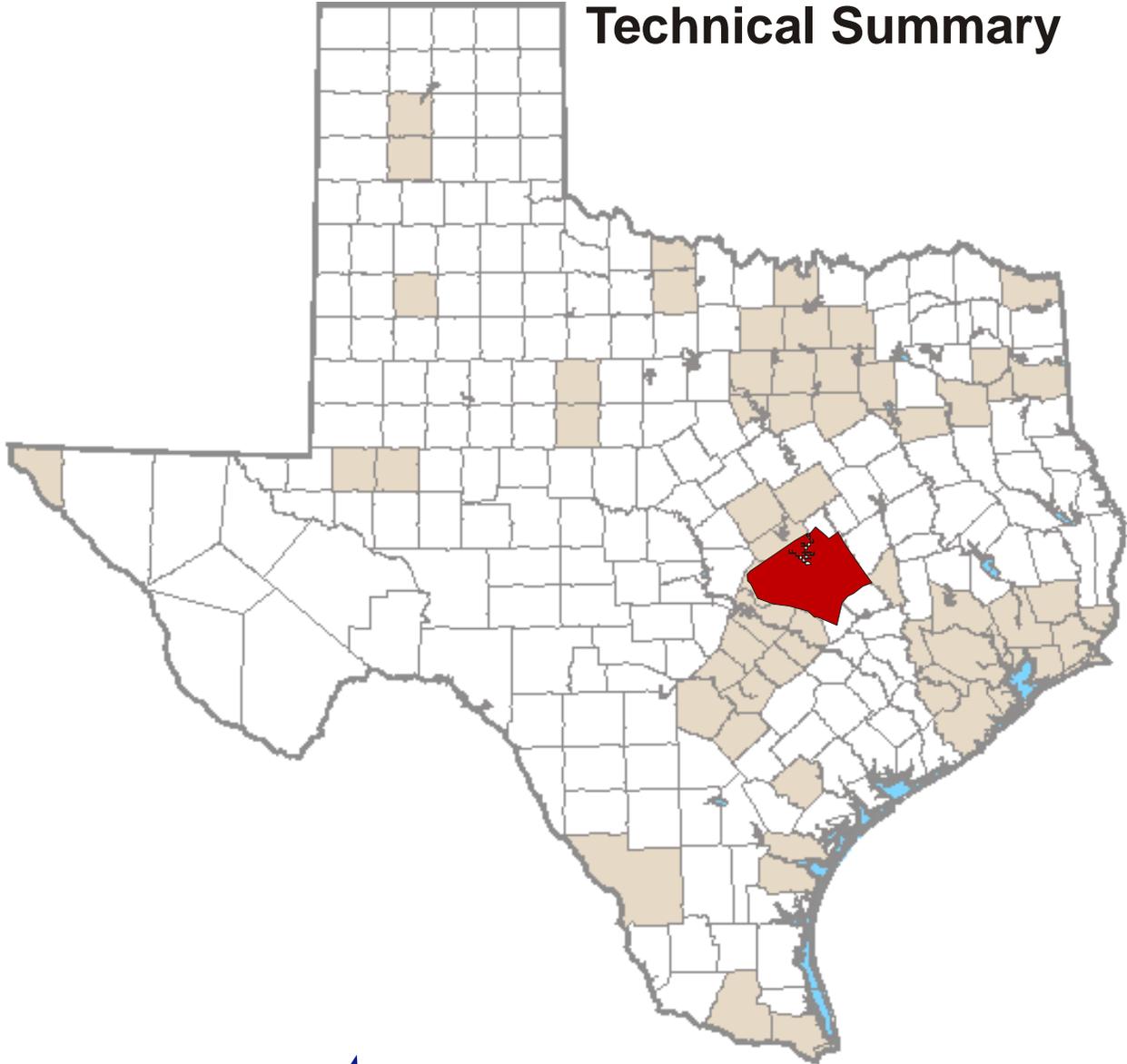


2008/2009 Killeen-Temple Commercial Vehicle Survey Technical Summary



Prepared by the
Texas Transportation Institute
December 2010

2008/2009 Killeen-Temple Commercial Vehicle Survey

TECHNICAL SUMMARY

Texas Department of Transportation Travel Survey Program

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INTRODUCTION

In 2008/2009, the Texas Department of Transportation (TxDOT) funded a commercial vehicle survey in the Killeen-Temple Urban Transportation Study (KTUTS) area. The purpose of this survey was to collect data on travel and trip-making characteristics of commercial vehicles that will enable TxDOT to plan for and forecast commercial vehicle travel demand within the Killeen-Temple urban areas.

The study area is located in Central Texas and, as shown in Figure 1, covers Bell County and portions of Coryell and Lampasas counties. The cities of Killeen and Temple had a total combined population of 176,600 in 2008. Fort Hood, which is a U.S. military base located outside of Killeen, is considered a special traffic generator in the study area. It is a census designated place in Bell County with some portions of the base lying in Coryell County, and has a total population of 34,200.

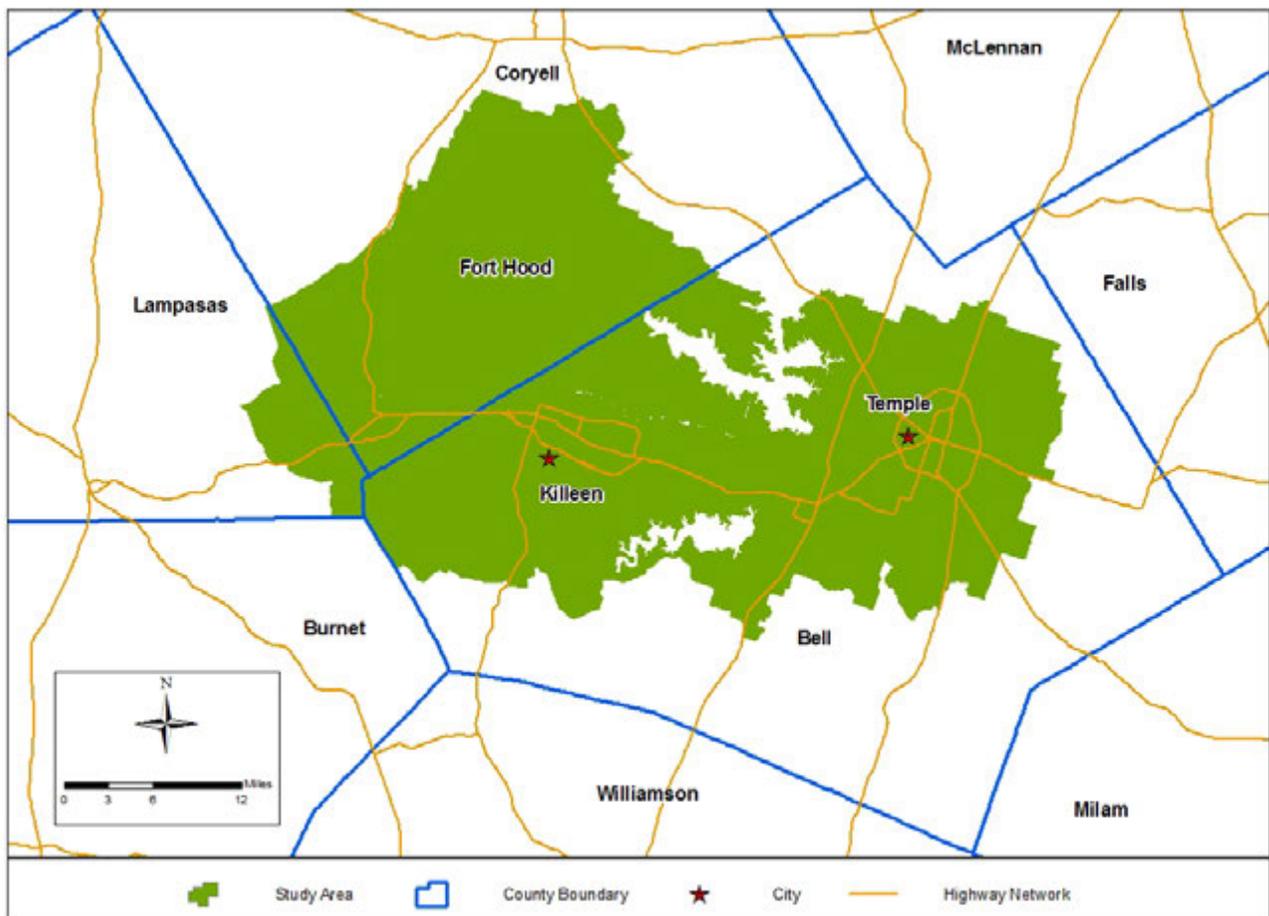


Figure 1. Killeen-Temple Study Area.

This report presents a technical summary of the commercial vehicle travel survey conducted in 2008/2009 in the Killeen-Temple urban area and documents the data collected and the analysis of results for the study area. The forms used in the survey are included in the Appendix of this report.

SURVEY METHODOLOGY

The commercial vehicle surveys for the Killeen-Temple study area were conducted during the period between April 2008 through May 2009, with a break during the summer months of June and July in 2008. TxDOT contracted with Alliance Transportation Group (ATG) to conduct the Killeen-Temple Commercial Vehicle Survey. The Texas Transportation Institute (TTI) provided technical assistance in the effort. Prior to the survey, a pilot study which consisted of 25 usable surveys from nine companies, was conducted to test the survey instrument and data collection procedures.

The survey sample was randomly selected from a listing of all businesses, individuals, and public agencies that own, operate, or lease commercial vehicles in the study area. The list was generated from the Texas Workforce Commission (TWC) employer database that was provided to the vendor in random order. Randomly selected businesses were contacted and requested to participate in the survey. Those who agreed to participate were provided survey packets and instructions on how the survey forms should be completed. Drivers of commercial vehicles from these establishments were asked to keep a 24-hour diary of the locations of all trips made by each vehicle.

Table 1 shows that more than 3,800 contacts were made during the recruitment process. Contacts were tracked based on the following three categories:

- Agreed to Participate. The company or individual operated qualifying vehicles making trips within the study area, agreed to participate, and complete and return the survey materials.
- Refused to Participate. The company or individual operated qualifying vehicles making trips within the study area but refused to participate in the survey.
- Not Participating. The company or individual did not operate a qualifying vehicle making trips within the study area; or the company or individual operated a qualifying vehicle, but it did not make trips within the study area.

Table 1. Survey Recruitment Participation.

Category	Contact Calls	
	Number	Percent of Total
Agreed to Participate	352	9.1
Refused to Participate	185	4.8
Not Participating	3,330	86.1
Total	3,867	100.0

Source: ATG, 2009.

A total of 147 companies participated in the Killeen-Temple commercial vehicle survey, from which a total of 310 surveys were obtained. TTI processed and reviewed the survey data collected to ensure that it was complete and followed the guidelines set forth in TxDOT's bid specification for the project. A data check program was utilized to examine the accuracy of geocoding of locations and the logic of survey responses.

The majority of data errors were expected to be corrected prior to final data submittals by the vendor. However, it was not unusual to find errors during actual data processing and analysis. In this study, three surveys were found to be duplicates, and another three surveys were found to be based outside the study area boundary. These were also some trip records that appeared inconsistent (arrival/departure hours were out of order or showed more than the 24-hour period activity). These surveys were considered void and were not included in the analysis.

The results presented in this technical summary are based on data from 304 surveyed commercial vehicles.

SURVEY RESULTS

Vehicle Characteristics

This section presents the characteristics of registered trucks and surveyed commercial vehicles to provide an overview of the type and condition of commercial vehicles operating within the Killeen-Temple study area. Information on registered trucks includes the number of diesel-fueled and gasoline-fueled trucks by gross vehicle weight and by model year. Information on surveyed commercial vehicles includes the vehicle make, model and year, odometer reading, gross vehicle weight, vehicle classification, and type of fuel used.

Registered Commercial Vehicles

Table 2 shows the distribution of registered trucks by gross vehicle weight, based on 2009 TxDOT vehicle registration data. It shows that there were 4,086 trucks registered in the Killeen-Temple study area in 2009 and that there were more diesel-fueled trucks (3,274) than gasoline-fueled trucks (812). Approximately 68 percent of the diesel-fueled trucks and 53 percent of the gasoline-fueled trucks had a gross vehicle weight between 8,500 lbs. and 10,000 lbs.

Figure 2 shows the distribution of registered trucks by model year. The majority of the diesel-fueled trucks (80 percent) were less than ten years old, compared to 54 percent for gasoline-fueled trucks. Approximately 17 percent of the gasoline-fueled trucks were older than 20 years, compared to less than 3 percent for diesel-fueled trucks.

Table 2. Gross Vehicle Weight of Registered Trucks in the Killeen-Temple Study Area.

Gross Vehicle Weight (lbs.)	Diesel-Fueled		Gasoline-Fueled		All Trucks	
	Number of Trucks	Percent of Total	Number of Trucks	Percent of Total	Number of Trucks	Percent of Total
> 8500	2,211	67.5	433	53.3	2,644	64.7
> 10000	268	8.2	151	18.6	419	10.3
> 14000	105	3.2	60	7.4	165	4.0
> 16000	67	2.0	41	5.1	108	2.6
> 19500	231	7.1	84	10.3	315	7.7
> 26000	117	3.6	24	3.0	141	3.5
> 33000	228	7.0	18	2.2	246	6.0
> 60000	47	1.4	1	0.1	48	1.2
Total	3,274	100.0	812	100.0	4,086	100.0

Source: TxDOT, 2009.

