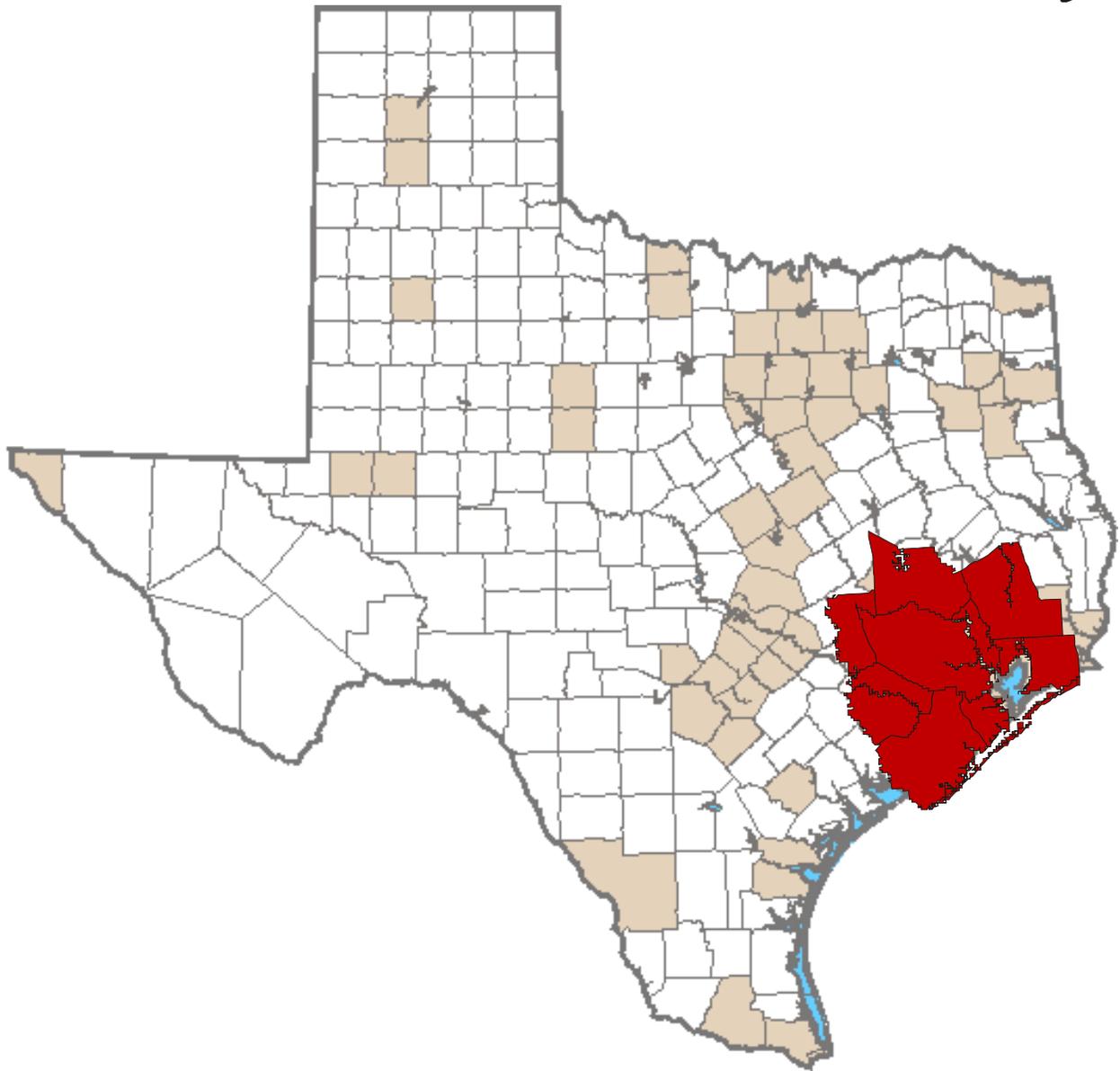


2010 H-GAC Commercial Vehicle Survey Technical Summary



Prepared by the
Texas A&M Transportation Institute
September 2013

2010 Houston-Galveston Area Council Commercial Vehicle Survey

TECHNICAL SUMMARY

Texas Department of Transportation Travel Survey Program

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INTRODUCTION

In 2010, the Texas Department of Transportation (TxDOT) funded a commercial vehicle survey in the Houston-Galveston Area Council (H-GAC) area. The purpose of this survey was to provide data that would enable TxDOT to forecast total commercial vehicle travel demand within the Houston-Galveston urban areas. The study area is located in southeast Texas, and as shown in Figure 1, it covers the entirety of Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, and Waller counties. The eight-county study area had a combined total population of approximately 5.9 million people in 2010.

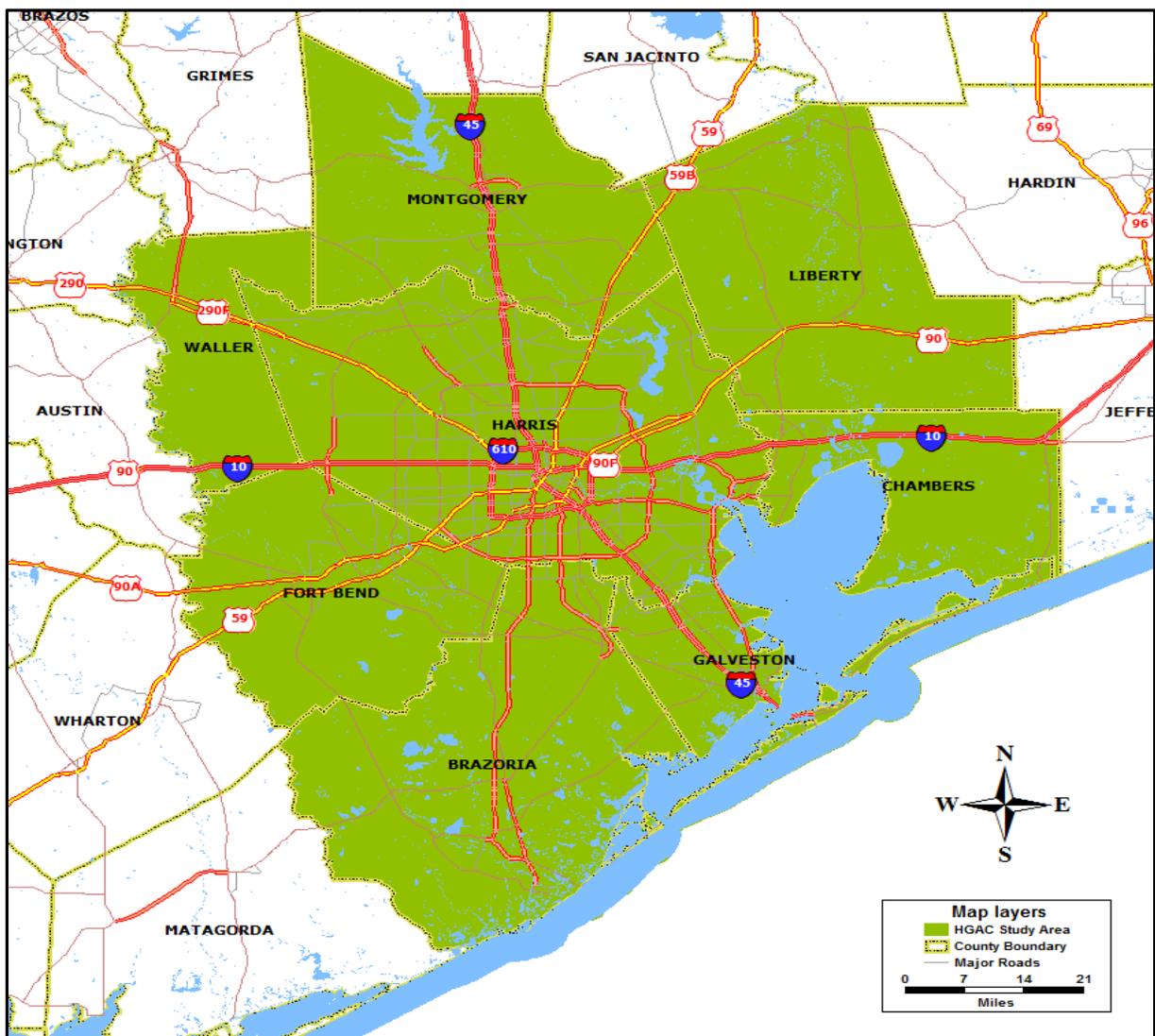


Figure 1. Houston-Galveston Study Area.

This report presents a technical summary of the commercial vehicle travel survey conducted in 2010 in the Houston-Galveston regions 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 H-GAC study area were conducted during the period between February 2010 and October 2010, with a break during the months of June and July in 2010. Alliance Transportation Group (ATG) was contracted by TxDOT to conduct the commercial vehicle surveys for the study area, with technical assistance from the Texas Transportation Institute (TTI). Prior to these surveys, a pilot study was carried out which consisted of 25 usable surveys from 14 companies. The over-sample rate was established at 35 percent, and a target number of 676 commercial vehicles was established for the H-GAC survey area.¹

The survey sample was randomly selected from a listing of all business individuals, companies, and public agencies that own, operate, or lease commercial vehicles within the study area. This list was generated from the Texas Workforce Commission (TWC) employer database that was provided by TxDOT in random order. 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 filled out. The drivers of the commercial vehicles were asked to keep a 24-hour diary of the locations of all trips made by each vehicle.

As Table 1 shows, 14,000 businesses were contacted 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.

¹ H-GAC JOHRTS Commercial Vehicle Survey – Final Report. Alliance Transportation Group, Inc. March 2011.

- Not Participating - The company or individual did not operate a qualifying vehicle making trips within the study area; or the company or individual did operate a qualifying vehicle that did not make trips within the study area.

Table 1. Survey Participation Rates.

