010. The result, provided by type of service, is shown in **Table 3-6** below and totals 363 million annual trips. This universe of trips forms the basis for estimating long distance trips. In the table below the scheduled and commuter services are one way trips and the packaged tour and charter services are round trips.

Table 3-6 Estimated 2010 Total Passenger Bus Trips

Type of Service	Total Trips	Round Trips
`Scheduled Service	165,573,367	82,786,684
Commuter	23,490,958	11.745,479
Packaged Tour	9,917,490	9,917,490
Charter	163,924,388	163,924,388
Total	362,906,204	268,374,041

In 2011 and 2012, the ABA asked its members to provide service ridership data as well as route level information about the services offered. About 10 percent of the members responded, and this information provided a means to estimate the percentage of trips that are long distance

Taking the total estimated trips from Table 3-6 along with trip distribution information from the survey the total estimated long distance passenger trips over 100 miles were obtained and is shown in Table 3-7.

Table 3-7 Estimated 2010 Total Passenger Bus Trips Over 100 Miles

Type of Service	Estimated Long Distance Trips	Percent Long-Distance Trips
Scheduled Service	49,672,010	60%
Commuter	3,392,094	38%
Packaged Tour	6,347,194	80%
Charter	134,417,998	80%
Total	193,829,296	

Using US Census derived growth rates, the team factored the 193 million passenger estimate down to 190 million to arrive at an estimate of 2008 long distance passenger trips. The team applied a trip generation model to create household-based trip generation rates, and the resulting productions were used to allocate to bus trips to individual states. The trip generation model is described below.

3.2.2 Trip Generation

According to the ATS, bus travel in the U.S. is associated with socio-economic characteristics for which forecasts have been produced from sources such Woods and Poole. These characteristics include gender, age, vehicle ownership, home ownership, income and education.

For estimating long-distance passenger bus trips, the team has made simplifying assumptions. We assume that a trip from home to an ultimate destination and back constitutes a round trip. Intermediate stops are not included explicitly in this travel estimation set. Additionally, we assume that trips are symmetrical, that is, the return trip, begins from the ultimate destination and returns to the trip origin.

The team developed a single, nation-wide set of trip rates that relate the number of annual long distance bus trips per household from the ATS survey with age, income and auto ownership. This set of rates produced an estimate of residential-based bus trip estimates for 2008 and 2040. While a number of different trip generation formulations were used, the rates based on income, age and number of vehicles clearly demonstrates a different pattern of trip making relative to auto and other modes. Bus trip rates are generally higher for 0-car households, higher for middle or higher income households and highest for the group of households with members in the 18-64 age group. The estimated trip generation rates are shown in **Table 3-6**.

Table 3-8 Household Bus Trip Generation Rates

Age	Income	Vehicles	
		0	1+
Under 18	Under $35,000	0.062	0.097
	$35,000-$75000	0.872	0.155
	>$75,000	0.868	0.156
18-64	Under $35,000	0.342	0.474
	$35,000-$75000	0.619	0.263
	>$75,000	0.411	0.151
65 and older	Under $35,000	0.679	0.212
	$35,000-$75000	1.045	0.190
	>$75,000	1.051	0.097

Source: CDM Smith and American Travel Survey

3.2.3 Special Generators

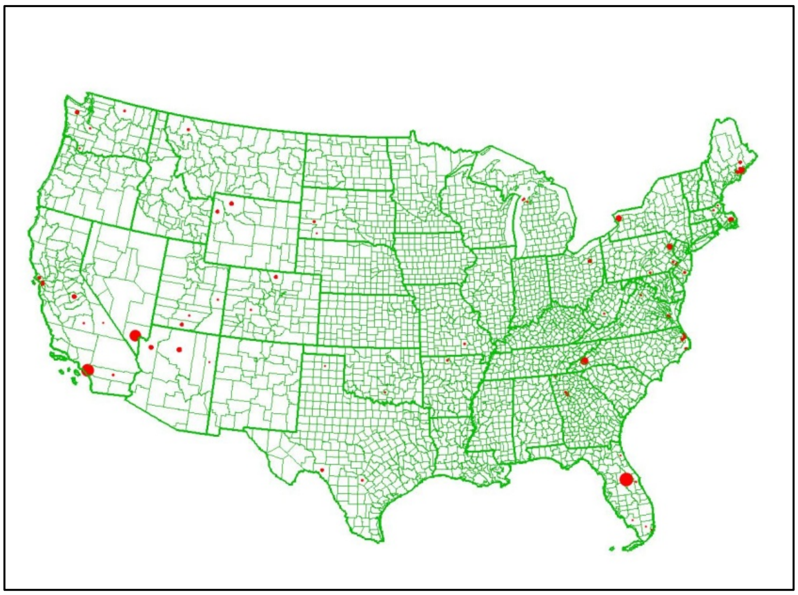
The team added trips from two additional sources:

1. Cross border entry points between the United States and Canada and between the United States and Mexico. The actual number of border crossings by persons traveling by in 2008 bus is reported in the Transportation Security Administration database. Using information from Statistics Canada about the destination state of Canadians entering the United States, the team used a factor of 0.75 to convert border crossings into long-distance trips.

2. Trips destined for popular recreation locations *outside of large metropolitan areas not likely to be addressed adequately by the American Travel Survey*. The American Travel Survey indicates the state and Metropolitan Statistical Area of a trip end, but does not indicate the location of trips outside of MSAs. Trips were added to account for travel to National Park Service locations and for a limited number of additional destinations such as Niagara Falls, Orlando and Las Vegas. Based on information from National Park Service visitor surveys, the team used a factor of 0.05 to estimate the total number of visitors arriving by bus, and a factor of 0.88 to convert total visitations to long-distance trips. Special generators are shown in **Figure 3-10**.

The team assumed that the nationwide ridership estimate derived from the ABA census and membership survey included and accounted for the special generators.

Figure 3-10 Bus Special Generators 2008



3.2.4 Trip Distribution

The team developed a state-level destination choice model to estimate the destinations of household-based bus trips. To estimate the model, the team extracted bus trip information from the American Travel Survey and augmented it with socio-economic information and average state-state distance data[3] to create a choice set for every trip record in the survey. The multinomial discrete choice model was estimated using the BIOGEME software package.

The final bus passenger destination choice model is formulated as:

$$T_{ij} = 1.41 * [\ln(households_i) + \ln(2 * employment_j)] - 2.34 * \ln(distance_{ij})$$

Where:

$T_{ij} = Trips\ between\ origin\ i\ and\ destination\ j$

$households_i = Number\ of\ households\ in\ origin\ i$

[3] State to state distance is calculated as the average of the county-county centroid distances between two states, weighted by county population.

$$employment_j = \ Number\ of\ employees\ in\ potential\ destination\ j$$
$$distance_{ij} = \ Distance\ in\ miles\ between\ origin\ i\ and\ potential\ destination\ j$$

The team applied the destination choice model to all bus trip end components. The model was applied to the household-based productions from the trip generation model, and to the cross border trips as productions as well. To apply the model to the visitor trips, the team converted the visitor attractions to productions, applied the destination choice model, and then transposed the result, converting the visitor trip ends back to attractions. The ATS is the only comprehensive and reliable spatial source of data relating traveler characteristics to bus travel

3.2.5 Allocation of Bus Trips to Counties

In the final step, the team distributed the state level bus trips to the counties within each state. The team started with the tally of the service frequencies by city from the 2008 Russell's guide, the ABA origin-destination membership survey and the research on curbside and Chinatown service provision amassed as part of this study. The initial results were adjusted by 2008 US Census population and employment estimates. The special generator trips were developed at the point level and were simply transferred to the appropriate county.

3.2.6 Results

The team applied the survey data, models and factors to develop forecasts for 2008. The 190 million passenger trips, using the ABA survey data as a starting point represent a substantial increase over the result that would have been achieved by applying population and employment growth rates directly to the 1995 ATS survey.

To check the results of the trip distribution model, the team aggregated the estimated trips into 100 mile trip length categories, and counted the distribution of trips. The results from the survey as well as from the application of the model for 2008 are shown in **Table 3-8**. In 1995, over 75% of all trips were 500 miles in length or less. The model results show a slightly lower distribution of trips under 500 miles in distance as compared to the ATS, and a slightly higher distribution of trips in the longer trip distance categories. The model compares reasonable well to the 2010 weighted ABA Survey Distribution.

Table 3-9 Bus Passenger Trip Length Frequency Distribution, by Year

Distance Category	1995 ATS Bus	2010 ABA Survey	Estimated 2008 Bus
100 to 200 miles	41.90%	31.80%	44.50%
200 to 300 miles	21.10%	30.10%	20.64%
300 to 400 miles	12.70%	10.10%	10.27%
400 to 500 miles	5.80%	8.10%	6.00%
500 to 600 miles	4.70%	2.80%	4.21%
600 to 700 miles	2.80%	4.90%	3.26%
700 to 800 miles	2.10%	2.20%	2.35%
800 to 900 miles	1.50%	1.50%	1.87%
900 to 1000 miles	1.00%	1.80%	1.66%
More than 1000 miles	6.40%	6.00%	5.25%

Figure 3-11 presents a series of maps that depict the origin location (MSA or county outside MSA) of several trip destinations. Origins are identified by straight line connections which converge on a single destination, including New York, Chicago, Orlando, Las Vegas and Seattle. The origins producing the largest number of trips tend to be closer to the destination, and the origins producing fewer trips tend to be further away.

Figure 3-11 Selected Bus Trip Desire Lines, 2008 (US Origins Only)

