PAPER

# Identifying Passenger Corridors on the U.S. Highway System Using ATS Data

**Shih-Miao Chin**
**Ho-Ling Hwang**
*Oak Ridge National Laboratory*
*Center for Transportation Analysis*

The 1995 American Travel Survey (ATS), conducted by the Bureau of Transportation Statistics (BTS), U.S. Department of Transportation (USDOT), represents the most comprehensive survey since 1977 on the long-distance travel (100 mi or more one-way) of persons living in the United States. Approximately 80,000 households were surveyed to collect information related to the characteristics of households and trips they made during 1995.

The ATS data provides detailed person and household long-distance travel information not only on a national basis, but also at state and metropolitan area levels. Data include trip origin, trip destination, travel purpose, mode of transportation, and duration of the trip, as well as demographic information about the traveler. One of the main objectives of the ATS was to provide policymakers with more accurate and comprehensive information about the travel of residents in the United States.

The ATS data reveals that U.S. households took nearly 685 million long-distance trips in 1995. Over 95 percent of those trips, a total of 1 billion person-trips, were to destinations within the United States. These trips, whether for business or pleasure, produced nearly 827 billion person-miles on our nation's transportation systems. Only about 4 percent of total trips taken by U.S. residents in 1995 were to destinations outside of the United States. Approximately half of the 41 million person-trips made to foreign destinations were to the neighboring countries of Canada (28 percent) and Mexico (23 percent).

Personal-use vehicles (PUV), which include car, van, truck, motorcycle, and recreational vehicles, were the dominant mode of transportation used for long-distance trips. They accounted for over 81 percent of the total person-trips and 77 percent of the total household trips in 1995. This result reflects the widespread availability, convenience, and the relatively low operating costs of automobiles in the United States.

In addition to the comprehensive and accurate coverage of long-distance trip characteristics, the ATS data also include detailed geographic information. This information provides the transportation analyst with a unique opportunity to examine national inter-city highway travel patterns. These studies can support transportation planners in identifying inter-city highway corridors utilized by travelers. Together with other data sources, the ATS data allow transportation analysts to gain a better understanding about the operation and performance characteristics of these passenger inter-city highway corridors.

Under Title 1A, Section 1118 of the recently passed Transportation Equity Act for the 21st Century (TEA-21), the USDOT is commissioned to establish and implement a

National Corridor Planning and Development Program. Under this program, USDOT is required to make funding allocations to states and metropolitan planning organizations (MPOs) for coordinated planning, design, and construction of corridors of national significance, economic growth, and international or interregional trade. Identification and understanding of national inter-city highway passenger travel corridors can contribute toward the completion of the National Corridor Planning and Development Program.

To understand the operational characteristics of inter-city passenger corridors is essential for the management of existing transportation facilities and for the planning of future investments. Sensible planning and development of transportation corridors can improve the mobility and accessibility to existing land use, mitigate unintended environmental consequence, as well as promote economic growth for cities and regions along the corridors. The planning and development of transportation corridors also provides a framework that enables city and regional planners or policymakers to precede, stimulate, and guide future regional land use along the corridors. Furthermore, by examining the operation and performance of the national inter-city highway passenger travel corridors, policymakers can be more informed in investing in new technologies. For example, this information could help to identify heavily traveled highway inter-city corridors where construction of a magnetic levitation railroad would provide better flexibility, better intermodal coordination, and a more efficient transportation system.

## OBJECTIVE

The objective of this study is to describe passenger long-distance travel patterns on the U.S. highway system. Based on the geographic travel patterns, major highway transportation corridors can be identified. These corridors are identified in terms of household trips (vehicle trips) and person-trips. The weighted average household trip (vehicle trip) length and the weighted average person-trip length also are provided. Information on three different types of vehicle trips presented in this paper are

1. Domestic PUV trips;
2. Domestic bus trips; and
3. Highway trips from the United States to Canada and Mexico (combined PUV and bus).

The resulting vehicle traffic and person-trip flows are presented as flow maps to illustrate the inter-city long-distance highway travel patterns within the United States. For domestic trips by PUV, related information is further categorized by trip purpose and household income levels. Results tabulated for the top 45 inter-city (i.e., inter-metropolitan) corridors are presented in the Appendix of this paper.

## BACKGROUND

Several efforts to identify and study the highway as well as rail freight corridors, with respect to trade with Canada and Mexico, have been conducted recently. McCray (1998) identified and examined the locations of U.S.–Mexico trade transportation corridors for both highway and railroad. In a 1999 report, McCray and Harrision (1999) studied trucks involved in international trade as part of the North America Free Trade Agreement on U.S. highway corridors. They investigated and identified highway corridors created by the flow of trucks, which facilitate the transportation of U.S.–Mexico and U.S.–Canada goods, between all U.S. customs ports along the borders of the United States and the dominant cities in the United States.

Another study by Rico et al. (1998) examined freight land transportation in Mexico for both highway and railroad. Information related to the modal shares between truck and rail, origin and destination of commodity flows, as well as major truck and rail freight corridors and their characteristics were identified. Possible extension of these corridors to the highway and railroad corridors in the United States that are important to the bilateral trade were also discussed.

The Eastern Border Transportation Coalition (EBTC) is currently conducting a study to review existing, as well as projected, freight and person movements crossing the eastern border between the United States and Canada. EBTC is an advisory group that was organized to represent transportation interests along the eastern U.S.–Canada border. Its membership includes five state transportation departments (Maine, Massachusetts, Michigan, New York, and Vermont); three provincial ministries of transportation (New Brunswick, Ontario, and Quebec); and the MPOs in Detroit, Michigan, and Buffalo, New York.

On a smaller scale, Krishnan and Hancock (1998) studied freight flows in Massachusetts using data from the 1993 Commodity Flow Survey. In their work, a quantitative methodology for estimating freight traffic on major corridors in Massachusetts was developed.

These studies were mostly conducted for the purpose of understanding the economic importance of the border. They searched for ways to help private and public agencies to improve border efficiency and to plan for the future, especially with respect to trades and freight flows. However, little effort has been devoted to identification of PUV and bus traffic corridors within the United States.

## Oak Ridge National Highway Network

In order to flow the long-distance passenger traffic, the Oak Ridge National Highway Network was used in this study (Peterson, 1997). The Oak Ridge National Highway Network is a geographically based analytic network of major highways in the United States. It was developed by Oak Ridge National Laboratory (ORNL) to support analyses of a wide variety of highway transportation studies that require the use of a highway network. Presently, the network contains approximately 400,000 centerline mi of roadway and, with varying degree of accuracy, shows the location of these roads and their characteristics. Although it includes many lower-class roads, it could be considered fundamentally as an arterial network.

The Oak Ridge National Highway Network is based on the 1:2,000,000 USGA Digital Line Graphs (DLG). The locational data were edge matched, scissored into state subnetworks, and element identifications were assigned. An initial clean-up was made through every state to check and add sign routes as well as to check the distances. The most serious topological problems identified were also resolved at this phase. In the second editing phase, many new links were added by ORNL based on user requirements. The entire Federal-Aid Primary system was also included during this phase. The third phase included the incorporation of 100k DLG alignments to improve geographic accuracy to 100 m, the incorporation of all urban principal arterials, and the reclassification of roadway functional classes.

### Metropolitan Statistics Areas and Primary Metropolitan Statistics Areas

The term inter-city passenger travel has been widely used without a clear definition on which cities should be included, and what the exact boundary of these cities should be. For the purpose of identifying inter-city highway corridors in this study, the metropolitan areas defined by the Office of Management and Budget (OMB, 1998) following the official standards published in the Federal Register (55 FR 12154–12160) on March 30, 1990, were used in this study. Under this definition, metropolitan areas are defined as metropolitan statistical areas (MSAs), consolidated metropolitan statistical areas (CMSAs), and primary metropolitan statistical areas (PMSAs). These areas are defined in terms of entire counties, except in the six New England states where they are defined in terms of cities and towns. New England county metropolitan areas are an alternative set of county-based areas defined for New England states. CMSAs are composed of collections of MSAs and/or PMSAs. Effective June 30, 1998, there were 259 MSAs, 19 CMSAs, and 76 PMSAs, including 3 MSAs, 1 CMSA, and 3 PMSAs in Puerto Rico. For the purpose of this study, only MSAs and PMSAs were used as the metropolitan areas.

The MSA/PMSA geographic database (1:100,000 base scale) which describes their boundaries were selected from the National Transportation Atlas Databases compact disc (NTAD97 CD–ROM, BTS, 1997). The NTAD97 CD–ROM contains a set of national geographic databases of transportation facilities published by the BTS to support research, analysis, and decision making across all modes of transportation.

## METHODOLOGY

There are four major steps in identifying inter-metropolitan highway corridors. In the first step, ATS highway trips were assigned to the Oak Ridge National Highway Network based on the minimum impedance path. Second, based on the network links' geographic relationship with respect to metropolitan area boundaries, all network links were clustered either to metropolitan centroids or to a set-a-side non-metropolitan area. Thus, the relationships between the ORNL highway network link identification number and metropolitan area identification numbers was established. The ORNL highway links can thus be expressed in terms of one or more ordered metropolitan identification numbers. Third, from this link-metropolitan area relationship, the ATS trip routes were collapsed from the ORNL highway network to inter-metropolitan highway corridors. And finally, the ATS traffic assigned to the ORNL highway network in the first step was aggregated to the inter-metropolitan highway corridors. This methodology carried detailed information throughout its calculation process and aggregated this information to a simplified matchstick inter-metropolitan highway corridor network in the final step. These steps are discussed in detail below.

