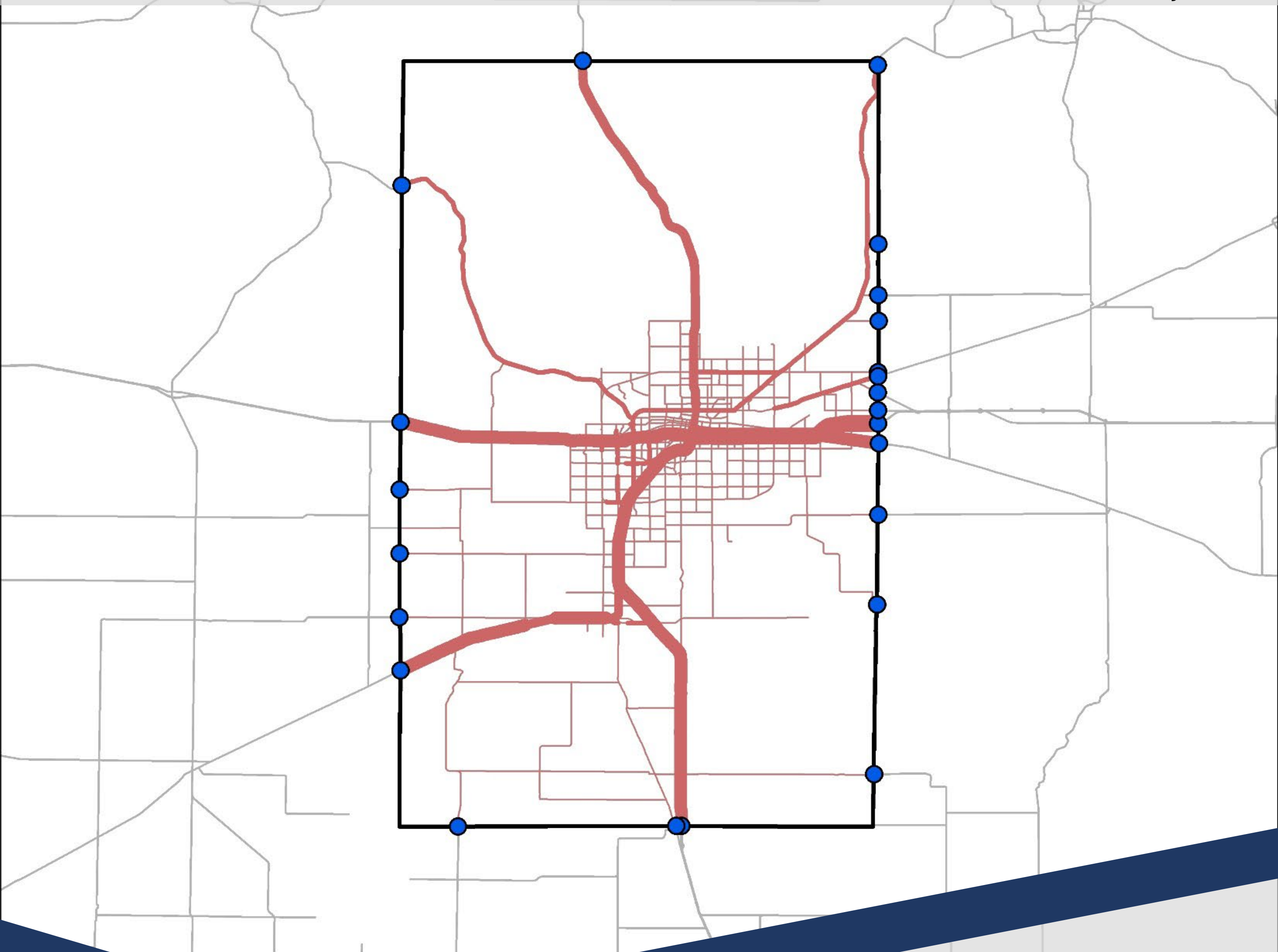
2020 AMARILLO MPO EXTERNAL STUDY

Technical Summary

July 2023



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2020 Amarillo MPO External Study Using LBS and GPS Data

Technical Summary

Texas Department of Transportation Travel Survey Program

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STUDY BACKGROUND AND OBJECTIVES

This technical memorandum provides a summary of an external travel study performed for the Amarillo Metropolitan Planning Organization using origin-destination (O-D) data acquired by the Texas Department of Transportation (TxDOT). The primary outcome of the study includes external-to-external (E-E), external-to-internal (E-I), and internal-to-external (I-E) travel data for passenger vehicles and trucks. TxDOT purchased Location Based Services (LBS) and Global Positioning System (GPS)-based O-D data for the study to provide estimates of external travel needed as input for the Amarillo MPO travel demand model. The GPS data were acquired from INRIX and the LBS data from AirSage. All data were acquired for the spring of 2020. The GPS data predominantly reflect commercial vehicle travel, while the LBS data predominantly reflect noncommercial vehicle travel.

The use of passive data for external studies has become state-of-the-practice in recent years and provides significant benefits over prior methods such as roadside interviews and license plate matching techniques that produce safety and privacy concerns. The results of this study benefit many uses of the travel model such as evaluation of freeway improvements, new location corridors and tolling studies, and air quality/conformity assessments. The study's primary objective was the development of traffic matrices of external O-D interactions for the regional travel demand model. Since the use of passive technology to study travel is still evolving, the study additionally included a comparison of GPS and LBS data results. Researchers used data management techniques, algorithms, and analytical computations to address the technical and data processing challenges inherent in using large amounts of passive data.

Amarillo MPO Study Area

The Amarillo MPO study area contains Potter and Randall counties, Texas. Core elements of the study area and design include Traffic Analysis Zones (TAZs) and external stations where major roadways and thoroughfares cross the study area boundary.

Figure 1 shows the study area, the study area boundary, the external stations, and the TAZs. The Amarillo MPO's model TAZ structure contains 433 TAZs and 23 external stations.