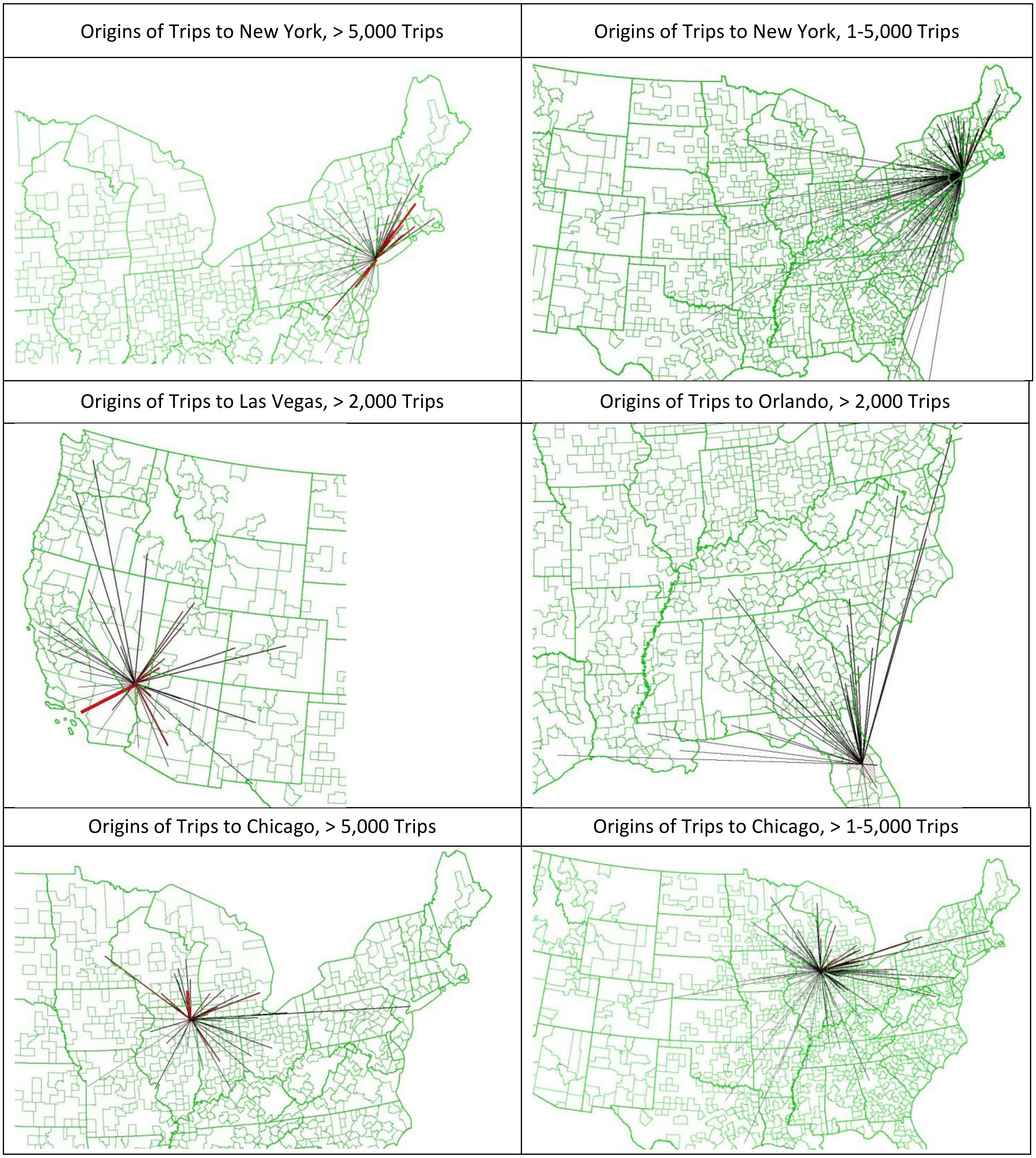


Figure 3-11. Selected Bus Trip Desire Lines, 2008 (US Origins Only) (Cont'd)

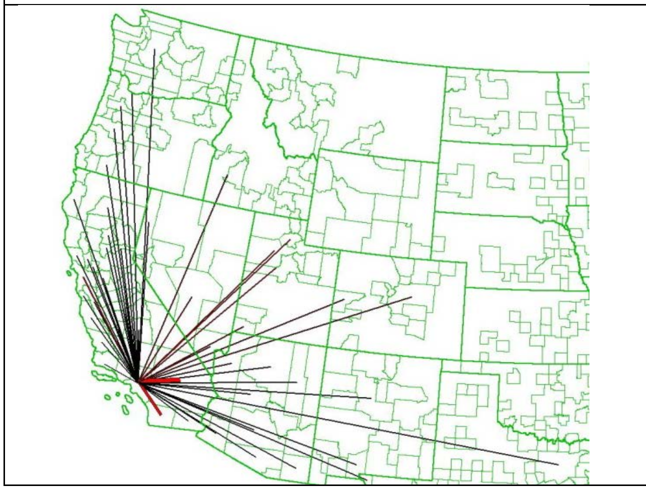
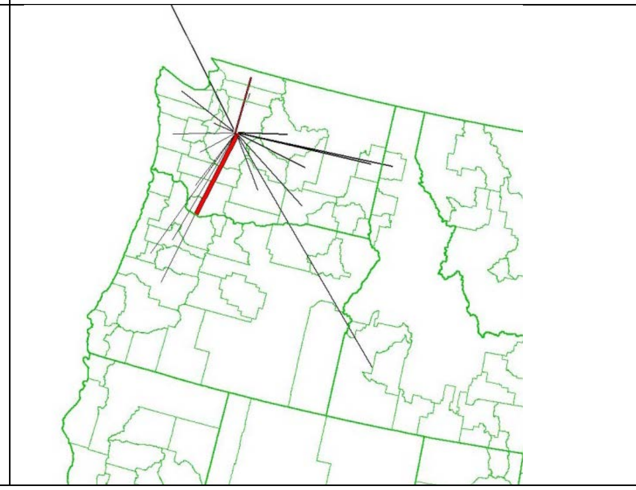
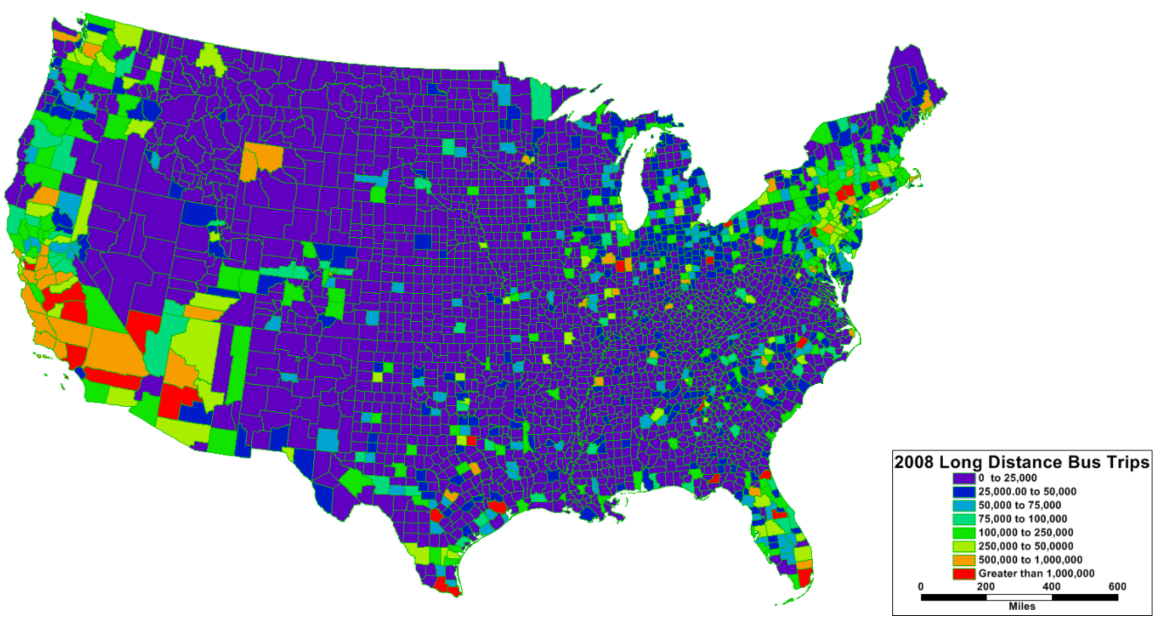
Origins of Trips to Los Angeles, > 5,000 Trips	Origins of Trips to Seattle, > 5,000 Trips
	

Figure 3-12 below presents the distribution of 2008 long distance passenger trip as trip destinations. The figure shows concentrations of trips in the northeast corridor, Florida, the southwestern United States and along much of the Pacific Coast.

Figure 3-12. 2008 Destinations of Long-Distance Passenger Bus Trips, by County



3.3 Air

3.3.1 Approach

3.3.1.1 Developing true OD tables

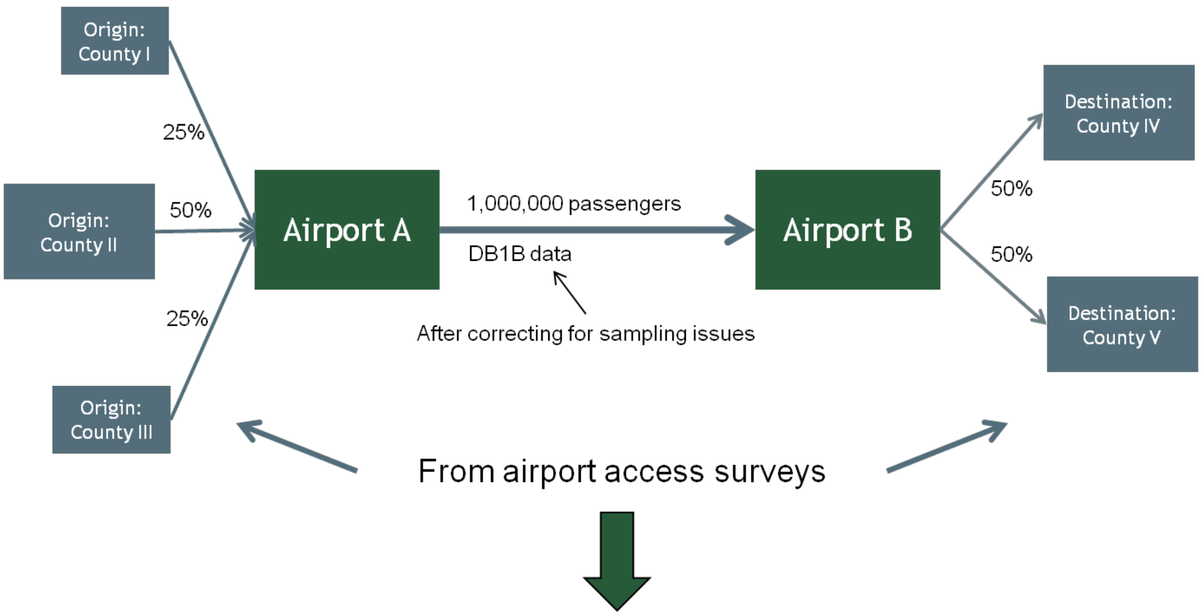
The approach to developing person OD tables on a true-origin to true-destination basis (i.e., a complete trip) combines distributions of airport ground access origins (the non-airport end of the airport access trip) with data on airport to airport OD flows, based on the DB1B data that contains a 10% sample of airline itineraries. Each air traveler survey record in a ground access survey includes a passenger's true origin, such as a ZIP code or the county where the trip to the origin airport started. These surveys were used to understand the distribution of true origins and true destinations at each airport. The DB1B data were used to understand the airport to airport demand for trips between each airport pair. The combination of the two sources resulted in the development of a dataset reflecting the following travel progression: true origin (by county) to origin airport to destination airport to true destination (by county).

Figure 3-13 illustrates one airport pair and trips in one direction, using example airport-to-airport demand and access trip distributions. In this case, the DB1B data (once expanded) shows that there are 1,000,000 air passenger trips annually between Airport A and Airport B. The ground access survey at Airport A shows that trips from three origin counties account for 25%, 50% and 25% of trip origin respectively. At Airport B, the ground access survey shows trips are distributed 50% each between two destination counties. The OD table is then derived by multiplying together the access proportion at Airport A, the demand between Airport A and Airport B, and the egress proportion at Airport B. For example, the number of trips from Origin County I and Destination County IV is:

$$25\% * 1{,}000{,}000 * 50\% = 125{,}000 \text{ trips.}$$

The resulting county-to-county OD table reveals the details of traveler origins and destinations for passengers passing through the two airports in question, and exposes the underlying county-to-county demand that an airport-to-airport OD table obscures.