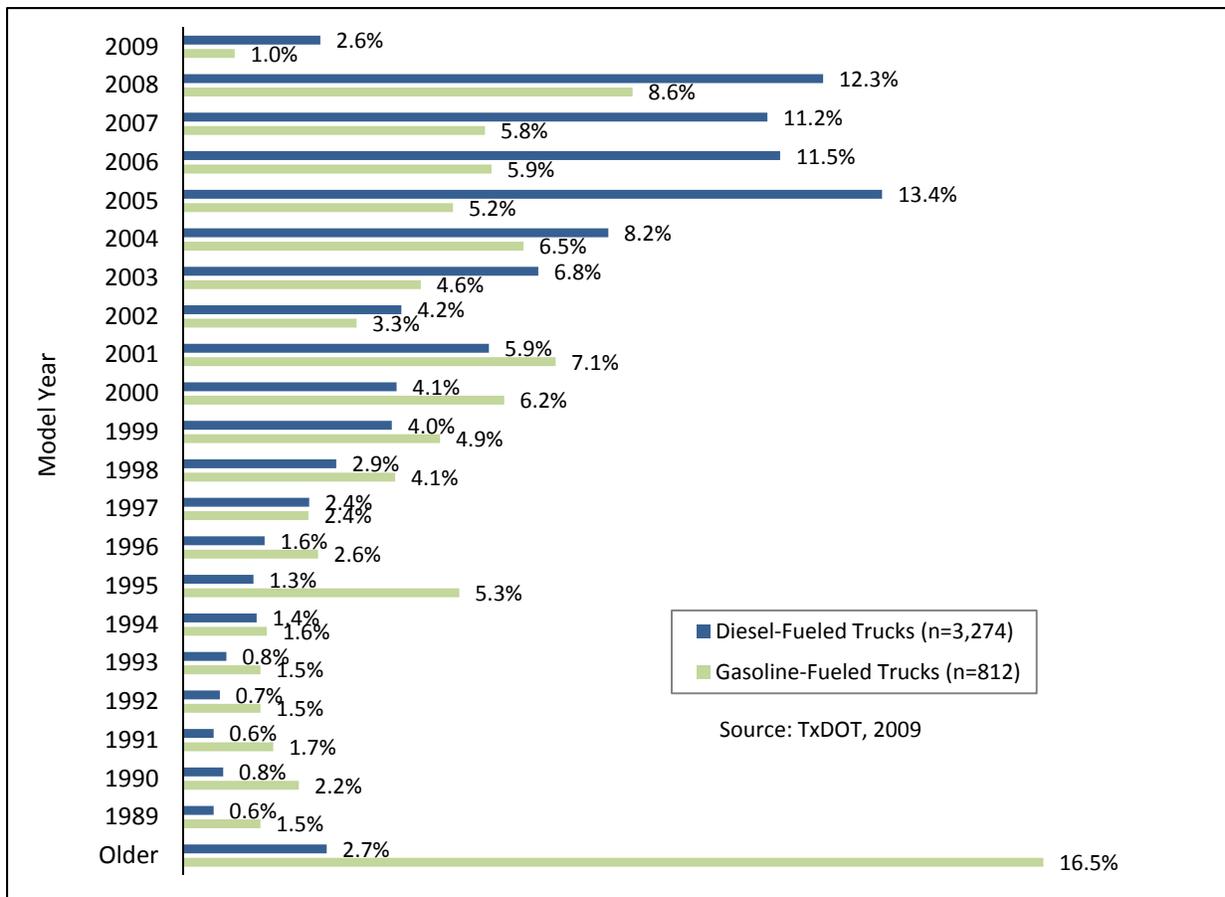


Figure 2. Model Year of Registered Trucks in the Killeen-Temple Study Area.

Surveyed Commercial Vehicles

Commercial vehicles that participated in the Killeen-Temple commercial vehicle survey were distinguished based on the nine vehicle types listed in Table 3. These types were further categorized by commercial type as either cargo/freight transport or service vehicles.

Cargo vehicles were defined as vehicles mainly used to transport cargo or freight, which were typically bulk goods, materials, and cargo in large quantities for wholesale distribution. Service vehicles were defined as vehicles mainly used to perform services such as those used by building contractors, plumbers, electricians, cable and telephone services/repairs, and delivery vans/vehicles used by local retailers. These also included company fleet vehicles or fleets and maintenance vehicles of public agencies such as TxDOT, city, county, or school districts.

Out of the total 304 commercial vehicles surveyed, 155 were cargo vehicles and 149 were service vehicles. Table 3 shows the vehicle classification type of these vehicles. Among surveyed cargo vehicles, approximately 47 percent were single unit two-axle trucks (six-wheelers), 14 percent were single unit three-axle trucks (10-wheelers), 21 percent were semi tractor/trailer combinations, and 14 percent were pick-up trucks. Among surveyed service vehicles, approximately 52 percent were pick-up trucks, 15 percent were vans, and 9 percent were either single unit two-axle and three-axle trucks. Vehicles classified as “other” were mostly buses, which neither belonged in the van or single unit two-axle categories. There were some vehicles that were coded as “refused,” and several cases of pick-up trucks were coded as cars or vans. These vehicles were re-classified to properly represent their characteristics.

Table 3. Vehicle Classification Type of Surveyed Commercial Vehicles.

Vehicle Classification	Cargo Vehicles		Service Vehicles		All Vehicles	
	Number of Vehicles	Percent of Total	Number of Vehicles	Percent of Total	Number of Vehicles	Percent of Total
Passenger Car	0	0.0	3	2.0	3	1.0
Pick-Up Truck	22	14.2	77	51.6	99	32.6
Van (passenger or mini)	6	3.9	22	14.8	28	9.2
Sport Utility Vehicle	0	0.0	5	3.4	5	1.6
Single Unit two-axle (six wheels)	73	47.1	13	8.7	86	28.3
Single Unit three-axle (10 wheels)	21	13.5	13	8.7	34	11.2
Single Unit four-axle (14 wheels)	1	0.6	0	0.0	1	0.3
Semi (all Tractor-Trailer Combinations)	32	20.7	5	3.4	37	12.2
Other	0	0.0	11	7.4	11	3.6
Total	155	100.0	149	100.0	304	100.0

Figure 3 shows the distribution of surveyed commercial vehicles by fuel type. Approximately 79 percent of cargo vehicles used diesel, 19 percent used gasoline, and less than two percent used another type of fuel such as propane. Among service vehicles, 64 percent used gasoline and 36 percent used diesel. Among total surveyed vehicles, 41 percent used gasoline and 58 percent used diesel.

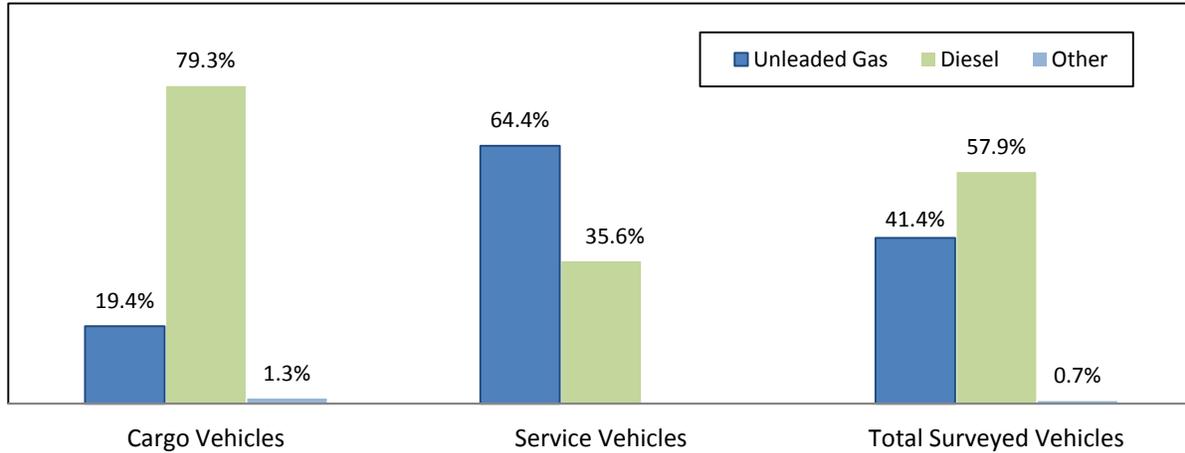


Figure 3. Type of Fuel Used by Surveyed Commercial Vehicles.

Table 4 shows the gross vehicle weight of surveyed commercial vehicles. Approximately 48 percent of the service vehicles had a gross vehicle weight of less than 8,500 lbs., while 63 percent of cargo vehicles had a gross vehicle weight of more than 19,500 lbs. but not exceeding 90,000 lbs.

Table 4. Gross Vehicle Weight of Surveyed Commercial Vehicles.

Gross Vehicle Weight (lbs.)	Cargo Vehicles		Service Vehicles		All Vehicles	
	Number of Vehicles	Percent of Total	Number of Vehicles	Percent of Total	Number of Vehicles	Percent of Total
< 8,500	19	12.2	72	48.3	91	29.9
> 8,500	7	4.5	11	7.3	18	5.9
> 10,000	8	5.2	14	9.4	22	7.3
> 14,000	4	2.6	5	3.4	9	3.0
> 16,000	8	5.2	0	0.0	8	2.6
> 19,500	27	17.4	7	4.7	34	11.2
> 26,000	12	7.7	6	4.0	18	5.9
> 33,000	29	18.7	10	6.7	39	12.8
> 60,000	30	19.4	5	3.4	35	11.5
Unknown	11	7.1	19	12.8	30	9.9
Total	155	100.0	149	100.0	304	100.0

Figure 4 shows the distribution of surveyed vehicles by model year. Approximately 72 percent of service vehicles and 66 percent of cargo vehicles were less than 10 years old. The average age for cargo vehicles was 8.0 years, while the average age for service vehicles was 6.3 years.

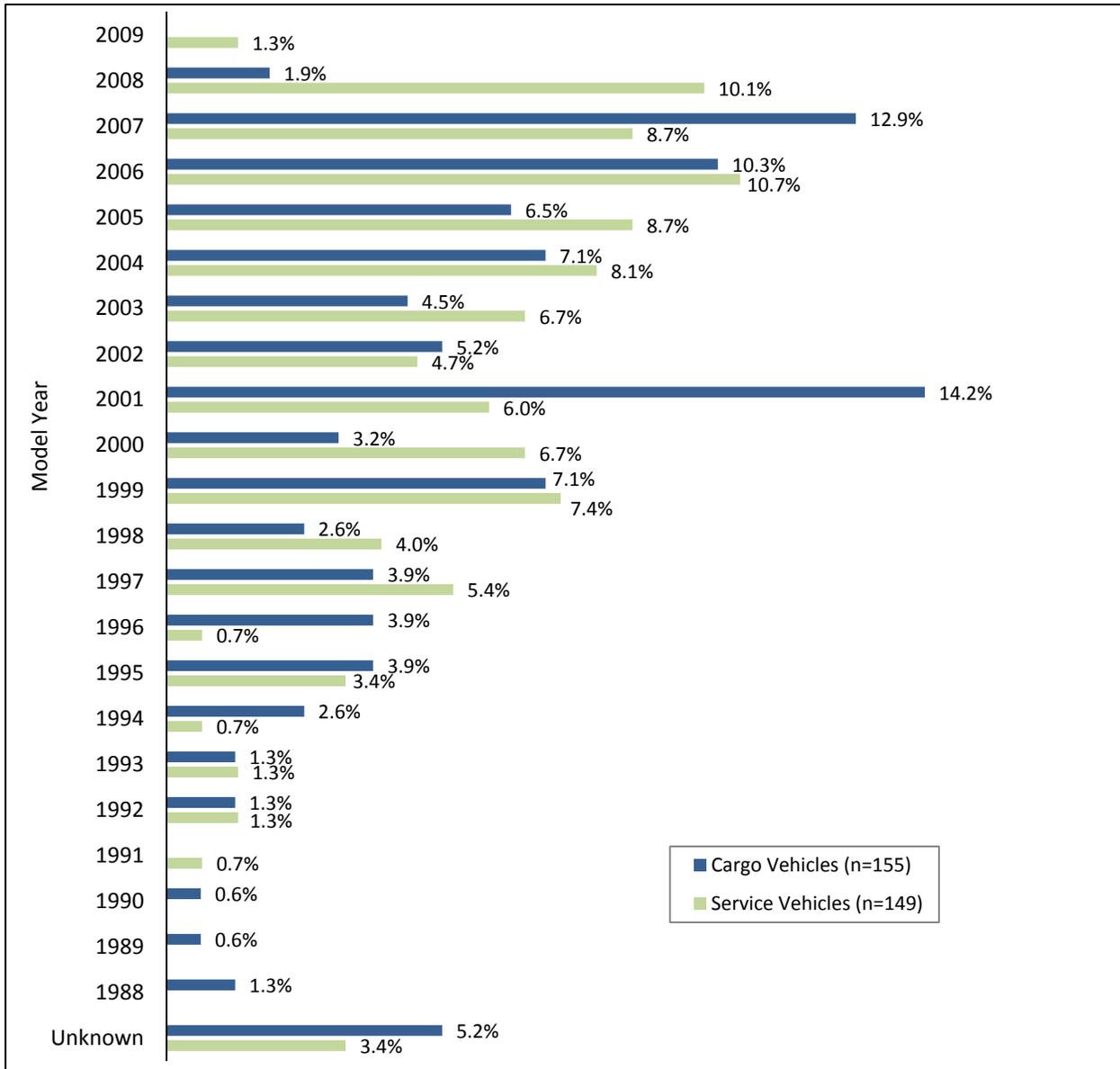


Figure 4. Model Year of Surveyed Commercial Vehicles.

Table 5 shows the average vehicle mileage by model year based on odometer readings reported by 223 of the surveyed vehicles (103 cargo vehicles and 120 service vehicles) at the beginning of their travel day. The average odometer mileage for cargo vehicles was 312,500 miles, compared to 131,100 miles for service vehicles.

Table 5. Model Year and Average of Reported Odometer Readings of Surveyed Commercial Vehicles.