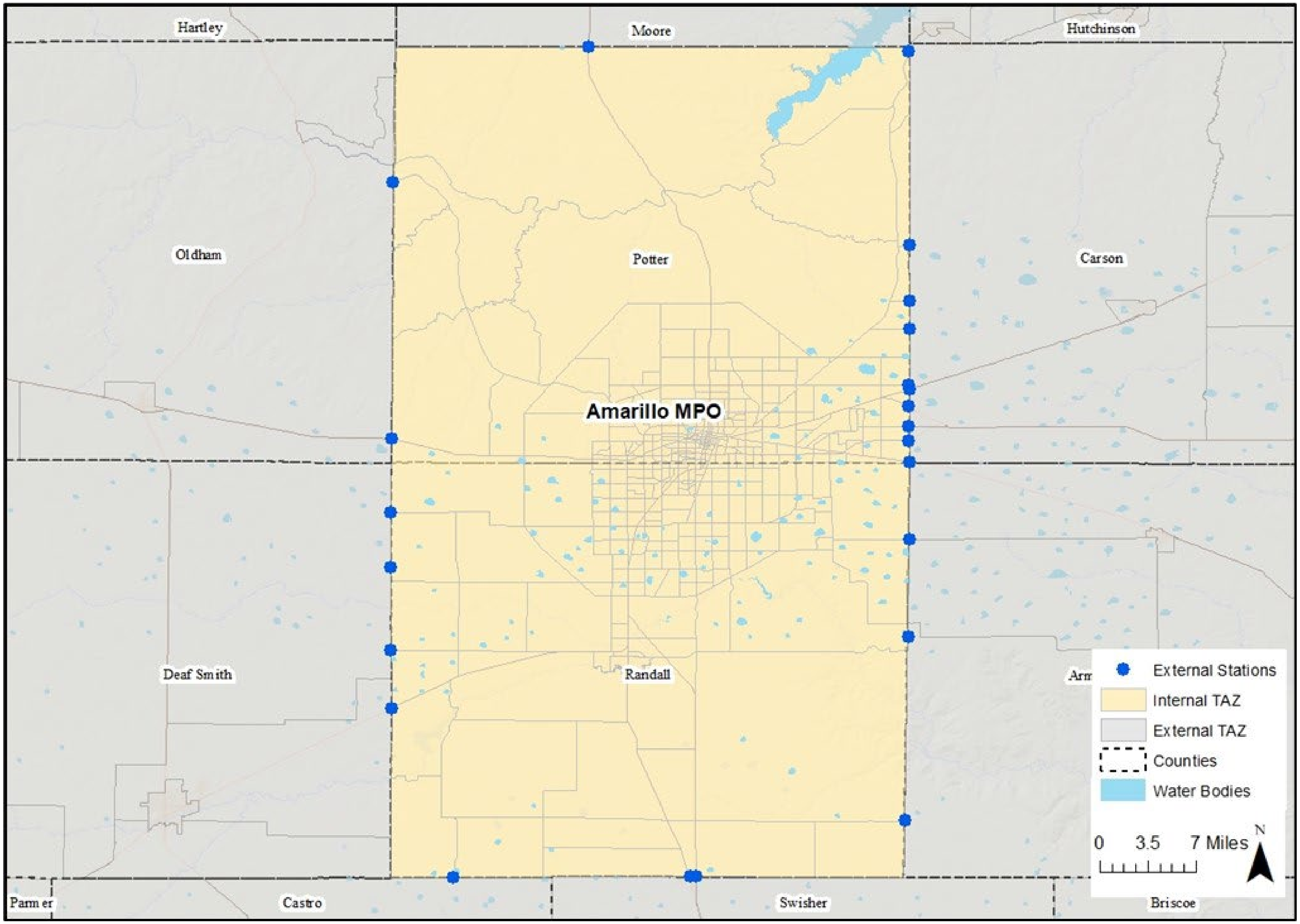

Figure 1. Amarillo MPO External Survey Geography and Zone Structure.

Identifying External Trips with GPS and LBS Data

Identifying the external station (or roadway) used by trips that cross the study area boundary is an essential part of an external travel study. For GPS data, the external station is determined using a process known as map matching, in which a trip's GPS points are electronically associated with the roadway network. This process reveals the route used between the trip's origin and destination that allows the external station to be identified.

LBS data are polygon-based rather than point-based (as with GPS data), which means that the analysis assigns trip O-D pairs to TAZs, and the route used between the trip's origin and destination often must be estimated. Typical analysis methods for LBS O-D data assign the route or roadway by association and assume that trips occurring within a geographic travel shed drawn around a road also occur on the road. While this process is generally effective for isolated roadways, it presents challenges in developed and urban areas where other parallel or nearby roadways exist. Where this occurs, roadways near each other will in fact serve distinct O-Ds that are problematic to distinguish empirically. To distinguish the distinct O-Ds served by all the region's external roadways, the study area for LBS data, as Figure 1 shows, includes 6,254 external zones around the periphery of the study area in counties bordering the area. The development of external zones involved a careful review of regional populations, roadway locations, and travel patterns. The external zones provide a basis for a select link analysis (see the Map Matching section for details) that routes observed O-D flows through the appropriate external roadway.

External zones serve several additional purposes. First, they distinguish between resident and nonresident travel, with nonresidents being those individuals who live in the external zones. Second, they capture device signals before they enter and after they exit the study area. Third, depending on forecasting needs, modelers can forecast each external zone independently, which allows for modeling different assumptions of growth in external traffic.

DATA COLLECTION

LBS and GPS data vendors maintain large archives of data over many years and have extraction tools that efficiently pull data from their archives based on a range of dates and geographies provided for each study. The traffic counts are data collected in the field that require direct interaction with the roadway under study. They provide relatively accurate ground truth data to establish a baseline and expand the LBS and GPS data.

Traffic Counts

As with previous data collection methodologies, LBS and GPS data sources represent a sample of traveler information for a study area, and therefore these data must be expanded to provide an estimate for the entire study area. The most common method to expand the data is the use of expansion factors derived from traffic counts. For external surveys, this equates to traffic counts at all external stations for a study area. To provide modelers the data needed to prepare a model for a particular study area, the survey results need to be disaggregated by noncommercial/passenger and commercial/truck vehicle types. To meet this need, the traffic data required for developing the expansion factors must be classification counts.

The passive O-D data purchased for the Amarillo MPO area are from the spring of 2020. TxDOT collects annual counts of on-system roads throughout the state every year and collects saturation counts every five years. The latest saturation counts for the Amarillo District are from also from 2020. The combination of saturation and annual counts in the Amarillo MPO area is useful for model calibration due to the abundance of counts for links within the model network. However, both saturation and annual counts are volume counts and do not provide the classification data needed for external station data expansion.