Figure 3-13 Graphical Illustration of True OD Approach



Air Mode OD Matrix

	Destination: County IV	Destination: County V
Origin: County I	125,000 passengers	125,000 passengers
Origin: County II	250,000 passengers	250,000 passengers
Origin: County III	125,000 passengers	125,000 passengers

Where ground access survey data are available, the data were used directly following the approach described above. In areas where ground access survey data are not available, the ground access data were simulated using travel patterns observed at the airports where data are available. This simulation process used trip distribution models to distribute the ground access trips across each airport's market area. The model estimation approach and results are presented below.

Once trips between each airport pair have been allocated to county origins and destinations, the airport pair specific trip tables were summed into a single total county to county air OD table, which was then aggregated to a TAF zone to TAF zone air OD table.

3.3.1.2 Completing and Adjusting Airport to Airport OD Data

The completion and adjustment of the DB1B data to represent more closely the T-100 data was undertaken in two steps:

1. The international itinerary data were requested from BTS and were processed and combined with the publicly available data for 2008. The international data are provided with confidentiality requirements and therefore this documentation and the data products developed with the data are designed to comply with those requirements.

2. Once the international itinerary data were included in the sample, the discrepancies between the T-100 data and the DB1B data were identified. The approach followed was not to systematically adjust the DB1B data so that T-100 market flows are perfectly matched, but rather to identify, check, and make adjustments where larger discrepancies existed.

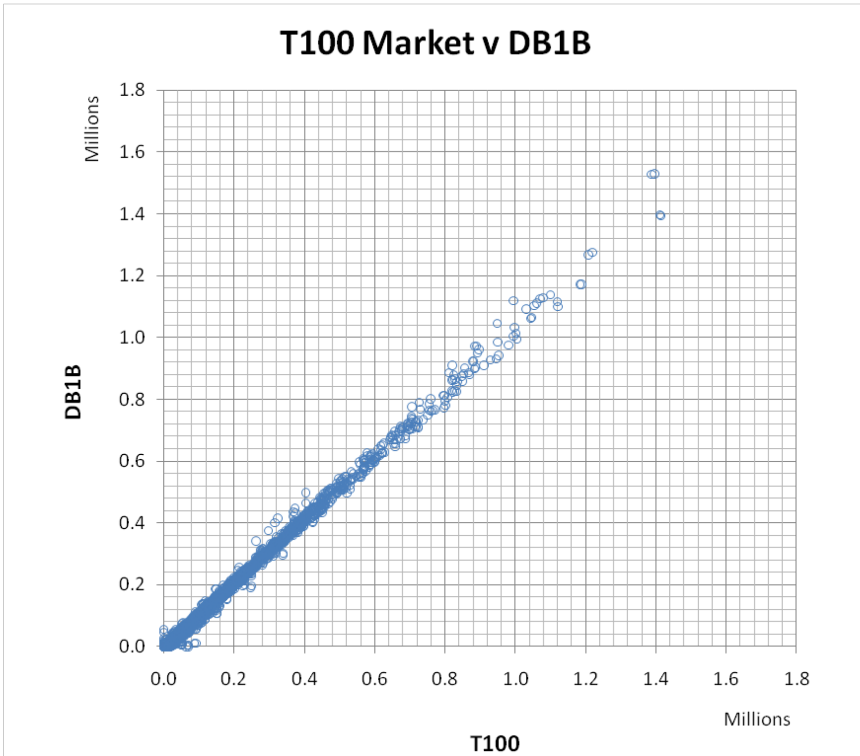
The analysis and adjustments made as part of the second step are documented here. After the international data were included with the DB1B data, the data were scaled up to represent all air travel using a factor of 10 (since DB1B is a 10% sample) and then split into individual flight markets between airport pairs. The objective of the analysis was to identify how well the scaled DB1B data including international trips compared with T-100 data at the market level and to possibly refine the scaling technique or augment the DB1B in other ways to generate more accurate airport-to-airport demand.

The T-100 market data were used for comparison purposes instead of the T-100 segment data as they are more closely comparable to the DB1B data. If a flight in an itinerary includes a stop that does not require a plane change, the stop is not recorded in the DB1B data. Similarly, the T-100 market data is based on the number of enplanements and deplanements between a pair of airports and does not reflect intermediate stops. However, the T-100 segment data does count those passengers for all the different segments formed as a result of the intermediate stops.

The comparison between the DB1B data and the T-100 data involved around 11,000 airport pairs. Nineteen airport pairs were identified in the DB1B that were unlikely to have air passengers (e.g. JFK-EWR and SFO-SJC) traveling between them. These airport pairs were eliminated from the comparison as they are assumed to represent ground transfers between flights. Once these ground transfers were removed, the difference between the total number of passengers from the scaled DB1B data and the T-100 market data for matching markets (i.e. those appearing in both the DB1B data and the T-100 markets data) was just over 1% in total. **Figure 3-13** shows a comparison between the DB1B data and the T-100 market data by airport pair. The charts show that, while there are outliers, the relationship between the DB1B data and the T-100 market data appears close.

The next stage of the comparison involved aggregating the DB1B data and T-100 market data into a regional origin-destination matrix to identify specific inter- or intra-regional markets where discrepancies exist. The three largest negative differences (i.e. the DB1B is less than the T-100 market data) in absolute terms are intra-regional flows within Alaska, the Caribbean, and the Pacific. Certain carriers such as intra-Alaskan carriers or those that operated small aircrafts (less than 60 seats) are not required to report to the DB1B sample. Many of these small carriers exist in the intra-island markets, such as the Hawaii market (e.g. Island Air and Pacific Wings). In order to account for this underreporting, where the T-100 market data included records for carriers operating within those three markets that were not in the DB1B data, DB1B records were synthesized to represent those passenger movements, with the assumption that the passengers were traveling on round trips between the airport pairs represented by that T-100 market. This is a reasonable but likely not a completely correct assumption, as any onward transfers would be missed in this case (as that detail is not captured in the T-100 market data), but only where all travel was completed on non-reporting carriers (as itineraries involving transfers to and from reporting carriers are captured in the DB1B data).

Figure 3-14 Comparison between DB1B and T-100 Market by Airport Pair Markets



3.3.1.3 Market Segmentation

To demonstrate the influence of market segmentation on the distribution of ground access trips from various catchment counties around airports, an analysis of the New York region was undertaken using ground access survey data for the three largest airports (JFK, LGA, and EWR). A clear difference in the distributions of residents and non-residents stands out in the case of New York County (Manhattan) where the proportion of non-residents originating (to access JFK, LGA, or EWR) is more than double that of the residents. This may be attributed to the business and tourist attractions located in New York County. It can also be seen that the proportions of non-residents from some of the more residential counties such as Kings, Queens, and Nassau, is lower than those of residents.

A comparison of the distributions of passengers across trip origin counties by business and non-business trip purposes showed smaller differences when compared to segmentation by residence status. Even New York County (which has the largest difference in the proportions of resident and non-resident trip origins) has a relatively small difference (5%) between the proportion of business passengers and non-business passengers. This indicates that segmenting air passengers (in the New York region) by trip purpose is not as important as segmenting them by residence status.

In order to separately distribute resident and non-resident (visitor) trips around each airport, it was necessary to identify the resident and non-resident end of each air trip in the DB1B data. For itineraries with more than one trip segment, it is possible to determine whether that trip was a round trip and thus the appropriate “resident” and “visitor” airports. For each itinerary, a comparison of the destination airports for trip segments after the first was made to the origin airport for the first trip segment. If there was a match, the trip was flagged as a round trip. The origin airport for the first trip segment was assumed to be the home airport for these trips and all other airports were considered visitor airports. If the airports did not match, the trip was flagged as such and all trip segments were assigned in a similar fashion to the itineraries with just one trip segment.

For all itineraries with one trip segment, it is impossible to make a realistic assumption about the direction of that trip or which airport should be considered “resident” and which should be considered “visitor”. Therefore, the directional split of round trips between each airport pair was used to assign the one way trips in proportion to the round trips.

3.3.1.4 Ground Access Trip Distribution Models

Where no ground access survey data were available, the origins of access trips and the destinations of egress trips (at the county level) were modeled. To do this, airport access trip distribution models were estimated that develop a set of trip origins for all access trips to an airport and a set of trip destinations for all egress trips from the airport. For these models, the quantity of trips to be distributed is known, from the weighted DB1B data. The models were estimated using the ground access survey data introduced above, demographic data such as population and employment data (from sources such as the U.S. Census and American Community Survey (ACS)), and spatial information such as distances calculated from county centroids to airports.

A common ground access survey dataset for model estimation was created from the ground access surveys. It contains data fields describing the airport, origin county for the ground access trip, resident/visitor status, trip purpose, access mode, and final destination airport for each survey record. Not all variables were available from all surveys (for example, final destination airport was not collected in all surveys). Additional variables were attached to each survey record:

1. Airport Trip Distance: Trip length to and from a particular airport is an important explanatory variable influencing the access distribution. In this case, straight line distance between the airport and the centroid of the origin county was assigned to each survey record as an approximation to trip length. The distance in miles was calculated by using coordinates of the airports and those of the county centroids obtained from U.S. Census GIS data.

2. County Population and Employment: Population and employment in the counties surrounding an airport are also relevant factors that may affect the airport access distribution. Population of the origin county in each case was obtained from Census population estimates based on the year of survey (http://www.census.gov/popest/counties/counties.html). County employment by employment category was added from the Quarterly Census of Employment and Wages (QCEW) (ftp://ftp.bls.gov/pub/special.requests/cew/beta).

3. Household Income Distributions: The proportion of households with high or low income levels may also explain a portion of the share of air passengers that a county contributes to an airport. County household income distributions from the 5-year ACS estimates (2005-09) were attached to all survey records (http://www2.census.gov/acs2005_2009_5yr/summaryfile/).

4. Enplanement Information: Airport enplanements for 2008 from the T-100 data were attached to each survey record. It was hypothesized that airport enplanements would be an appropriate size variable that could explain the absolute number passengers accessing a particular airport.

Based on the observed difference in trip distributions between resident and visitors, separate models were developed for Residents and Non-Residents (Visitors). This segmentation matches with the segmentation that was achieved for the DB1B data (the DB1B data cannot be segmented by trip purpose due to the lack of information about trip purpose in those data).

Once the county level attributes were attached to each ground access survey record and the total number of residents and visitors were obtained for each airport-county pair, the dataset could be used for model estimation. The objective initially was to estimate linear regression models based on aggregate passengers accessing a particular airport from each surrounding county. The number of residents or visitors for each county-airport pair was the dependent variable and other county-level attributes such as distance, population, employment etc. were the explanatory variables. All the variables were transformed by applying the natural logarithm function. It was found that in addition to distance, population and employment, 2008 airport enplanements is a significant explanatory variable. **Table 3-9** shows the model estimation results.