## ASSIGNMENT OF ATS TRIPS TO THE OAK RIDGE NATIONAL HIGHWAY NETWORK

ATS trips using highway as their mode of transportation were routed between the highway network nodes closest to the population centroids of the origin and destination zip codes. A shortest path algorithm was used to determine the minimum impedance route between the origin and destination of a trip on a mathematical representation of the highway network. Impedance is a relative measure of the level of resistance or deterrence to traffic flow on a particular link in the highway network. Trip impedance for PUVs, as well as for bus, was calculated as a function of travel time and was designed to simulate the most likely choice of route. Each link's impedance was related to the distance and modified by the physical and functional characteristics of the road relevant to highway passenger traffic (i.e., whether the road is within an urban area, divided, access controlled, subject to congestion, type of the road, number of lanes, and other related information). The impedance function does not account for all traffic conditions. For example, the algorithm does not split traffic on an urban beltway circling urban areas, instead, it always selects the shortest impedance path. In reality, some portion of the vehicles may elect to take a slightly longer path in order to avoid local traffic congestion. Although this may affect the distance calculations, and consequently the estimate of average trip length, effects on the inter-metropolitan highway corridor flows should not be significant.

### Clustering of Nodes to Metropolitan Centroids

For each link in the Oak Ridge National Highway Network, there is a polyline of longitude and latitude pairs of coordinates which approximates the geographic location of the roadway segment. For each MSA or PMSA, there is a polygon of longitude and latitude pairs of coordinates that represents the geographic boundary of the metropolitan area. A computational algorithm was developed to determine the network link's geographic relationship with respect to the metropolitan boundary.

A network link can only be

1. Completely outside any metropolitan area,
2. Completely enclosed within a metropolitan area, or
3. Intersecting one or more metropolitan areas.

The MSA and PMSA Federal Information Processing Standards code was used as the metropolitan centroid identification number. Number zero was assigned to areas outside metropolitan areas. Based on the above-mentioned algorithm, a set of one or more metropolitan identification numbers was generated for each link on the network. For a link that falls completely outside any metropolitan area, its metropolitan identification number was set to zero. When a link is completely enclosed within a given metropolitan area, its metropolitan identification number was assigned with the MSA or PMSA code for the given area. Similarly, when the link intersects one or more metropolitan areas, an ordered set of metropolitan identification numbers was generated from the MSA or PMSA codes of those metropolitan areas. For example, link ID 05004920 in Arkansas with beginning node number 0500146 and ending node number 0500142 has a new set of metropolitan identification numbers 4400, 0, 6240. This means that link 05004920 started from Little Rock-North Little Rock metropolitan area (4400), went through a non-metropolitan area (0), and then ended in the Pine Bluff metropolitan area (6240). Using this new sequencing of metropolitan area codes and zeros to represent network links, network nodes can be logically clustered to metropolitan centroids and node zero (i.e., for non-MSA and non-PMSA area).

### Collapsing of ATS Trips from the Oak Ridge Highway Network Links into the Inter-Metropolitan Highway Corridors

Based on trip assignments, all ATS trip routes were described by an ordered list of links representing the trip from its origin node to destination node. By applying the algorithm as discussed in the above step, the network link’s geographic relationship with respect to the metropolitan boundaries was determined. Consequently, each network link was associated with one or more metropolitan identification numbers. Based on the link list of a particular trip route, a list of metropolitan identification numbers associated with the trip were then generated. Since frequently consecutive links are totally enclosed within the same metropolitan area, duplicate metropolitan identification numbers often appear in the metropolitan number list. By eliminating these duplicate metropolitan identification numbers from the list, a given trip can be traced from one metropolitan area to another. Following this process, all ATS highway trip routes originally assigned on the Oak Ridge Highway Network were collapsed into inter-metropolitan highway corridors.

### Accumulating ATS Trip Statistics on Inter-Metropolitan Highway Corridors

From step 1 of this process, statistics such as the number of household trips (vehicle trips), the number of person-trips, and the average trip length weighted by number of household trips (vehicle trips), as well as by number of person-trips, were accumulated to the inter-metropolitan level. It should be noted that trip length was estimated based on the distance of the shortest impedance path on the Oak Ridge Highway Network not on the shorter distance defined by the simplified inter-metropolitan corridor network.

## TRIPS NOT INCLUDED IN THE IDENTIFIED INTER-METROPOLITAN CORRIDORS

Although the ATS provides the most comprehensive and accurate data ever available on long-distance travel, there are some data gaps. First, the ATS lacks information on foreign visitors traveling in the United States during 1995 because the sampling frame included only U.S. households. Second, the ATS excludes trips under 100 mi one-way. As a result, flows between places less than 100 mi apart were not captured in the ATS data set. Table 1, taken from Transportation Statistics Annual Report 1998, shows a list of metropolitan pairs of over 1 million people where the metropolitan centroids are about 100 miles or less apart. Note that because these distances were measured from the centroid of one metropolitan area to the centroid of the other metropolitan area, some trips between a far side in one metropolitan area to a far side in another metropolitan area might be 100 mi or more one-way and hence would be included in the ATS.

In addition to data gaps identified above, not all ATS highway trips were included in the final simplified network. As trips from the Oak Ridge National Highway Network were collapsed to the inter-metropolitan highway corridor network, two types of highway trips were dropped from the inter-metropolitan highway corridor network by definition of the process. These are

1. Trips that do not touch any metropolitan area (i.e., trips that traveled entirely outside metropolitan areas); and
2. Trips involving only one metropolitan area (i.e., intra-metropolitan trips and trips that either originated from or destined to non-metropolitan areas).

## CORRIDORS FOR THE DOMESTIC PUV TRIPS

The domestic inter-metropolitan corridors are presented in Figures 1 and 2 for household trips and person-trips, respectively. The volume of flows, representing either household trips or person-trips, between a metropolitan pair is represented by the thickness of the line connecting these two metropolitan areas. Average trip length for the links between these two metropolitan areas is represented by different shadings. A fixed scale for average trip length is used within a particular group of flow maps when possible. From Figures 1 and 2, there is no evidence of a significant east–west cross-continental corridor. The long distance required to travel from one coast of the United States to the other (over 2,500 mi) might have prevented many people from taking these east–west cross-country trips. On the other hand, many significant north–south corridors on both the Pacific West

**TABLE 1 Metropolitan Pairs of Over 1 Million People Where the Metropolitan Centroids Are About 100 Mi or Less Apart**

| Metropolitan Pair | | Approximate Distance (miles) |
|---|---|---|
| Cincinnati | Columbus | 100 |
| New York | Hartford | 100 |
| Indianapolis | Cincinnati | 100 |
| Boston | Hartford | 90 |
| Chicago | Milwaukee | 90 |
| Baltimore | Philadelphia | 90 |
| New York | Philadelphia | 80 |
| San Francisco | Sacramento | 80 |
| Orlando | Tampa | 80 |
| Buffalo | Rochester | 60 |
| Baltimore | Washington | 40 |

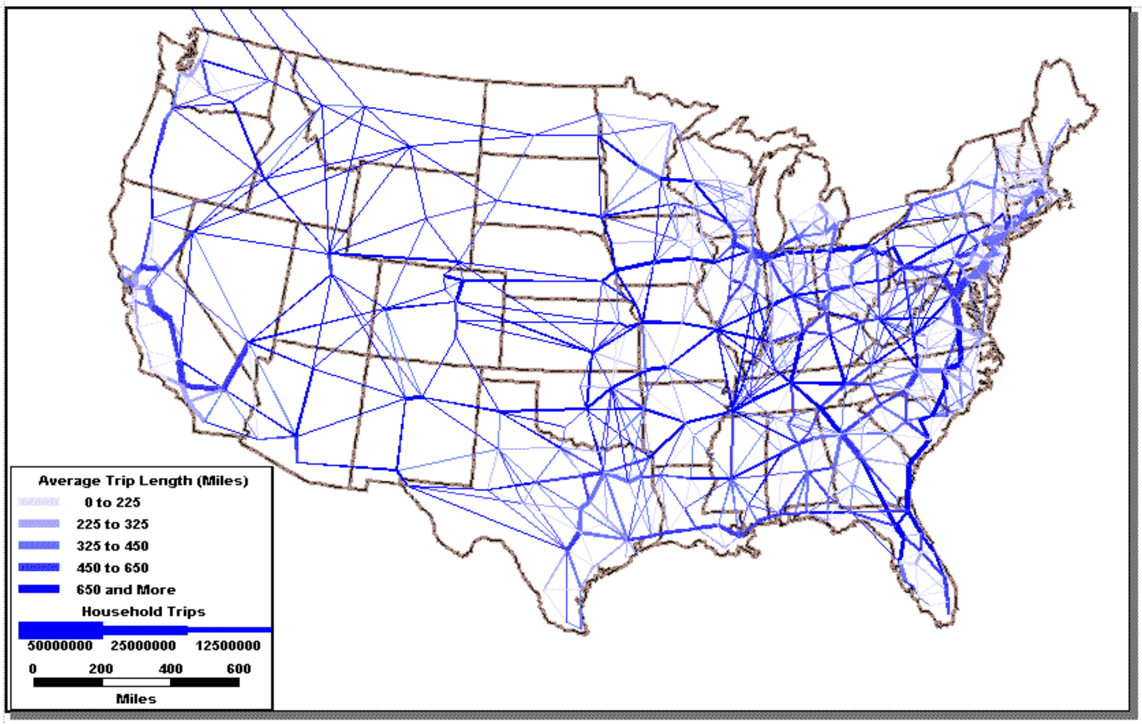


**FIGURE 1 Highway flow map of domestic inter-metropolitan household trips by PUV.**

Coast and the Atlantic East Coast are observed in these maps.