Model Year	Cargo Vehicles		Service Vehicles		All Vehicles	
	Number of Vehicles	Average of Reported Odometer Readings	Number of Vehicles	Average of Reported Odometer Readings	Number of Vehicles	Average of Reported Odometer Readings
2009	0	0	2	16,279	2	16,279
2008	2	14,686	14	15,597	16	15,483
2007	12	32,917	8	51,462	20	40,335
2006	9	769,527	16	65,068	25	318,673
2005	7	104,879	9	73,744	16	87,365
2004	8	354,167	11	262,797	19	301,269
2003	7	140,719	6	100,096	13	121,970
2002	4	386,351	7	124,700	11	219,846
2001	12	216,178	6	108,614	18	180,323
2000	4	234,873	8	170,394	12	191,887
1999	9	196,355	10	277,694	19	239,165
1998	3	250,137	5	184,788	8	209,294
1997	2	248,502	7	223,280	9	228,885
1996	5	983,768	1	131,000	6	841,640
1995	4	473,544	4	159,014	8	316,279
1994	4	688,150	1	156,735	5	581,867
1993	2	394,406	0	0	2	394,406
1992	2	23,046	2	213,381	4	118,213
1991	0	0	1	197,011	1	197,011
1990	1	134,000	0	0	1	134,000
1989	1	672,440	0	0	1	672,440
1988	2	137,407	0	0	2	137,407
Unknown	3	235,748	2	86,076	5	175,879
Total	103	312,479	120	131,083	223	214,867

Trip Frequency

The surveyed commercial vehicles generated 2,414 total trips, of which 1,945 were internal trips and 469 were external trips. Internal trips were defined as those trips made within or between zones inside the Killeen-Temple study area. These trips were further distinguished as inter-zonal trips, those trips made from one zone to another, or intra-zonal, those trips made within the same zone. External trips were those having one or both ends of the trip outside of the study area.

Figure 5 shows the distribution of inter-zonal, intra-zonal, and external trips, and Table 6 provides a breakdown of these trips. Approximately 81 percent of the total trips were internal, of which nearly 75 percent were inter-zonal and 6 percent were intra-zonal. The remaining 19 percent were external trips. Cargo vehicles generated 1,172 trips, of which approximately 68 percent were inter-zonal trips, 5 percent were intra-zonal trips, and 27 percent were external trips. Service vehicles generated 1,242 trips, of which 81 percent were inter-zonal trips, 7 percent were intra-zonal trips, and 12 percent were external trips.

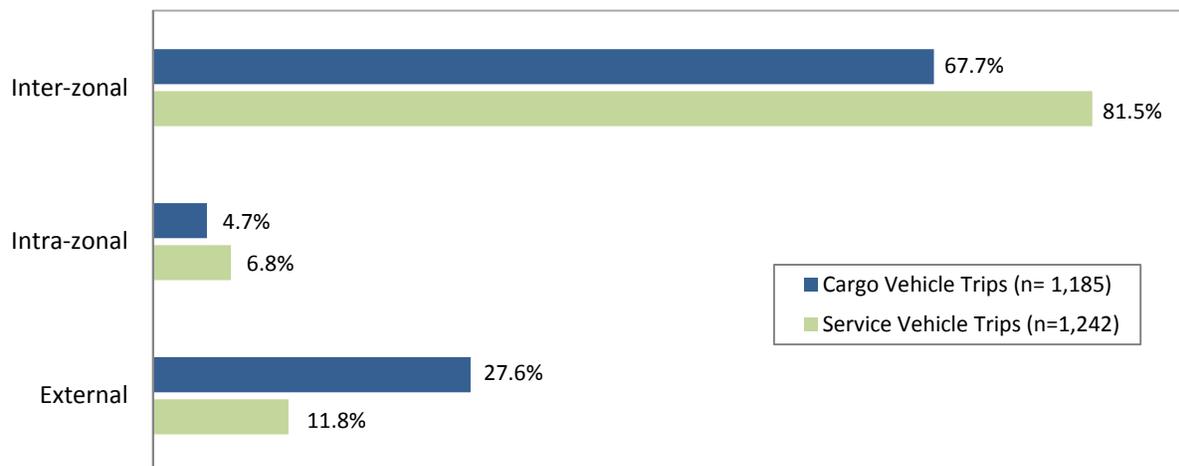


Figure 5. Inter-Zonal, Intra-Zonal, and External Trips.

Table 6. Total Internal and External Trips.

Trip Type	Cargo Vehicles		Service Vehicles		All Vehicles	
	Number of Trips	Percent of Total	Number of Trips	Percent of Total	Number of Trips	Percent of Total
Inter-Zonal	794	67.7	1,012	81.5	1,806	74.8
Intra-Zonal	55	4.7	84	6.8	139	5.8
Total Internal	849	72.4	1,096	88.2	1,945	80.6
External	323	27.6	146	11.8	469	19.4
Total	1,172	100.0	1,242	100.0	2,414	100.0

Figure 6 shows the distribution of total commercial vehicle trips (internal and external trips), which varied from two trips to 19 trips per cargo and service vehicle. However, there were 10 vehicles, mostly service vehicles and specifically buses, which made more than 19 trips on their survey day. These vehicles generated 62 additional trips that were not recorded in their travel diary due to lack of space. Including these unrecorded trips, the average number of total trips per day was 7.6 trips for cargo vehicles and 8.7 trips for service vehicles.

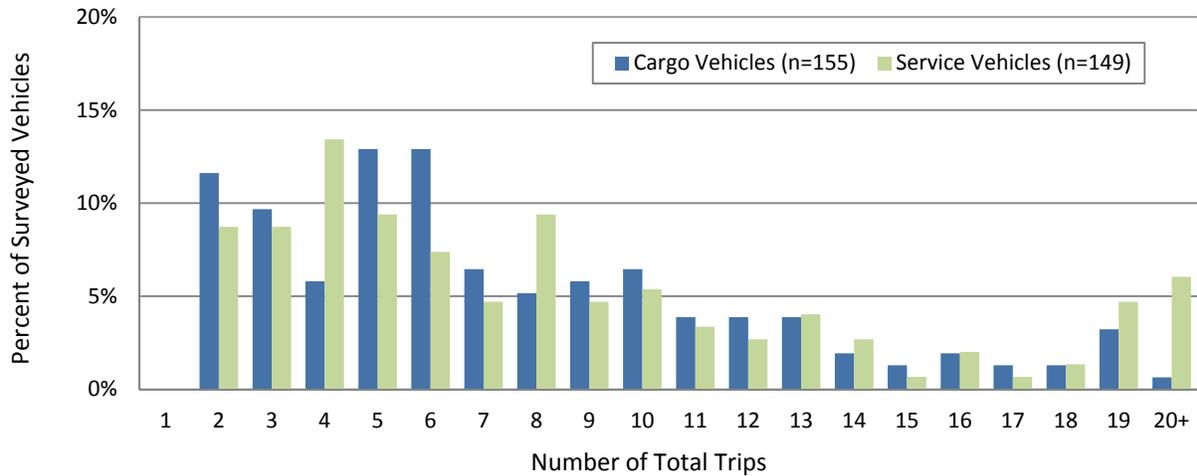


Figure 6. Total Trips per Vehicle.

Figure 7 shows the distribution of total internal trips only. Approximately 8 percent of the cargo vehicles and 4 percent of the service vehicles made one internal trip per day. In contrast, the total trips made by the surveyed vehicles indicated a minimum of two trips per day. The variation is attributed to the exclusion of external trips. The average number of internal trips per day, including the 62 unrecorded trips, was 6.5 trips for cargo vehicles and 8.6 trips for service vehicles.

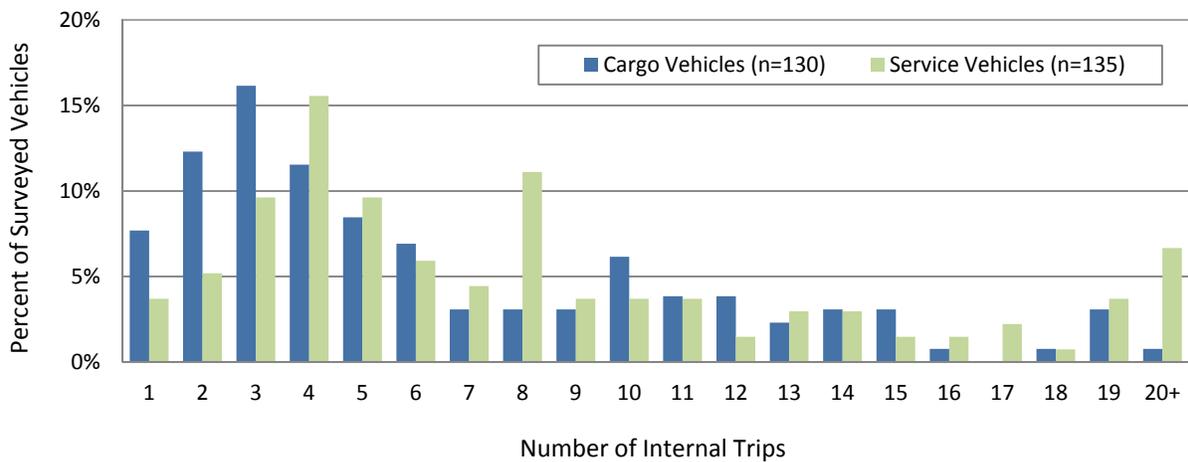


Figure 7. Total Internal Trips per Vehicle.

Trip Characteristics

Information on travel purpose and the type of land use activity where these trips occurred are important in estimating commercial vehicle trip patterns. The analysis of trips presented in this section is based solely on internal trips, and does not include external trips.

Table 7 shows the land use types at trip destinations. Approximately 24 percent of the total internal cargo vehicle trips occurred at retail/shopping places, 20 percent occurred at industrial sites, and 16 percent occurred at construction sites. For service vehicle trips, 24 percent occurred at residential sites, 12 percent occurred at retail/shopping places, and 11 percent occurred at office buildings.

Table 7. Land Use Types at Trip Destinations.

Land Use Type	Cargo Vehicles		Service Vehicles	
	Number of Trips	Percent of Total	Number of Trips	Percent of Total
Office Building (non-government)	40	4.7	120	10.9
Retail/Shopping	200	23.6	131	12.0
Industrial/Manufacturing	172	20.2	35	3.2
Medical/Hospital	7	0.8	78	7.1
Education (12th grade or less, college, trade)	12	1.4	42	3.8
Government Office/Building	11	1.3	25	2.3
Residential	96	11.3	257	23.5
Warehouse	73	8.6	33	3.0
Distribution Center	21	2.5	26	2.4
Construction Site	137	16.1	46	4.2
Other	77	9.1	134	12.2
Refused/Unknown	3	0.4	169	15.4
Total Trips	849	100.0	1,096	100.0

Table 8 shows the trip purposes at destination locations. Approximately 55 percent of the total internal cargo vehicle trips were delivery, 17 percent were return-to-base location, and 14 percent were pick-up. For service vehicle trips, approximately 31 percent were service-related, 24 percent were delivery, 17 percent were pick-up, and 15 percent were return-to-base location.

Table 8. Trip Purposes at Trip Destinations.

Trip Purpose	Cargo Vehicles		Service Vehicles	
	Number of Trips	Percent of Total	Number of Trips	Percent of Total
Base Location	140	16.5	166	15.2
Delivery	470	55.4	261	23.8
Pick-Up	121	14.3	189	17.2
Pick-Up and Delivery	24	2.8	35	3.2
Maintenance (fuel, oil, etc.)	14	1.6	26	2.4
Driver Needs (lunch, etc.)	18	2.1	42	3.8
Service-Related	57	6.7	338	30.8
Other	5	0.6	39	3.6
Total	849	100.0	1,096	100.0

Cargo Characteristics

Information on the type of cargo being delivered or picked up at each stop, the weight of cargo, and the type of land use where the cargo trip occurred were collected in the Killeen-Temple commercial vehicle survey to examine the movement of commodities within and outside of the study area. The analysis presented in this section is for internal and external trips made by surveyed cargo vehicles only, and does not include the trips made by service vehicles.

The analysis of cargo trip data examined the types of cargo being transported at trip destinations, the trip purpose and land use activity at each stop, and the estimated net weight of the cargo being picked up and/or delivered for each trip. There were several inconsistencies observed in the cargo trip data. Some trips that reported full or partial cargo loads did not provide the weight of the cargo but indicated the type of cargo being transported. Some trips that reported the delivery trip purpose did not provide the cargo weight at drop-off. There were some trips that reported the cargo weight at pick-up, but the weight was not consistent at drop-off. Such inconsistencies generated errors in the estimation of net weight of cargo for that particular trip. Hence, it was necessary to manually process the cargo trip data, and use the researchers' judgment when making changes as deemed fit.

Figure 8 shows the load status of surveyed cargo vehicles at the beginning of the trip. Approximately 52 percent of the 155 cargo vehicles reported partial load status, while 26 percent were fully loaded with cargo, and the remaining 22 percent were empty. Table 9 lists the types of cargo in the survey based on the 22 classification types.

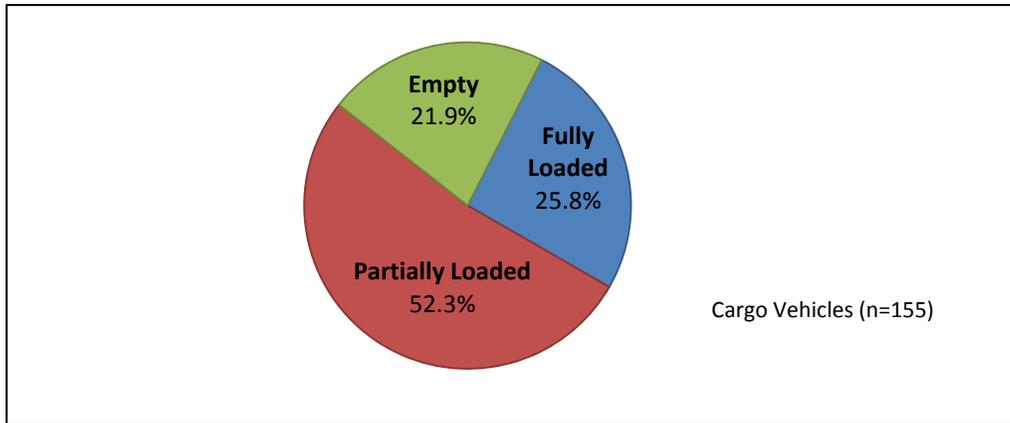


Figure 8. Cargo Load Status at Trip Start.

Table 9. Cargo Classification Types.