The survey team extracted 2020 count data from the Statewide Traffic Analysis and Reporting System (STARS) II database for each external location. They additionally queried the STARS II database to identify permanent count locations that aligned or were near external locations and had classification count data. Table 1 shows the STARS II count locations.

Table 1. TxDOT STARS II Count Locations.

Highway	STARS ID	Count Year
US-87 N	188 E20	2020
SH-136 N	171D9	2020
FM-1342 E	188 H13	2020
FM-293 E	188 H15	2020
FM-245 E	33D14	2019
St Francis	188 CE4	2020
US-60 E	188 E5	2020
BI-40 E	33D12	2020
IH-40 E	188 E7	2020
US-287 S	188 SP120	2020
FM-1151 E	191 E21	2020
FM-1258 E	191 H13	2020
FM-285 E	6H19	2020
IH-27 S	219 H47A	2019
US-87 S	191 E22	2020
FM-168 S	191 H48	2020
US-60 W	59 H14	2020
FM-1062 W	59D3	2020
CR-956 W	191 E23	2020
CR-954	191 CR193	2020
IH-40 W	188 H69A	2019
RM-1061 W	180D2	2019
FM-2575 E	188 H27A	2020

LBS Data

TxDOT coordinated with the Texas A&M Transportation Institute (TTI) to purchase one month of LBS data covering average weekdays from AirSage for the month of February 2020. Analysis of the data shows that an estimated 681,162 (expanded) trips were taken on an average weekday in the Amarillo MPO study area, including 584,234 internal trips and 96,928 external trips. TxDOT purchased the data for average weekday trips since only weekday travel is modeled for the Amarillo MPO area. Additional options that were purchased include three trip purposes and the trip home census tract. The home census tract was used to determine resident and nonresident status for each trip.

Unlike GPS data, there is a lack of clear data on commercial vehicle travel with LBS data. Presumably, commercial vehicle travel is present in the data. However, since LBS data are primarily sourced from cell phone application usage, which is ultimately tied back to a subscriber's device, it is not possible to determine whether a subscriber left home and started driving a truck when they arrived at work. In addition, for LBS studies, regional trips made by nonresidents and transients (i.e., briefly observed devices) are detected. For these trips, it is difficult to determine the residence or primary activity place of the device, which precludes methods to determine whether that place is associated with commercial vehicle activity. These trips are often external; however, their mode is unknown.

The E-E, I-E, and E-I trip-type designations are based upon the trip's direction of travel relative to the study area and whether its origin or destination is inside or outside of the internal model region. Accordingly, a trip with an external zone origin and an internal zone destination is an E-I trip and vice versa for an I-E trip. E-E trips are those with both ends of the trip being external (i.e., located outside of the study area). It is important to note that for a trip to be E-E it must pass through the model region. Table 2 shows the percentage breakdown of each of these types of trips. Based on the LBS data, approximately 17.4 percent of all external traffic entering and exiting the area are E-E trips.

Table 2. LBS Area-Wide Weekday Averages.

	E-I	I-E	E-E	I-I	All Types
Total Trips	42,552	37,516	16,860	584,234	681,162
Percent Total Trips	6.3%	5.5%	2.5%	85.8%	100.0%
Percent Total External Trips	43.9%	38.7%	17.4%	NA	100.0%

GPS Data

TxDOT made a statewide purchase of preprocessed GPS trip data from INRIX for the year 2020. The data were acquired for the months of February, March, April, September, October, and November to coincide with when saturation counts were conducted in numerous MPO areas, including the Amarillo MPO. Considering the COVID-19 pandemic, researchers concluded that utilizing one month of the acquired data would be most appropriate. February of 2020 was chosen as the preferred month since it was prior to covid-related lockdowns and supply chain issues. The data are from the INRIX's Trajectory™ product. The trajectory data comes with trip routes mapped to the INRIX's own road segmentation built on top of the OpenStreetMap (OSM) road networks. The OSM network encompasses the entire study area, and the complete network including local streets allowing for a greater understanding of the paths for car and truck trips. Having the trips pre-routed allows for a quicker processing time and greater flexibility with the data. INRIX provided a combined dataset of GPS data sources from noncommercial passenger cars/vehicles, commercial/freight vehicles (including trucks), and mobile applications.

The initial GPS dataset included 949,727 trip records. The study team processed each trip to determine if the trip was a weekday trip, whether it entered the study area, and if it entered the study area by way of a roadway with an external station. This process revealed that 21,852 trips from the dataset did not meet these criteria because they were mostly weekend trips, thereby making the final sample for analysis 927,875 trips. Each record contained a unique device identification (ID) and the trip ID with time-stamped trip end locations.

The sources of GPS data included in this sample are passenger vehicles, field service/local delivery fleets, and for hire/private trucking fleets. Within the sample, the distribution of these sources is 51.7 percent field service/local delivery fleets and 48.3 percent for hire/private trucking fleets.

Unlike LBS data, the GPS data require significant postprocessing by the data user. This processing requires large computing resources and data management to extract and impute additional details of the data. These details include TAZ attribution, map matching to roadways, and study area determinations of trip ends for E-E, E-I, and I-E attribution. Despite the additional labor and computations involved in the analysis of GPS data, they offer a richer source of routing data and more flexibility than LBS data. Table 3 through Table 5 provide unweighted distributions of total, passenger vehicle, and truck trips.

Table 3. GPS Weekday Total Sample.

	E-I	I-E	E-E	I-I	All Types
Total Trips*	46,155	51,091	24,436	806,193	577,231
Percent Total Trips	5.0%	5.5%	2.6%	86.9%	100.0%
Percent Total External Trips	37.9%	42.0%	20.1%	NA	100.0%

*Unweighted results.

Table 4. GPS Weekday Total Sample Cars/Light Trucks.

	E-I	I-E	E-E	I-I	All Types
Total Trips*	28,054	32,525	6,082	724,863	791,524
Percent Total Trips	3.5%	4.1%	7.6%	91.6%	100.0%
Percent Total External Trips	42.1%	48.8%	9.1%	NA	100.0%

*Unweighted results.

Table 5. GPS Weekday Total Sample Medium and Heavy Trucks.

	E-I	I-E	E-E	I-I	All Types
Total Trips*	18,101	18,566	18,354	81,330	136,351
Percent Total Trips	13.3%	13.6%	13.5%	59.6%	100.0%
Percent Total External Trips	32.9%	28.4%	33.7%	NA	100.0%

*Unweighted results.