Category	Contact Calls	
	Number	Percent of Total
Agreed to Participate	229	1.6
Refused to Participate	962	6.9
Not participating	12,809	91.5
Total	14,000	100.0

Source: H-GAC Commercial Vehicle Survey – Final Report, 2011. ATG.

A total of 229 companies agreed to participate in the H-GAC commercial vehicle survey, from which a total of 552 commercial vehicle surveys were obtained. Data editing and review processes were performed by TTI to ensure that the survey data collected were complete and followed the guidelines set forth in the TxDOT bid specification for the project. A data check program was also utilized to examine the accuracy of geocoding of locations and logic of survey responses. The majority of data errors were expected to be corrected prior to final data submittals by the contractor (ATG). However, it was not unusual to find errors during actual data processing and analysis. In this study, survey responses with irreconcilable data were not included in the survey analysis. Additionally, inconsistent trip records were dropped from the survey analysis.

The results presented in this technical summary are therefore based on data from 551 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 H-GAC study area. Information on registered trucks includes the number of diesel-fueled, gasoline-fueled, propane-fueled, and other-fueled trucks by gross vehicle weight and by model year. Information on surveyed commercial vehicles includes the vehicle's make, model and year, odometer reading, gross vehicle weight, vehicle classification, and fuel use.

Registered Commercial Vehicles

Based on TxDOT's vehicle registration data, there were nearly 94,000 trucks registered in the H-GAC study area in 2010. Table 2 shows the distribution of registered diesel trucks and gasoline trucks by gross vehicle weight. Approximately 73 percent of all trucks registered in the H-GAC study area are diesel-fueled vehicles. Over half of all registered trucks (54 percent) had a gross vehicle weight of less than 10,000 pounds.

Table 2. Gross Vehicle Weight of Registered Trucks in H-GAC Study Area.

Gross Vehicle Weight	Diesel Trucks		Gasoline Trucks		Total	
	Number of Vehicles	% of Diesel Trucks	Number of Vehicles	% of Gasoline Trucks	Number of Vehicles	% of Total Trucks
< 10000	32,569	47.7	17,760	70.2	50,329	53.8
> 10000	8,126	11.9	4,205	16.6	12,331	13.2
> 14000	3,856	5.6	1,207	4.8	5,063	5.4
> 16000	3,457	5.1	503	2.0	3,960	4.2
> 19500	8,338	12.2	952	3.8	9,290	9.9
> 26000	3,243	4.7	289	1.1	3,532	3.8
> 33000	6,431	9.4	339	1.3	6,770	7.2
> 60000	2,299	3.4	39	0.2	2,338	2.5
Total	68,319	100.0	25,294	100.0	93,613	100.0

Source: TxDOT 2010

Figure 2 shows the distribution of registered diesel trucks and gasoline trucks by model year. The two vehicles with fuel types listed as "other" were not included in summary tables involving fuel

type. Registered gasoline trucks were slightly newer relative to the diesel trucks. The majority of the diesel trucks (76 percent) were less than ten years old, which was slightly more than the 71 percent of gasoline trucks within that age range. Less than 3 percent of the nearly 68,000 registered diesel trucks were older than 20 years or older, while slightly more than 5 percent of registered gasoline trucks were 20 years or older.

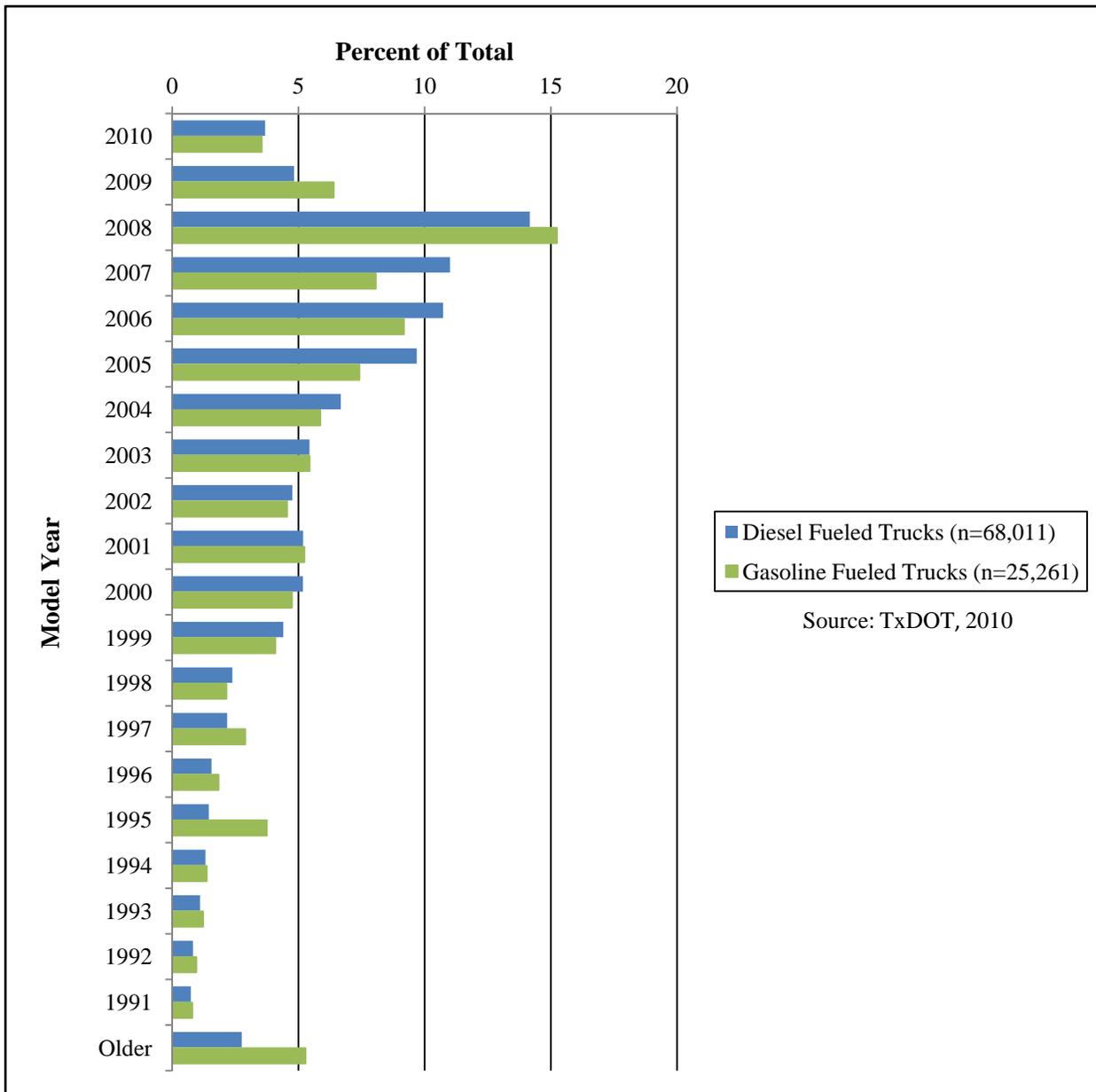


Figure 2. Model Year of Registered Trucks in the H-GAC Study Area.

Surveyed Commercial Vehicles

Commercial vehicles that participated in the H-GAC commercial vehicle survey were distinguished based on the 10 classification types listed in Table 3. These were further categorized by commercial type as either major cargo/freight transport or local service vehicles, simply referred to in this report as cargo vehicles and service vehicles, respectively.

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 district.

Table 3 shows the distribution of surveyed vehicles by vehicle classification type and commercial type. Out of the total 551 vehicles surveyed, 264 were cargo vehicles and 287 were service vehicles. Among cargo vehicles, approximately 35 percent were single unit 2-axle trucks (6-wheelers), 26 percent were semi-tractor/trailer combinations, 19 percent were pick-up trucks, and 5 percent were single unit 3-axle (10-wheelers). Among service vehicles, approximately 55 percent were pick-up trucks, 23 percent were vans, and 13 percent were either single unit 2-axle or 3-axle trucks. Vehicles classified as “other” were mostly buses which neither belonged in the van nor single unit 2-axle categories. There were some vehicles that were coded as “refused”, and several cases in which pick-up trucks were coded as cars or vans. These vehicles were re-classified in order to properly represent their characteristics.

Table 3. Vehicle Classification Type of Surveyed Commercial Vehicles.

Vehicle Classification	Cargo Vehicles		Service Vehicles		Total Vehicles	
	Number of Vehicles	Percent of Cargo	Number of Vehicles	Percent of Service	Number of Vehicles	Percent of Total
Passenger Car	3	1.1	17	5.9	20	3.6
Pickup Truck	50	18.9	159	55.4	209	38.0
Van (passenger or mini)	32	12.1	65	22.7	97	17.6
Sport Utility Vehicle	1	0.4	9	3.1	10	1.8
Single Unit 2-axle (6 wheels)	91	34.5	33	11.5	124	22.5
Single Unit 3-axle (10 wheels)	12	4.6	3	1.0	15	2.7
Single Unit 4-axle (14 wheels)	5	1.9	0	0.0	5	0.9
Semi (tractor-trailer)	69	26.1	0	0.0	69	12.5
Other	1	0.4	1	0.4	2	0.4
Total	264	100.0	287	100.0	551	100.0

Figure 3 shows the distribution of surveyed vehicles by fuel type. Approximately 48 percent of the surveyed vehicles used unleaded gasoline and 52 percent used diesel. Among cargo vehicles, 71 percent used diesel and 29 percent used gasoline. Among service vehicles, 78 percent used diesel and 22 percent used gasoline. Among service vehicles, 78 percent used gasoline and 22 percent used diesel.