Table 3-10 Ground access model coefficients

Variable	Residents	Non-residents
Log of airport trip distance	-1.300*** (-0.048)	-0.887*** (-0.03)
Log of county population	0.371*** (-0.025)	0.144*** (-0.039)
Log of 2008 enplanements	0.173*** (-0.023)	0.117*** (-0.015)
Log of county employment in hospitality sector		0.172*** (-0.042)
McFadden R-sq.	0.787	0.700
Likelihood-ratio	4228.48	2581.923
Log-likelihood	-1199.01	-1495.167
AIC	2406.02	3000.334
N	730	1,027

*Signif. codes: '***' = 0, '**' = 0.001, '*' = 0.01, '.' = 0.05*

It can be seen from the estimated coefficients that distance affects residents more negatively than non-residents. In case of non-residents, county employment in the hospitality sector is a significant variable; it is intuitively correct that visitors would egress the airport and go to areas with larger numbers of hotels/motels.

Forecasting tests were conducted using various model specifications before selecting the final model. Estimation was done using all surveys except one, which was then used to test the predictions against. The final models fared well against the hold out data. Other specifications that were tried but performed less well in forecasting or gave poorer model fit statistics included employment variables in sectors such as construction, manufacturing, wholesale, retail, management, and professional services. Squared and cubed values of distances were used as explanatory variables in other specifications to increase the penalty on airport trip distance. The proportion of households in certain high income categories in counties such as annual income greater than 100k or between 100k and 150k was also tested.

3.3.1.5 Application to Create OD Table

The following application sequence was used to produce the air OD table from the inputs of processed DB1B data, observed ground access data, and estimated ground access trip distribution models.

5. The first step involved the identification of catchment counties around an airport. This is a set of counties around an airport from which air passengers are likely to access that particular airport. A limit of 150 miles was set as the maximum distance that may be traveled by a passenger from his or her county of origin to the county in which an airport is present. This limit encompasses 98% of all access trips in the ground access survey data. The same threshold was applied to passengers landing at an airport to go to their destination counties. The distances between origin and destination counties and airport counties were obtained using highway distances from county-to-county skims produced by Oak Ridge National Laboratory (http://cta.ornl.gov/transnet/SkimTree.htm). Using this 150 mile threshold, some remote counties do not have access to any airports or just have access to just one or two airports. It is reasonable to assume that air passengers may travel to different airports for different trips based on trip distance and other itinerary constraints and therefore each county was provided access to at least the three closest airports irrespective of the distance.

6. The predictor variables from the ground access trip distribution model (2008 airport enplanements, county population, county employment etc.) were merged in to the airport-catchment county dataset.

7. The estimated resident and visitor linear regression models were then applied to all the airport-county pairs to forecast the absolute number of passengers for each catchment county to/from each airport.

8. For each airport, the share of access/egress passengers from the catchment counties was calculated. This was taken from the observed ground access survey data where that was available or otherwise from the estimates in step 3.

9. The DB1B data were formatted as an airport to airport table with the number of resident and visitors between each airport pair. A loop was then run on all origin airports in the DB1B data and the following steps were applied:

    a. Catchment county share information is merged in for both the origin and destination airports to create a county-to-county flows dataset.

    b. Unlikely (for air travel) county pairs are filtered out based on the circuity rule that travel time by air should not be greater than 110% of highway travel time between a pair of counties. Highway travel times are calculated based on highway distance from the county-to-county skims and assuming 60 mph average auto speed. Air travel times are calculated as the sum of origin county to origin airport county auto travel time, 60 minutes for check-in, airport to airport flight time, and destination airport county to destination county auto travel time. Airport to airport flight time is obtained from the OAG schedule data. For airport pairs not in OAG data, flight time is calculated using straight line distance between airports and 550 mph average airplane speed.

    c. After the elimination of unlikely county-to-county pairs, the access and egress catchment county shares are renormalized for origin and destination airports so that they sum to 100 percent.

    d. County to county passenger volumes are then calculated as the product of airport to airport passengers and access and egress county shares.

10. At the end of the loop over all origin airports, passenger trips were aggregated by origin and destination counties to obtain the final county-to-county air OD table.

11. The final air OD table was produced by aggregating origins and destinations from counties to TAF zones.

3.3.2 Results

3.3.2.1 Trip Length Frequencies

The trip length frequencies presented in this section demonstrate that the application process used to develop the air OD table successfully replicated the observed data.

Figure 3-14 shows the trip length distribution from the air OD table ("Model") compared with the observed trip length distribution from the DB1B data ("DB1B"). Since the development of the air OD table builds from the DB1B data and adds access and egress trips around the airports at each end of the trip, it is to be expected that the modeled county to county distances for the full trip from origin to destination would match closely the observed airport to airport distances, and that is shown by the figure. The overall shape of the distribution is indicative of the high volumes of air passengers in short to medium distance markets of up to 1,200 miles such as LA to the Bay Area in California and north east to Florida. Medium to long haul markets such as west coast to Midwest (e.g. LA to Chicago) and east coast to west coast that fall in the 1,200 to 2,700 mile range encompass lower but still significant passenger volumes.

Figure 3-15 shows a comparison of the airport access/egress trip length distribution from the air OD table ("Model") and the trip length distribution derived from the ground access surveys ("Survey"). The distributions are relatively close in shape. It should be noted that the distribution shown for the air OD table covers access and egress trip lengths for all airports in the U.S. while the survey distribution is based on trips to just some airports.

3.3.2.2 Results Summary

The air OD table for 2008 contains a total of 533 million one-way air trips, of which 442 million are domestic one-way air trips (including trips to, from, and within U.S. territories in the Caribbean and the Pacific) as shown in Table 3-10, which is expressed in terms of domestic round trips. The top 10 county pairs for air travel in 2008 are shown in **Table 3-11**, with intra-island travel in Hawaii providing three of the top five county pairs. Travel from LA County to counties in the Bay Area, Las Vegas, Hawaii, and New York completes the remainder of the top 10.

Table 3-10 Estimated Air Passenger Trips

Parameter	Air
1995 ATS	161,165,000
2008 Estimate	221,161,444
Share 1995	16.1%
Share 2008	13.4%
Total Growth (1995 to 2008)	37.2%
Annual Total Growth (1995 to 2008)	2.5%

Figure 3-15 Air Trip Length Distribution, Comparison of Air OD Table and DB1B Data

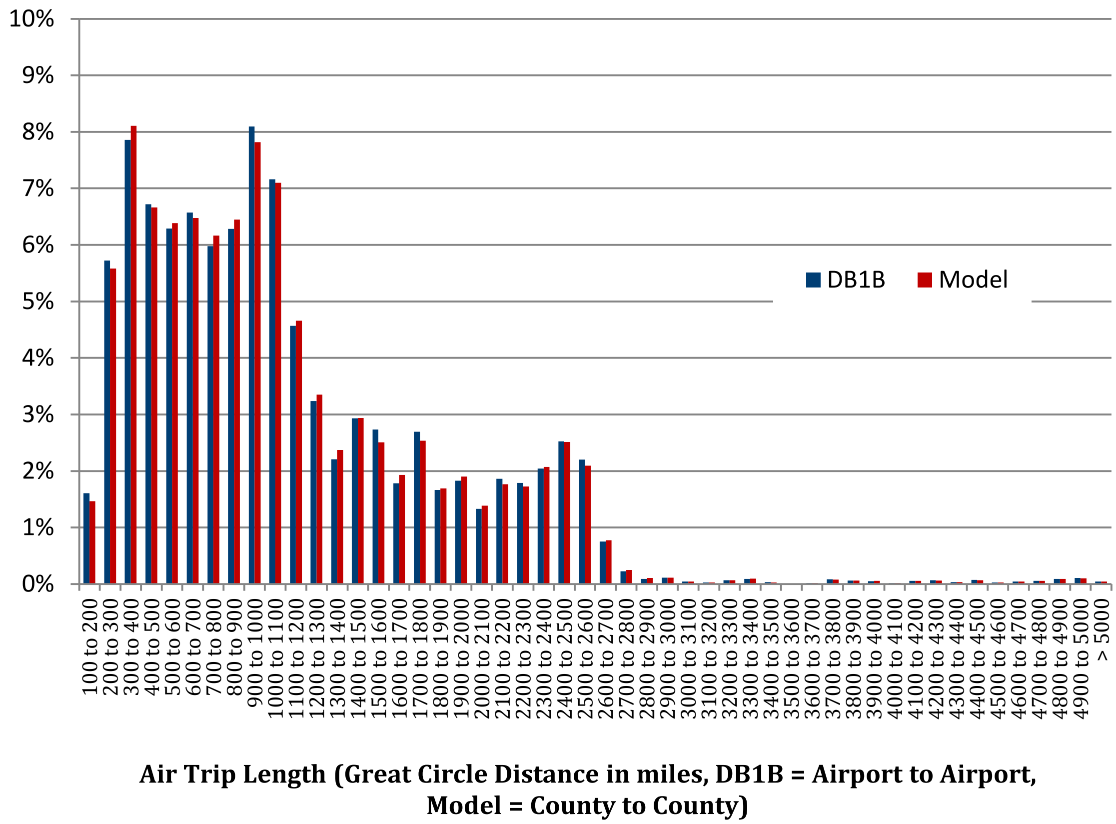


Figure 3-16 Airport Access Trip Length Frequency Distribution, Comparison of Air OD Table and Survey Data

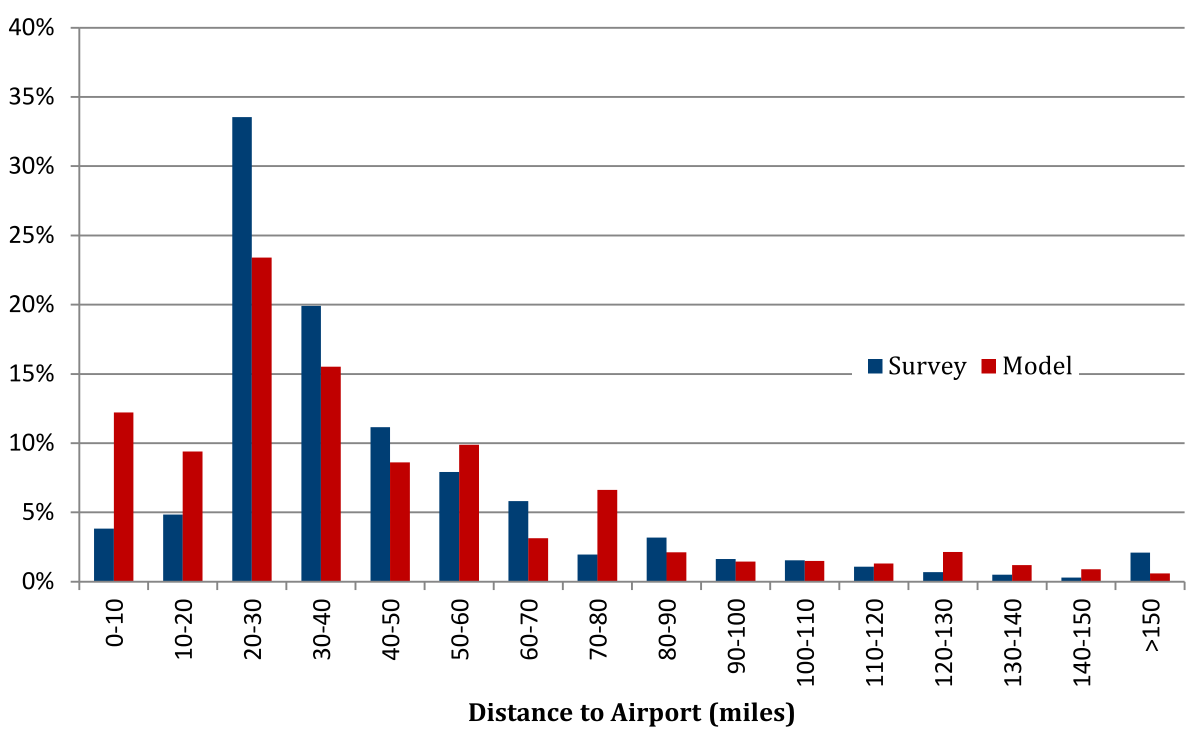


Table 3-11 Top 10 County Pairs for Air Travel in 2008

Origin County	Destination County	Air Trips
Honolulu, Hawaii	Hawaii, Hawaii	2,067,001
Maui, Hawaii	Honolulu, Hawaii	1,803,166
Clark, Nevada	Los Angeles, California	1,130,224
New York, New York	Los Angeles, California	1,072,251
Kauai, Hawaii	Honolulu, Hawaii	1,071,040
Santa Clara, California	Los Angeles, California	1,007,071
San Francisco, California	Los Angeles, California	984,966
New York, New York	Broward, Florida	914,086
Los Angeles, California	Alameda, California	857,364
Honolulu, Hawaii	Los Angeles, California	854,590