Survey Cargo Classification	Cargo Description
1. Farm Products	Livestock, fertilizer, dirt, landscaping, etc.
2. Forest Products	Trees, sod, etc.
3. Marine Products	Fresh fish, seafood, etc.
4. Metals and Minerals	Crude petroleum, natural gas, propane, metal, gypsum, etc.
5. Food, Health, and Beauty Products	Assorted food products, cosmetics, etc.
6. Tobacco Products	Cigarettes, cigars, and chewing tobacco
7. Textiles	Clothing, linens, etc.
8. Wood Products	Lumber, paper, cardboard, wood pulp, etc.
9. Printed Matter	Newspapers, magazines, books, etc.
10. Chemical Products	Soap, paint, household or industrial chemicals, etc.
11. Refined Petroleum or Coal	Gasoline, etc.
12. Rubber, Plastic, and Styrofoam	Finished products of rubber, plastic, or styrofoam
13. Clay, Concrete, Glass, or Stone	Finished products of clay, concrete, glass, or stone
14. Manufactured Goods and Equipment.	Miscellaneous products - machinery, appliances, furniture, etc.
15. Wastes	Waste products including scrap and recyclable materials
16. Miscellaneous Shipments	U.S. mail, U.P.S., Federal Express, and other mixed cargo
17. Hazardous Materials	Hazardous chemicals and substances
18. Transportation	Automobiles and other transport vehicles
19. Unclassified Cargo	Cargo not falling within one of the above categories
20. Driver Refused to Answer	Driver refused to answer
21. Unknown to Driver	Unknown to driver
22. Empty	Empty (including empty shipping containers)

Table 10 shows the distribution of trips by cargo type at destination locations. Approximately 84 percent of the total cargo vehicle trips were transporting cargo, while the remaining 16 percent were not carrying cargo. The most frequently transported cargo were manufactured goods and equipment (25 percent), food, health, and beauty products (23 percent), unclassified or other cargo (13 percent), and clay, concrete, glass or stone products (11 percent).

Table 10. Types of Cargo being Transported at Trip Destinations.

Cargo Type	Cargo Vehicles	
	Number of Trips	Percent of Total
Farm Products	6	0.6
Forest Products	3	0.3
Marine Products	1	0.1
Metals and Minerals	40	4.1
Food, Health, and Beauty Products	228	23.2
Tobacco Products	1	0.1
Textiles	1	0.1
Wood Products	55	5.6
Printed Matter	0	0.0
Chemical Products	40	4.1
Refined Petroleum or Coal Products	30	3.1
Rubber, Plastic, and Styrofoam Products	6	0.6
Clay, Concrete, Glass, or Stone	112	11.4
Manufactured Goods and Equipment.	248	25.2
Wastes	37	3.7
Miscellaneous Shipments	8	0.8
Hazardous Materials	0	0.0
Transportation	0	0.0
Unclassified/Other Cargo	129	13.1
Driver Refused to Answer	37	3.8
Unknown to Driver	1	0.1
Total Trips with Cargo	983	83.9*
Empty	189	16.1*
Total Cargo Vehicle Trips	1,172	100.0

Note: * Value is computed from total cargo vehicle trips.

The commodity grouping scheme used by TxDOT in the Texas Statewide Analysis Model (SAM) was used to aggregate the cargo types into 10 commodity groups. The types of place option in the survey were categorized into seven land use categories. Table 11 shows the equivalency between SAM commodity groups and cargo classification types from the survey, while Table 12 shows the equivalency between land use categories and type of place options from the survey. Those items *in italics* did not have equivalents but were added or grouped together so as not to exclude any trips in the analysis.

Table 11. Equivalency between SAM Commodity Groups and Survey Cargo Classification Types.

Commodity Group	Survey Cargo Classification
1 Agriculture	Farm Products, Forest Products, Marine Products
2 Raw Materials	Metals and Minerals, Chemical Products, Refined Petroleum or Coal Products
3 Food	Food, Health and Beauty Products, Tobacco Products
4 Textiles	Textiles, Rubber, Plastic, and Styrofoam Products
5 Wood	Wood Products, Printed Matter
6 Building Materials	Clay, Concrete, Glass or Stone Products
7 Machinery	Manufactured Goods/Equipment
8 Miscellaneous	Wastes, Miscellaneous Shipments
9 Secondary	Unclassified Cargo
10 Hazardous Materials	Hazardous Materials
<i>Transportation</i>	<i>Transportation</i>
<i>Empty</i>	<i>Empty</i>
<i>Unknown</i>	<i>Unknown to Driver/ Driver Refused to Answer</i>

Table 12. Equivalency between Land Use Categories and Survey Types of Place.

Land Use Category	Survey Type of Place
1 Office	Office Building
2 Retail	Retail/Shopping
3 Industrial	Industrial/Manufacturing
4 Medical	Medical/Hospital
5 Education	Educational (12th grade or less and college, trade, etc.)
6 Government	Government Office/Building
7 Residential	Residential
<i>Other</i>	<i>Airport, Inter-Modal Facility, Warehouse, Distribution Center, Construction Site, Other</i>

Figure 9 shows the distribution of cargo trips at the destination locations by commodity group and Figure 10 shows distribution by land use type. Machinery and food commodities made up 42 percent of the cargo trips. Approximately 16 percent were not transporting cargo. Nearly 22 percent of the trips occurred at retail sites, 19 percent occurred at industrial sites, and 11 percent occurred at residential sites. Approximately 40 percent of the trips occurred at “other” land use types, mainly warehouses, distribution centers and construction sites. Table 13 provides the breakdown of cargo trips by commodity group and land use type.

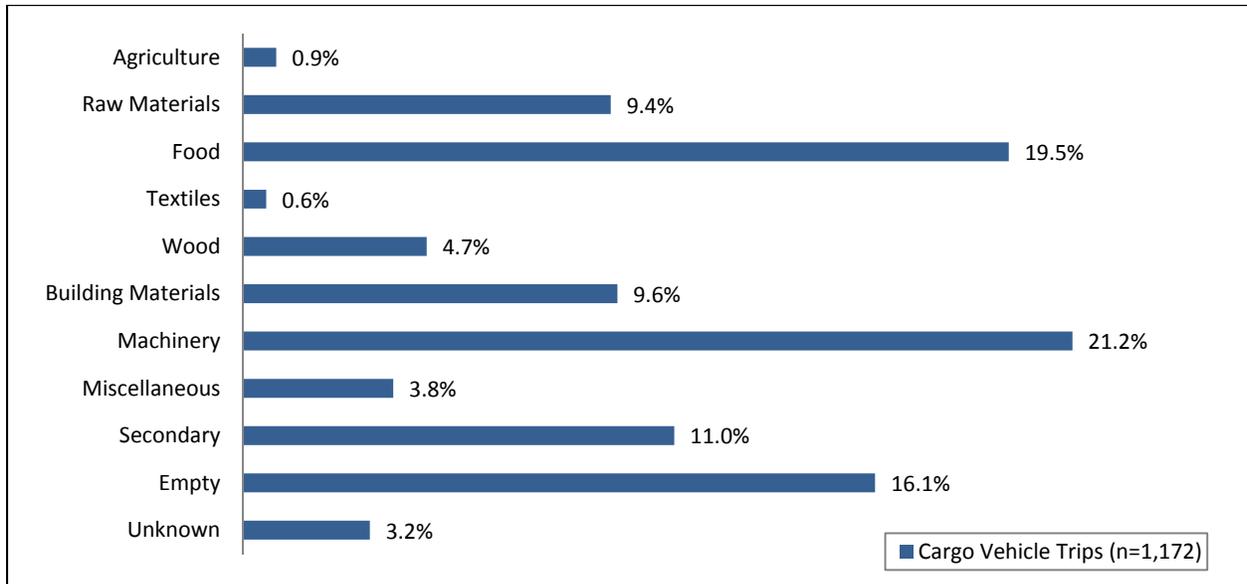


Figure 9. Commodity Groups at the Trip Destinations.

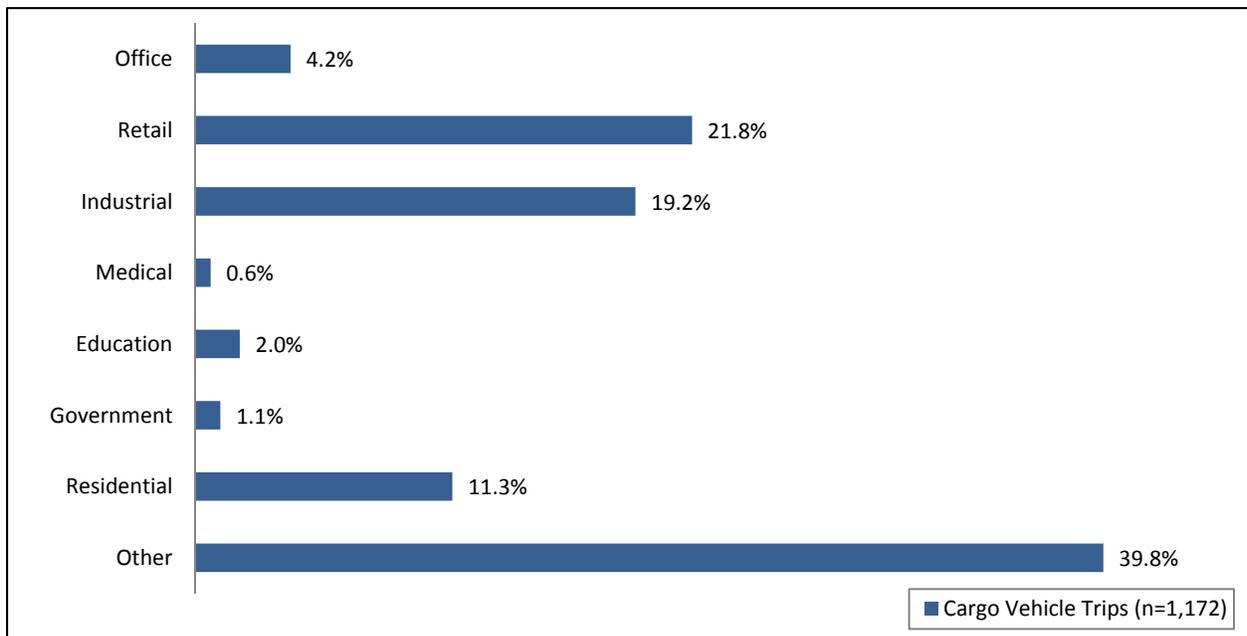


Figure 10. Land Use Types at the Trip Destinations.

Table 13. Cargo Trips by Commodity Group and Land Use at the Trip Destinations.

Commodity Group	Land Use								Total Trips	Percent of Total
	Office	Retail	Ind'l	Med	Edu	Gov't	Res	Other		
Agriculture	0	1	1	0	0	0	1	7	10	0.9
Raw Materials	1	11	16	0	4	3	17	58	110	9.4
Food	7	120	9	1	3	0	6	83	229	19.5
Textiles	1	1	2	0	0	0	0	3	7	0.6
Wood	1	2	21	0	1	1	11	18	55	4.7
Building Materials	4	3	26	0	1	0	8	70	112	9.6
Machinery	5	23	78	0	3	4	40	95	248	21.2
Miscellaneous	1	2	19	2	2	0	0	19	45	3.8
Secondary	14	28	8	5	6	3	26	39	129	11.0
Empty	12	63	33	0	3	2	23	53	189	16.1
Unknown	3	1	13	0	0	0	0	21	38	3.2
Total	49	255	226	8	23	13	132	466	1,172	100.0
Percent of Total	4.1	21.8	19.3	0.6	2.0	1.1	11.3	39.8	100.0	

The analysis of cargo weight by cargo type provides information on the volume and type of commodities being moved from the time the surveyed cargo vehicle left its base location, began its trip and continued making trips until it reached its destination(s) and returned to its base location. The net cargo weight for each trip was estimated based on the cargo weight being picked-up and/or being dropped-off, consistent with the reported trip purpose for each stop. There were several cases when cargo types were changed between trips (i.e., reported as empty cargo or food type), even if the same cargo was being transported either for delivery or pick-up. The driver of the surveyed cargo vehicle reported a different trip purpose during a particular stop (i.e., driver needs - lunch, etc.), which indicated that no cargo was either delivered and/or picked-up but the cargo remained in transit. In such cases, the cargo weight from the trip origin should be the net cargo weight at that particular stop or trip destination with its corresponding cargo type. If a delivery occurred during that particular stop, the cargo weight for that particular drop-off should be deducted from the current weight load, and if cargo was picked-up, the cargo weight should be added to the current weight load, thus resulting in an estimated net cargo weight for that particular trip.

Figure 11 shows the distribution of trips at destination locations by trip purpose, while Table 14 shows a detailed summary of trips by commodity group and trip purpose. Approximately 55 percent of the total cargo vehicle trips were delivery, with food and machinery as the most frequently delivered among the commodity groups. Machinery showed the highest number of trips for pick-up. The trip purpose “pick-up” made up 14 percent of the total cargo trips. However, these do not represent the actual proportion of trips that picked up cargo because some of the trips coded as “base location” trip purpose were also the pick-up locations for cargo.

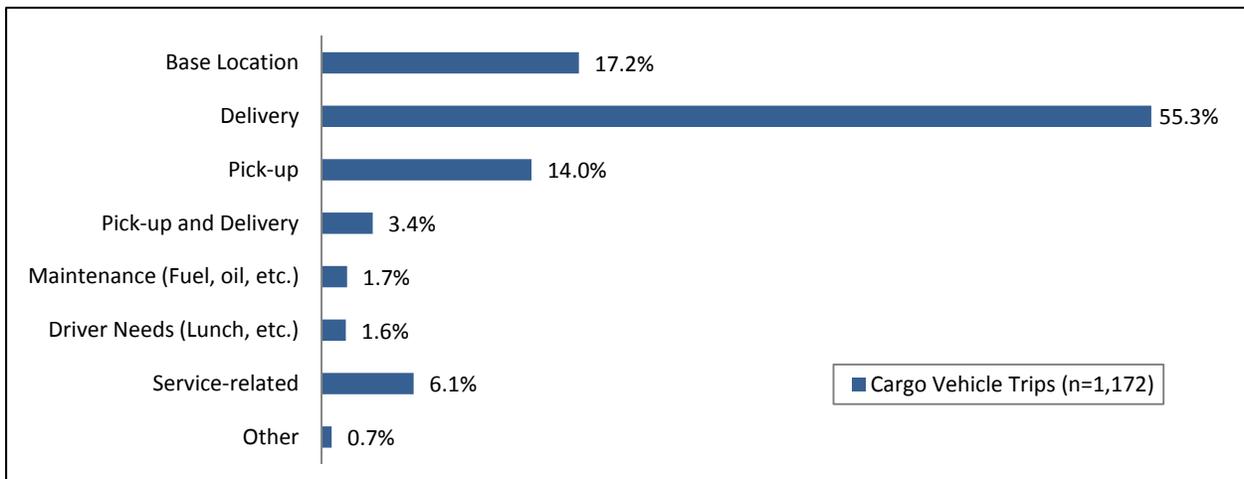


Figure 11. Cargo Trip Purposes at the Trip Destinations.