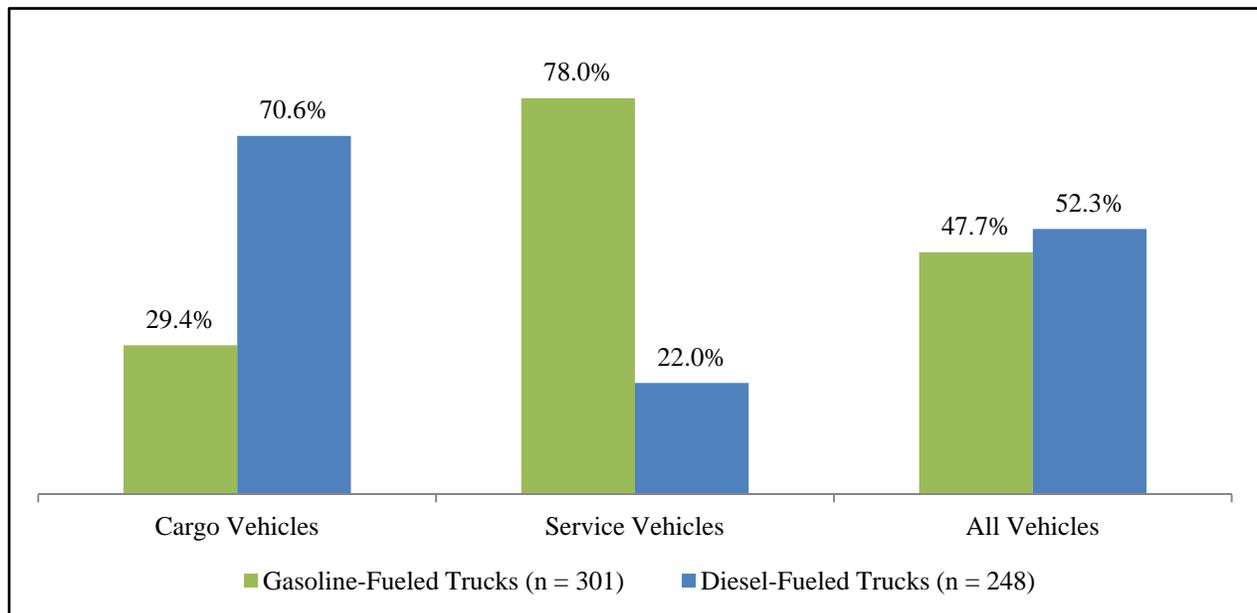


Figure 3. Type of Fuel Used by Surveyed Commercial Vehicles.

Table 4 shows the distribution of surveyed vehicles by gross vehicle weight. The survey included commercial vehicles with gross vehicle weight of less than 10,000 pounds. Approximately 85 percent of the service vehicles belonged to this category, while approximately 45 percent of the cargo vehicles weighed more than 19,500 pounds.

Table 4. Gross Vehicle Weight.

Gross Vehicle Weight (lbs.)	Cargo		Service		Total	
	Number of Vehicles	% of Cargo Vehicles	Number of Vehicles	% of Service Vehicles	Number of Vehicles	% of Total Vehicles
< 10,000	94	35.6	245	85.4	339	61.5
> 10,000	16	6.1	14	4.9	30	5.4
> 14,000	11	4.1	11	3.8	22	4.0
> 16,000	25	9.5	2	0.7	27	4.9
> 19,500	16	6.1	7	2.4	23	4.2
> 26,000	28	10.6	5	1.8	33	6.0
> 33,000	31	11.7	1	0.3	32	5.8
> 60,000	43	16.3	2	0.7	45	8.2
Unknown	-	0.0	-	0.0	-	0.0
Total	264	100.0	287	100.0	551	100.0

Figure 4 shows the distribution of surveyed vehicles by model year. Also note that while Figure 4 includes the model years of 1992-2011 as individual categories, this was not the case in the previously shown Figure 2 (which included the separate categories of 1991-2010). This difference is a reflection of the data available, and in the creation of both figures, the most up-to-date data were used. Approximately 75 percent of service vehicles and 65 percent of cargo vehicles were newer than 10 years. The average age for cargo vehicles was 7.7 years, while the average age for service vehicles was 6.7 years (assuming a base year of 2011).

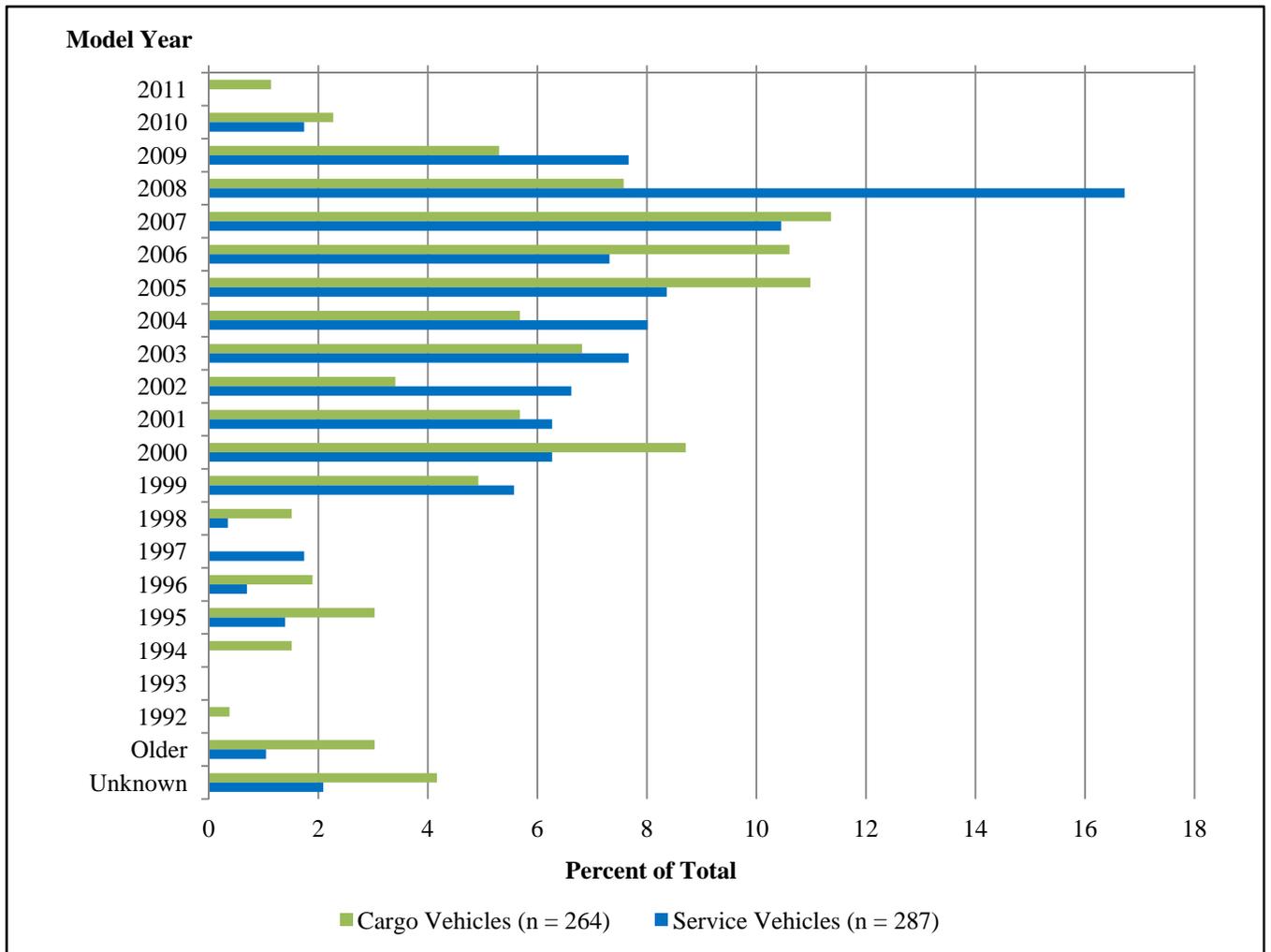


Figure 4. Vehicle Model Year.

Table 5 shows the average vehicle mileage by model year based on reported odometer readings from 502 surveyed vehicles at the beginning of their survey travel day. Cargo vehicles reported higher average odometer readings of just over 201,000 miles compared to just over 107,000 miles for service vehicles.

Table 5. Average of Reported Odometer Readings by Model Year.

Model Year	Cargo Vehicles		Service Vehicles		Total Vehicles	
	Number of Vehicles	Avg. Odometer Reading	Number of Vehicles	Avg. Odometer Reading	Number of Vehicles	Avg. Odometer Reading
2011	3	17,111	0	0	3	17,111
2010	6	14,845	5	8,498	11	11,960
2009	10	39,817	20	23,444	30	28,901
2008	17	83,170	44	45,842	61	56,245
2007	26	143,421	29	101,759	55	121,454
2006	26	102,691	17	128,499	43	112,894
2005	27	216,966	22	115,160	49	171,257
2004	14	183,687	22	151,036	36	163,734
2003	17	197,435	19	135,850	36	164,932
2002	9	200,223	18	122,563	27	148,449
2001	13	476,404	16	129,324	29	284,911
2000	22	202,460	16	137,512	38	175,113
1999	12	385,288	15	164,478	27	262,616
1998	4	98,764	0	0	4	98,764
1997	0	0	5	109,424	5	109,424
1996	4	457,609	2	211,204	6	375,474
1995	8	332,460	4	225,206	12	296,708
1994	4	700,705	0	0	4	700,705
1993	0	0	0	0	0	0
1992	1	86,275	0	0	1	86,275
Older	8	266,489	3	166,693	11	239,272
Unknown	9	125,754	5	137,875	14	130,083
Total	240	201,034	262	107,267	502	152,096

Trip Frequency

The surveyed vehicles generated a total of 3,701 trips, of which 3,591 were internal trips and 110 were external trips. Internal trips were defined as those trips made within the Houston-Galveston area. These trips were further distinguished by travel within or between zones. Inter-zonal trips were those trips made from one zone to another, while intra-zonal trips were made within the same zone. External trips were those trips made outside of the study area.