3.4 Rail

3.4.1 Approach

In general terms, the approach used to construct the 2008 rail OD table is identical to that used to construct the 2008 air OD table. The station to station OD data from Amtrak is used in place of the airport to airport DB1B data, and adjusted versions of the access/egress trip distribution models estimated using airport ground access survey data were used to allow complete trips from origin to boarding station to destination station to trip destination to be constructed.

The access/egress trip distribution models were adjusted for use in the development of the 2008 rail OD table by adjusting the trip length frequencies derived by applying the models to replicate the observed trip length frequencies for Amtrak station access from the CHSRA survey data. The resident model was applied (the Amtrak station to station OD data does not link outbound and return trips to allow resident and visitor ends of trips to be identified) with the distance coefficient multiplied by four to increase the importance of distance and reduce the average station access trip length.

The application process for developing the rail OD table is similar to that used for the air OD table, with some variation in the assumptions for removing unlikely trips: travel time by rail should not be greater than 300% of highway travel time between a pair of counties, where rail travel time is the sum of origin county to origin station county auto travel time, station to station travel time based on county to county highway distance from skims and an assumed speed of 60mph, and destination station county to destination county auto travel time.

3.4.2 Results and Validation

3.4.2.1 Trip Length Frequencies

The trip length frequencies presented in this section demonstrate that the application process used to develop the rail OD table successfully replicated the observed data.

Figure 3-17 shows the trip length distribution from the rail OD table (“Model”) compared with the observed trip length distribution from the Amtrak station to station OD data (“Station OD”). The match is very close. The overall shape of the distribution shows that most Amtrak trips are relatively short, in the less than 300 miles category. This is as expected given the dominance of travel in the north east corridor and southern California amongst Amtrak’s ridership.

Figure 3-18 shows a comparison of the station access/egress trip length distribution from the rail OD table ("Model") and the trip length distribution derived from the CHSRA station access surveys ("Survey"). The distributions are relatively close in shape. It should be noted that the distribution shown for the rail OD table covers access and egress trip lengths for all stations in the U.S. while the survey distribution is based on trips to just some California stations.

Figure 3-17 Rail Trip Length Distribution, Comparison of Rail OD Table and Amtrak OD Data

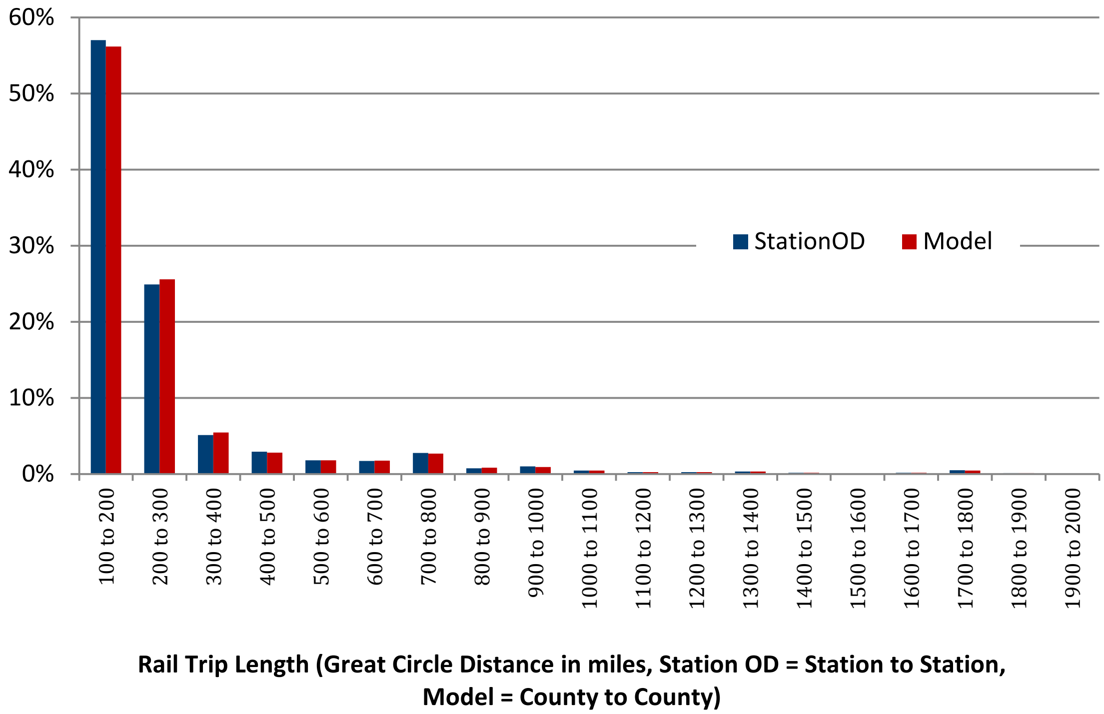
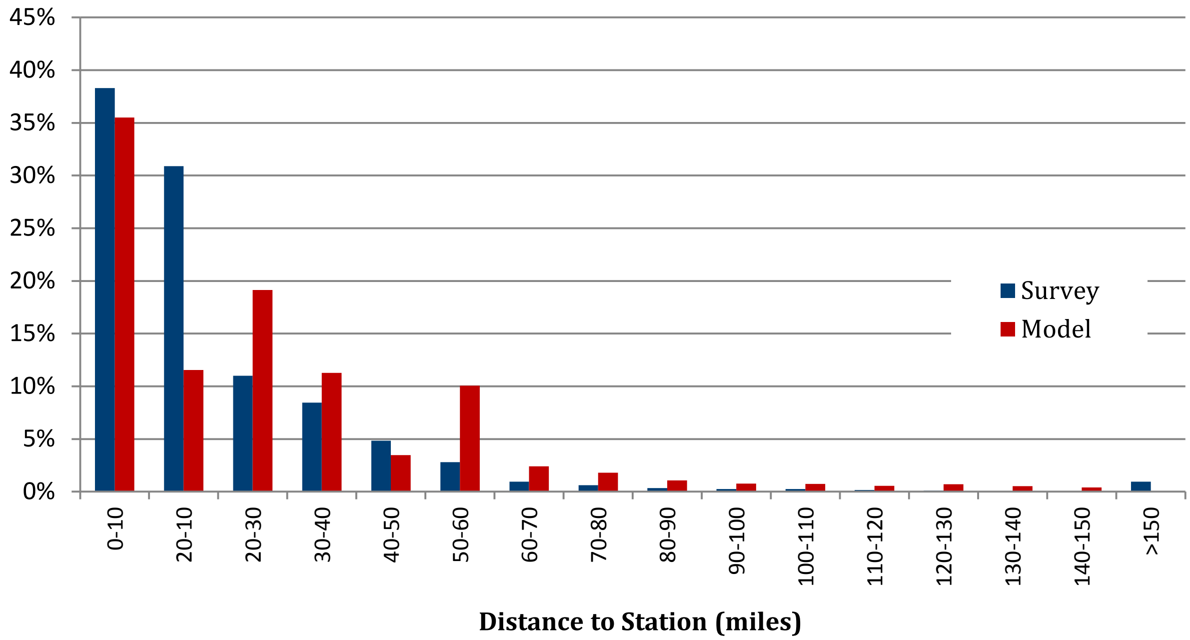


Figure 3-18 Station Access Trip Length Frequency Distribution, Comparison of Rail OD Table and Survey Data



3.4.2.2 Results Summary

The rail OD table for 2008 contains a total of 22 million one-way rail trips that exceed 100 miles, as shown in Table 3-11, which is expressed in terms of round trips.. The top 10 county pairs for rail travel are shown in **Table 3-12**, with travel to and from New York providing the top three county pairs. Travel in southern California, elsewhere in the northeast corridor, and between Chicago and Milwaukee completes the remainder of the top 10.

Table 3-12 Estimated Rail Passenger Trips

Parameter	Rail
1995 ATS	4,994,000
2008 Estimate	11,980,162
Share 1995	0.5%
Share 2008	0.7%
Total Growth (1995 to 2008)	140%
Annual Total Growth (1995 to 2008)	7.0%

Table 3-14 Top 10 County Pairs for Rail Travel in 2008

Origin County	Destination County	Rail Trips
New York, New York	District of Columbia	1,569,177
Philadelphia, Pennsylvania	New York, New York	1,475,847
New York, New York	Suffolk, Massachusetts	829,924
San Diego, California	Orange, California	821,853
Philadelphia, Pennsylvania	District of Columbia	633,860
San Diego, California	Los Angeles, California	424,327
New York, New York	Albany, New York	382,347
New York, New York	Baltimore City, Maryland	328,056
Waukesha, Wisconsin	Cook, Illinois	207,910
New York, New York	Providence County, Rhode Island	200,573

Section 4

Future Year Trip Table Development

The future year trip table was developed using Woods & Poole data. This data was available to the project team and allowed the project team to prepare the future year trip table. The project team estimated the 2040 trip tables using the equations developed in section 3 and grew it using the population and employment projected by Woods & Poole.

Table 4-1 shows the results of the growth and Table 4-2 shows the trip length distribution.