The Pacific West Coast corridor connects San Diego, California, and Bellingham, Washington. The California portion of this corridor, from San Diego to Vallejo–Fairfield–Napa, seems to be more heavily traveled than the rest of that corridor. There were two branches visible in this portion of the corridor. Most of the trips passed through San Joaquin Valley; the others traversed California coastal highways.

Two significant eastward corridors from California can be seen in both Figures 1 and 2. One exists between the Los Angeles-Long Beach area and the Las Vegas metro area; the other links San Francisco, California, and Reno, Nevada. No other significant corridor can be identified within the mountain west region of the United States

Clearly, there was more travel by PUVs in the midwestern and eastern states than in the western states. This can be observed from the rather crowded and broader flows that connect metropolitan pairs in these regions. The Atlantic coastal corridor that connects Miami, Florida, and Bangor, Maine, can be easily detected by visual inspection of these figures. It mostly follows Interstate 95. Small portions of this corridor went from New Haven-Meriden, Connecticut, via Hartford, and Worcester, Massachusetts, to the Boston area, instead of following Interstate 95. The most traveled portion on this Atlantic coastal corridor was on the link that connects the metropolitan area of Richmond-Petersburg, Virginia, to Boston, Massachusetts. This corridor is also referred to as the Northeast

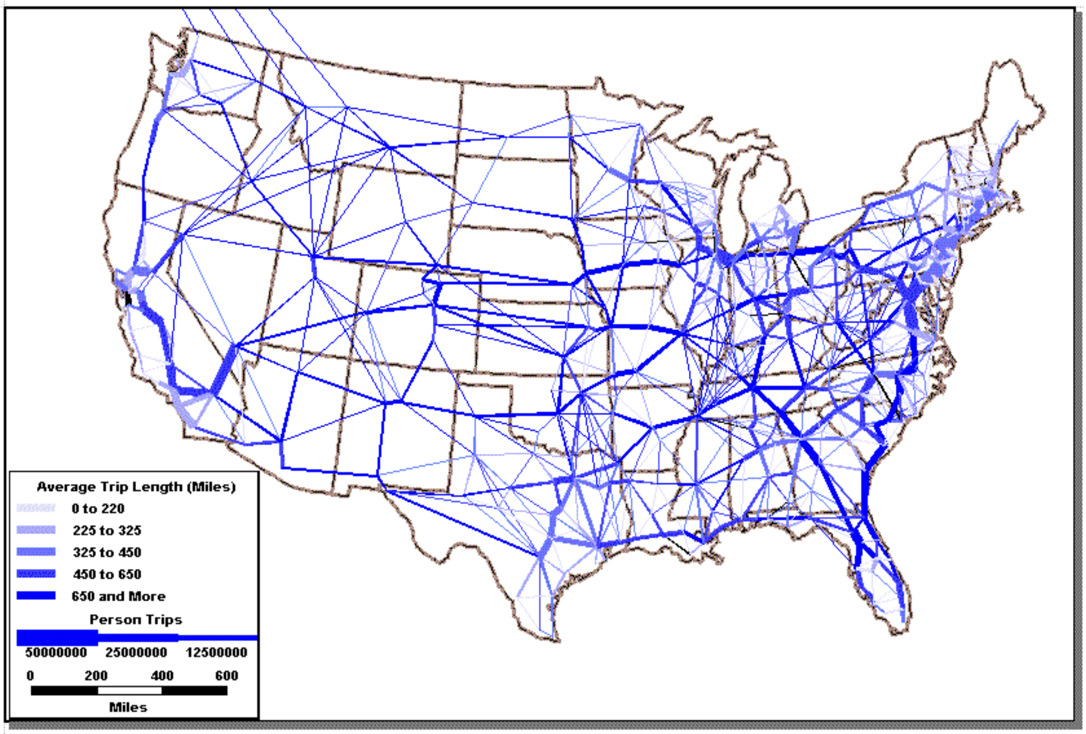


**FIGURE 2 Highway flow map of domestic inter-metropolitan person-trips by PUV.**

corridor. The average trip length for links within the state of Florida was around 700 mi. The average trip length increased to about 800 mi through the states of Georgia, South Carolina, and North Carolina. This reflects the fact that a large portion of PUV trips using the highway systems in this region result from passenger travel between the northeast states and Florida. In contrast, average trip length dropped to around 400 mi between Baltimore and Boston, and further dropped to approximately 300 mi between Boston and Bangor, Maine. This indicates passenger travel on these segments is more intra-regional in nature.

Several other long north–south corridors in the midwestern and eastern states can also be identified. Parallel to the Atlantic coastal corridor, another long north–south corridor extends from Naples, Florida, to Saginaw–Bay City–Midland, Michigan. This corridor follows Interstate 75. Other north-south corridors include from Columbia, South Carolina, to Cleveland–Lorain–Elyria, Ohio, along Interstate 77; from Mobile, Alabama, to Gary, Indiana, along Interstate 65; and from New Orleans, Louisiana, to Chicago, Illinois, along Interstate 55.

In addition to the north–south corridors, some east–west corridors can also be recognized:

1. In the northern portion of the midwestern United States, between Fargo–Moorhead, North Dakota, and Detroit, Michigan (primarily along Interstate 94);
2. Between Lincoln, Nebraska, and Bergen–Passaic, New Jersey (mostly Interstate 80); and

3. Between Kansas City, Missouri, and Pittsburgh, Pennsylvania (along Interstate 70).

## CORRIDORS FOR THE DOMESTIC BUS TRIPS

The domestic inter-metropolitan bus flow maps are presented in Figures 3 and 4. Similar to flow maps for the domestic PUVs, no major coast-to-coast cross-country bus corridor is evident from these maps. Furthermore, there is no significant bus corridor in the mountain west region. However, bus corridors are visible on both East and West coasts. In the Pacific coastal region, only one major bus corridor connecting the metropolitan area of Riverside–San Bernardino with the San Joaquin Valley and extending to the Modesto area in California is observed.

Two significant east–west bus corridors from California to Nevada can be clearly seen from the map. One extends from Riverside–San Bernardino, to Las Vegas, Nevada. The other extends from Sacramento, California, and stretches to Reno, Nevada.

The most prominent bus corridor in the northeast region connects the Washington, D.C., metropolitan area to the Boston metropolitan area (Figure 4). In contrast to the PUV flows, the Atlantic City–Cape May, New Jersey, metropolitan area emerged as one of the major bus destinations in this region. Other bus corridors with moderate amount of traffic can also be found throughout the Midwest and the South. It is interesting to note that three of the most prominent destinations on the domestic bus-flow map (Las Vegas,