Figure 5 shows the distribution of inter-zonal, intra-zonal and external trips, while the breakdown of these trips is provided in Table 6. Cargo vehicles generated 1,856 trips, of which approximately 90 percent were inter-zonal trips, five percent were intra-zonal trips, and five percent were external trips. Service vehicles generated 1,845 trips, of which 87 percent were inter-zonal trips, 12 percent were intra-zonal trips, and one percent were external trips.

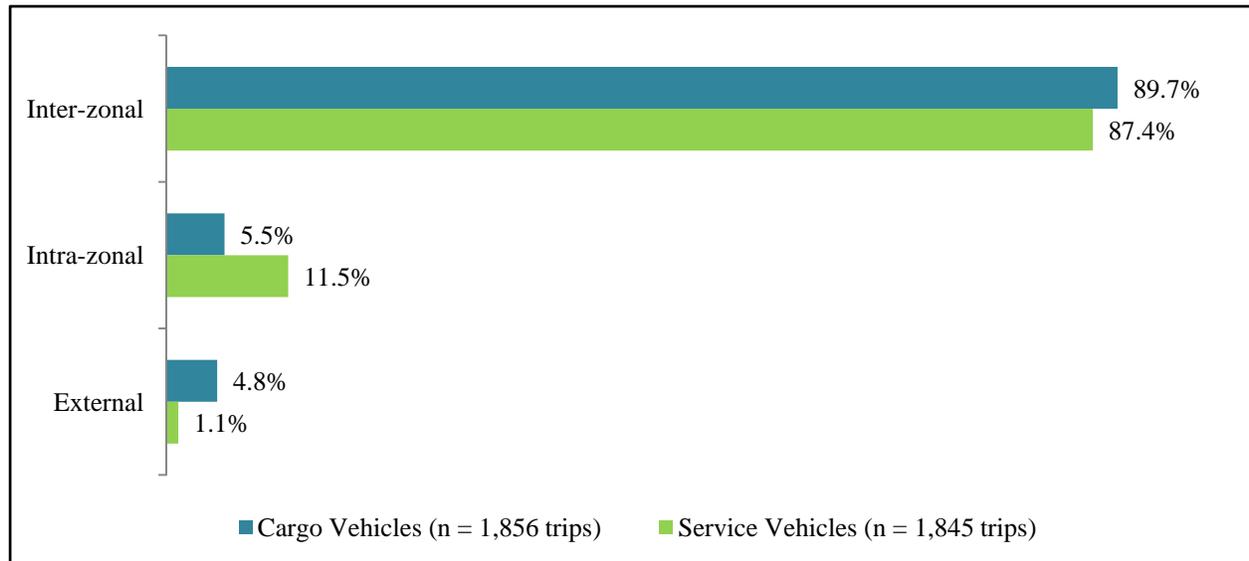


Figure 5. Inter-Zonal, Intra-Zonal, and External Trips.

Table 6. Total Internal and External Trips.

Vehicle Type Trip Type	Cargo Vehicles		Service Vehicles		Total Vehicles	
	Number	% of Total	Number	% of Total	Number	% of Total
Inter-zonal	1,665	89.7	1,612	87.4	3,277	88.5
Intra-zonal	102	5.5	212	11.5	314	8.5
Total Internal	1,767	95.2	1,824	98.9	3,591	97.0
External	89	4.8	21	1.1	110	3.0
Total	1,856	100.0	1,845	100.0	3,701	100.0

Figure 6 shows the distribution of total trips (internal and external trips) which varied from 1-to-22 trips per cargo vehicle and from 1-to-25 trips per service vehicle on their survey day. The average number of total trips per day was 7.0 trips for cargo vehicles and 6.4 trips for service vehicles. The average number of trips per day for all commercial vehicles combined was 6.7.

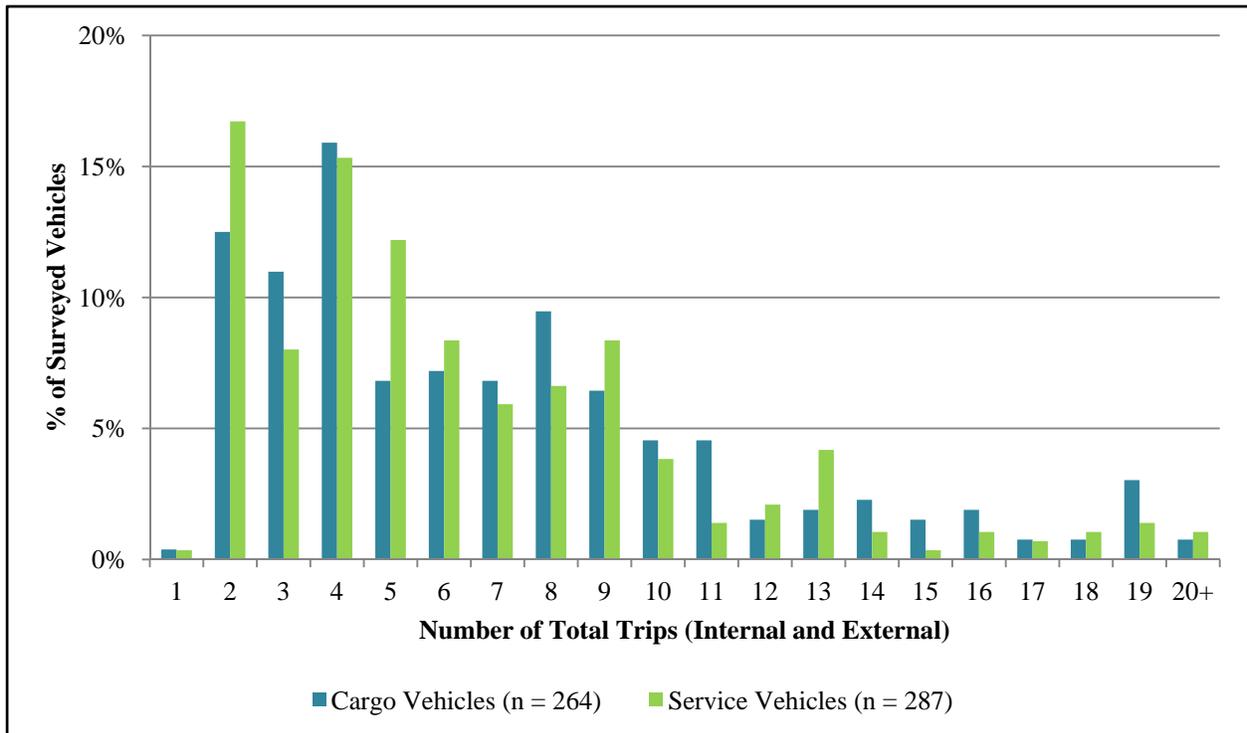


Figure 6. Total Trips per Vehicle.

Figure 7 shows the distribution of internal trips only. Approximately 4 percent of cargo vehicles made one internal trip per day, while only one service vehicle reported making one internal trip per day. Only a very small fraction of surveyed vehicles did not make any internal trips (1.1 percent of cargo vehicles and 0.7 percent of service vehicles). These very low proportions for no internal trips may partially be a reflection of the relatively large and dense study area associated with the Houston study area. The average number of internal trips per day was 6.7 trips for cargo vehicles and 6.4 trips for service vehicles. Overall, the average number of internal trips per day was 6.5 per commercial vehicle.

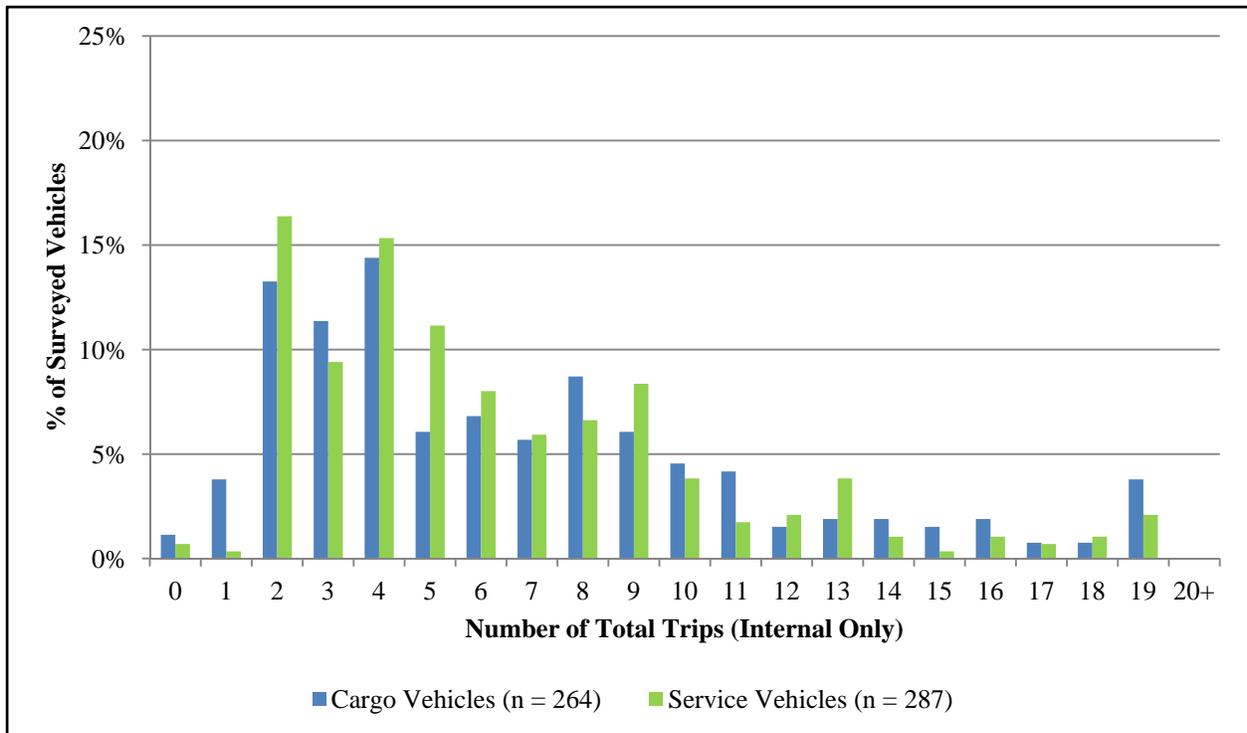


Figure 7. Total Internal Trips per Vehicle.