Table 4-1 Estimated Auto Passenger Trips, by Year

	Auto
1995 ATS	813,858,000
2008 Estimate	1,225,711,728
2040 Estimate	1,749,657,865
Auto Share 1995	81.3%
Auto Share 2008	74.3%
Auto Share 2040	72.9%
Total Growth (1995 to 2008)	50.6%
Annual Total Growth (1995 to 2008)	3.2%
Total Growth (2008 to 2040)	42.7%
Annual Total Growth (2008 to 2040)	1.1%

Table 4-2 2040 Trip Length Distribution

Distance Bin	Estimated 2008 Auto	1995 ATS Auto	2002/2003 Ohio Long Distance Survey	2008/2011 California Long Distance Survey		Estimated 2040 Auto
100 to 200 miles	52.6%	54.9%	59.7%	59.3%		50.5%
200 to 300 miles	18.8%	20.8%	15.2%	13.9%		18.0%
300 to 400 miles	10.1%	8.9%	9.7%	19.6%		9.8%
400 to 500 miles	6.2%	4.5%	5.5%	6.4%		5.9%
500 to 600 miles	4.3%	2.8%	3.6%	0.7%		4.1%
600 to 700 miles	3.1%	1.8%	1.9%	0.1%		3.0%
700 to 800 miles	2.2%	1.3%	1.8%	0.0%		2.2%
800 to 900 miles	1.6%	1.0%	1.1%	0.0%		1.7%
900 to 1000 miles	1.2%	0.7%	0.7%	0.0%		1.3%
More than 1000 miles	2.6%	3.3%	0.8%	0.0%		3.5%

4.1 Bus

The team applied the trip generation and destination choice models to 2040 county-level household and employment data to develop forecasts for those two years. Cross-border trips and visitor trips were assumed to grow at a rate consistent with population growth between 2008 and 2040. The resulting trip totals, shown in **Table 4-3**, forecast a slower rate of growth in bus travel between 2008 and 2040 (1.2% per year), than the 5.2% annual growth estimated for the 1995-2008 time period. There are 47.4 million bus passenger round-trips forecast for 2040, an increase of 38 % over 2008.

Table 4-3 Estimated Bus Passenger Trips, by Year

Parameter	Bus
1995 ATS	20,445,000
2008 Estimate	190,665,970
2040 Estimate	285,708,005
Share 1995	2.0%
Share 2008	11.6%
Share 2040	11.8%
Total Growth (1995 to 2008)	832.6%
Annual Total Growth (1995 to 2008)	19%
Total Growth (2008 to 2040)	49.8%
Annual Total Growth (2008 to 2040)	1.3%

To check the results of the trip distribution model, the team aggregated the estimated trips into 100 mile trip length categories, and counted the distribution of trips. The results from the survey as well as from the application of the model for 2008 and 2040 are shown in **Table 4-4**. In 1995, over 75% of all trips were 500 miles in length or less. The model results show a slightly lower distribution of trips under 500 miles in distance as compared to the ATS, and a slightly higher distribution of trips in the longer trip distance categories.

Table 4-4 Bus Passenger Trip Length Frequency Distribution, by Year

Distance Category	1995 ATS Bus	Estimated 2008 Bus	Estimated 2040 Bus
100 to 200 miles	41.9%	41.1%	42.1%
200 to 300 miles	21.1%	19.3%	17.0%
300 to 400 miles	12.7%	10.7%	10.8%
400 to 500 miles	5.8%	6.9%	6.7%
500 to 600 miles	4.7%	4.4%	4.6%
600 to 700 miles	2.8%	3.2%	3.3%
700 to 800 miles	2.1%	2.6%	2.6%
800 to 900 miles	1.5%	2.1%	2.2%
900 to 1000 miles	1.0%	1.8%	1.8%
More than 1000 miles	6.4%	8.0%	8.9%

4.2 Air

4.2.1 Approach

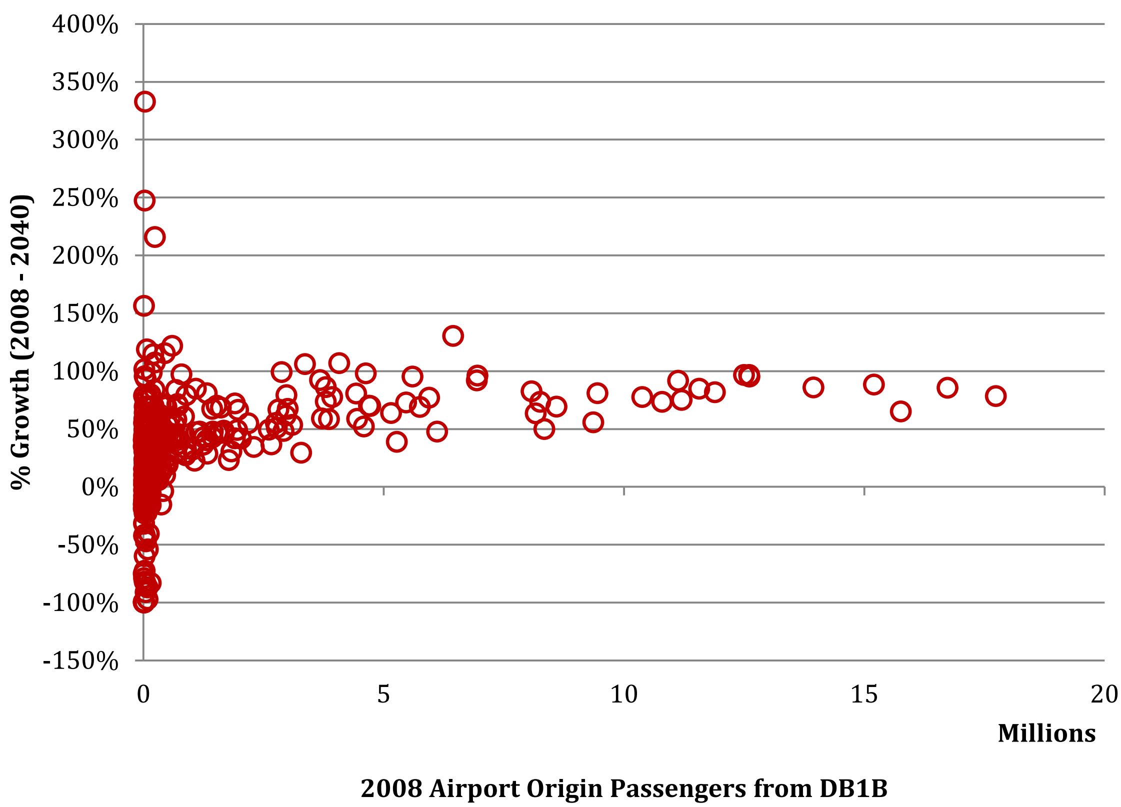
The approach used to develop the 2040 air OD table was to, where possible, update the input datasets from 2008 to 2040 to incorporate expected changes over time and reapply the same process used to produce the 2008 air OD table.

The 2008 airport to airport movements were taken from the DB1B data as described above. Future forecasts, for 2040, of these airport to airport movements are currently being developed by FAA. FAA provided access to domestic forecasts of airport to airport OD trips for the development of the 2040 air OD table. International OD trips were not included in the data provided by FAA and were instead estimated using the international enplanement growth included in the FAA published Terminal Area Forecasts (http://aspm.faa.gov/main/taf.asp),

In order to develop revised airport access and egress distributions, 2040 population, employment and airport enplanements forecasts were used to update the trip distributions estimated for 2008 using the trip distribution models. 2040 population and employment forecasts were obtained from Woods and Poole CEDDS, which has projections to 2040 of population and employment by industry data for all counties in the U.S. The FAA's Terminal Area Forecasts include enplanement forecasts for 2040 for all airports with an FAA tower.

Figure 4-1 shows a comparison of trips originating at each domestic airport in the 2008 DB1B with the forecasted growth to 2040 produced by FAA. The majority of larger airports are forecasted to have growth between 50% and 100% between 2008 and 2040, with a wider band of estimates for small airports

Figure 4-1 Growth by Airport, Comparing FAA 2040 OD data with 2008 DB1B data



4.2.2 Results and Validation

4.2.2.1 Trip Length Frequencies

Figure 4-2 shows the trip length distribution from the 2040 air OD table ("Model") compared with the trip length distribution from the FAA OD data ("FAA"). As expected. The two distributions are very similar, and also very similar to the 2008 distributions shown in Figure 3. As with the 2008 distributions, the overall shape of the distribution is indicative of the high volumes of air passengers in short to medium distance markets and the lower but still significant passenger volumes in medium to long haul markets.

Figure 4-2 Air Trip Length Distribution, Comparison of 2040 Air OD Table and FAA OD Data

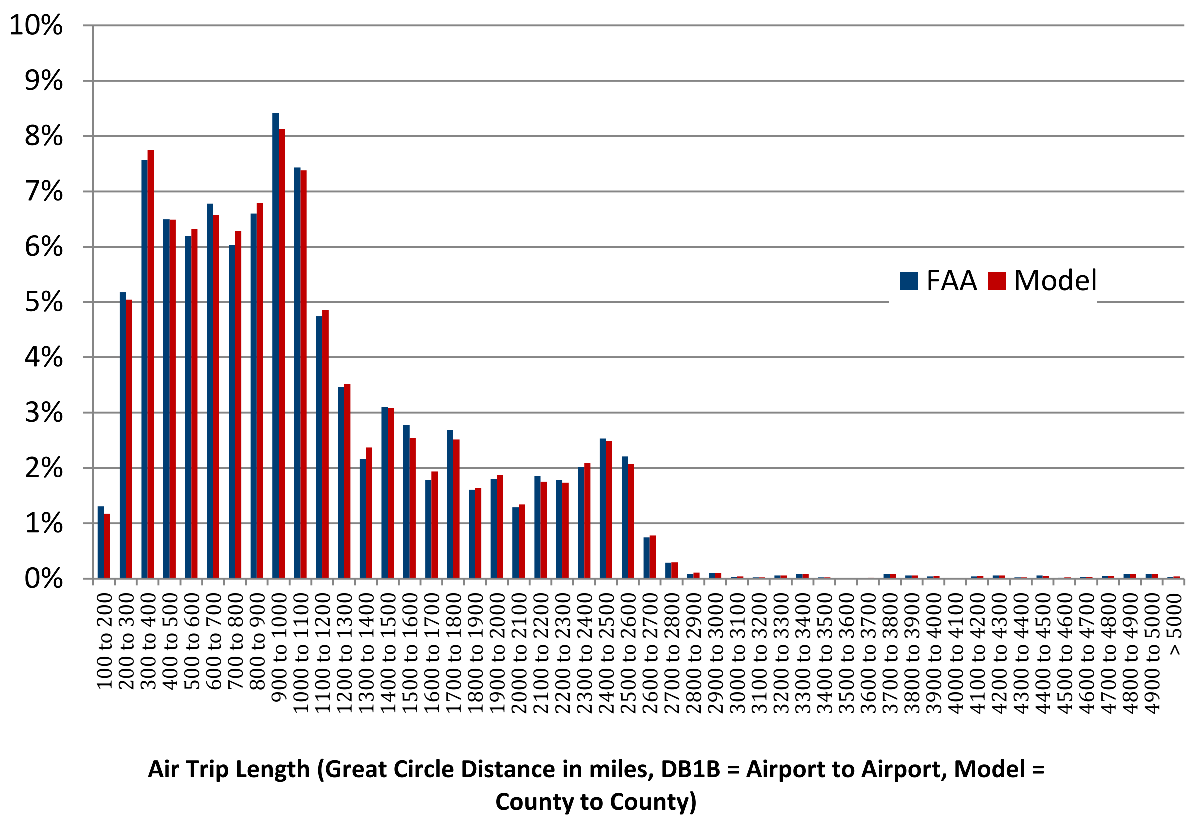


Figure 4-3 shows a comparison of the airport access/egress trip length distribution from the 2040 air OD table ("Model") and the trip length distribution derived from the ground access surveys ("Survey"). As was the case with the 2008 air OD table, the distributions are relatively close, with small changes between 2008 and 2040 caused by some redistribution of access and egress trip origins and destinations based on differing rates of growth in the catchment counties around each airport.