Table 14. Cargo Trips by Commodity Group and Trip Purpose at the Trip Destinations.

Commodity Group	Trip Purpose								Total Trips	Percent of Total
	Base Location	Delivery	Pick-Up	Pick-up & Delivery	Main-tenance	Driver Needs	Service-related	Other		
Agriculture	2	5	2	0	0	0	1	0	10	0.9
Raw Materials	11	67	15	9	6	1	0	1	110	9.4
Food	2	209	2	4	1	0	11	0	229	19.5
Textiles	0	6	1	0	0	0	0	0	7	0.6
Wood	12	36	3	0	1	1	0	2	55	4.7
Building Materials	18	60	18	7	2	1	6	0	112	9.6
Machinery	11	144	77	4	1	5	6	0	248	21.2
Miscellaneous	7	20	16	0	1	1	0	0	45	3.8
Secondary	8	82	16	13	0	0	9	1	129	11.0
Empty	127	2	1	1	8	9	39	2	189	16.1
Unknown	3	17	13	2	0	1	0	2	38	3.2
Total Trips	201	648	164	40	20	19	72	8	1,172	100.0
Percent of Total	17.2	55.3	14.0	3.4	1.7	1.6	6.1	0.7	100.0	

Table 15 shows the distribution of average net cargo weight per trip by commodity group and land use type at destination locations and Table 16 shows the distribution by commodity group and trip purpose. Building materials being transported to office and industrial land use types showed the highest average net cargo weight, followed by textiles being transported to retail sites. Food and textile products showed the highest average net cargo weight for pick-up, while building materials showed the highest average net cargo weight for base location and pick-up and delivery.

Table 15. Average Net Cargo Weight by Commodity Group and Land Use at Trip Destinations.

Commodity Group	Land Use (Average Net Cargo Weight in lbs.)							
	Office	Retail	Ind'l	Med	Educ	Gov't	Res	Other
Agriculture	0	495	29,240	0	0	0	1,300	14,199
Raw Materials	2,100	12,509	9,060	0	20,390	7,927	3,856	13,787
Food	702	7,685	663	370	4,800	0	762	8,007
Textiles	1,335	40,000	20,100	0	0	0	0	763
Wood	305	3,750	7,452	0	500	8,000	763	2,729
Building Materials	64,000	300	43,682	0	0	0	32,167	36,137
Machinery	13,123	1,550	22,510	0	683	5,036	1,908	19,047
Miscellaneous	20,100	15,500	15,678	4,980	900	0	0	12,761
Secondary	3,685	6,099	185	78	1,210	2,153	5,574	5,351
Unknown	27,690	0	29,150	0	0	0	0	26,152

Table 16. Average Net Cargo Weight by Commodity Group and Trip Purpose at Trip Destinations.

Commodity Group	Trip Purpose (Average Net Cargo Weight in lbs.)							
	Base Location	Delivery	Pick-Up	Pick-up & Delivery	Main-tenance	Driver Needs	Service-related	Other
Agriculture	8,543	16,461	15,270	0	0	0	495	0
Raw Materials	6,086	9,558	26,561	9,026	7,407	3,000	0	7,835
Food	269	7,118	60,400	310	492	0	562	0
Textiles	0	7,304	40,000	0	0	0	0	0
Wood	3,067	4,846	20,190	0	1,500	500	0	440
Building Materials	55,159	37,720	29,602	50,193	0	300	333	0
Machinery	502	13,530	23,456	779	5,850	1,641	2,521	0
Miscellaneous	13,269	12,177	14,758	0	15,240	12,500	0	0
Secondary	2,888	3,898	3,387	8,512	0	0	9,560	650
Unknown	17,190	27,359	29,000	28,000	0	0	0	0

Table 17 shows the distribution of cargo trips and net cargo weights at trip destinations by commodity group. Overall, the average net cargo weight per trip was 13,500 lbs. Building materials showed the highest average net cargo weight of approximately 38,600 lbs. per trip. However, machinery and food were the most frequently transported commodity groups with net cargo weights of 15,300 lbs. and 7,000 lbs. per trip, respectively.

Table 17. Cargo Trips and Net Cargo Weight by Commodity Group at Trip Destinations.

Commodity Group	Total Cargo Trips	Total Net Cargo Weight (lbs.)	Number of Trips*	Average Net Cargo Weight (lbs.)*
Agriculture	10	130,426	10	13,043
Raw Materials	110	1,172,456	104	11,274
Food	229	1,616,952	229	7,061
Textiles	7	83,824	7	11,975
Wood	55	210,895	45	4,687
Building Materials	112	3,742,540	97	38,583
Machinery	248	3,740,976	244	15,332
Miscellaneous	45	539,390	40	13,485
Secondary	129	580,863	127	4,574
Empty	189	-	-	-
Unknown	38	849,760	31	27,412
Total	1,172	12,668,082	934	13,563

*Excluding trips with empty cargo.

Table 18 shows the number of trips and net cargo weights at trip destinations by land use type. Industrial sites showed the highest average net cargo weight of 20,000 lbs. per trip. However, more trips occurred at other land use types, with average net cargo weight of 16,900 lbs. per trip.

Table 18. Cargo Trips and Net Cargo Weights by Land Use at Trip Destinations.

Land Use	Total Cargo Trips	Total Net Cargo Weight (lbs)	Number of Trips*	Average Net Cargo Weight (lbs)*
Office	49	457,332	36	12,704
Retail	255	1,342,399	187	7,179
Industrial	226	3,786,501	189	20,034
Medical	8	10,718	8	1,340
Education	23	107,570	19	5,662
Government	13	58,384	11	5,308
Residential	132	392,580	99	3,965
Other	466	6,512,598	385	16,916
Total	1,172	12,668,082	934	13,563

*Excluding trips with empty cargo.

Table 19 shows the distribution of cargo trips and net cargo weights by trip purpose. Cargo pick-up had the highest average net weight of 22,400 lbs. per trip. However, there were more delivery trips, with average net cargo weight of 11,600 lbs. per trip.

Table 19. Cargo Trips and Net Cargo Weights by Trip Purpose at Trip Destinations.

Trip Purpose	Total Cargo Trips	Total Net Cargo Weight (lbs.)	Number of Trips*	Average Net Cargo Weight (lbs.)*
Return to Base Location	201	1,208,874	71	17,026
Delivery	648	7,195,141	618	11,643
Pick-Up	164	3,556,810	159	22,370
Pick-Up and Delivery	40	506,582	34	14,899
Maintenance (fuel, oil, etc.)	20	67,522	10	6,752
Driver Needs (lunch, etc.)	19	24,505	9	2,723
Service-Related	72	99,283	29	3,424
Other	8	9,365	4	2,341
Total	1,172	12,668,082	934	13,563

*Excluding trips with empty cargo.

Trip Length

Odometer readings at the beginning and end of the trip are useful in estimating travel distances for external and intra-zonal trips. The Killeen-Temple commercial vehicle survey, however, only provided odometer mileage on each vehicle for the beginning of the trip and not for the end of the trip. Because this incomplete information makes odometer readings not particularly useful for trip length measurement in this analysis, network matrices available for the study area were used to estimate trip lengths. The network matrices provide travel distance and time estimates from one zone to another zone in the Killeen-Temple study area network. Since each reported trip in the survey was coded with a traffic analysis zone (TAZ) number assigned to the study area, it was then possible to estimate the trip length based on the distance provided in the network matrix.

Figure 12 shows the TAZ boundary and base locations of surveyed vehicles within the Killeen-Temple study area, while Figure 13 shows the origin and destination locations of trips made by the surveyed vehicles. Any trip that had at least one trip outside of the Killeen-Temple TAZ structure was considered an external trip.

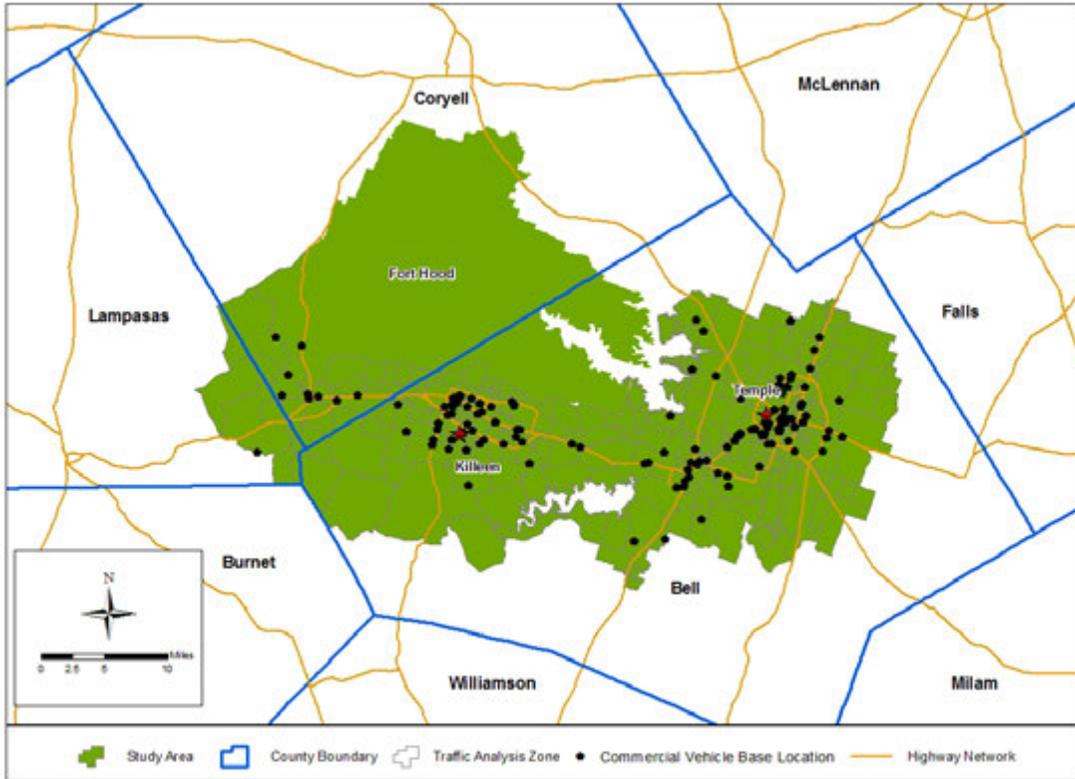


Figure 12. TAZ Boundary and Base Locations of Surveyed Commercial Vehicles.

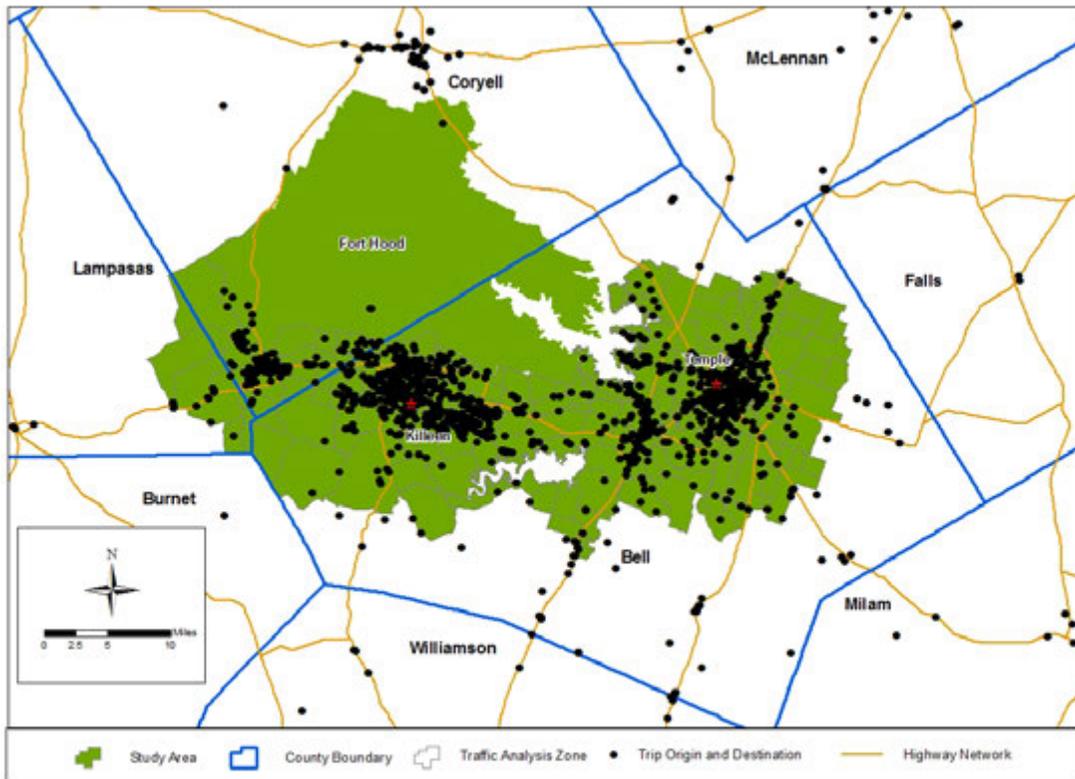


Figure 13. Trip Origins and Destinations of Surveyed Commercial Vehicles.

The results presented in this section pertain to trip length characteristics for 1,796 inter-zonal trips only. There were 10 reported inter-zonal trips with unknown origin and destination zones. These trips were not included in the analysis and estimation of average trip lengths.

Table 20 shows the trip length frequency distribution (TLFD), grouped at five-mile intervals, while Figure 14 and Table 21 show the ungrouped TLFD. Approximately 63 percent of the cargo and vehicle trips had trip lengths less than five miles, and 21 percent of the cargo vehicle trips and 23 percent of the service vehicles had trip lengths between six miles and 10 miles. The longest trip lengths reported by cargo and service vehicles were 43 miles and 35 miles, respectively.