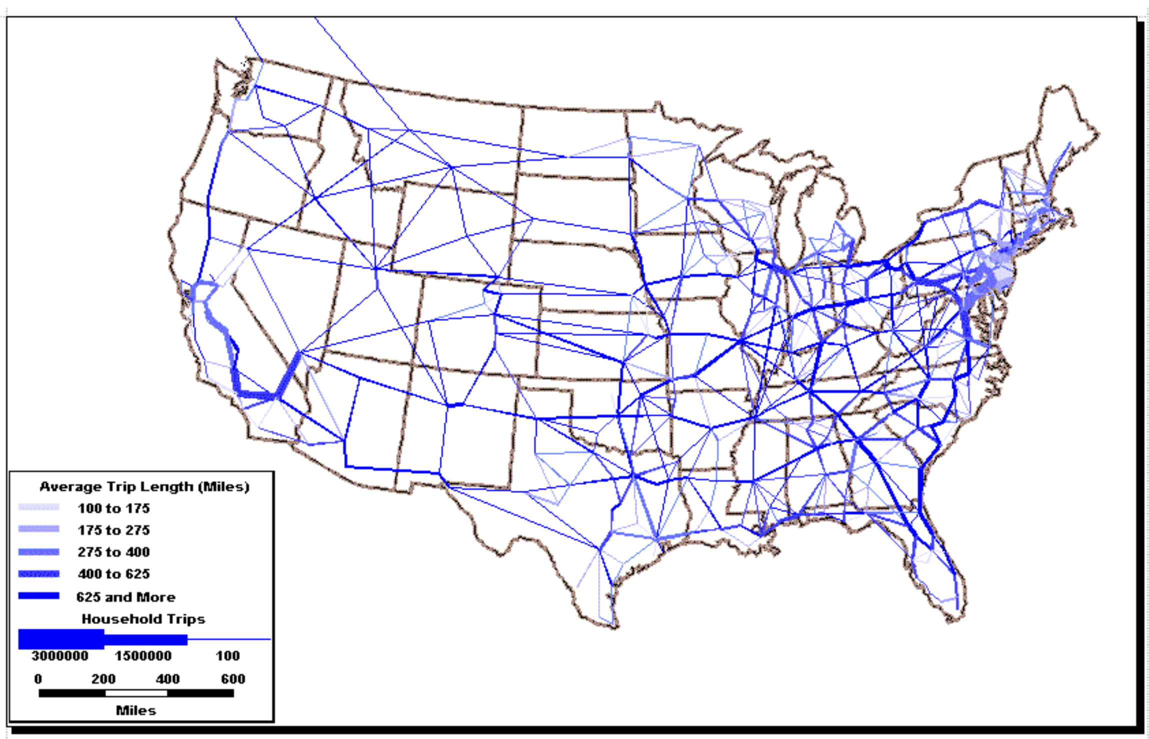


**FIGURE 3 Highway flow map of domestic inter-metropolitan household trips by bus.**

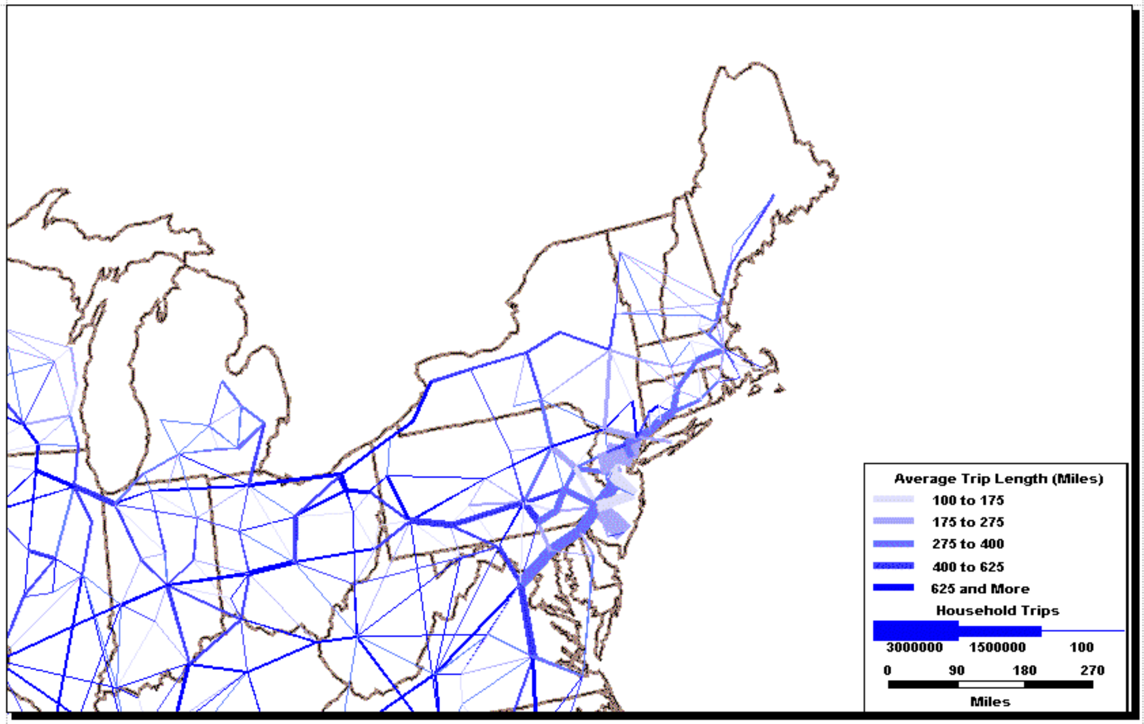


**FIGURE 4 Highway flow map of domestic inter-metropolitan household trips by bus in the Northeastern United States.**

Reno, and Atlantic City–Cape May) have legalized gambling. The bus flows may reflect local casinos' successful promotion of charter bus casino excursions from neighboring areas.

Most of the bus traffic within the Springfield, Missouri, metropolitan area was related to Branson, which recently has emerged as a popular vacation destination. Unlike many other vacation destinations, there are many charter bus tours to live music theaters in Branson. Since Branson was not included in any MSA or PMSA, the bus trips to Branson were not captured by the inter-metropolitan bus flow maps.

## CORRIDORS FOR THE BORDER CROSSING TRIPS TO CANADA AND MEXICO

The inter-metropolitan corridor flow maps for U.S. residents traveling to Canada and Mexico by PUV or bus are presented in Figures 5 and 6. Several heavily traveled corridors used by U.S. residents traveling to Mexico can be identified from these two maps. The most prominent corridor to Mexico starts from the Dallas and Houston areas in Texas, passes through San Antonio, and enters Mexico via the border city of Laredo. Another corridor, also in Texas, collects traffic from Arizona and New Mexico and crosses the border at El Paso. Arizona has its own gateway to Mexico via Tucson. The California corridor started from northern California and ends in Mexico through San Diego.

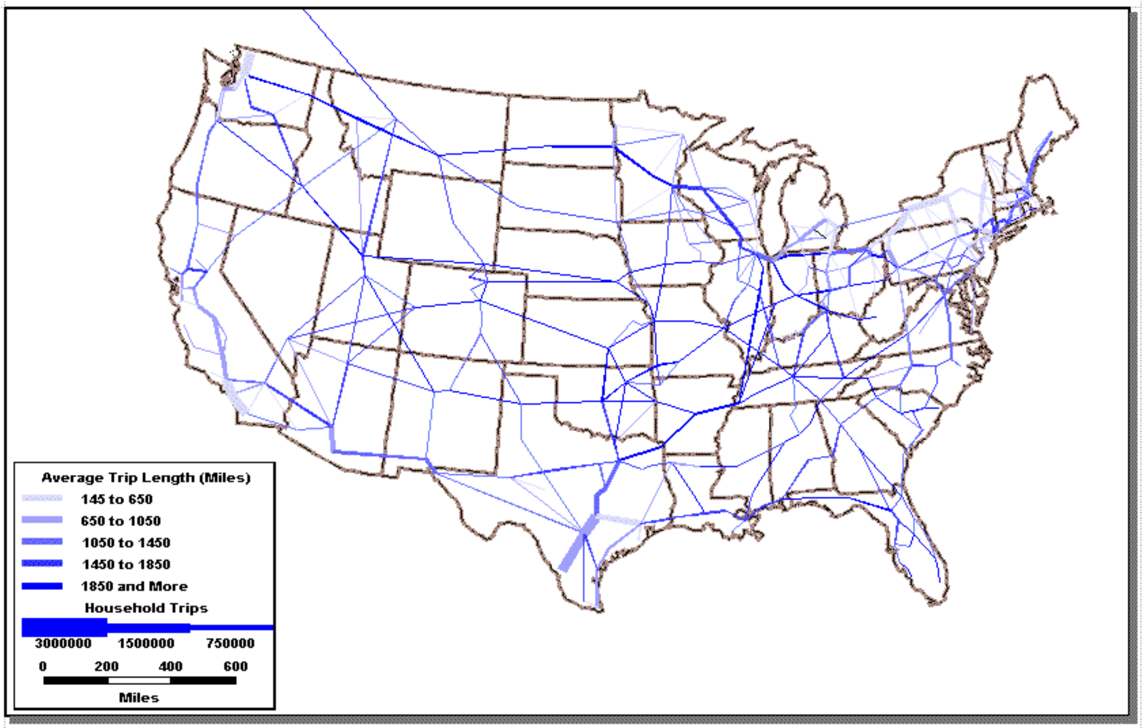


**FIGURE 5 Highway flow map of household trips by U.S. residents to Canada and Mexico (by PUV or bus).**

On the Canadian side, the northern Pacific coastal corridor starts from northern California, passes through Oregon, and enters Canada at Bellingham, Washington. In the Midwest region, the corridor starts at Bismarck, North Dakota, passes through the Fargo–Moorhead metropolitan, in North Dakota, Minneapolis–St. Paul, Minnesota, as well as Chicago, and finally crosses the Canadian border at Detroit. Several eastern corridors can also be identified from the maps. They collect traffic from New York and Pennsylvania, as well as other northeastern states, and enter Canada at the Buffalo–Niagara Falls metropolitan area in New York. International corridors ending in the metropolitan areas of Glens Falls, New York, and Bangor, Maine, are destined to Quebec and New Brunswick in Canada, respectively (Figures 5 and 6).

Since these trips are transborder and naturally have longer travel distances, scales used for the average trip length are different than those used for other travel groups presented in this paper. Since the volume of transborder trips is relatively small, the scale used for these flows maps, therefore, is also adjusted. Also, bus trips are not separated from the PUV trips for the transborder group.