MAP MATCHING

Map matching is the process of matching coordinate data to a digital roadway network. Most mobile device users see this process when using routing directions on mapping apps. It is most commonly associated with GPS data, but in this study, it also included the process of matching LBS data to a roadway network. As with GPS data, no intrinsic association of the data to a given roadway exists.

LBS Data

The map matching process for LBS data uses the Texas Statewide Analysis Model (SAM) network. Use of this network allows for trip assignment outside of the study area in the external zones to the internal network based on the shortest path. The shortest path is typically a measure of distance or time between O-D pairs and the route to take that minimizes one or the other. The analysis for this study uses the shortest time path, which is calculated using the speed limits of the network.

TransCAD is a software used in the development of travel demand models. One of its core functions is to assign an O-D matrix of traffic to a network. Built into TransCAD is an analytical component, termed *select link*, to obtain the O-Ds of traffic that crosses a particular link during assignment. Accordingly, the analysis methodology uses a select-link analysis of roadway segments located at each of the 23 external stations. The select-link analysis process assigned E-E and I-E/E-I trips to the roadway network while tracking the O-D of the trips that passed through each external link (see external stations in Figure 1).

Figure 2 shows that the E-E traffic appears logically assigned to the freeways and major roadways that bisect the study area, while Figure 3 alternatively shows that I-E/E-I traffic also appears logically assigned to the major roadway network since more of the internal network is used to distribute the internal trips. Overall, the percentage breakdown of LBS derived external traffic per station is logical and consistent.

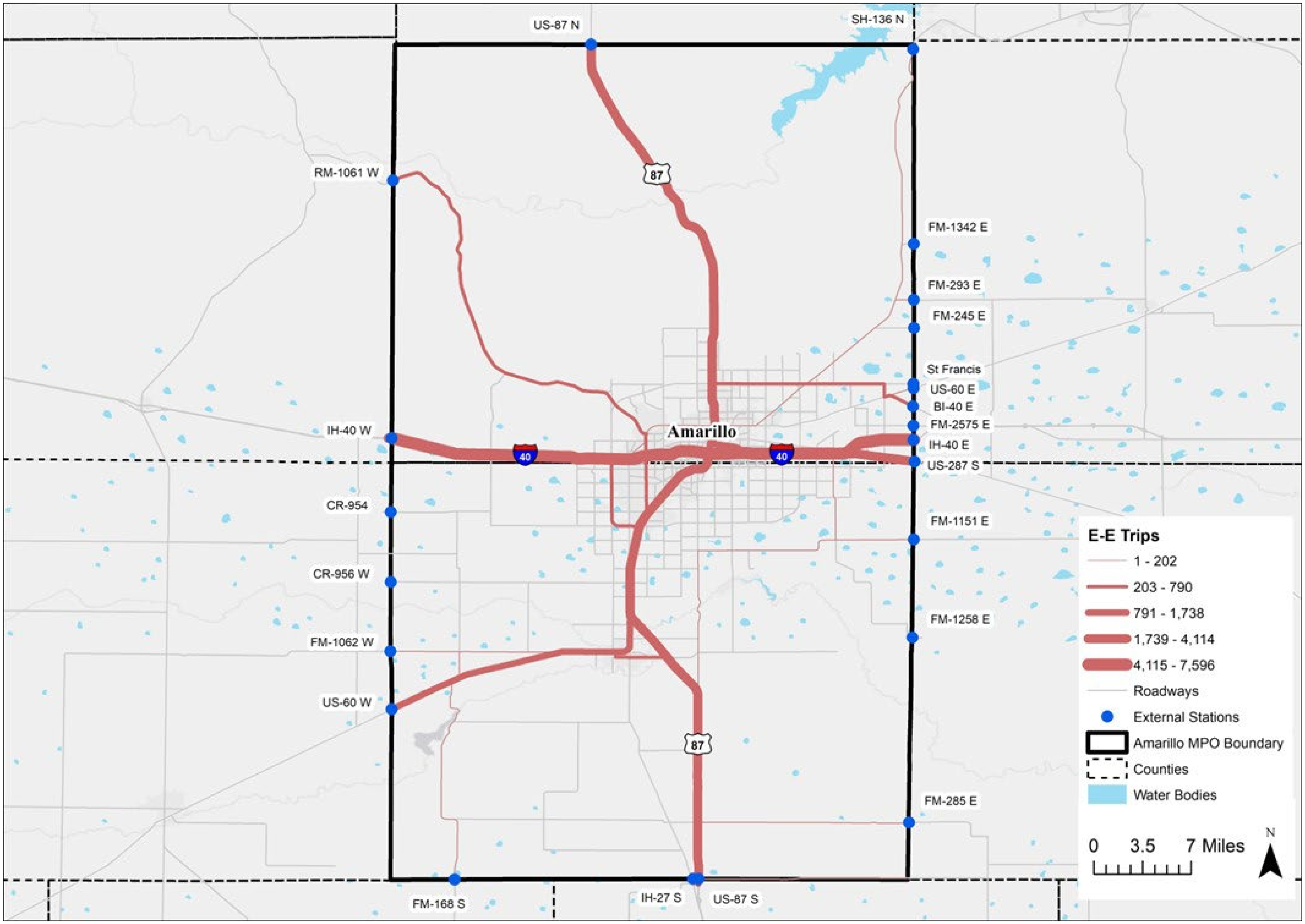

Figure 2. LBS External Trip (E-E) Assignment Flow Bands.