Table 20. Trip Length Frequency Distribution (Grouped Interval).

Trip Length (miles)	Cargo Vehicles		Service Vehicles		All Vehicles	
	Number of Trips	Percent of Total	Number of Trips	Percent of Total	Number of Trips	Percent of Total
Less than 5	496	62.5	629	62.8	1,125	62.6
6 to 10	166	20.9	230	23.0	396	22.0
11 to 15	47	5.9	82	8.2	129	7.2
16 to 20	25	3.1	34	3.4	59	3.3
21 to 25	29	3.7	21	2.1	50	2.8
26 to 30	12	1.5	5	0.5	17	0.9
31 to 35	10	1.3	1	0.1	11	0.6
36 to 40	6	0.8	0	0.0	6	0.3
41 to 45	3	0.4	0	0.0	3	0.2
Total	794	100.0	1,002	100.0	1,796	100.0

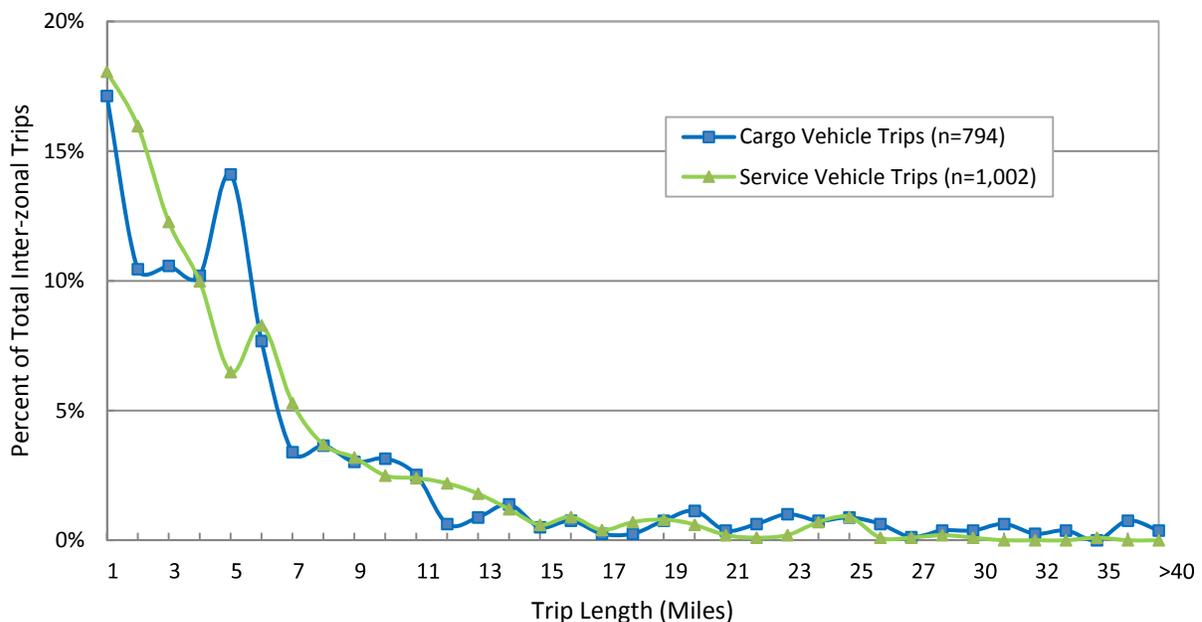


Figure 14. Surveyed Commercial Vehicle Trips TLFD.

Table 21. Trip Length Frequency Distribution (Ungrouped).

Trip Length (miles)	Cargo Vehicles		Service Vehicles		All Vehicles	
	Number of Trips	Percent of Total	Number of Trips	Percent of Total	Number of Trips	Percent of Total
1	136	17.1	181	18.1	317	17.7
2	83	10.5	160	16.0	243	13.5
3	84	10.6	123	12.3	207	11.5
4	81	10.2	100	10.0	181	10.1
5	112	14.1	65	6.5	177	9.9
6	61	7.6	83	8.2	144	8.0
7	27	3.4	53	5.2	80	4.5
8	29	3.7	37	3.7	66	3.7
9	24	3.0	32	3.2	56	3.1
10	25	3.1	25	2.5	50	2.8
11	20	2.5	24	2.4	44	2.4
12	5	0.6	22	2.2	27	1.5
13	7	0.8	18	1.8	25	1.4
14	11	1.4	12	1.2	23	1.2
15	4	0.5	6	0.6	10	0.6
16	6	0.8	9	0.9	15	0.8
17	2	0.3	4	0.4	6	0.3
18	2	0.3	7	0.7	9	0.5
19	6	0.8	8	0.8	14	0.8
20	9	1.1	6	0.6	15	0.8
21	3	0.4	2	0.2	5	0.3
22	5	0.6	1	0.1	6	0.3
23	8	1.0	2	0.2	10	0.6
24	6	0.8	7	0.7	13	0.7
25	7	0.8	9	0.9	16	0.9
26	5	0.6	1	0.1	6	0.3
27	1	0.1	1	0.1	2	0.1
28	3	0.4	2	0.2	5	0.3
30	3	0.4	1	0.1	4	0.2
31	5	0.6	0	0.0	5	0.3
32	2	0.3	0	0.0	2	0.1
33	3	0.4	0	0.0	3	0.2
35	0	0.0	1	0.1	1	0.1
38	6	0.8	0	0.0	6	0.3
43	3	0.4	0	0.0	3	0.2
Total	794	100.0	1,002	100.0	1,796	100.0

Table 22 shows the average trip length to destinations by land use type for cargo and service vehicle trips. Overall, the average distance traveled by the surveyed vehicles was 6.6 miles, with cargo vehicles averaging 7.2 miles and service vehicles averaging 6.0 miles. The most number of trips by cargo vehicles occurred at “other” land use types, with an average trip length of 8.8 miles, followed by retail and industrial sites with average trip lengths of 5.8 miles and 6.3 miles, respectively. For service vehicles, the highest frequency of trips also occurred at “other” land use types, with an average trip length of 6.3 miles. A significant number of trips occurred at residential, retail, and office sites.

Table 22. Average Trip Length to Destinations by Land Use Type.

Land Use	Cargo Vehicles			Service Vehicles			All Vehicles		
	Number of Trips	Total Trip Length (miles)	Average Trip Length (miles)	Number of Trips	Total Trip Length (miles)	Average Trip Length (miles)	Number of Trips	Total Trip Length (miles)	Average Trip Length (miles)
Office	34	228	6.7	113	743	6.6	147	970	6.6
Retail	176	1,025	5.8	126	608	4.8	302	1,634	5.4
Industrial	167	1,053	6.3	30	206	6.9	197	1,259	6.4
Medical	7	30	4.2	67	273	4.1	74	303	4.1
Education	11	71	6.5	39	148	3.8	50	219	4.4
Government	11	55	5.0	25	183	7.3	36	238	6.6
Residential	86	644	7.5	230	1,525	6.6	316	2,169	6.9
Other	302	2,645	8.8	372	2,356	6.3	674	5,001	7.4
Total	794	5,751	7.2	1,002	6,042	6.0	1,796	11,793	6.6

Table 23 shows the average trip length to destinations by commodity group for trips made by cargo vehicles only. Machinery was the most frequently transported cargo, with an average trip length of 7.4 miles per trip, followed by food, with average trip length of 5.3 miles per trip. While trips transporting textile showed the longest average trip length of 17.2 miles per trip, the number of trips that occurred was insignificant. The average trip length for trips with empty cargo was 7.9 miles.

Table 23. Average Trip Length to Destinations by Commodity Group.

Commodity Group	Cargo Vehicles		
	Number of Trips	Total Trip Length (miles)	Average Trip Length (miles)
Agriculture	7	81	11.6
Raw Materials	49	502	10.2
Food	161	852	5.3
Textiles	5	86	17.2
Wood	35	249	7.1
Building Materials	83	565	6.8
Machinery	175	1,287	7.4
Miscellaneous	23	132	5.7
Secondary	96	705	7.3
Empty	127	1,008	7.9
Unknown	33	283	8.6
Total	794	5,751	7.2

Travel Time and Speed

The Killeen-Temple commercial vehicle survey provided travel logs on the arrival and departure times for each trip made by surveyed commercial vehicles. The travel logs can be compared with the network travel time matrix table available for the study area. However, some of the reported travel logs had missing departure or arrival times and were not reliable in generating accurate estimates. The estimation of travel time could not be generated from the network travel time matrix table that was available either. Unlike the travel distance data, the travel time data for the Killeen-Temple network is still incomplete. Using the network travel time matrix table would only generate missing travel time values for 875 inter-zonal trips and underestimate the travel time and speed for the study area. Hence, this report does not include any analysis on travel time and speed characteristics of surveyed trips in the study area.

Trip Tours

The analyses of trip tours show the amount of circuitous travel undertaken by commercial vehicles in the study area. Trip tours are defined as a combination (or chaining) of trips in which a vehicle leaves and returns to a common point, typically its base location.

To accurately analyze trip tours, external trips had to be included in the analysis. This is done because it is possible for trip tours to begin within the study area, then travel outside the study area, and then travel ends or returns to the study area. Therefore, to exclude external trips in the analysis may result in not capturing those trips that occur outside the study area that occur within the trip tour.

There were 2,414 trips observed from the Killeen-Temple commercial vehicle survey. Each trip in the survey provided information on whether or not the origin of the trip was the vehicle's base location. This served as the basis for determining if the trip was a base trip or a non-base trip. A base trip was defined as when either trip end (origin or destination) began or ended at the base location. If neither trip end was at the base location, then the trip was considered as a non-base trip.

As Table 24 shows, approximately 52 percent of the total trips generated by cargo vehicles were non-base trips and 48 percent were base trips. For trips made by service vehicles, 62 percent were non-base trips and 38 percent were base trips.

Table 24. Base and Non-Base Trips.

Trip Type	Cargo Vehicles		Service Vehicles		All Vehicles	
	Number of Trips	Percent of Total	Number of Trips	Percent of Total	Number of Trips	Percent of Total
Base	569	48.5	470	37.8	1,039	43.0
Non-Base	603	51.5	772	62.2	1,375	57.0
Total	1,172	100.0	1,242	100.0	2,414	100.0

The analyses of trip tours involved counting all the trips that began at the base location until the vehicle returned to its base location. Those trips that did not start and end at their base location were considered open tours. There were five cargo vehicles and 22 service vehicles surveyed that made open tours. The open tours consisted of 411 trips, of which 82 were cargo vehicle trips and 329 were service vehicle trips. The following results pertain only to the 2,003 trips that occurred within the trip tours and do not include the 411 trips that occurred within the open tours.

Table 25 shows the distribution of trip tours for cargo and service vehicles. There were 505 trip tours generated by the surveyed vehicles, with cargo vehicles making 290 tours and service vehicles producing 215 tours. The number of tours varied from one-to-eight tours for cargo vehicles, and one-to-six tours for service vehicles. Approximately 52 percent of the cargo vehicles made at least one trip tour, 17 percent produced two tours, 11 percent made three tours, and the remaining 20 percent made more than three tours. In the case of service vehicles, approximately 59 percent made at least one trip tour, 21 percent completed two tours, 11 percent made three tours, and the remaining 9 percent made more than three tours.

Table 25. Trip Tours per Vehicle.

Number Of Trip Tours	Cargo Vehicles		Service Vehicles		All Vehicles	
	Total Tours	Percent of Total	Total Tours	Percent of Total	Total Tours	Percent of Total
1	150	51.7	127	59.1	277	54.9
2	50	17.2	45	20.9	95	18.8
3	33	11.4	23	10.7	56	11.1
4	22	7.6	12	5.6	34	6.7
5	16	5.5	7	3.3	23	4.6
6	12	4.1	1	0.5	13	2.6
7	6	2.1	0	0.0	6	1.2
8	1	0.3	0	0.0	1	0.2
Total	290	100.0	215	100.0	505	100.0

The analyses of trip tours also involved counting the number of non-base trips, external trips, inter-zonal trips, and intra-zonal trips within trip tours to determine the total amount and types of travel that occur during the course of the tour. There were 2,003 trips observed within the total 505 trip tours. Out of these trips, 433 were external trips, 1,452 were inter-zonal trips, and 118 were intra-zonal trips.

Table 26 shows the distribution of these trips for cargo and service vehicles. Table 27 shows the number of non-base trips within trip tours separately since these trips are not mutually exclusive of the other trip types (i.e., a non-base trip may also be an inter-zonal or external trip).

Table 26. External, Inter-Zonal and Intra-Zonal Trips within Trip Tours.

No. of Trip Tours	External		Inter-Zonal		Intra-Zonal		Total Trips	
	Cargo Vehicles	Service Vehicles						
1	250	96	488	489	45	53	783	638
2	37	20	83	125	3	10	123	155
3	16	5	54	62	0	2	70	69
4	6	0	40	28	0	3	46	31
5	2	0	30	17	0	2	32	19
6	1	0	21	1	0	0	22	1
7	0	0	12	0	0	0	12	0
8	0	0	2	0	0	0	2	0
Total	312	121	730	722	48	70	1,090	913

Table 27. Non-Base Trips within Trip Tours.

No. of Trip Tours	Non-Base Trips within Trip Tours			Total Trips within Trip Tours					
	Cargo Vehicles	Service Vehicles	All Vehicles	Cargo Vehicles	Percent of Total	Service Vehicles	Percent of Total	All Vehicles	Percent of Total
1	487	386	873	783	71.8	638	69.9	783	70.9
2	28	68	96	123	11.3	155	17.0	123	13.9
3	10	24	34	70	6.4	69	7.6	70	6.9
4	5	7	12	46	4.2	31	3.4	46	3.8
5	3	5	8	32	2.9	19	2.1	32	2.5
6	1	0	1	22	2.0	1	0.1	22	1.1
7	0	0	0	12	1.1	0	0.0	12	0.6
8	0	0	0	2	0.2	0	0.0	2	0.1
Total	534	490	1,024	1,090	100.0	913	100.0	2,003	100.0

Figures 15 and 16 show the distribution of non-base trips, external trips, inter-zonal trips, and intra-zonal trips within trip tours for cargo vehicles and service vehicles, respectively. The trips made by cargo vehicles that completed seven and eight tours were all inter-zonal trips, and none of the trips were non-base trips. Those service vehicles that completed six tours had trips that were all inter-zonal trips.