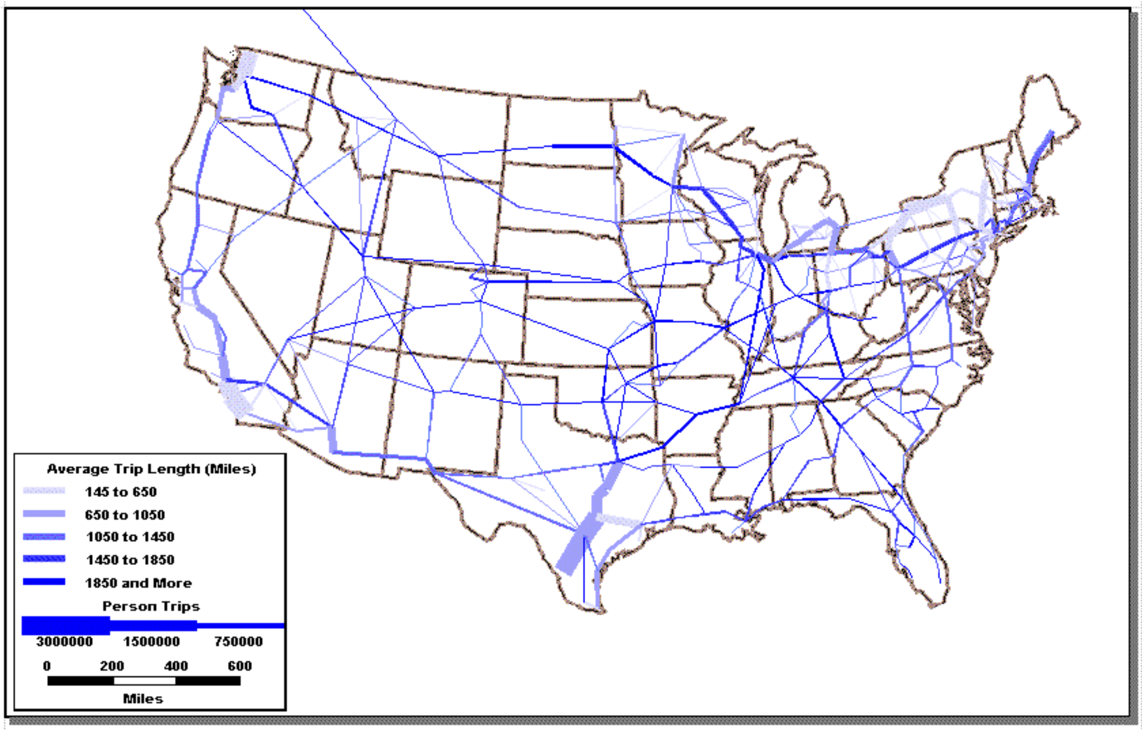


**FIGURE 6 Highway flow map of person-trips by U.S. residents to Canada and Mexico (by PUV or bus).**

## TRIP PURPOSES AND HOUSEHOLD INCOME LEVELS

In order to examine possible differences that might have existed in travel behavior due to trip purpose or income level, efforts were made to generate inter-metropolitan flow maps by trip purpose and by household income level. Trip purposes were grouped into three major categories: business, pleasure, and other purposes. Business trips include travel for the reason of business, combined business with pleasure, or convention, conference, or seminar. Pleasure trips include trips made for the purpose of visiting relatives or friends, rest or relaxation, sightseeing, outdoor recreation, entertainment, or shopping. Trips made for school-related activities or for personal or family business (e.g., weddings and funerals) were grouped in the "other" category. Household income level was also defined in three groups. The low-income group includes households with an annual income of less than $25,000. The middle-income group includes households with an annual income from $25,000 to $74,999. The high-income group includes households with an annual income of $75,000 or more.

Percentages of long-distance highway travel, for the three types of trips as discussed in previous sections, are presented in Table 2 by trip purpose, as well as by household income level. One obvious pattern emerges from this table. Based on data presented in Table 2, pleasure trips, as well as trips made by the middle-income household group, dominate the long-distance highway travel. While business travelers are less likely to use buses than are those who traveled for pleasure or other reasons, the share of bus rides by the lower income household is clearly higher than for those who traveled by PUV.

**TABLE 2 Percentage of Long-Distance Highway Travel by Trip Purpose and Household Income**

| | | Household Trips (%) | Person-Trips (%) | Vehicle Miles Traveled (%) | Person-Miles Traveled (%) |
|---|---|---|---|---|---|
| **Domestic Travel by PUV** | | | | | |
| Purpose | Business | 25 | 19 | 22 | 17 |
| | Pleasure | 60 | 66 | 63 | 68 |
| | Others | 15 | 15 | 15 | 15 |
| Income | <$25K | 18 | 16 | 18 | 16 |
| | $25–75K | 66 | 67 | 65 | 67 |
| | > = $75K | 16 | 17 | 17 | 17 |
| **Domestic Travel by Bus** | | | | | |
| Purpose | Business | 9 | 9 | | 13 |
| | Pleasure | 66 | 66 | N/A | 63 |
| | Others | 25 | 25 | | 24 |
| Income | <$25K | 35 | 34 | | 34 |
| | $25–75K | 53 | 54 | N/A | 55 |
| | > = $75K | 12 | 12 | | 11 |
| **Travel from United States to Canada and Mexico (PUV and Bus)** | | | | | |
| Purpose | Business | 15 | 12 | | 10 |
| | Pleasure | 72 | 74 | N/A | 79 |
| | Others | 13 | 14 | | 11 |
| Income | <$25K | 22 | 23 | | 24 |
| | $25–75K | 63 | 62 | N/A | 62 |
| | > = $75K | 15 | 15 | | 14 |

Because of the relatively small volume of domestic bus and transborder travel, only PUV domestic trip flows divided by trip purposes and by household income levels are presented here. The inter-metropolitan person-trip flow maps by business, pleasure, and other purposes are presented in Figures 7, 8, and 9, respectively (*1*). Since business-related trips accounted for a small portion (19 percent) of the overall person-trips using PUVs, they would be represented by very thin lines if the same scale was used. In that case, difference in travel patterns would not be easily observed from the flow maps on business trips. In order to show different travel patterns between trips made for separate reasons, different line thickness scales are used.

The inter-metropolitan corridor travel patterns for pleasure trips by PUV, as well as trips made for other reasons, are similar to those shown in Figure 2. They show distinct northeast and Pacific coastal corridors for all trip purposes. However, travel patterns on business trips show concentration in nearby metropolitan areas. For example, business travel on the coast of California is concentrated in the areas including San Francisco, Oakland, and San Jose. Similar conditions can be found at the following metropolitan areas: Los Angeles–Long Beach, California; Dallas, Texas; Tampa–St. Petersburg–Clearwater, Florida; and Columbus, Ohio.