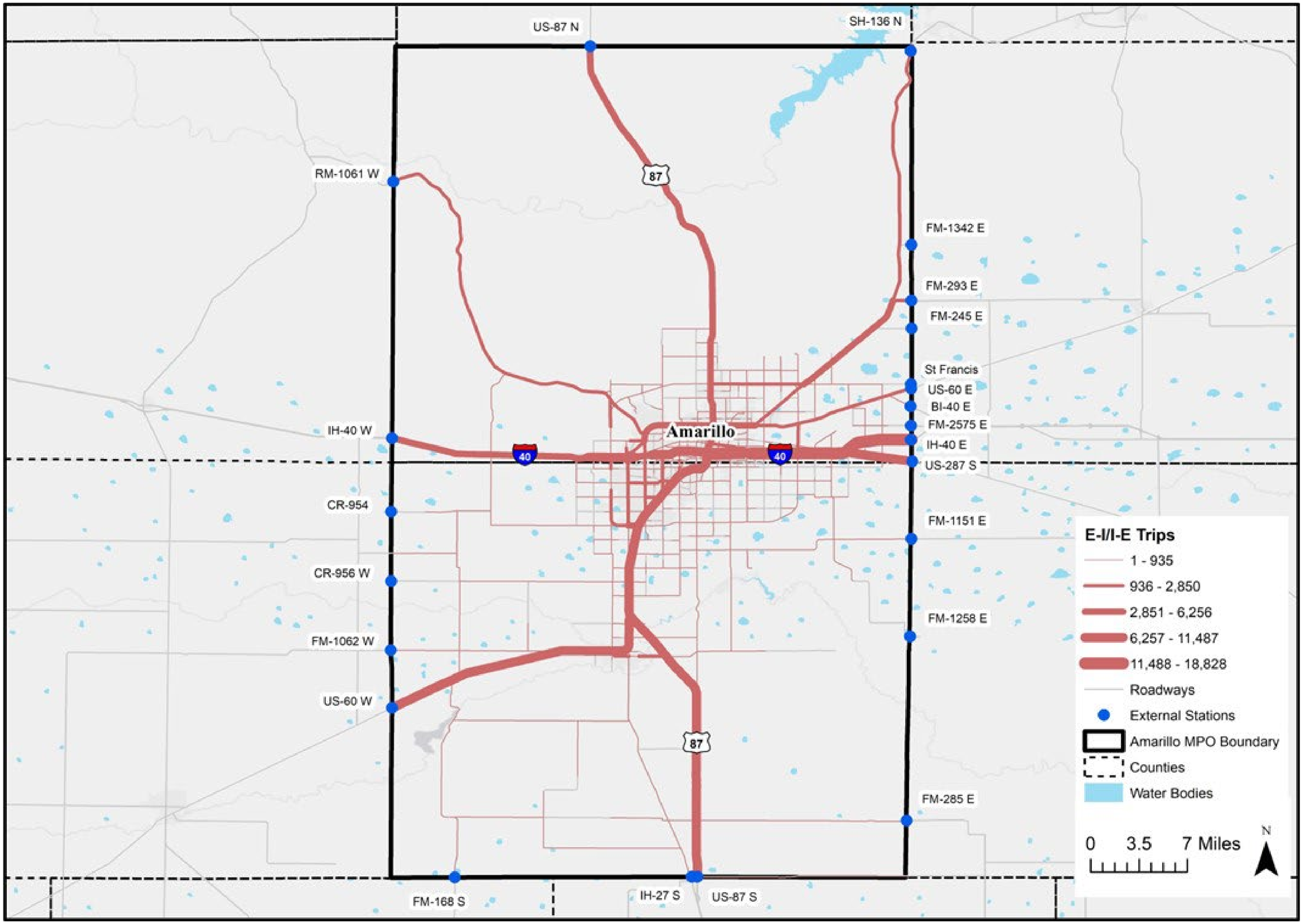

Figure 3. LBS External-Local (E-I /I-E) Assignment Flow Bands.

GPS Data

The INRIX Trajectory™ data come with an O-D matrix pre-routed to the Open-Source Routing Machine (OSRM) network. The OSRM network encompasses the entire study area. During processing, segments of the OSRM roadways are identified. These segments pass through the external station locations. These roadway segments help to determine whether a trip is going to be defined as I-E, E-I, or E-E. For example, if one trip passes from the interior of the study area and then crosses one of the OSRM segments and ends outside the study area, then that trip is defined as I-E. Alternatively, if a trip begins in the exterior and ends in the interior, then it is defined as E-I. When a trip starts outside the study area, passes through two of the identified OSRM segments, and ends outside of the study area, it is identified as an E-E trip. Figure 4 identifies the roads that were selected during processing.

In most cases, a 100-meter buffer is used to determine the roadways selected. However, in some cases, many roads exist in a given area. In those cases, the buffer is reduced to 50 meters, and the nearest roadway is selected. These roadway segments are then manually checked against TxDOT's RHINO network to confirm that the selected links are correct. When dealing with divided roadways, multiple OSRM segments have to be selected. These cases tend to occur on the major roadways heading into or out of the study area. For example, SH-6 entering and leaving the Bryan-College Station study area, IH-20 in the Midland-Odessa study area, and IH-30 in the Texarkana study area all require two segments be selected.