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 distribution of internal trips by land use type at trip destinations. Approximately 23 percent of the trips made by cargo vehicles occurred at industrial sites, followed by 14 percent to retail locations, and 13 percent at warehouses. For service vehicles, nearly 29 percent of the trips took place at residential sites, followed by nearly 16 percent at locations classified as “other”, and 12 percent at office locations.

Table 7. Distribution of Internal Trips by Land Use Type at Trip Destinations.

Land Use	Cargo		Service	
	Number	Percent of Cargo	Number	Percent of Service
Office Building (Non-government)	162	9.2	227	12.4
Retail/Shopping	255	14.4	142	7.8
Industrial/Manufacturing	407	23.0	70	3.8
Medical/Hospital	25	1.4	19	1.0
Education (< 12th grade)	67	3.8	60	3.3
Education (College, Trade)	12	0.7	5	0.3
Government Office/Building	46	2.6	164	9.0
Residential	120	6.8	524	28.7
Airport	1	0.1	18	1.0
Intermodal Facility	11	0.6	1	0.1
Warehouse	220	12.5	72	3.9
Distribution Center	66	3.7	19	1.0
Construction Site	133	7.5	99	5.4
Other	209	11.8	297	16.3
Refused/Unknown	33	1.9	107	5.9
Total Trips	1,767	100.0	1,824	100.0

Table 8 shows the distribution of internal trips by trip purposes at trip destinations. Slightly over half of the cargo vehicle internal trips (53 percent) were delivery, 14 percent were cargo pick-up, and 14 percent were classified as “unknown”. For trips made by service vehicles, approximately 50 percent were service-related trip purpose, 16 percent were classified as “unknown”, and nine percent were delivery.

Table 8. Trip Purposes at Destination Locations.

Trip Purpose	Cargo		Service	
	Number	Percent of Cargo	Number	Percent of Service
Return to Base Location	77	4.4	89	4.9
Delivery	927	52.5	164	9.0
Pick-up	253	14.3	122	6.7
Pick-up and Delivery	108	6.1	6	0.3
Maintenance (Fuel, oil, etc.)	16	0.9	35	1.9
Driver Needs (Lunch, etc.)	25	1.4	81	4.4
Service-Related	88	5.0	913	50.1
Other	20	1.1	115	6.3
Unknown	253	14.3	299	16.4
Total Trips	1,767	100.0	1,824	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 was collected in the H-GAC commercial vehicle survey to examine the movement of commodities within and outside of the study area. The analyses presented in this section are for both internal and external trips made by surveyed cargo vehicles only, and do not include the trips made by service vehicles. The types of cargo in the survey were based on 22 classification types listed in Table 9.

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. Several inconsistencies were observed during the processing and analysis of cargo trip data. There were some trips with full or partial cargo loads that did not report cargo weights but actually reported the type of cargo being transported. There were some trips that indicated delivery trip purpose but did not report any cargo weights at drop-off. There were some trips that reported cargo weights at pick-up but the weights that were reported were 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.

Table 9. Cargo Classification Types.

Cargo Type	Cargo Descriptions
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, metals, gypsum, ores, 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	Soaps, paints, household or industrial chemicals, etc.
11. Refined Petroleum or Coal Products	Gasoline, etc.
12. Rubber, Plastic, and Styrofoam Products	Finished products of rubber, plastic, or Styrofoam
13. Clay, Concrete, Glass, or Stone	Finished products of clay, concrete, glass, or stone
14. Manufactured Goods/Equip.	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. Approximately 37 percent of the total cargo vehicle trips were transporting unclassified cargo types, followed by 13 percent transporting manufactured goods, and about 8 percent transporting food, health, and beauty products. Approximately 14 percent of the cargo trips reported an unknown cargo type and 5 percent were empty shipping containers.

Table 10. Distribution of Trips by Cargo Type at Destinations.

Cargo Type	Number of Trips	% of Total
Farm Products	22	1.2
Forest Products	4	0.2
Marine Products	1	0.1
Metals and Minerals	93	5.0
Food, Health, and Beauty Products	141	7.6
Tobacco Products	14	0.7
Textiles	18	1.0
Wood Products	13	0.7
Printed Matter	19	1.0
Chemical Products	17	0.9
Refined Petroleum or Coal Products	10	0.5
Clay, Concrete, Glass, or Stone	31	1.7
Manufactured Goods/Equipment.	239	12.9
Wastes	15	0.8
Miscellaneous Shipments	131	7.1
Unclassified/Other Cargo	690	37.2
Driver Refused to Answer	38	2.0
Unknown to Driver	268	14.4
Total Trips with Cargo	1,764	95.0
Empty	92	5.0
Total Cargo Vehicle Trips	1,856	100.0

The commodity grouping scheme used by TxDOT in its Texas Statewide Analysis Model (SAM) was used to simplify the cargo types into ten commodity groups. The type of place option in the survey was categorized into seven land use categories. Table 11 shows the equivalency between SAM commodity groups and cargo classifications from the survey, while Table 12 shows the land use categories and their corresponding equivalents in the 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 Classifications.

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 Category and Survey Type of Place.

Land Use Category	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
-- Other	Airport, Inter-modal Facility, Warehouse, Distribution Center, Construction Site, Other
-- Unknown	Land use category not provided, Omitted, Driver refused to answer

Table 13 shows the distribution of cargo trips by commodity group and land use type at trip destinations. Nearly 36 percent of the trips occurred at “Other” land use types, which were mainly warehouses, distribution centers and construction sites. Approximately 24 percent of the

trips occurred at industrial sites, and 15 percent occurred at retail sites. By commodity group, approximately 37 percent of the trips were transporting secondary materials, and about 13 percent were transporting machinery. Around 5 percent were not transporting cargo.

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

Commodity Group	Land Use									Total Trips	% of Total
	Office	Retail	Ind'l	Med	Edu	Gov't	Res	Other	Unkn		
Agriculture	4	4	9	0	0	3	1	6	0	27	1.4
Raw Materials	1	0	81	2	1	0	1	34	0	120	6.5
Food	24	78	4	6	19	0	0	24	0	155	8.3
Textiles	0	0	0	0	0	18	0	0	0	18	1.0
Wood	15	1	7	1	0	3	1	4	0	32	1.7
Building	2	7	3	0	1	3	4	11	0	31	1.7
Miscellaneous	1	28	49	0	0	0	10	56	2	146	7.9
Machinery	9	53	21	1	6	2	8	138	1	239	12.9
Secondary	61	81	183	10	51	11	69	220	4	690	37.2
Empty	8	10	8	4	1	4	18	38	1	92	4.9
Unknown	38	18	75	2	0	3	8	133	29	306	16.5
Total	163	280	440	26	79	47	120	664	37	1,856	100.0
Percent of Total	8.8	15.1	23.7	1.4	4.2	2.5	6.5	35.8	2.0	100.0	---

Figure 8 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 52 percent of the total cargo vehicle trips were delivery, with secondary materials as the most frequently delivered among the classified commodity groups. Secondary materials were also the most frequently picked-up commodity group. The trip purpose “pick-up” made up nearly 15 percent of the total cargo trips. However, these do not represent the actual portion of trips that picked up cargo because some of the trips coded as “base location” trip purpose were also the pick-up location for cargo.

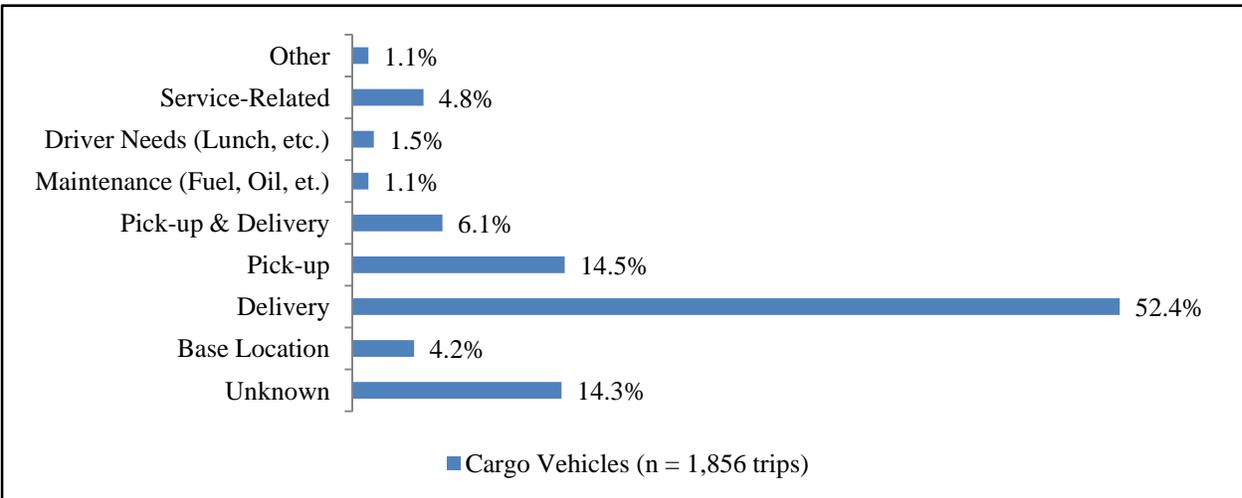


Figure 8. Cargo Trip Purposes at the Trip Destinations.