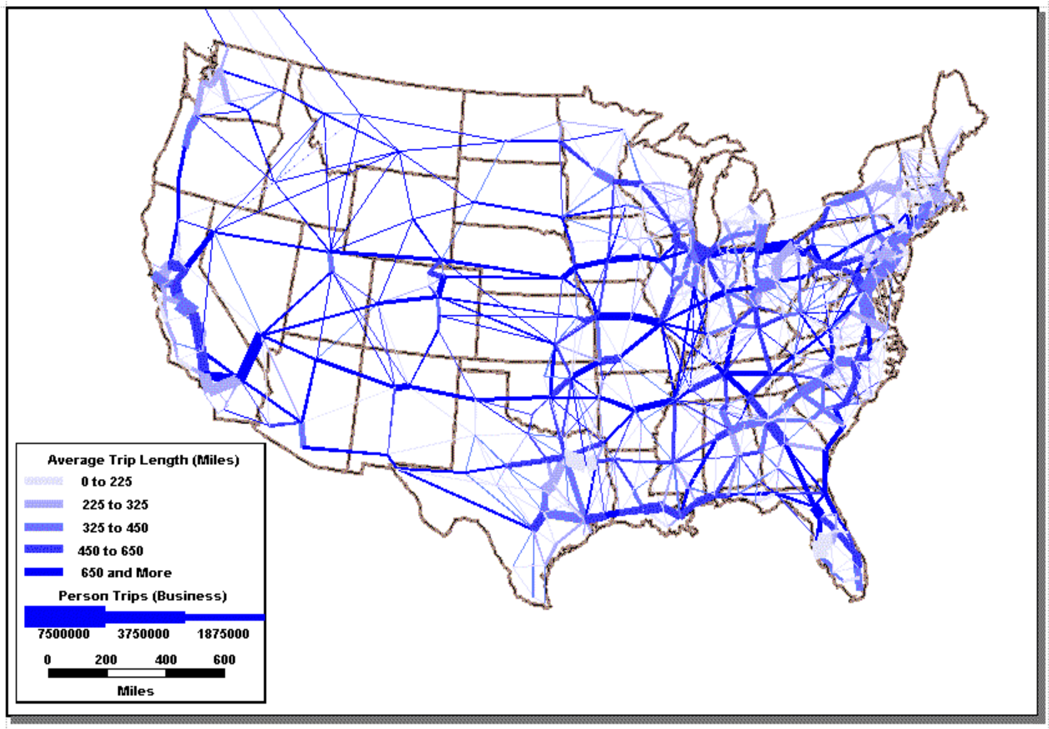


**FIGURE 7 Highway flow map of domestic inter-metropolitan corridor person-trips for business (by PUV).**

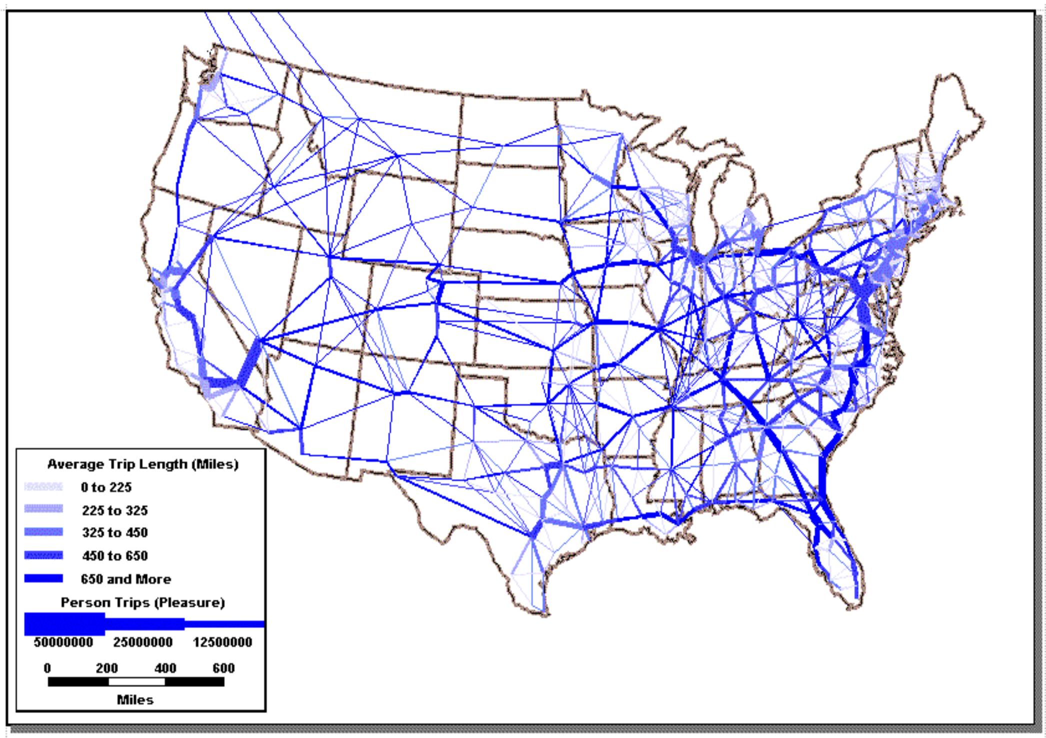


**FIGURE 8 Highway flow map of domestic inter-metropolitan corridor person-trips for pleasure (by PUV).**

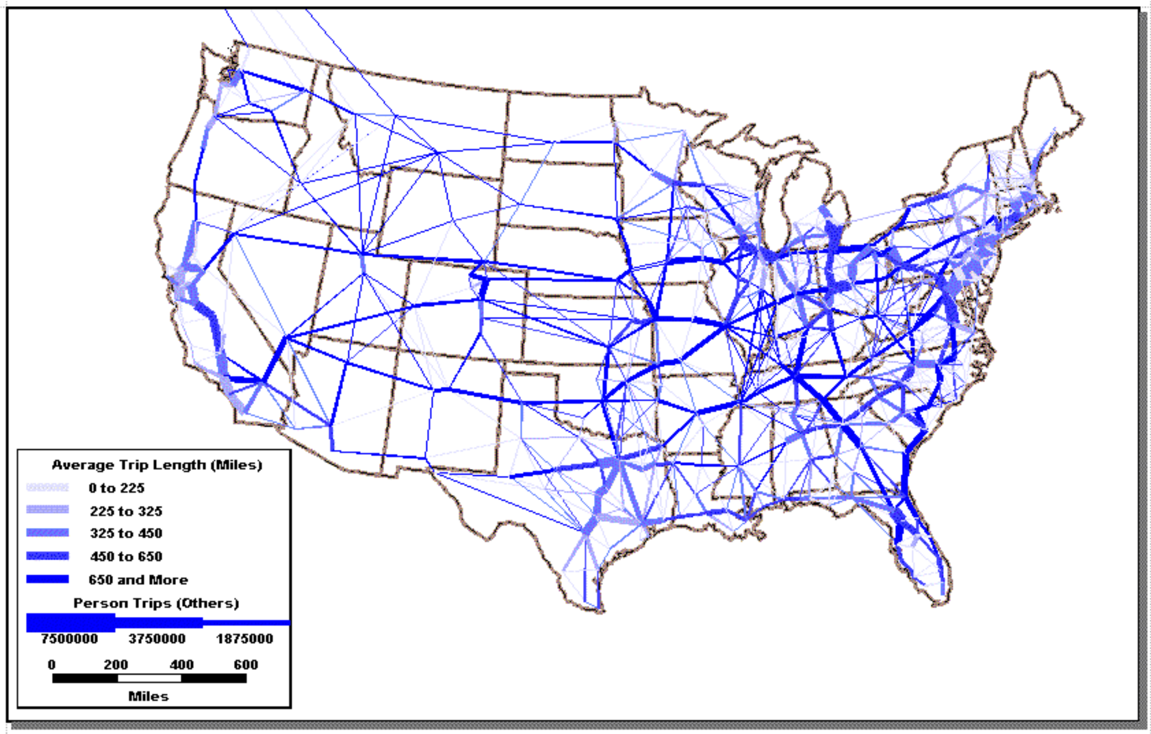


**FIGURE 9 Highway flow map of domestic inter-metropolitan corridor person-trips for pleasure (by PUV).**

These concentrations of business trips might be due to a high concentration of business establishments in these areas. Furthermore, the relatively short inter-metropolitan distances among these metropolitan areas might have been too short for travelers to select air as their mode of transportation.

The inter-metropolitan PUV person-trip flow maps by household income groups (i.e., high, middle, and low) are presented in Figures 10, 11, and 12, respectively (*2*). Trips made by persons with an annual household income between $25,000 and $74,999 (i.e., middle-income group) constitute a major portion of the total PUV person-trips (67 percent). Consequently, the travel pattern of the middle household income group is similar to the travel pattern of the overall person-trips (Figure 2). The trips made by persons with annual household income $75,000 or over (i.e., high-income group) constitute only a small portion of the total PUV person-trips (16 percent). Similar to the flow pattern presented in Figure 2, PUV trips made by persons with high household income clearly showed the northeast corridor and Pacific coastal corridor. However, no significant corridors can be observed for travel made by persons with high household income in the mountain west, midwestern, and southern regions of the United States. In addition to the northeast and the Pacific coastal corridors, trips made by persons from low-income households (i.e., under $25,000 annually) also show prominent corridors in the southern and part of the Midwest (northeast central) regions in the United States. Noticeable corridors reflecting the travel of persons with lower household income included

1. Inter-metropolitan areas connecting Orlando, Tampa–St. Petersburg–Clearwater, and Sarasota–Bradenton areas in Florida; and