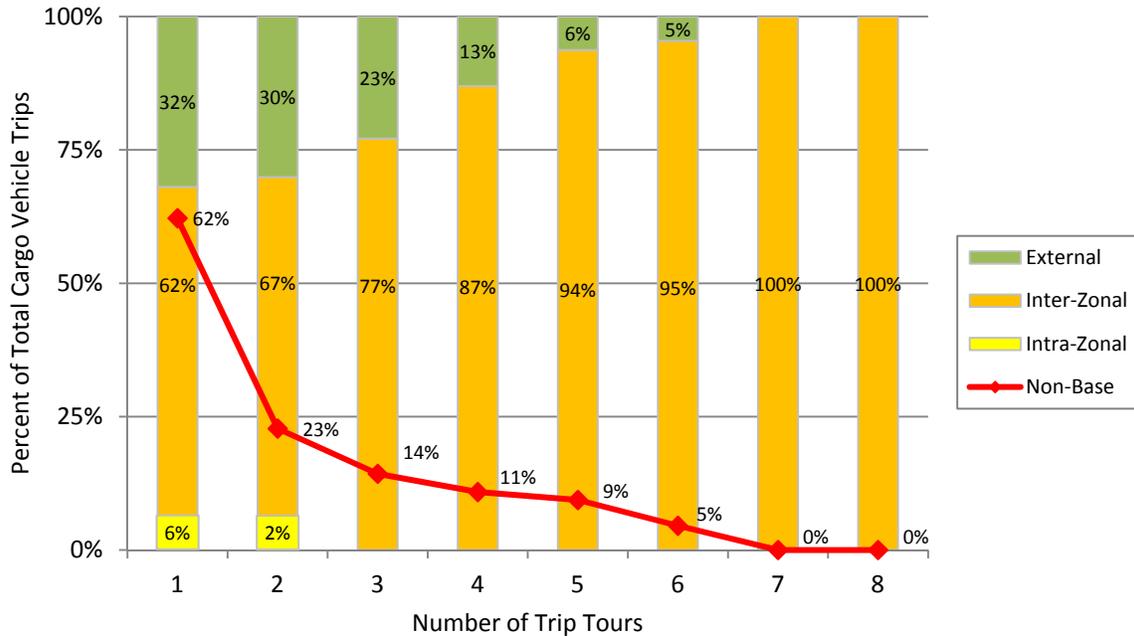


Figure 15. Cargo Vehicle Trips within Trip Tours by Trip Type.

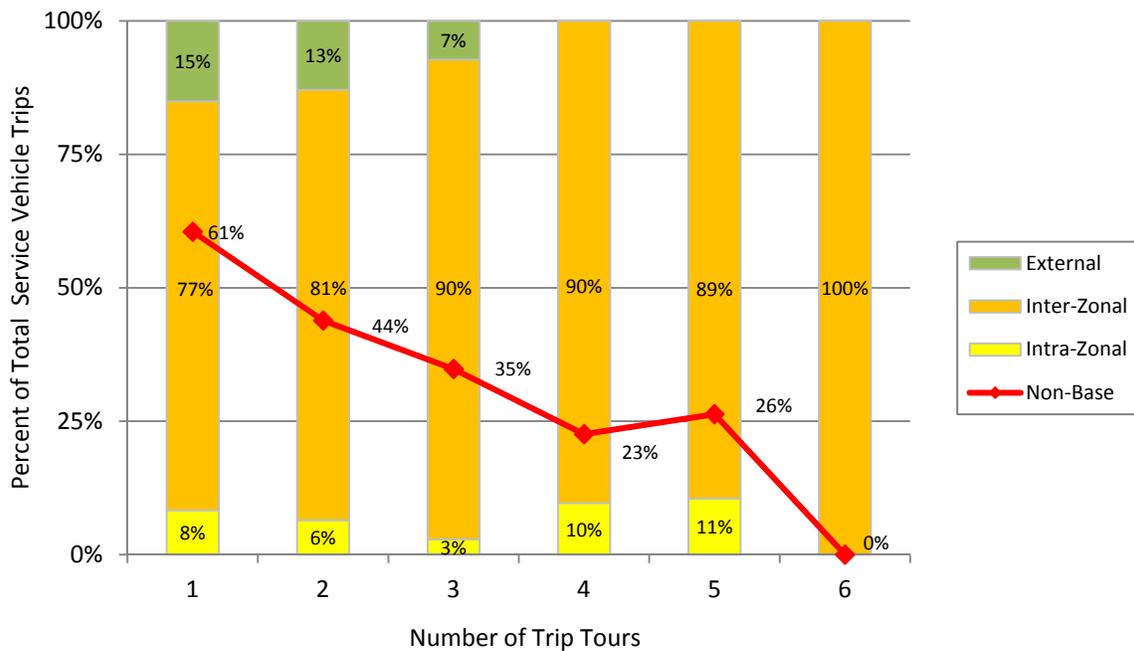


Figure 16. Service Vehicle Trips within Trip Tours by Trip Type.

Survey Expansion

The expansion of commercial vehicle survey data is conducted in an indirect manner. In typical travel surveys, an estimate of the population being sampled is known and data are then expanded to represent that population. In the case of commercial vehicle surveys, the population of vehicles operating in the study area is unknown. Vehicle registration data are not considered a viable basis to estimate the number of commercial vehicles in the study area because other vehicles operating in the area may be registered in neighboring counties. In the Killeen-Temple commercial vehicle survey analysis, however, information on registered trucks have been presented in this technical summary to show how the survey data compare with existing vehicle registration data.

The methodology currently used to expand commercial vehicle survey data is based on vehicle miles of travel (VMT) estimates from the Highway Performance Monitoring System (HPMS), and vehicle classification counts by functional classification for the study area. In essence, an estimate of the commercial VMT is developed from the HPMS data and is then used to expand the VMT observed from sampled commercial vehicles. HPMS data contains annual average daily traffic (AADT) estimates of the total VMT for functionally classified facilities such as freeways, arterials, collectors, and local roadways. Since AADT includes weekend traffic, a correction factor is applied to the data to obtain the average weekday VMT by functional classification. Table 28 provides the adjusted 2007 HPMS VMT estimates for the Killeen-Temple study area.

Table 28. 2007 HPMS Estimates of Weekday VMT in the Killeen-Temple Study Area.

Functional Classification	Total Weekday VMT
Freeway	2,900,605
Arterial	3,908,506
Collector	1,719,616
Local	611,683
Total	9,140,410

The percentage of commercial and non-commercial vehicles by functional classification were determined by using the commercial vehicle counts from the 2006 Killeen-Temple External Survey and vehicle classification counts conducted at 127 randomly selected locations in the Killeen-Temple study area (Figure 17).

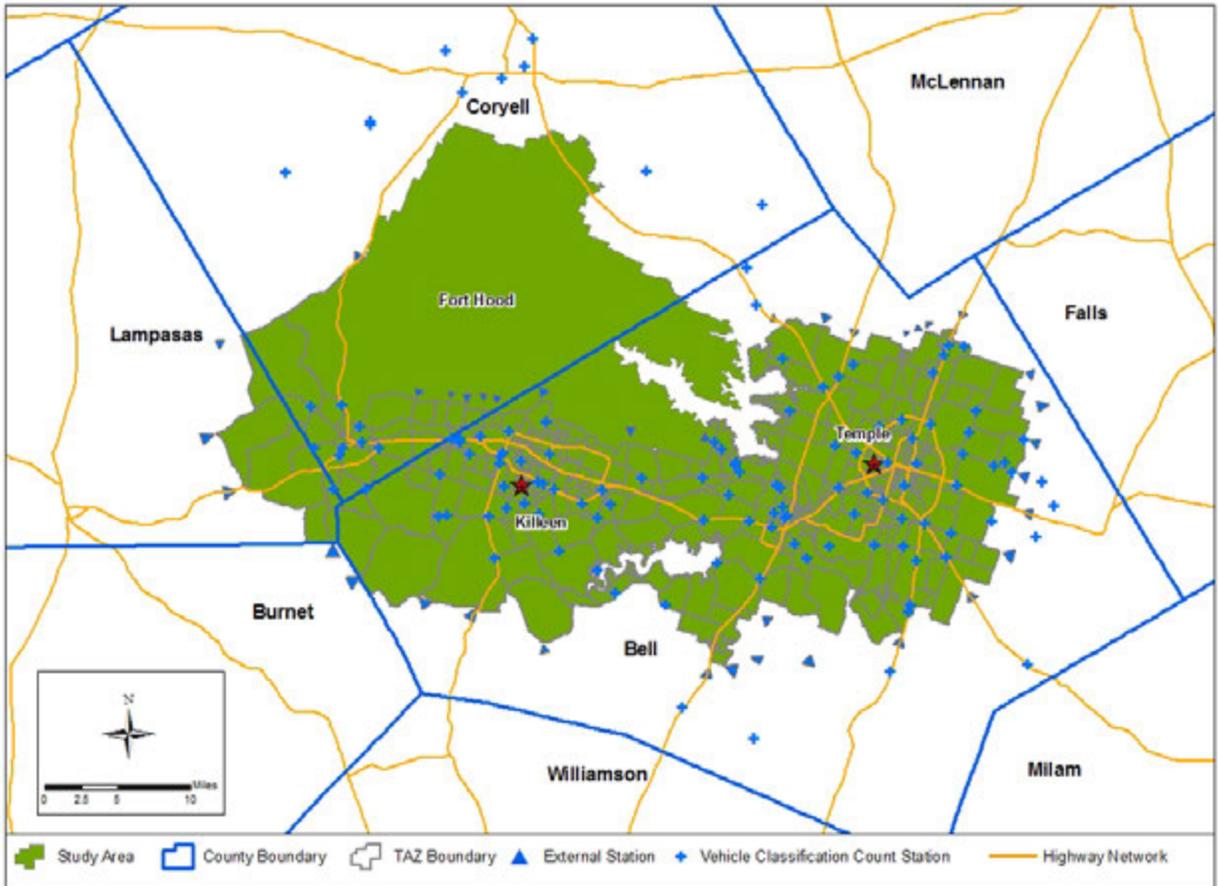


Figure 17. Vehicle Classification Count Stations in the Killeen-Temple Study Area.

The percentage of commercial vehicles for internal sites for each functional classification was combined with the corresponding percentage for external sites based on the percentage of regional VMT estimated as external travel. Based on the 2006 external survey, external VMT for the study area was 2,390,983 miles. This is approximately 26 percent of the total HPMS VMT of 9,140,410 miles. Therefore, it was reasonable to assume that 74 percent of the total VMT was internal travel. These percentages were applied to obtain the weighted average for each functional classification.

Table 29 provides the internal, external, and weighted percentages of commercial and non-commercial vehicles by functional classification. These weighted percentages were applied to the HPMS estimated weekday VMT shown in Table 28 to estimate the total commercial and non-commercial VMT. Table 30 shows the VMT estimates for commercial and non-commercial vehicles.

Table 29. Percentage of Commercial and Non-Commercial Vehicles by Functional Classification.

Functional Classification	Percent of Commercial Vehicles			Percent of Non-Commercial Vehicles		
	Internal Sites (76%)	External Sites (24%)	Weighted Average	Internal Sites (76%)	External Sites (24%)	Weighted Average
Freeway	15.2	23.9	17.3	84.8	76.1	82.7
Arterial	10.6	10.6	10.6	89.4	89.4	89.4
Collector	18.3	11.2	16.6	81.7	88.8	83.4
Local	13.9	N/A	13.9	86.1	N/A	86.1

Table 30. Estimated VMT for Commercial and Non-Commercial Vehicles.

Functional Classification	Commercial VMT	Non-Commercial VMT	Total VMT
Freeway	501,849	2,398,756	2,900,605
Arterial	415,202	3,493,304	3,908,506
Collector	284,878	1,434,737	1,719,616
Local	85,085	526,598	611,683
Total	1,287,014	7,853,396	9,140,410

The total commercial VMT of 1,287,014 miles represented all commercial vehicles that traveled within and outside the Killeen-Temple study area. To properly expand the survey data and determine the total internal commercial vehicle trips generated in the study area, VMT estimates from the external survey had to be subtracted from the total commercial VMT. The external commercial VMT, based on the 2006 external survey, was 475,001 miles. Therefore, internal commercial VMT was around 812,013 miles.

The total internal VMT observed from the commercial vehicle survey was 11,729 miles, of which 5,717 miles were cargo VMT and 6,012 miles were service VMT. This estimate was based on 1,796 inter-zonal trips (794 cargo vehicle trips and 1,002 service vehicle trips), multiplied by the average trip length (7.2 miles for cargo and 6.0 miles for service vehicles).

The total internal commercial VMT (812,013) miles represented all commercial vehicles and is not distinguished by cargo or service vehicles. Based on the vehicle classification counts conducted in the study area, approximately 42 percent of the commercial vehicles belonged to Class 5 (two-axle six-tire single unit trailers) through Class 13 (seven or more axle multi-trailers) and were assumed as cargo transport vehicles. Approximately 58 percent of the commercial vehicles belonged to Class 3 (pick-up, van, or 2-axle 4-tire single unit trailers) and Class 4 (buses) and were assumed as service vehicles.

Therefore, to establish the VMT estimates by commercial cargo and service types, it was deemed reasonable to apply these percentages to the total internal commercial VMT. The resulting VMT estimates were 341,046 miles for cargo vehicles and 470,968 miles for service vehicles.

Expansion factors were derived based on the quotient between total internal VMT and the observed internal VMT (from the survey) for each commercial vehicle type. The expansion factors of 59.7 for cargo vehicles and 78.3 for service vehicles were then multiplied by the observed number of inter-zonal trips for cargo and service vehicles to estimate the total vehicle trips. The resulting trip estimates were 47,367 cargo vehicle trips and 78,495 service vehicle trips.

Based on the average number of internal trips per day of 6.5 trips for cargo vehicles and 8.6 trips for service vehicles, approximately 16,414 commercial vehicles (7,287 cargo vehicles and 9,127 service vehicles) were estimated to be operating within the Killeen-Temple study area on a daily basis. This estimate is approximately four times the 4,086 trucks registered in the study area in 2009.