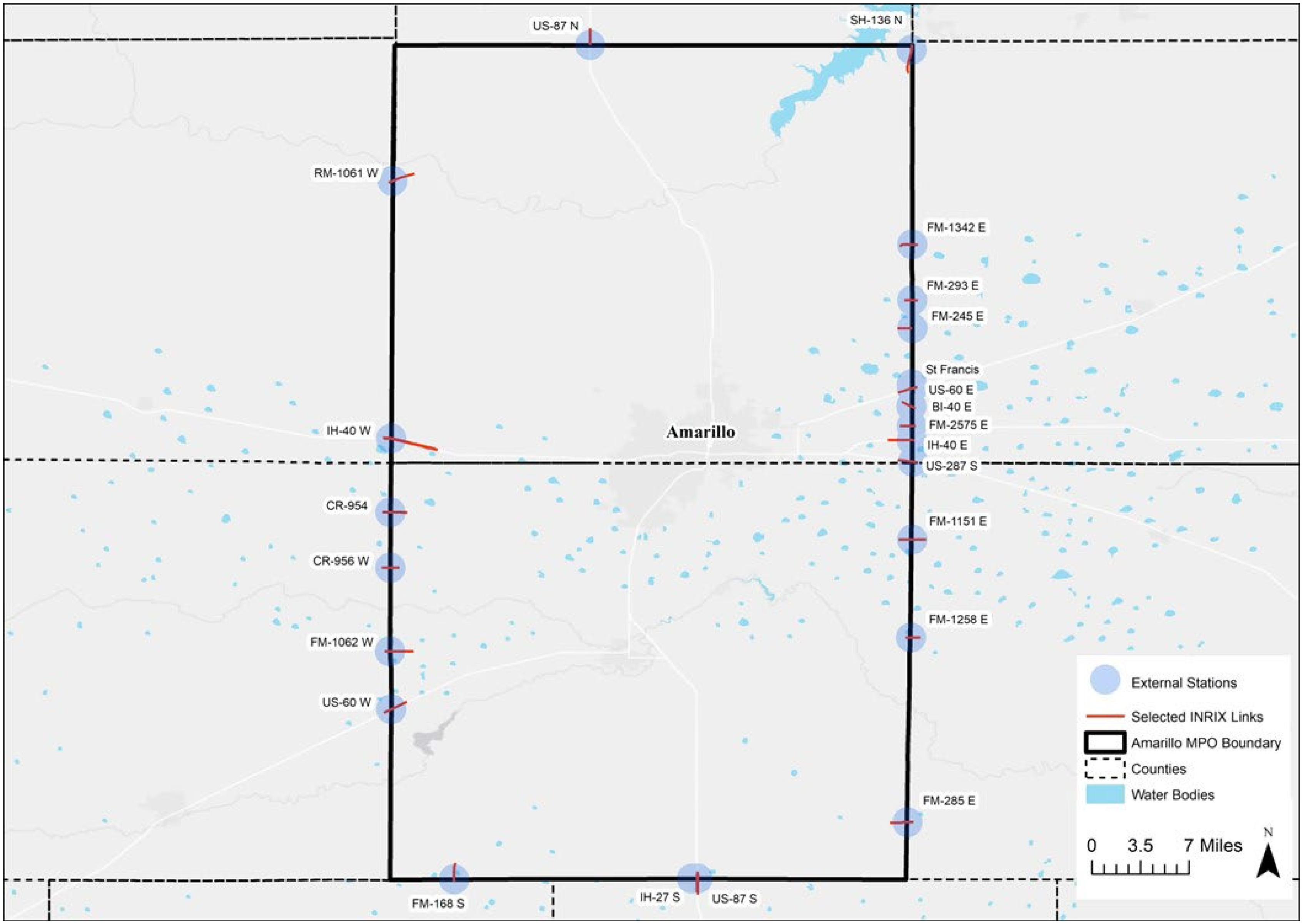

Figure 4. INRIX Selected Links.

DATA EXPANSION

Data expansion is the process of growing sample data to match a known population. Part of data expansion is calculating different weights representing each category of the population relative to the sample and vice versa. This process controls for biases in the sample data that may be over- represented. For external analysis, the basis for expansion is traffic counts, which represent the known population. Many techniques exist for weighting data. This study used a process known as iterative proportional fitting (IPF). The IPF procedure fixes values in a matrix to a known total. The process is iterative because it estimates initial weights. From the initial estimate, the resultant error is calculated, and the process then recalculates the weight using the error until it minimizes a specified minimum error. The IPF procedure seeks to minimize the weighted mean absolute percentage error (MAPE), which best controls for errors in higher volume roadways rather than large errors in smaller volume roadways.

LBS Data

LBS data from AirSage represent expanded results. AirSage expands LBS data by aggregating residents in the data, also known as resident clusters, to census tracts. The ratio of resident clusters to the total residents in the census tract is the penetration rate of the LBS data. AirSage applies this ratio to each trip made by each resident cluster. AirSage only provides expanded results, which the study team post processes as part of the external analysis. Figure 5 shows the locations that produce and attract the highest number of I-E/E-I trips per square mile within the Amarillo MPO area.

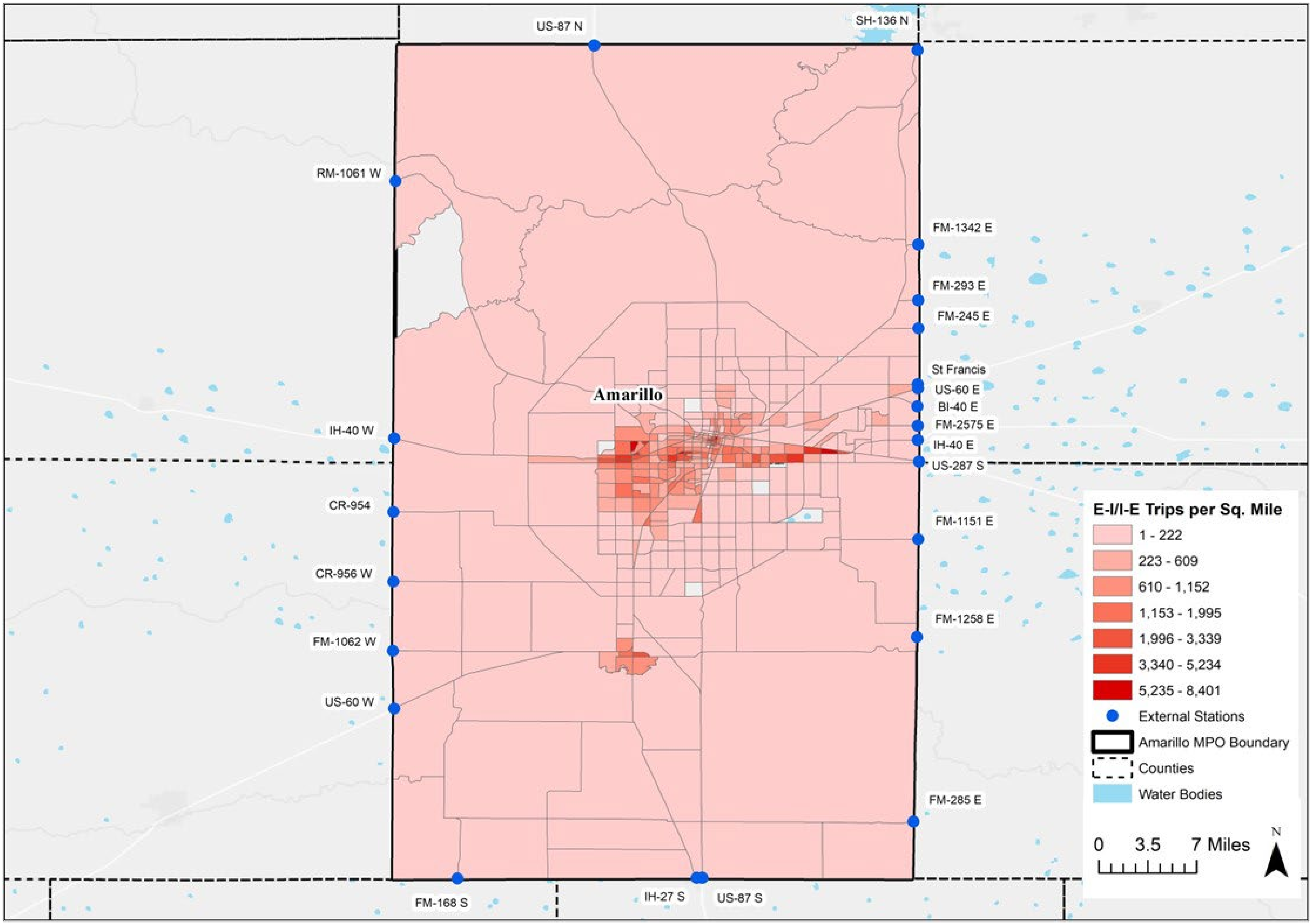

Figure 5. LBS External-Local Trips per Square Mile by Zone.