4.2.2.2 Results Summary

The air OD table for 2040 contains a total of 926 million air trips, growth of 74% from the 533 million air trips in 2008. There are 742 million domestic air trips, growth of 68% from the 442 million in 2008 (domestic air trips include trips to, from, and within U.S. territories in the Caribbean and the Pacific). International trips grow more quickly, increasing to 184 million air trips, which is growth of 98% from the 93 million in 2008. A summary of the 2040 air trips is shown in Table 4-5, which is expressed in terms of domestic round trips.

The top 10 county pairs for air travel in 2040 are shown in **Table 4-6**, and are similar to the top 10 county pairs from 2008. Intra-island travel in Hawaii still provides three of the top ten county pairs, but travel from LA County to counties in the Bay Area, Las Vegas, Chicago, and New York grows slightly more quickly. Travel from New York to Chicago and Broward County, Florida completes the top 10.

Figure 4-3 2040 Airport Access Trip Length Distribution, Comparison of Air OD Table and Survey Data

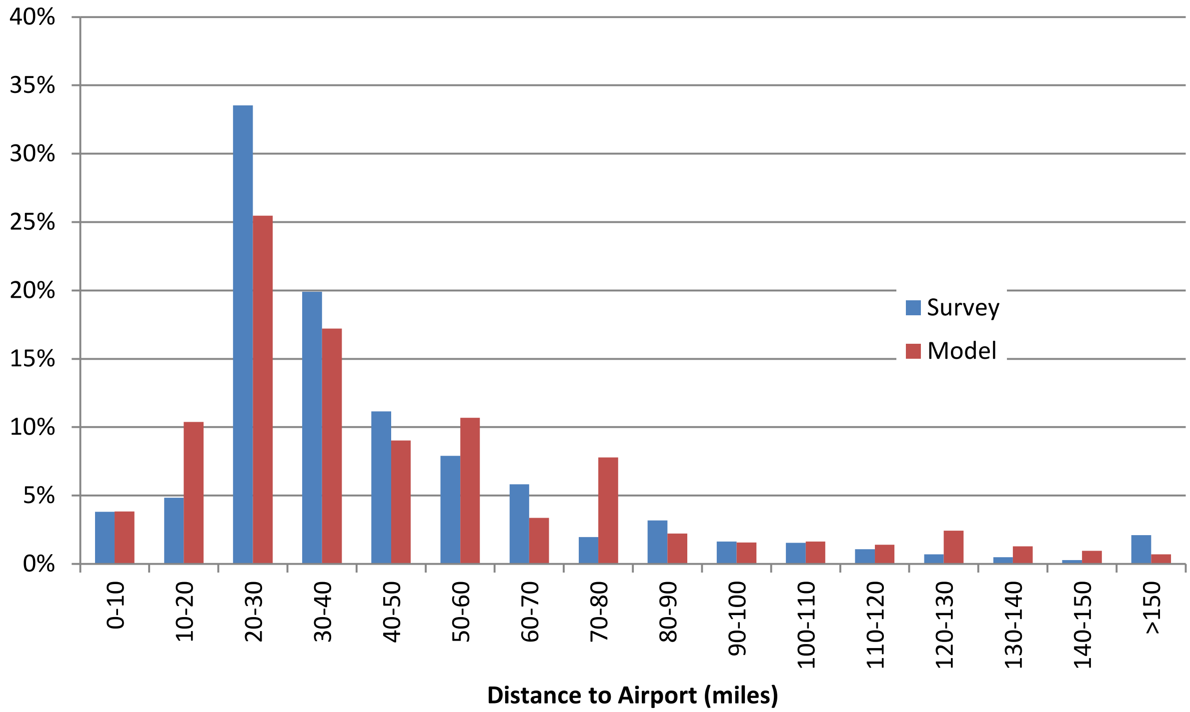


Table 4-5 Estimated Air Passenger Trips in 2040

Parameter	Air
1995 ATS	161,165,000
2008 Estimate	221,161,444
2040 Estimate	370,826,826
Share 1995	16%
Share 2008	13%
Share 2040	15%
Total Growth (1995 to 2008)	37%
Annual Total Growth (1995 to 2008)	2.5%
Total Growth (2008 to 2040)	68%
Annual Total Growth (2008 to 2040)	1.6%

Table 4-6: Top 10 County Pairs for Air Travel in 2040

Origin County	Destination County	Air Trips
Honolulu, Hawaii	Hawaii, Hawaii	2,937,380
Clark, Nevada	Los Angeles, California	2,193,684
Maui, Hawaii	Honolulu, Hawaii	2,080,910
New York, New York	Los Angeles, California	1,888,749
San Francisco, California	Los Angeles, California	1,680,853
New York, New York	Broward, Florida	1,651,397
Santa Clara, California	Los Angeles, California	1,531,600
Cook, Illinois	Los Angeles, California	1,446,101
New York, New York	Cook, Illinois	1,394,278
Kauai, Hawaii	Honolulu, Hawaii	1,335,970

4.3 Rail

4.3.1 Approach

The approach used to develop the 2040 rail OD table is generally the same as that used to develop the 2040 air OD table except that there are no publicly available future forecasts of rail activity that are comparable to the 2040 forecasts of airport to airport trips developed by FAA. Instead, a relatively simple growth factor approach based on forecasts of population and employment growth was used to grow the existing rail demand. The approach embodies the assumption that rail service supply would increase to meet the demand but that no large rail infrastructure or service investments would take place that might cause demand growth over and above that expected purely based on population and employment growth. For example, no new high speed rail service was assumed to be introduced.

A growth factor for each station to station OD pair was calculated using population and employment growth in catchment area around each station:

$$GF_{ij} = \frac{P_{i,2040} + P_{j,2040} + E_{i,2040} + E_{j,2040}}{P_{i,2008} + P_{j,2008} + E_{i,2008} + E_{j,2008}}$$

GF_{ij} – Growth factor for station OD ij

$P_{i,yyyy}$ – Catchment population for station i in year yyyy

$E_{i,yyyy}$ – Catchment employment for station i in year yyyy

The catchment areas were those used for access trip distribution model application in the development of the 200 rail OD table. The 2008 county population and employment data were those described above, collected for the application of the access trip distribution model application. The 2040 forecasts of population and employment by county were from Woods and Poole CEDDS data.

The growth factors were used to grow the Amtrak station to station OD data from observed 2008 values to forecast 2040 values. Revised station access trip distributions were developed using access trip distribution models with the 2040 forecasts of population and employment by county. As with the development of the 2008 rail OD table, a rule was used (with the same assumptions as 2008) to remove unlikely trips between counties based on a comparison with the auto travel time those counties.

4.3.2 Results and Validation

4.3.2.1 Trip Length Frequencies

Figure 4-4 shows the trip length distribution from the rail OD table ("Model") compared with the observed trip length distribution from the Amtrak station to station OD data ("Station OD"). As with the 2008 rail OD table, the match is very close, with only slight changes caused by the growth of the OD data from 2008 to 2040.

Figure 4-5 shows a comparison of the station access/egress trip length distribution from the 2040 rail OD table ("Model") and the trip length distribution derived from the CHSRA station access surveys ("Survey"). As with the 2008 comparison, the distributions are a relatively close match.

Figure 4-4 Rail Trip Length Distribution, Comparison of 2040 Rail OD Table and Amtrak OD Data

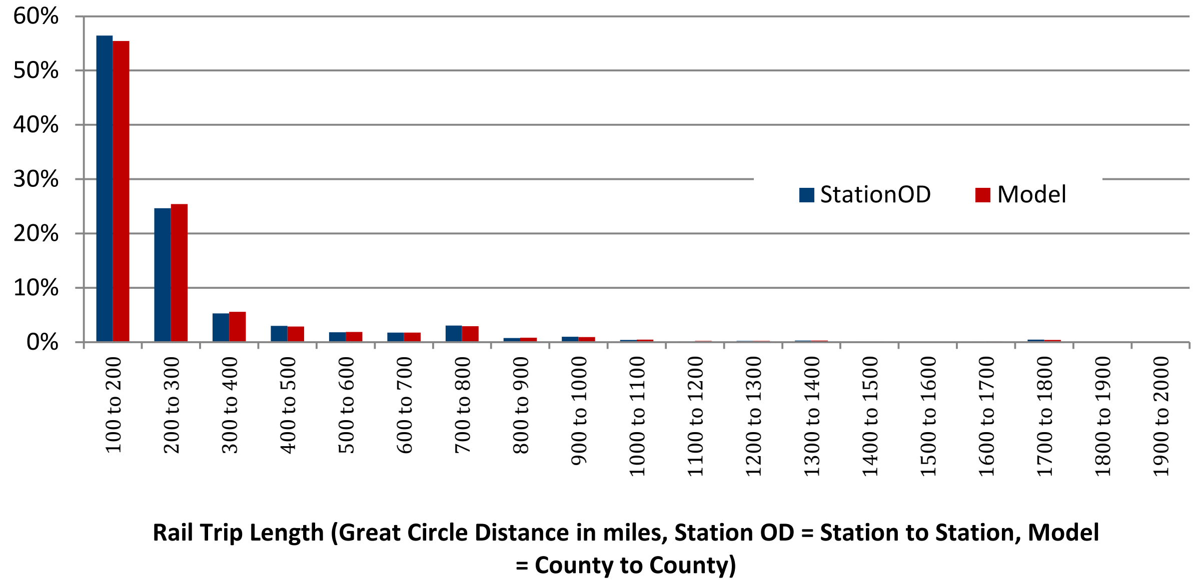
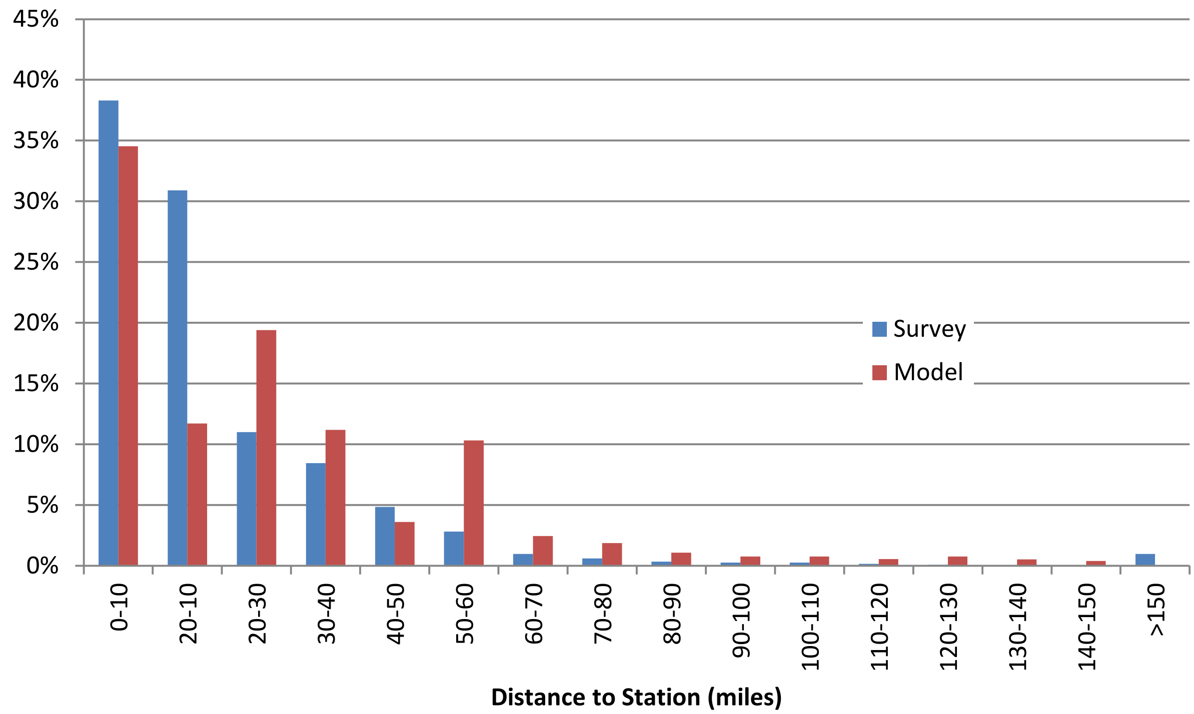