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

Commodity Group	Land Use									Total Trips	% of Total
	Base	Deliv	Pick-Up	Pick-up & Delivery	Maintenance	Driver Needs	Serv	Other	Unkn		
Agriculture	7	3	5	3	3	4	2	0	0	27	1.4
Raw	11	55	38	9	2	0	5	0	0	120	6.5
Food	0	151	2	1	0	1	0	0	0	155	8.3
Textiles	0	0	18	0	0	0	0	0	0	18	1.0
Wood	1	25	5	0	0	0	0	1	0	32	1.7
Building	3	15	4	3	0	1	4	1	0	31	1.7
Misc.	13	106	13	8	3	1	0	2	0	146	7.9
Machinery	7	184	29	7	3	2	3	3	1	239	12.9
Secondary	8	419	140	78	2	6	28	8	1	690	37.2
Empty	22	0	0	0	6	11	48	5	0	92	4.9
Unknown	6	15	15	5	1	1	0	0	263	306	16.5
Total	78	973	269	114	20	27	90	20	265	1,856	100.0
Percent of Total	4.2	52.4	14.5	6.1	1.1	1.5	4.8	1.1	14.3	100.0	---

The analysis of cargo weights 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, 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 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.

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. Secondary goods being transported to unknown land uses showed the highest average net cargo weight by land use. Raw materials for delivery had the highest average net cargo weight by trip purpose.

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

Commodity Group	Land Use								
	Office	Retail	Ind'l	Med	Edu	Gov't	Res	Other	Unkn
Agriculture	0	0	0	0	0	0	20	588	0
Raw Materials	0	0	7,074	1,022	0	0	0	14,946	0
Food	99	281	13	342	551	0	0	449	0
Textiles	0	0	0	0	0	0	0	0	0
Wood	13	100	12,571	10	0	600	1,500	1,375	0
Building Materials	0	0	1,667	0	0	0	8,250	6,600	0
Miscellaneous	0	17	0	0	0	0	0	16	0
Machinery	428	752	340	1,500	17	50	228	194	0
Secondary	242	384	5,173	302	40	77	273	4,386	50
Hazardous Materials	0	0	0	0	0	0	0	0	0
Transportation	0	0	0	0	0	0	0	0	0
Empty	0	0	0	0	0	0	0	395	0
Unknown	3	528	6	0	0	0	6	864	0

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

Commodity Group	Trip Purpose						
	Base Location	Delivery	Pick-Up	Pick-up & Delivery	Driver Needs	Service	Other
Agriculture	504	7	0	0	0	0	0
Raw Materials	0	16,481	0	12,605	0	12,660	0
Food	0	315	0	150	0	0	0
Textiles	0	0	0	0	0	0	0
Wood	0	3,884	0	0	0	0	0
Building Materials	5,700	4,000	0	10,667	0	375	0
Miscellaneous	27	9	0	0	0	0	0
Machinery	18	425	0	39	0	833	0
Secondary	938	4,323	197	1,293	50	1,120	384
Hazardous Materials	0	0	0	0	0	0	0
Transportation	0	0	0	0	0	0	0
Empty	682	0	0	0	0	0	0
Unknown	4,202	3,165	0	10,472	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 about 2,000 lbs. Of the classified commodity groups, raw materials showed the highest average net cargo weight of approximately 9,000 lbs. per trip. Secondary was the most frequently transported of the commodity groups, with average net cargo weights of about 2,900 lbs. per trip.

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	27	3,546	27	131
Raw Materials	120	1,083,211	120	9,027
Food	155	47,673	155	308
Textiles	18	0	18	0
Wood	32	97,105	32	3,035
Building Materials	31	110,600	31	3,568
Miscellaneous	146	1,355	146	9
Machinery	239	81,070	239	339
Secondary	690	1,982,236	690	2,873
Hazardous	0	0	0	0
Transportation	0	0	0	0
Empty	92	15,000	0	0
Unknown	306	125,052	306	409
Total	1,856	3,546,848	1,764	2,011

* Excluding trips with empty cargo.

Table 18 shows the number of trips and net cargo weights at trip destinations by land use type. Industrial land use sites showed the highest average net cargo weight of nearly 3,700 lbs. per trip, followed by “other” sites, with an average net cargo weight of 2,600 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	163	21,278	155	131
Retail	280	103,013	270	368
Industrial	440	1,620,268	432	3,682
Medical	26	8,622	22	332
Education	79	12,602	78	160
Government	47	2,750	43	59
Residential	120	55,214	102	460
Other	664	1,722,901	626	2,595
Unknown	37	200	36	5
Total	1,856	3,546,848	1,764	2,011

* Excluding trips with empty cargo.

Table 19 shows the distribution of cargo trips and net cargo weights by trip purpose. Delivery trip purposes had the highest average net weight at over 3,100 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.)*
Other	20	3,072	15	205
Service	90	98,661	42	2,349
Driver Needs	27	300	16	19
Maintenance	20	0	14	0
Pick-up & Delivery	114	299,089	114	2,624
Pick-up	269	27,600	269	103
Delivery	973	3,049,314	973	3,134
Base	78	68,812	56	1,229
Unknown	265	0	265	0
Total	1,856	3,546,848	1,764	2,011

* 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 Houston-Galveston 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 the 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 all other zones in the H-GAC study area. 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 9 shows the TAZ boundary and base locations of surveyed vehicles within the Houston-Galveston study area, while Figure 10 shows the origin and destination locations of trips made by the surveyed vehicles. Any trip that had at least one trip outside of the H-GAC study area was considered an external trip.

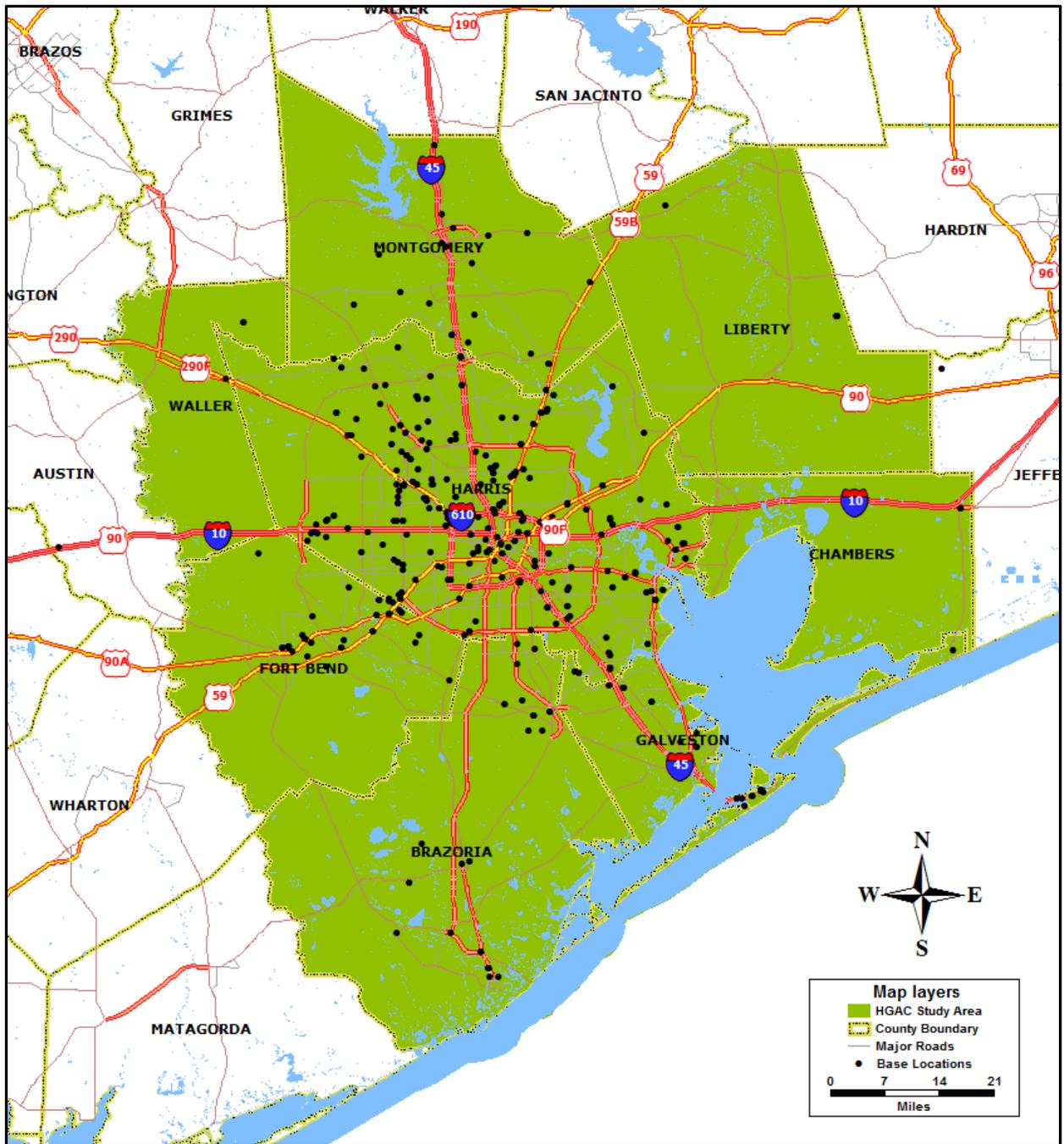


Figure 9. TAZ Boundary and Base Locations of Surveyed Commercial Vehicles.