Table 6 provides sample size distributions for each of the external roadways for LBS and GPS data, sorted by roadway total volume. In reviewing Table 6, it is important to note that LBS data represent an expanded sample that is subject to error. Ultimately, what the LBS data provide are an approximate distribution of trips that will use the roadways. In later analysis, these distributions and overages are adjusted by fitting the data to the traffic counts. Presuming that LBS data are mostly passenger vehicles, they are approximately 94 percent of traffic counts. Alternatively, presuming that LBS data are representative of trucks and passenger vehicles, they are approximately 152 percent of traffic counts. AirSage and TTI researchers believe that LBS data have a significant passenger vehicle bias, and the proportion of passenger to commercial vehicles in the data is unknown.

The sample size overages contained in the LBS data reflect that the LBS data are device trips and not vehicular trips. In light of this finding, the study team calculated correction factors that negatively expanded the LBS results relative to traffic counts of cars. These LBS correction factors apply only to the external trips in the data.

In Table 6, the average GPS data are based on the total workdays during the study dates, which were 19 of the total 24 days within the study period.

Table 6. Passive Data Sample Size Distributions.

Highway	Count of Cars	Count of Trucks	Total Count	LBS	GPS Cars	GPS Trucks	% LBS Sample to Cars	% LBS Sample to Counts	% GPS Car to Counts (Avg)	% GPS Trucks to Counts (Avg)
IH-40 W	8,003	13,626	21,629	19,860	11,914	23,717	248%	92%	149%	174%
IH-40 E	9,400	10,600	20,000	33,013	11,651	20,327	351%	165%	124%	192%
US-287 S	12,969	5,664	18,633	10,524	7,690	10,524	81%	56%	59%	186%
US-87 N	9,145	5,749	14,894	13,064	6,706	8,149	143%	88%	73%	142%
IH-27 S	8,964	4,027	12,991	16,177	7,255	3,924	180%	125%	81%	97%
US-60 E	8,632	1,718	10,350	1,970	9,923	1,825	23%	19%	115%	106%
US-60 W	3,822	2,206	6,028	9,848	6,505	3,024	258%	163%	170%	137%
SH-136 N	4,640	633	5,273	2,918	5,449	560	63%	55%	117%	88%
RM-1061 W	4,247	369	4,616	2,653	2,227	771	62%	57%	52%	209%
US-87 S	926	355	1,281	218	959	76	24%	17%	104%	21%
FM-1151 E	678	205	883	438	785	96	65%	50%	116%	47%
FM-1062 W	588	186	774	512	406	97	87%	66%	69%	52%
FM-293 E	503	177	680	1,035	0	0	206%	152%	0%	0%
BI-40 E	468	110	578	1,294	263	196	276%	224%	56%	178%
FM-245 E	451	86	537	0	330	2	0%	0%	73%	2%
FM-168 S	316	179	495	178	243	53	56%	36%	77%	30%
FM-2575 E	366	95	461	0	0	0	0%	0%	0%	0%
CR-954	337	11	348	0	260	23	0%	0%	77%	209%
St Francis	226	7	233	0	58	6	0%	0%	26%	86%
FM-1342 E	125	38	163	0	15	1	0%	0%	12%	3%
FM-1258 E	85	26	111	0	39	1	0%	0%	46%	4%
FM-285 E	69	17	86	71	49	1	103%	83%	71%	6%
CR-956 W	22	1	23	21	16	2	95%	91%	73%	200%
Total	74,982	46,085	121,067	113,794	72,743	73,375	152%	94%	97%	159%

GPS Data

Table 6 shows that commercial vehicles make up about 50 percent of the GPS data. This result is ideal for developing external truck O-D matrices. Overall, the average sample for trucks was 159 percent, which generally increases as the roadway volume increases. This finding matches expectations since commercial vehicles comprise a greater portion of freeway traffic than non- freeway traffic. The results from cars have a lower average sample size of 97 percent.

Expansion of GPS results uses the total of all weekday trips observed in the data. This total compensates for empty cells within a trip O-D matrix. This phenomenon occurs due to the lack of observations of trips between an O-D pair on any given day. Using the total trips instead of a daily average allows for the capture of trips within these empty cells over time rather than using a snapshot. As with LBS data, the expansion process uses IPF to calculate correction factors. The procedure expands trucks negatively and cars positively.

O-D External Trip Matrices

The external data expansion process yields the external O-D trip matrices, which serve as input for the travel demand model. The model directly applies the final O-D trip matrices. These matrices are calculated by developing a ratio of the sample trips to the expanded trips for each external roadway. This ratio is then applied to all O-D pairs associated with that external roadway. For trucks, the O-D matrix only uses the GPS truck results. For passenger vehicles, the resulting trip table is an average of the LBS data.

RESULTS

Table 7 and Table 8 show the expanded results for LBS and GPS data. Overall, the expansion process minimally altered the distribution of external trips to correct for the differences in the sample and the traffic counts.

Table 7. LBS Area-Wide Weekday Expanded Trips.

	E-I	I-E	E-E	Total	Unexpanded E-E
Total Trips	28,109	28,109	8,582	64,800	16,862
Percent Total Trips	43.4%	43.4%	13.2%	100.0%	17.4%

Table 8. GPS Area-Wide Weekday Expanded Trips.

	E-I	I-E	E-E	Total	Unexpanded E-E
GPS Car Trips	41,730	41,730	3,166	86,626	2,707
GPS Truck	9,033	9,033	10,540	28,606	171,584
Total Trips	50,763	50,763	13,706	115,232	174,291
Percent Car Trips*	48.2%	48.2%	3.7%	100.1%	27.5%
Percent Truck Trips	31.6%	31.6%	36.8%	100.0%	43.3%
Percent Total Trips	44.1%	44.1%	11.8%	100.0%	43.0%

*Total may not sum to 100 percent due to rounding.