Table 31 shows a summary of key results from the Killeen-Temple commercial vehicle survey and data expansion.

Table 31. Key Survey Results and Expanded Trip and VMT Data.

Indicator	Cargo Vehicles	Service Vehicles	All Vehicles
Sample Size	155	149	304
Total Inter-Zonal Trips*	794	1,002	1,796
Total Intra-Zonal Trips	55	84	139
Total Internal Trips**	849	1,096	1,945
Total External Trips	323	146	469
Total Internal and External Trips	1,172	1,242	2,414
Average Total Trips per Vehicle	7.6	8.7	8.2
Average Total Internal Trips per Vehicle***	6.5	8.6	7.6
Average Trip Length	7.2	6.0	6.6
Observed Internal VMT	5,717 miles	6,012 miles	11,729 miles
Total Internal Commercial VMT	341,046 miles	470,968 miles	812,013 miles
Survey Expansion Factor	59.7	78.3	69.2
Total Expanded Commercial Vehicle Trips	47,367	78,495	125,862
Number of Commercial Vehicles Operating on a Daily Basis	7,287	9,127	16,414

*Excluded 10 trips with unknown trip lengths.

** Included 62 unrecorded trips reported by surveyed vehicles that made more than 19 trips.

*** Based on internal trips of 265 surveyed commercial vehicles (130 cargo vehicles and 135 service vehicles).

SURVEY SUMMARY

This section provides a summary of vehicle and trip characteristics of 304 commercial vehicles that participated in the 2008/2009 Killeen-Temple commercial vehicle survey. Based on the results from the survey, significant differences as well as similarities on travel characteristics were observed between cargo vehicles and service vehicles.

The average vehicle age for cargo vehicles was 8.0 years compared to 6.3 years for service vehicles. The odometer readings reported by cargo vehicles indicated an average mileage of 312,500 miles, compared to 131,100 miles for service vehicles. In terms of fuel use, around 79 percent of cargo vehicles used diesel and 19 percent used unleaded gasoline, while 64 percent of service vehicles used unleaded gasoline and 36 percent used diesel.

The analyses of trip characteristics included in-depth examinations of trip frequency, trip type, average trip length, trip purpose, and land use activity at the trip destinations by commercial vehicle type. Surveyed cargo vehicles made an average of 7.6 total trips per day, compared to 8.7 trips per day for service vehicles. Excluding the trips made outside of the study area (external trips), cargo vehicles produced 6.5 internal trips per day, with an average travel distance of 7.2 miles, compared to service vehicles, which made 8.6 internal trips per day, with an average trip length of 6.0 miles. The average travel time and speed could not be estimated in this study due to incomplete travel time data for the Killeen-Temple network.

In terms of trip purpose at trip destinations, approximately 55 percent of the internal cargo vehicle trips were delivery, 17 percent were return-to-base location, and 14 percent were pick-up. For internal trips made by service vehicles, approximately 31 percent were service-related, 24 percent were delivery, 17 percent were pick-up, and 15 percent were return-to-base location purposes.

Regarding land use activity, approximately 23 percent of the internal trips made by cargo vehicles occurred at retail/shopping places, 19 percent occurred at industrial sites, and 16 percent occurred at construction sites. For service vehicles, 24 percent of the trips occurred at residential sites, 12 percent occurred at retail/shopping places, and 11 percent occurred at office buildings.

The analyses of cargo characteristics were exclusive to trips made by cargo vehicles only and involved examining the types of cargo/commodities being transported at the trip destination, the trip purpose and land use activity at each stop, and the net weight of the cargo being picked-up and/or dropped off for each trip. Overall, the average net cargo weight was 13,500 lbs. per trip. Building materials showed the highest average net cargo weight of 38,600 lbs. per trip. However, the most frequently transported commodity was machinery with an average net cargo weight of 15,100 lbs. per trip. Industrial land use showed the highest average net cargo weight of 16,700 lbs. per trip. However, the highest frequency of trips occurred

at the “other” land use category with an average net cargo weight of 16,900 lbs. per trip. By trip purpose, pick-up had the highest average net cargo weight of 22,300 lbs. per trip, but there were more delivery trips with an average net cargo weight of 11,600 lbs. per trip.

The analyses of trip tours involved examining the amount of circuitous travel performed by the commercial vehicles in the study area. It also involved counting the number of non-base trips, external trips, inter-zonal trips, and intra-zonal trips within trip tours to determine the total amount and types of travel that occur during the course of the tour. There were 505 trip tours generated by the surveyed vehicles, with cargo vehicles making 290 tours and service vehicles producing 215 tours. The number of trip tours per vehicle ranged from one-to-eight tours for cargo vehicles, and one-to-six tours for service vehicles. The number of trips within a tour varied from one trip to a maximum of 18 trips, generating 2,000 trips (1,100 trips by cargo vehicles and 900 trips by service vehicles). Within the trip tours, approximately 72 percent were inter-zonal trips, 22 percent were external trips, and the remaining 6 percent were intra-zonal trips. Non-base trips, which were not mutually exclusive of the other trip types, comprised 51 percent of the total trips within the tours.

Finally, the expansion of commercial vehicle survey data were based on VMT estimates and vehicle classification counts for the Killeen-Temple study area, as well as on key survey results such as average number of trips and trip length per cargo and service vehicles. Since the commercial VMT estimates do not distinguish by cargo and service vehicle types, the proportion of cargo and service vehicles were established based on the class types of the commercial vehicles from the vehicle classification counts conducted in the study area. In summary, internal commercial cargo VMT was estimated at 341,000 miles while internal commercial service VMT was estimated at 471,000 miles. Cargo vehicles generated approximately 47,400 trips and service vehicles generated 78,500 trips. On a daily basis, approximately 16,400 commercial vehicles (7,300 cargo vehicles and 9,100 service vehicles) were estimated to be operating within the Killeen-Temple study area for the 24-hour survey period. This estimate is four times the volume of trucks registered in the study area in 2009.

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Alliance Transportation Group (ATG), Inc. *Waco-Killeen-Temple Commercial Vehicle Survey Final Report*. August 2009.

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Texas Department of Transportation (TxDOT). *Rural, Small Urban, and Urbanized Mileage by County and Functional System*. Austin, TX, July 2009.

Alliance-Texas Engineering Company and Wilbur Smith and Associates. *Texas Statewide Analysis Model (SAM) Theory Report*. Texas Department of Transportation. March 2004.

Farnsworth, Stephen F. *2006 Killeen-Temple External Survey Technical Summary*. Texas Transportation Institute, The Texas A&M University System, College Station, TX, August 2008.

APPENDIX

**COMMERCIAL VEHICLE SURVEY
PART 1: VEHICLE INFORMATION**

(If you have participated in prior surveys, please fill out this form anyway.)

Vehicle ID#: _____

Vehicle License # : _____

Survey Location (zone): _____

SIC Code: _____

Travel Day: _____
Month / Day

Company or Name of Owner (name on registration):

Address of location where vehicle was based at beginning of travel day:

(Street Address or Nearest Intersection)

City _____ State _____ ZIP _____

Type of Place vehicle was based at on beginning of travel day. (SEE BELOW) _____

Vehicle Info: Make _____ ; Model: _____ ; Year: _____

- Vehicle Type
- 1) Cargo / Freight Transport Vehicle
 - 2) Service Vehicle (vehicle is not used to transport cargo or freight)

- Vehicle Fuel:
- 1) Unleaded Gas 2) Diesel 3) Propane 4) Hybrid
 - 5) Other _____ (Specify)

Vehicle Classification:

- 1) Passenger Car
- 2) Pick-up
- 3) Van (Cargo or Mini)
- 4) Sport Utility Vehicle (SUV)
- 5) Single Unit 2-axle (6 wheels)
- 6) Single Unit 3-axle (10 wheels)
- 7) Single Unit 4-axle (14 wheels)
- 8) Semi (all Tractor-Trailer combinations)
- 9) Other _____

Gross Vehicle Weight: _____ pounds

Beginning Odometer Reading: _____ **Number of Trips Total:** _____

Type of Place Codes		
(1) Office Building	(6) Educational (college, trade, etc.)	(11) Warehouse
(2) Retail / Shopping	(7) Government Office / Building	(12) Distribution Center
(3) Industrial / Manufacturing	(8) Residential	(13) Construction Site
(4) Medical / Hospital	(9) Airport	(14) Other (specify)
(5) Educational (12 th grade or less)	(10) Intermodal Facility	(99) Refused / Unknown

Commercial Vehicle Survey PART 2: Travel Log

VEHICLE LICENSE #: _____

THE PLACE MY TRAVEL BEGAN TODAY WAS:

Work / Base Location Other Location (Please describe) _____

Type of Place (Specify Type of Place 1-14 or 99, see codes below) _____

(Street address or nearest intersection for place travel began)

TRAVEL DATE _____
Month / Day

(City, state, zip code)

DEPARTURE TIME: _____ am/pm

When you left the above location was your vehicle: Fully Loaded Partially Loaded Empty Not Applicable (Service Vehicle)

If loaded, what is the total weight in pounds of the cargo being transported? (Please provide an estimate if unsure of exact weight) _____

RECORD EVERY PLACE YOU GO, INCLUDING QUICK STOPS

	RECORD the following information about each place <i>NAME of Place:</i> _____ <i>Address including city, state, and zip OR Nearest street intersection or Landmark</i> _____	What time did you arrive and depart this location? (record exact times)	Activity What are you doing at this Location (See options below)	What type of place is this? (see options below)	Is this the work / base location for this vehicle? <input type="checkbox"/> - Yes <input type="checkbox"/> - No	Type of Cargo What is it?	Cargo Weight (in Pounds)
PLACE 1		Arrive: _____ am/pm Depart: _____ am/pm					Delivery Picked Up
PLACE 2		Arrive: _____ am/pm Depart: _____ am/pm					Delivery Picked Up
PLACE 3		Arrive: _____ am/pm Depart: _____ am/pm					Delivery Picked Up

ACTIVITY OPTIONS	TYPE OF PLACE OPTIONS
<ul style="list-style-type: none"> (1) Base Location / Return to Base Location (2) Delivery (3) Pick-Up (4) Pick-Up and Delivery (5) Maintenance (fuel, oil, etc.) (6) Driver Needs (lunch, etc.) (7) Service-Related Business (8) Other (please specify) 	<ul style="list-style-type: none"> (1) Office Building (non-government) (2) Retail / Shopping (3) Industrial / Manufacturing (4) Medical / Hospital (5) Education (12th grade or less) (6) Education (college, trade) (7) Government Office / Building (8) Residential (9) Airport (10) Intermodal Facility (11) Warehouse (12) Distribution Center (13) Construction Site (14) Other (specify) (99) Refused / Unknown

Commercial Vehicle Survey Travel (continued)

	RECORD the following information about each place NAME of Place: Address including city, state, and zip OR Nearest street intersection or Landmark	What time did you arrive and depart this location? (record exact times)	Activity What are you doing at this location? (see options below)	What type of place is this? (see options below)	Is this the work / base location for this vehicle? <input type="checkbox"/> - Yes <input type="checkbox"/> - No	Type of Cargo What is it?	Cargo Weight (in Pounds)
PLACE 10		Arrive: _____ am/pm Depart: _____ am/pm					Delivery <hr/> Picked Up
PLACE 11		Arrive: _____ am/pm Depart: _____ am/pm					Delivery <hr/> Picked Up
PLACE 12		Arrive: _____ am/pm Depart: _____ am/pm					Delivery <hr/> Picked Up
PLACE 13		Arrive: _____ am/pm Depart: _____ am/pm					Delivery <hr/> Picked Up
PLACE 14		Arrive: _____ am/pm Depart: _____ am/pm					Delivery <hr/> Picked Up

ACTIVITY OPTIONS	TYPE OF PLACE OPTIONS
(1) Base Location / Return to Base Location (2) Delivery (3) Pick-Up (4) Pick-Up and Delivery (5) Maintenance (fuel, oil, etc.) (6) Driver Needs (lunch, etc.) (7) Service-Related Business (8) Other (please specify)	(1) Office Building (non-government) (2) Retail / Shopping (3) Industrial / Manufacturing (4) Medical / Hospital (5) Education (12 th grade or less) (6) Education (college, trade) (7) Government Office / Building (8) Residential (9) Airport (10) Intermodal Facility (11) Warehouse (12) Distribution Center (13) Construction Site (14) Other (specify) (99) Refused / Unknown

Commercial Vehicle Survey (continued)

	RECORD the following information about each place NAME of Place: Address including city, state, and zip OR Nearest street intersection or Landmark	What time did you arrive and depart this location? (record exact times)	Activity What are you doing at this location? (see options below)	What type of place is this? (see options below)	Is this the work / base location for this vehicle? <input type="checkbox"/> - Yes <input type="checkbox"/> - No	Type of Cargo What is it?	Cargo Weight (in Pounds)
PLACE 15		Arrive: _____ am/pm Depart: _____ am/pm					_____ Delivery _____ Picked Up
PLACE 16		Arrive: _____ am/pm Depart: _____ am/pm					_____ Delivery _____ Picked Up
PLACE 17		Arrive: _____ am/pm Depart: _____ am/pm					_____ Delivery _____ Picked Up
PLACE 18		Arrive: _____ am/pm Depart: _____ am/pm					_____ Delivery _____ Picked Up
PLACE 19		Arrive: _____ am/pm Depart: _____ am/pm					_____ Delivery _____ Picked Up

ACTIVITY OPTIONS	TYPE OF PLACE OPTIONS
(1) Base Location / Return to Base Location (2) Delivery (3) Pick-Up (4) Pick-Up and Delivery (5) Maintenance (fuel, oil, etc.) (6) Driver Needs (lunch, etc.) (7) Service-Related Business (8) Other (please specify)	(1) Office Building (non-government) (2) Retail / Shopping (3) Industrial / Manufacturing (4) Medical / Hospital (5) Education (12 th grade or less) (6) Education (college, trade) (7) Government Office / Building (8) Residential (9) Airport (10) Intermodal Facility (11) Warehouse (12) Distribution Center (13) Construction Site (14) Other (specify) (99) Refused / Unknown