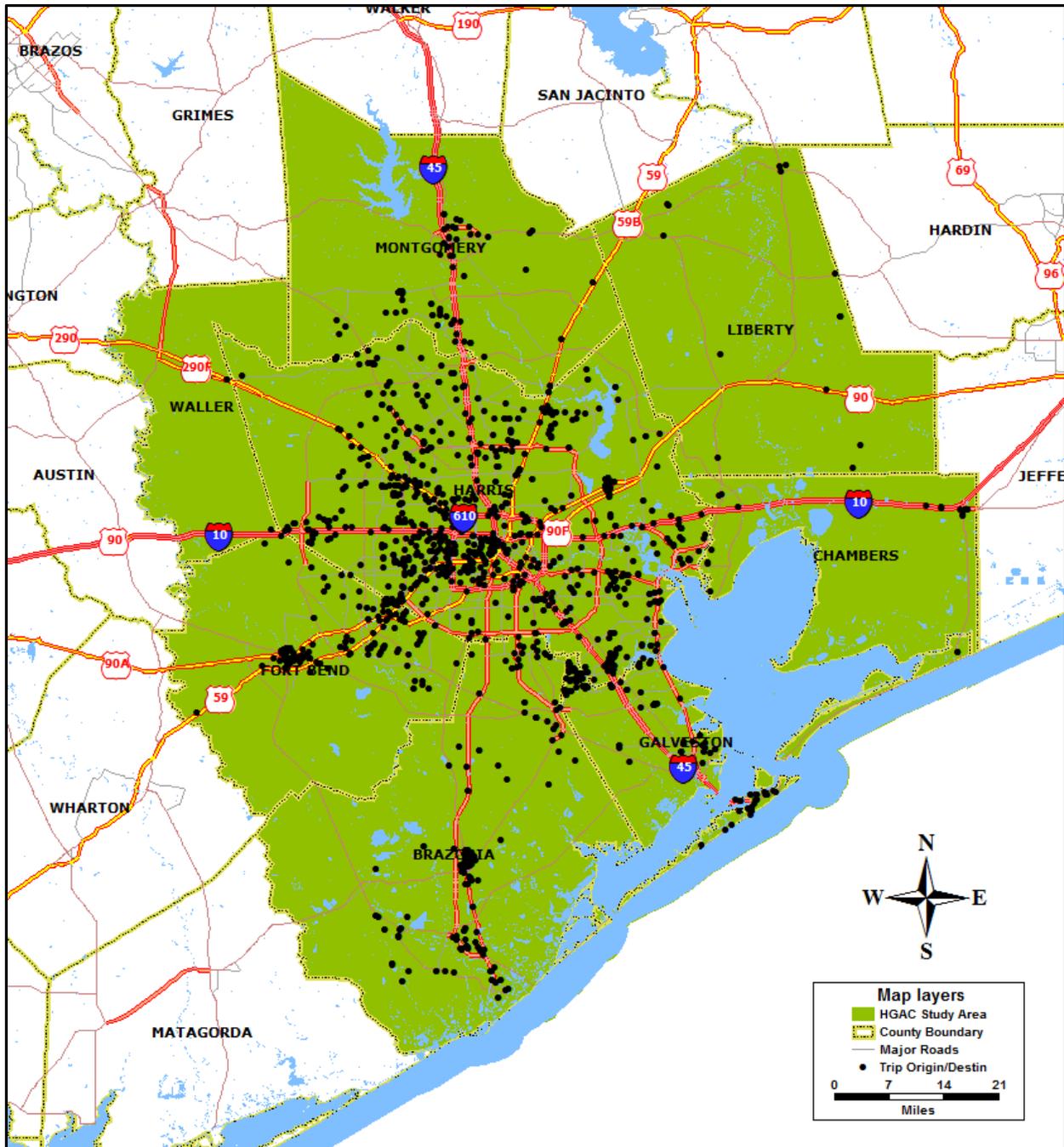


Figure 10. Trip Origins and Destinations of Surveyed Commercial Vehicles.

The results presented in this section pertain to trip length characteristics for 3,247 inter-zonal trips only. Table 20 shows the trip length frequency distribution (TLFD), grouped at five-mile intervals, while Table 21 show the ungrouped TLFD. Approximately 31 percent of the cargo vehicles and 47 percent of the service vehicle trips had trip lengths less than five miles. Additionally, 20 percent of the cargo vehicle trips and 18 percent of the service vehicles had trip

lengths between six miles and ten miles. The longest trip lengths reported by cargo and service vehicles were 82 and 76 miles, respectively.

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

Trip Length (miles)	Cargo		Service		All Vehicles	
	# of Trips	% of Total	# of Trips	% of Total	# of Trips	% of Total
Less than 5	503	30.5	744	46.6	1,247	38.4
6 to 10	323	19.6	286	17.9	609	18.8
11 to 15	303	18.4	194	12.2	497	15.3
16 to 20	165	10.0	118	7.4	283	8.7
21 to 25	105	6.4	82	5.1	187	5.8
26 to 30	77	4.7	71	4.4	148	4.6
31 to 35	50	3.0	42	2.6	92	2.8
36 to 40	47	2.8	19	1.2	66	2.0
41 to 45	18	1.1	14	0.9	32	1.0
Over 45	59	3.5	27	1.7	86	2.6
Total	1,650	100.0	1,597	100.0	3,247	100.0

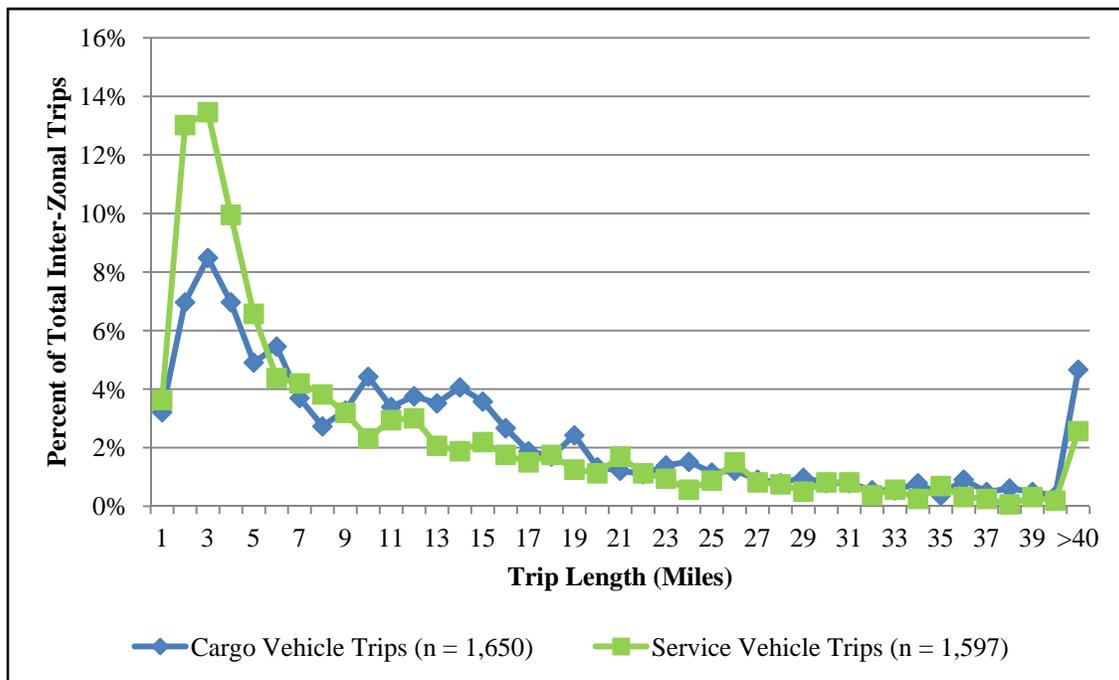


Figure 11. Surveyed Commercial Vehicle Trips TLFD.

Table 21. Trip Length Frequency Distribution (Ungrouped).

Trip Length (miles)	Cargo Vehicles		Service Vehicles		All Vehicles	
	# of Trips	% of Total	# of Trips	% of Total	# of Trips	% of Total
1	53	3.2	58	3.6	111	3.4
2	115	7.0	208	13.0	323	9.9
3	140	8.5	215	13.5	355	10.9
4	115	7.0	159	10.0	274	8.4
5	81	4.9	105	6.6	186	5.7
6	90	5.5	70	4.4	160	4.9
7	61	3.7	67	4.2	128	3.9
8	45	2.7	61	3.8	106	3.3
9	54	3.3	51	3.2	105	3.2
10	73	4.4	37	2.3	110	3.4
11	56	3.4	47	2.9	103	3.2
12	62	3.8	48	3.0	110	3.4
13	58	3.5	33	2.1	91	2.8
14	67	4.1	30	1.9	97	3.0
15	59	3.6	35	2.2	94	2.9
16	44	2.7	28	1.8	72	2.2
17	31	1.9	24	1.5	55	1.7
18	28	1.7	28	1.8	56	1.7
19	40	2.4	20	1.3	60	1.8
20	22	1.3	18	1.1	40	1.2
21	20	1.2	27	1.7	47	1.4
22	18	1.1	18	1.1	36	1.1
23	23	1.4	15	0.9	38	1.2
24	25	1.5	9	0.6	34	1.0
25	19	1.2	14	0.9	33	1.0
26	20	1.2	24	1.5	44	1.4
27	15	0.9	13	0.8	28	0.9
28	13	0.8	12	0.8	25	0.8
29	16	1.0	8	0.5	24	0.7
30	13	0.8	13	0.8	26	0.8
31	13	0.8	13	0.8	26	0.8
32	9	0.5	6	0.4	15	0.5
33	9	0.5	9	0.6	18	0.6
34	13	0.8	4	0.3	17	0.5
35	6	0.4	11	0.7	17	0.5
36	15	0.9	5	0.3	20	0.6
37	8	0.5	4	0.3	12	0.4
38	10	0.6	1	0.1	11	0.3
39	8	0.5	5	0.3	13	0.4
40	6	0.4	3	0.2	9	0.3
> 40	77	4.7	41	2.6	118	3.6
Total	1,650	100.0	1,597	100.0	3,247	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 per trip traveled by the surveyed vehicles was 11.8 miles, with cargo vehicles averaging 13.5 miles and service vehicles averaging 10.1 miles. The most number of trips by cargo vehicles occurred at “other” land use types, with an average trip length of 14.3 miles, followed by industrial and retail sites with average trip lengths of 16.9 and 10.1 miles, respectively. For service vehicles, the highest frequency of trips occurred at “other” land use types, with an average trip length of 9.6 miles. Over one-half (55 percent) of the trips made by service vehicles occurred at residential and “other” land use sites.