Table 9 shows a summary comparison of the total and percentage of E-E trips between the GPS and LBS data. The percentage of E-E trips reflects the percent of trips in relation to E-I/I-E trips for the entire study area.

Table 9. Comparison of E-E Trips and Total External Traffic Percentages between GPS and LBS Data.

Vehicle Category	GPS Expanded		LBS Expanded	
	E-E Trips	% E-E	E-E Trips	% E-E
Car	3,166	3.7%	8,582	13.2%
Truck	10,540	36.9%	NA	NA
Total	13,706	11.9%	8,582	13.2%

The percent of car E-E trips for the study area is 3.7 percent for GPS and 13.2 percent for LBS data. Considering the sample size and data coverage of both LBS and GPS data, researchers developed external estimations for cars based on the LBS results and for trucks based on GPS data. In cases where the LBS results were inconclusive, the GPS results were used for the estimation of cars. Table 10 shows the final summary of expanded trips from LBS and GPS data. Table 11 provides expanded, aggregate external estimations as a percent of total trips by station.

Table 10. Summary of Expanded External Trips from LBS and GPS Data.

Vehicle Category	Expanded Trips			Percent of Expanded Trips	
	E-E	Total	E-I/I-E	E-E	
Car	8,582	64,800	86.8%	13.2%	
Truck	10,540	28,606	63.2%	36.8%	
Total	19,122	93,406	79.5%	20.5%	

Table 11. Amarillo MPO Expanded External Trips.

Highway	Count of Cars**	Count of Trucks**	Total Count**	% I-E+E-I Cars	% E-E Cars	% I-E+E-I GPS Trucks	% E-E GPS Trucks
IH-40 W	8,003	13,626	21,629	49.0%	51.0%	39.1%*	60.9%*
IH-40 E	9,400	10,600	20,000	70.3%	29.7%	39.1%	60.9%
US-287 S	12,969	5,664	18,633	75.8%	24.2%	57.1%	42.9%
US-87 N	9,145	5,749	14,894	70.0%	30.0%	59.3%	40.7%
IH-27 S	8,964	4,027	12,991	73.4%	26.6%	67.1%	32.9%
US-60 E	8,632	1,718	10,350	90.0%*	10.0%*	79.2%	20.8%
US-60 W	3,822	2,206	6,028	85.7%	14.4%	70.0%	30.0%
SH-136 N	4,640	633	5,273	95.2%	4.8%	90.0%*	10.0%*
RM-1061 W	4,247	369	4,616	81.4%	18.6%	80.0%*	20.0%*
US-87 S	926	355	1,281	80.0%*	20.0%*	88.8%	11.2%
FM-1151 E	678	205	883	97.3%	2.7%	87.4%	12.6%
FM-1062 W	588	186	774	79.9%	20.1%	73.4%	26.6%
FM-293 E	503	177	680	99.6%	0.4%	80.0%	20.0%
BI-40 E	468	110	578	57.7%	42.3%	85.5%	14.6%
FM-245 E	451	86	537	85.0%	15.0%	90.0%*	10.0%*
FM-168 S	316	179	495	71.5%	28.5%	84.4%	15.6%
FM-2575 E	366	95	461	80.0%	20.0%	90.0%	10.0%
CR-954	337	11	348	90.0%	10.0%	90.0%	10.0%
St Francis	226	7	233	90.0%	10.0%	90.0%*	10.0%*
FM-1342 E	125	38	163	95.0%	5.0%	80.0%*	20.0%*
FM-1258 E	85	26	111	95.0%	5.0%	90.0%*	10.0%*
FM-285 E	69	17	86	85.3%	14.7%	90.0%*	10.0%*
CR-956 W	22	1	23	100.0%*	0.0%*	100.0%*	0.0%*

**Unique trips are differentiated from total counts (e.g., the total count of cars is not the sum of the counted cars) because each E-E trip crosses two external count stations and is thus double counted. Accordingly, to derive the total unique vehicle count, the E-E trips at each station are divided by a factor of two.

*Indicates that the value was estimated based on evaluation of similar type of facilities and the external station's location within the model area because there were no observations in the LBS or GPS data for the external station.

SUMMARY AND CONCLUSIONS

The 2020 Amarillo External Study used origin-destination (O-D) data acquired by TxDOT to develop estimates of external-to-external (E-E), external-to-internal (E-I), and internal-to-external (I-E) travel of passenger vehicles and trucks The LBS and GPS data were from the September of 2020 to coincide with the TxDOT saturation counts.

The Amarillo MPO study area consists of 433 TAZs and 23 external stations. These locations, along with some of the external zones are shown in Figure 1. The LBS and GPS sample travel data were expanded to 2020 traffic counts at each of the 23 external stations to develop I-E, E-I, and E-E O-D trip matrices. The LBS data are used for the passenger vehicle matrices, while GPS data are used for commercial vehicle matrices. Table 11 shows the expanded I-E/E-I and E-E trips by percentage for passenger cars and trucks at each external station. These results are used to develop four O-D trip matrices (or tables) needed as input to the Amarillo MPO TDM. These include matrices of I-E/E-I trips for the passenger vehicles and trucks and matrices of E-E trips for passenger vehicles and trucks. The matrices are developed using a ratio of the sampled trips to the expanded trips for each external station.

The study revealed that about 80 percent of external trips are for travel into and out of the Amarillo MPO study area (I-E and E-I trips), while the remaining 20 percent are for trips that travel completely through the study area (E-E trips). However, the splits between I-E/E-I and E-E trips are significantly different for passenger vehicles versus trucks. The LBS data revealed that 87 percent of passenger vehicle trips were I-E/E-I and 13 percent were E-E. By comparison, the GPS data showed that 63 percent of truck trips were I-E/E-I and 37 percent were E-E. The high percentage of truck travelling through Amarillo area can largely be attributed to the major freeways such as IH-40, IH-27, and US-287. For example, the study found that 61 percent of all trucks on IH-40 were travelling through the Amarillo area. As expected, results show that lower volume county roads and FM highways generally have fewer through trips and commercial vehicles than higher volume roadways such as U.S. highways and interstate freeways.

In summary, the study shows that the LBS and GPS proved to be a valuable data source for conducting external analysis. It can reveal both passenger vehicle and trucks travel patterns consistently at a large geographic scale, provides necessary input for planning needs.