Figure 4-5 Station Access Trip Length Distribution, Comparison of 2040 Rail OD Table and Survey Data



4.3.2.2 Results Summary

The rail OD table for 2040 contains a total of 35 million rail trips, growth of 45% from the 24 million rail trips in 2008. A summary of the 2040 air trips is shown in Table 4-7, which is expressed in terms of domestic round trips. The top 10 county pairs for rail travel in 2040 are shown in **Table 4-8**, and are the same as the top 10 county pairs from 2008. As in 2008, travel to and from New York, travel in southern California, travel elsewhere in the northeast corridor, and travel between Chicago and Milwaukee comprises the top 10 county pairs.

Table 4-7 Estimated Rail Passenger Trips in 2040

Parameter	Rail
1995 ATS	4,994,000
2008 Estimate	11,980,162
2040 Estimate	17,420,775
Share 1995	0.5%
Share 2008	0.7%
Share 2040	0.7%
Total Growth (1995 to 2008)	140%
Annual Total Growth (1995 to 2008)	7%
Total Growth (2008 to 2040)	45%
Annual Total Growth (2008 to 2040)	1.2%

Table 4-8 Top 10 County Pairs for Rail Travel in 2040

Origin County	Destination County	Rail Trips
New York, New York	District of Columbia	2,260,704
Philadelphia, Pennsylvania	New York, New York	1,994,664
San Diego, California	Orange, California	1,313,332
New York, New York	Suffolk, Massachusetts	1,125,988
Philadelphia, Pennsylvania	District of Columbia	920,750
San Diego, California	Los Angeles, California	589,510
New York, New York	Albany, New York	510,673
New York, New York	Baltimore City, Maryland	450,667
Waukesha, Wisconsin	Cook, Illinois	283,734
New York, New York	Providence County, Rhode Island	270,615

4.4 Modal Comparisons

Table 4-7 shows the modal comparisons and indicates that the auto and bus trip estimated data perform well in comparison to the available benchmarks.

Table 4-9 Modal Comparisons

	Auto	Air	Rail	Bus
1995 ATS	813,858,000	161,165,000	4,994,000	20,445,000
2008 Estimate	1,225,711,728	221,161,444	11,980,162	190,665,970
2040 Estimate	1,749,657,865	370,826,826	17,420,775	285,708,005
Share 1995	81.3%	16.1%	0.5%	2.0%
Share 2008	74.3%	13.4%	0.7%	11.6%
Share 2040	72.2%	15.3%	0.7%	11.8%
Total Growth (1995 to 2008)	50.6%	37.2%	139.9%	832.6%
Annual Total Growth (1995 to 2008)	3.2%	2.5%	7.0%	18.7%
Total Growth (2008 to 2040)	42.7%	67.7%	45.4%	49.8%
Annual Total Growth (2008 to 2040)	1.1%	1.6%	1.2%	1.3%

Section 5

Conversion of Auto Person to Vehicle Trips

In order to release the data from Person to Vehicle Trips, the 1995 ATS auto occupancy factors were calculated. These were done by ensuring that duplicates were removed from households traveling together and ensuring that consistent estimates were obtained. **Table 5-1** shows the auto occupancy factors used for conversion of person auto trips to vehicle trips. The table also shows comparisons with the 2001 NHTS data. As can be seen in the table, the overall auto occupancy rates match pretty close to each other showing a consistency in travel patterns and this offers a measure of reassurance when growing the 1995 ATS data to 2008.

The auto person trip tables are converted to vehicle trip tables by dividing the person trip tables by the auto occupancy factor. **Table 5-2** shows the person and vehicle trips.

Table 5-1 Auto Occupancy Factors

Trip Purpose	1995 ATS	2001 NHTS
Business	1.88	1.43
Non Business	2.92	2.8
Overall	2.97	2.38

Source: NCHRP 8-84 Long Distance and Rural Travel Transferable Parameters for Statewide Travel Forecasting Models

Table 5-2 Annual Person and Vehicle Trips (Round Trips)

	Person Trips	Vehicle Trips
1995 ATS	813,858,000	274,026,263
2008 Estimate	1,225,711,728	412,697,552
2040 Estimate	1,749,657,865	589,110,392

Section 6

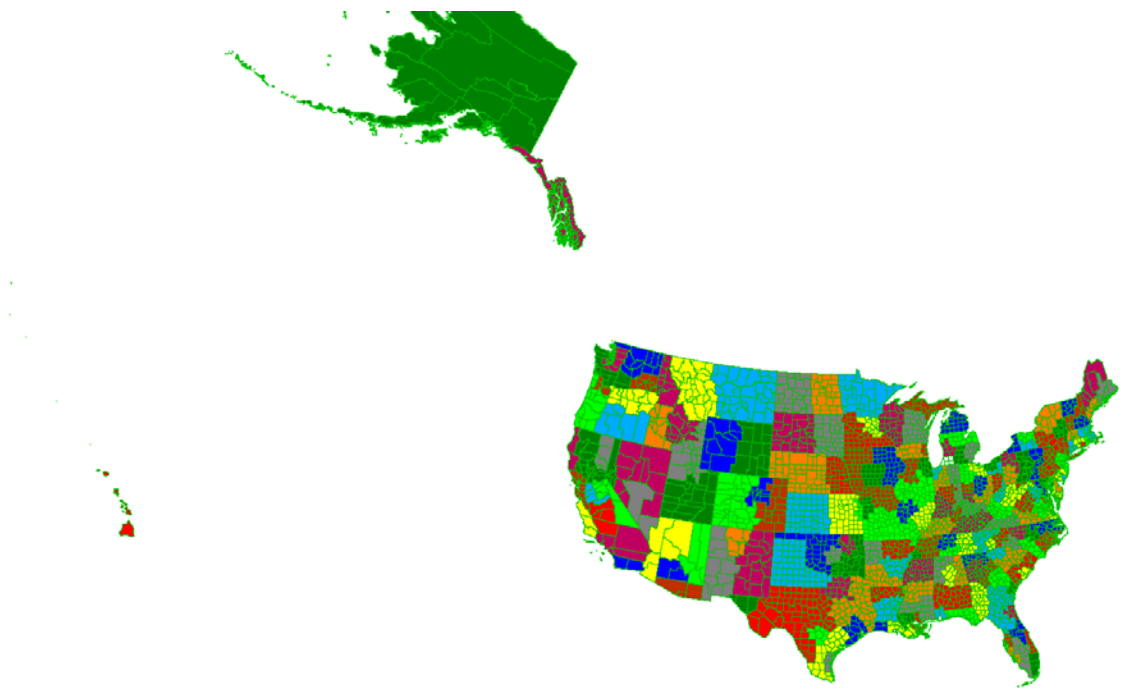
Geography of Data Release

In order to ensure that small geography disclosure requirements met and provide a convenient means of data analysis, the geography of the data release is aggregated into groups of counties following this rule:

- No Traveler Analysis Framework (TAF) zone will cross state borders;
- If a state has multiple Freight Analysis Framework (FAF) zones, then the TAF zone will have the same geography as the FAF zone;
- For FAF zones which are not contiguous, new TAF zones are created resulting in contiguous TAF zones; and
- Where states have a single FAF zone, multiple FAF zones are created following rules of contiguity, and split in an east-west direction. This is especially true for the large sparsely populated states in the Mountain West and the Midwest.

Following these rules, 213 TAF zones were created and **Figure 6-1** shows the zones. Hawaii is a considered a single zone.

Figure 6-1 Proposed TAF Zones



Section 7

Caveats For Data Usage and Next Steps

The Traveler Analysis Framework is a multi-year effort intended to create a multi-model analysis capability for long-distance passenger travel. This version 1.0 data release is the first step in this effort. As data sources for the development of these travel estimates improve, their accuracy will improve as well.

7.1 Data Sources

The air and rail travel estimates should be considered to be of higher reliability than the auto and bus travel estimates. While the air travel estimates are based on actual ridership data obtained from the Federal Aviation Administration, and the rail estimates from AMTRAK and the Federal Railroad Administration, the auto and bus estimates are largely based on 1995 household travel survey.

- **Auto trips**: The primary source for developing the auto trip estimates are the 1995 ATS, the 2001 NHTS, the 2008 American Community Survey and forecast socio-economic data from Woods and Poole. The primary validation sources were long-distance passenger surveys from the States of Ohio and California. No network-based volume data were available for validation. The team has done its best to account for shifting consumer preferences, the impact of changing fuel prices, changing growth patterns and other factors which have influenced long-distance travel since 1995, especially at the national level. The data should be used with caution, especially at small geographic levels or in attempting to disaggregate the data.

- **Bus trips**: The primary source for developing the bus trip estimates are data from 2010 and 2012 ABA motor coach census reports and member surveys, the 1995 ATS, the 2001 NHTS, the 2008 American Community Survey, Russell's motor coach guide, published research on curbside bus services, the 2010 U.S. Census and forecast socio-economic data from Woods and Poole. The primary validation source was the ATS itself along with the ABA survey. No network-based volume data were available for validation. The team has done its best to account for shifting consumer preferences, the shift of industry services to the curbside model, the impact of changing fuel prices, changing growth patterns and other factors which have influenced long-distance travel. The team recognizes the limited ability of trip distribution forecasting techniques based on the ATS to capture adequately recent phenomena such as the high growth in demand for curbside bus service, particularly in urban markets. The data should be used with caution, especially at small geographic levels or in attempting to disaggregate the data.