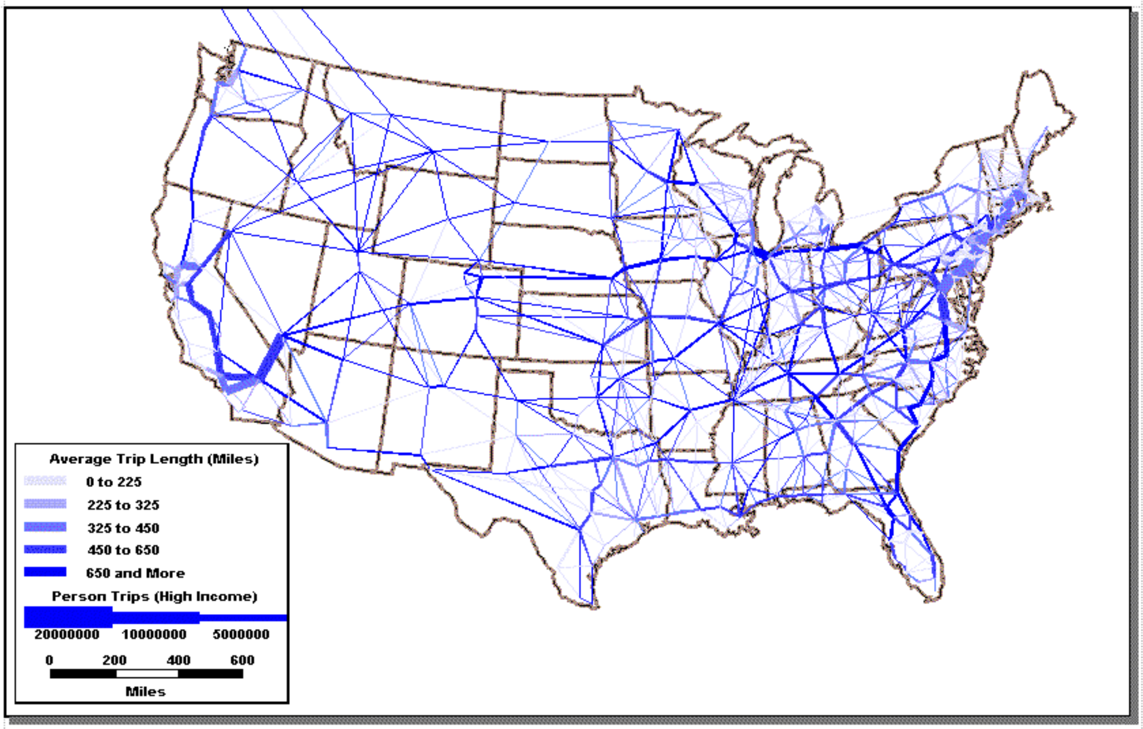


**FIGURE 10 Flow map of person-trips by high-income group (by PUV).**

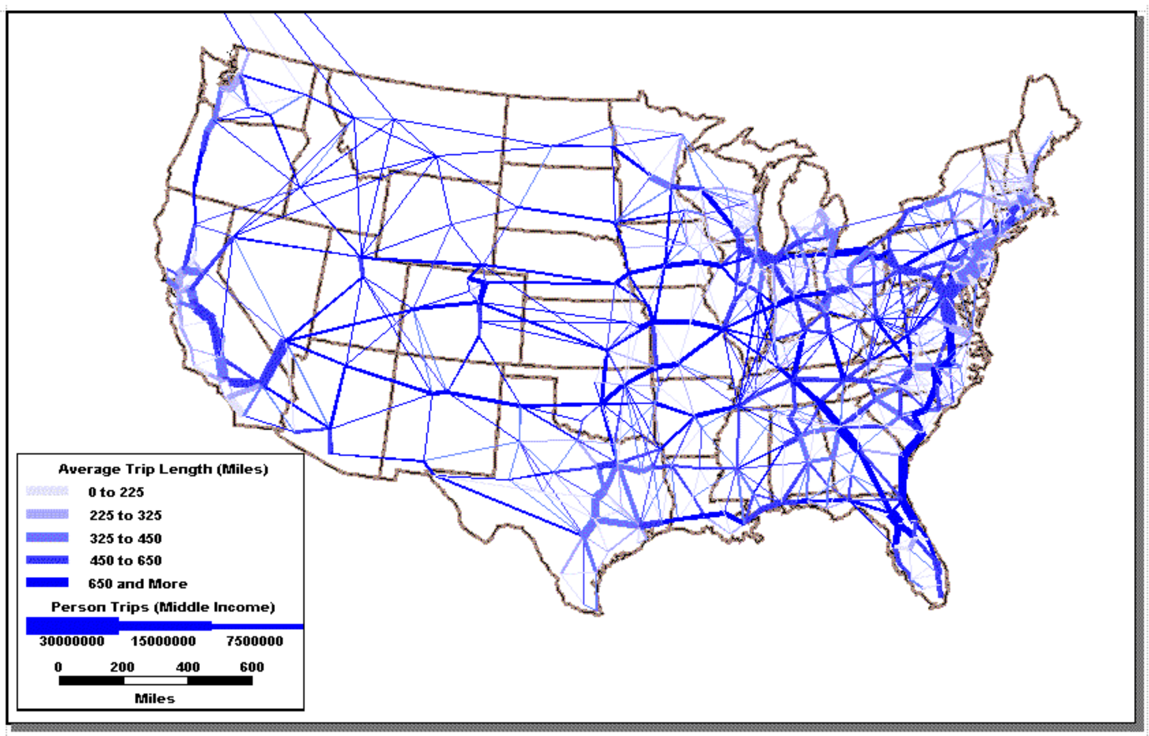


**FIGURE 11 Flow map of person-trips by middle-income group (by PUV).**

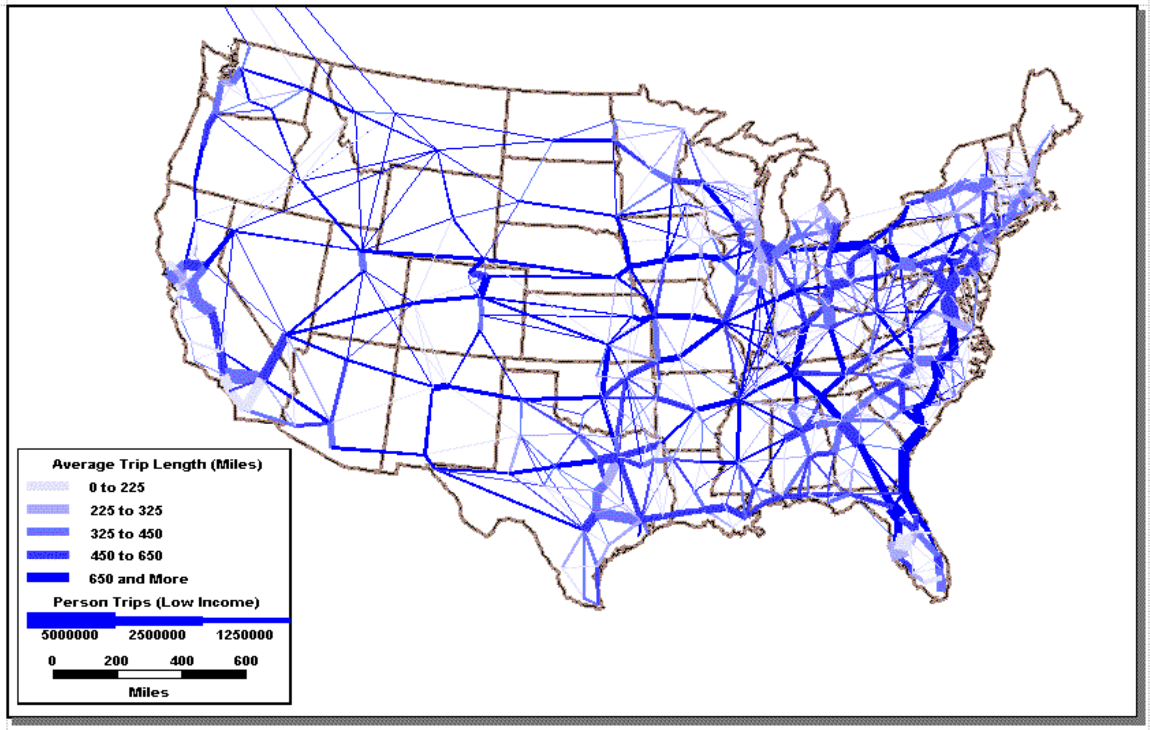


**FIGURE 12 Flow map of person-trips by low-income group (by PUV).**

2. Inter-metropolitan areas connecting Houston, San Antonio, and Dallas areas in Texas; as well as

3. Inter-metropolitan areas connecting Glens Falls, Albany–Schenectady–Troy, Syracuse, and Rochester areas in New York.

## SUMMARY

In this paper, long-distance highway travel patterns by U.S. residents were presented and inter-metropolitan highway corridors were identified based on data from the 1995 ATS. It was found that the most traveled highway corridors are concentrated on both east and west coasts for domestic travels. No significant east–west cross-country corridor was identified. Along the Atlantic coast, the most traveled highway corridor is the northeast corridor between Richmond–Petersburg, Virginia, and Boston, Massachusetts (mostly follows Interstate 95). Along the Pacific Coast, the heavily traveled highway corridors concentrate in or around California. The corridor that connects Rockford, Illinois, through Chicago, then to Gary, Indiana, is the most traveled corridor in the Midwest. Several prominent corridors in the states of Florida, North Carolina, Texas, and Georgia can also be seen from the flow maps presented.

The bus flow map suggests that popular destinations of bus trips include Atlantic City–Cape May, Las Vegas, and Reno. All these metropolitan areas have legalized gambling. Apparently the promotion of charter bus casino excursions for these areas is quite successful and attracts many visitors to the areas. Another popular bus destination is the Springfield, Missouri, metropolitan area, which includes bus traffic to Branson. Many charter bus tours visit live music theaters in this area.

Highway corridors from the United States to Canada and Mexico were also identified. One of the most traveled corridors to Mexico starts from the Dallas and Houston areas in Texas, passes through San Antonio, and enters Mexico via the border city of Laredo. Torontois the most popular Canadian destination for U.S. residents. One such corridor starts from Bismarck, North Dakota, passes through Fargo–Moorhead, North Dakota, Minneapolis–St. Paul, Minnesota, and Chicago, then crosses the Canadian border at Detroit, Michigan. Several other eastern corridors convey traffic from New York, Pennsylvania, and other northeastern states, entering Canada through the Buffalo–Niagara Falls metropolitan area in New York.

When separated by trip purpose, the inter-metropolitan corridor travel patterns for pleasure trips and trips made for other reasons showed distinct northeast and Pacific coastal corridors. Travel patterns for business trips, on the other hand, showed concentration between nearby metropolitan areas. When household income level was used to subdivide these domestic travels, trips made by the high-income group (i.e., $75,000 or higher annually) clearly showed the northeast and Pacific coastal corridors with little travel in between. In addition to these two corridors, trips made by low-income households (i.e., under $25,000 annually) also showed prominent corridors in the southern and Midwest (northeast central) regions in the United States.

As indicated in this paper, there are some gaps in the 1995 ATS data. It lacks information on foreign visitors traveling in the United States during 1995. Information on travel between cities that are less than 100 mi apart is also missing from the ATS. Further research in these areas will be needed in order to collect these data and to provide better understanding of the total passenger travel on the U.S. transportation systems. Title 1A, Section 1118 of the TEA-21 calls to establish and implement a National Corridor Planning and Development Program. TEA-21 recognizes that the development of transportation corridors is the most efficient and effective way of integrating regions, and improving the efficiency and safety of commerce and travel, as well as further promoting economic development. Long-distance passenger travel data collected by the 1995 ATS as well as flow information presented in this paper can be used as one of the data sources to complete the National Corridor Planning and Development Program.

## ACKNOWLEDGMENTS

The authors would like to acknowledge the funding support from the BTS in preparation of this paper. The data used were from the 1995 ATS. The authors also would like to express their appreciation to Dr. Janet Hopson of ORNL for her many reviews and suggestions during the writing of this paper.

## NOTES

1. The number of person-trips between a metropolitan pair is represented by the thickness of the line connecting the two metropolitan areas as in previous figures. Average trip length for the links between metropolitan areas is represented by different shades. A fixed scale for average trip length is used in all person-trip flow maps; however, the scale of the line thickness varies by trip purposes.

2. Similar to the flow maps by trip purpose, these maps also used line thickness to represent the volumes and line shadings to represent the average trip length. As indicated previously, a common scale was used for the average trip length ranges in all three income flow maps. However, different line thickness scales were used in flow maps for different household income groups.

## REFERENCES

Krishnan, V., and K. L. Hancock. Highway Freight Flow Assignment in Massachusetts Using Geographic Information Systems. Presented at the 77th Annual Meeting of the Transportation Research Board, Washington, D.C., 1998.

McCray, J. P., and R. Harrison. North American Free Trade Agreement Trucks on U.S. Highway Corridors. In *Transportation Research Record: Journal of the Transportation Research Board, No. 1653*, TRB, National Research Council, Washington, D.C., 1999, pp. 79–85.

McCray, J. P. North American Free Trade Agreement Truck Highway Corridors: U.S.–Mexican Truck Rivers of Trade. In *Transportation Research Record 1613*, TRB, National Research Council, Washington, D.C., 1998, pp. 71–78.

OMB Bulletin No. 98-06 Revised Statistical Definition of Metropolitan Areas (MAs) and Guidance on Uses of MA Definitions. OMB, Statistical Policy Office, Washington, D.C., 1998.

Peterson, B. Description of the Oak Ridge National Highway Network, Version 1.3(c), unpublished manuscript. Center for Transportation Analysis, ORNL, Oak Ridge, Tenn., 1997.

Rico, A., A. Mendoza, and E. Mayoral. Main Freight Land Transport Corridors in Mexico. Presented at the 77th Annual Meeting of the Transportation Research Board, Washington, D.C., 1998.

*National Transportation Atlas Databases, 1997*. BTS-CD-19, BTS, USDOT, Washington, D.C., 1997.

*Transportation Statistics Annual Report, 1998.* BTS98-S-01, BTS, USDOT, Washington, D.C., 1998.

## APPENDIX

**TABLE A-1 Top 45 Inter-Metropolitan Long-Distance Travel Corridors**

| Metropolitan Area | Metropolitan Area | Person-Trips (1,000) | Avg. Trip Length[1] (Miles) | Household Trips (1,000) | Avg. Trip Length[2] (Miles) |
|---|---|---|---|---|---|
| Middlesex–Somerset–Hunterdon, N.J. | Newark, N.J. | 56,675 | 349 | 35,795 | 350 |
| Philadelphia, Pa.–N.J. | Wilmington–Newark, Del.–Md. | 45,476 | 389 | 28,964 | 378 |
| Philadelphia, Pa.–N.J. | Trenton, N.J. | 42,307 | 380 | 27,066 | 372 |
| Baltimore, Md. | Wilmington–Newark, Del.–Md. | 42,119 | 391 | 25,329 | 395 |
| Middlesex–Somerset–Hunterdon, N.J. | Trenton, N.J. | 40,206 | 382 | 25,738 | 373 |
| Baltimore, Md. | Washington, D.C.–Md.–Va.–W.V. | 39,947 | 457 | 24,711 | 452 |
| Bergen–Passaic, N.J. | New York, N.Y. | 38,226 | 403 | 22,808 | 410 |
| Jersey City, N.J. | Newark, N.J. | 37,651 | 367 | 24,150 | 359 |
| Richmond–Petersburg, Va. | Washington, D.C.–Md.–Va.–W.V. | 36,166 | 563 | 22,443 | 553 |
| Chicago, Ill. | Gary, Ind. | 35,497 | 617 | 22,334 | 643 |
| Boston, Mass.–N.H. | Worcester, Mass.–Conn. | 33,434 | 334 | 21,113 | 332 |
| Las Vegas, Nev.–Ariz. | Riverside–San Bernardino, Calif. | 28,907 | 556 | 15,219 | 600 |
| Bridgeport, Conn. | New Haven–Meriden, Conn. | 28,126 | 385 | 16,845 | 389 |
| Bridgeport, Conn. | Stamford–Norwalk, Conn. | 27,377 | 399 | 16,323 | 405 |
| Akron, Ohio | Cleveland–Lorain–Elyria, Ohio | 27,012 | 597 | 17,090 | 606 |
| New York, N.Y. | Stamford–Norwalk, Conn. | 26,697 | 418 | 15,953 | 420 |

*continued on next page*

**TABLE A-1 (*continued*) Top 45 Inter-Metropolitan Long-Distance Travel Corridors**

| | | | | | |
|---|---|---|---|---|---|
| Hartford, Conn. | New Haven–Meriden, Conn. | 26,580 | 441 | 16,503 | 439 |
| Gainesville, Fla. | Ocala, Fla. | 26,559 | 747 | 16,300 | 737 |
| Fresno, Calif. | Merced, Calif. | 26,186 | 465 | 17,626 | 463 |
| Vallejo–Fairfield–Napa, Calif. | Yolo, Calif. | 25,704 | 321 | 18,126 | 329 |
| Hagerstown, Md. | Washington, D.C.–Md.–Va.–W.V. | 25,111 | 493 | 15,334 | 502 |
| Bakersfield, Calif. | Los Angeles–Long Beach, Calif. | 24,758 | 452 | 15,575 | 470 |
| Modesto, Calif. | Stockton–Lodi, Calif. | 24,721 | 420 | 17,252 | 411 |
| Atlanta, Ga. | Macon, Ga. | 24,169 | 657 | 15,055 | 640 |
| Los Angeles–Long Beach, Calif. | Orange County, Calif. | 24,155 | 246 | 14,701 | 255 |
| Orange County, Calif. | San Diego, Calif. | 23,311 | 232 | 12,488 | 237 |
| Sacramento, Calif. | Yolo, Calif. | 23,228 | 438 | 15,336 | 457 |
| Los Angeles–Long Beach, Calif. | Riverside–San Bernardino, Calif. | 23,054 | 526 | 12,985 | 558 |
| Boston, Mass.–N.H. | Lowell, Mass.–N.H. | 22,909 | 294 | 13,533 | 300 |
| Oakland, Calif. | Vallejo–Fairfield–Napa, Calif. | 22,811 | 300 | 16,351 | 299 |
| Fayetteville, N.C. | Raleigh–Durham–Chapel Hill, N.C. | 22,596 | 705 | 12,880 | 727 |
| Hartford, Conn. | Worcester, Mass.–Conn. | 22,226 | 415 | 13,908 | 417 |
| Merced, Calif. | Modesto, Calif. | 21,512 | 459 | 15,038 | 448 |
| Bergen–Passaic, N.J. | Jersey City, N.J. | 21,296 | 399 | 12,584 | 397 |
| Charlotte–Gastonia–Rock Hill, N.C.–S.C. | Greensboro–Winston–Salem–High Point, N.C. | 20,878 | 545 | 13,632 | 533 |

*continued on next page*

**TABLE A-1 (*continued*) Top 45 Inter-Metropolitan Long-Distance Travel Corridors**

| | | | | | |
|---|---|---|---|---|---|
| Lawrence, Mass.–N.H. | Lowell, Mass.–N.H. | 20,739 | 300 | 12,418 | 303 |
| Austin–San Marcos, Tex. | San Antonio, Tex. | 20,571 | 449 | 12,097 | 459 |
| Raleigh–Durham–Chapel Hill, N.C. | Rocky Mount, N.C. | 20,369 | 736 | 12,202 | 739 |
| Johnstown, Pa. | Pittsburgh, Pa. | 19,865 | 475 | 11,924 | 507 |
| Columbus, Ohio | Dayton–Springfield, Ohio | 19,377 | 566 | 12,000 | 562 |
| Jacksonville, Fla. | Savannah, Ga. | 19,234 | 867 | 11,473 | 880 |
| Killeen–Temple, Tex. | Waco, Tex. | 19,218 | 393 | 11,763 | 383 |
| Charleston–North Charleston, S.C. | Savannah, Ga. | 18,904 | 883 | 11,294 | 895 |
| Chicago, Ill. | Rockford, Ill. | 18,755 | 479 | 11,158 | 528 |
| Richmond–Petersburg, Va. | Rocky Mount, N.C. | 18,698 | 783 | 10,812 | 806 |

[1]Average trip length in miles weighted by person-trips.
[2]Average trip length in miles weighted by household trips.