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

Land Use	Cargo			Service			All Vehicles		
	Number of Trips	Total Trip Length (miles)	Avg. Trip Length (miles)	Number of Trips	Total Trip Length (miles)	Avg. Trip Length (miles)	Number of Trips	Total Trip Length (miles)	Avg. Trip Length (miles)
Office	153	1,854	12.1	213	2,426	11.4	366	4,280	11.7
Retail	236	2,376	10.1	131	1,429	10.9	367	3,805	10.4
Industrial	398	6,735	16.9	70	1,271	18.2	468	8,006	17.1
Medical	22	235	10.7	18	207	11.5	40	442	11.0
Education	64	439	6.9	62	521	8.4	126	960	7.6
Government	43	262	6.1	135	786	5.8	178	1,047	5.9
Residential	114	1,399	12.3	435	4,056	9.3	549	5,455	9.9
Other	589	8,443	14.3	436	4,171	9.6	1,025	12,614	12.3
Unknown	31	460	14.8	97	1,310	13.5	128	1,770	13.8
Total	1,650	22,203	13.5	1,597	16,176	10.1	3,247	38,378	11.8

Table 23 shows the average trip length to destinations by commodity group for trips made by cargo vehicles only. Over one-third (38 percent) of the trips cited the commodity group “secondary”. The commodity group “unknown” was the next most frequently transported commodity group, and it had an average trip length of 17.6 miles per trip. Vehicles transporting raw materials showed the longest average trip length of 18.4 miles per trip. The average trip length for vehicles with no cargo (empty) was 8.9 miles.

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

Commodity Group	Cargo		
	Number of Trips	Total Trip Length (miles)	Average Trip Length (miles)
Agriculture	22	332	15.1
Raw Materials	108	1,985	18.4
Food	126	763	6.1
Textiles	18	60	3.3
Wood	31	315	10.2
Building Materials	22	249	11.3
Machinery	217	2,740	12.6
Miscellaneous	128	1,580	12.3
Secondary	635	8,720	13.7
Unknown	275	4,851	17.6
Empty	68	608	8.9
Total	1,650	22,203	13.5

Travel Time and Speed

The H-GAC commercial vehicle survey provided travel logs on the arrival and departure times for each trip made by the 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, which rendered them unreliable in generating accurate estimates. Hence, as has been done in the estimation of trip lengths, travel time estimates were generated from the network travel time matrix table available for the H-GAC study area, and travel speed estimates were derived from the estimated trip lengths.

Table 24 shows the travel time frequency distribution of inter-zonal trips, grouped at five-mile intervals, while Figure 12 and Table 25 show the ungrouped TLFD. Approximately 14 percent of the trips made by cargo vehicles were less than five minutes, 21 percent were between 6-and-10 minutes, and 15 percent were between 11-and-15 minutes. For service vehicles, approximately 23 percent of the trips were less than five minutes, 28 percent were between 6-and-10 minutes, and 13 percent were between 11-and-15 minutes. The longest duration of travel time for cargo vehicles was 98 minutes, while the longest travel duration for service vehicles was 91 minutes.

Table 24. Travel Time Frequency Distribution (Grouped Interval).

Travel Time (minutes)	Cargo		Service		All Vehicles	
	# of Trips	% of Total	# of Trips	% of Total	# of Trips	% of Total
Less than 5	223	13.5	359	22.5	582	17.9
6 to 10	341	20.7	446	27.9	787	24.2
11 to 15	239	14.5	199	12.5	438	13.5
16 to 20	226	13.7	168	10.5	394	12.1
21 to 25	187	11.3	112	7.0	299	9.2
26 to 30	119	7.2	90	5.7	209	6.5
31 to 35	76	4.6	66	4.1	142	4.4
36 to 40	64	3.9	50	3.1	114	3.5
41 to 45	48	2.9	43	2.7	91	2.8
Over 45	127	7.7	64	4.0	191	5.9
Total	1,650	100.0	1,597	100.0	3,247	100.0

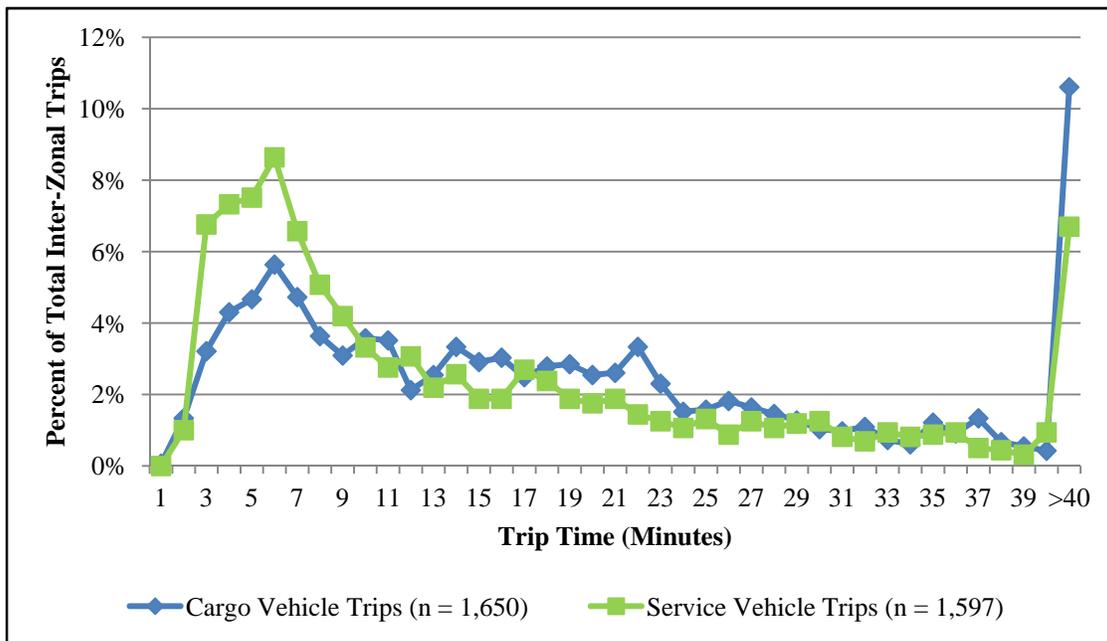


Figure 12. Surveyed Commercial Vehicle Trips Travel Time.

Table 25. Travel Time Frequency Distribution (Ungrouped).

Travel Time (minutes)	Cargo Vehicles		Service Vehicles		All Vehicles	
	# of Trips	% of Total	# of Trips	% of Total	# of Trips	% of Total
1	1	0.1	0	0.0	1	0.0
2	22	1.3	16	1.0	38	1.2
3	53	3.2	108	6.8	161	5.0
4	71	4.3	117	7.3	188	5.8
5	77	4.7	120	7.5	197	6.1
6	93	5.7	138	8.6	231	7.1
7	78	4.7	105	6.6	183	5.6
8	60	3.7	81	5.1	141	4.3
9	51	3.1	67	4.2	118	3.6
10	59	3.6	53	3.3	112	3.5
11	58	3.5	44	2.8	102	3.1
12	35	2.1	49	3.1	84	2.6
13	42	2.5	35	2.2	77	2.4
14	55	3.3	41	2.6	96	3.0
15	48	2.9	30	1.9	78	2.4
16	50	3.0	30	1.9	80	2.5
17	41	2.6	43	2.7	84	2.6
18	46	2.8	38	2.4	84	2.6
19	47	2.8	30	1.9	77	2.4
20	42	2.6	28	1.8	70	2.2
21	43	2.6	30	1.9	73	2.2
22	55	3.3	23	1.4	78	2.4
23	38	2.3	20	1.2	58	1.8
24	25	1.5	17	1.1	42	1.3
25	26	1.6	21	1.3	47	1.4
26	30	1.8	14	0.9	44	1.4
27	27	1.6	20	1.2	47	1.4
28	24	1.5	17	1.1	41	1.3
29	21	1.3	19	1.2	40	1.2
30	17	1.0	20	1.2	37	1.1
31	16	1.0	13	0.8	29	0.9
32	18	1.1	11	0.7	29	0.9
33	12	0.7	15	0.9	27	0.8
34	10	0.6	13	0.8	23	0.7
35	20	1.2	14	0.9	34	1.0
36	15	0.9	15	0.9	30	0.9
37	22	1.3	8	0.5	30	0.9
38	11	0.7	7	0.4	18	0.6
39	9	0.5	5	0.3	14	0.4
40	7	0.4	15	0.9	22	0.7
> 40	175	10.6	107	6.7	282	8.7
Total	1,650	100.0	1,597	100.0	3,247	100.0

Table 26 shows the average travel time and speed to destinations by land use for cargo and service vehicles. Overall, the average travel time for all surveyed vehicles was 17.2 minutes, with cargo vehicles averaging 19.3 minutes and service vehicles averaging 15.1 minutes. By land use types, trips made by cargo vehicles to industrial sites had the longest average travel duration of 23.5 minutes, with an average travel speed of 43.2 minutes. For service vehicles, trips to industrial sites also had the highest average travel time of 25.1 minutes and an average travel speed of 43.3 mph.

Table 26. Average Travel Time and Speed to Destinations by Land Use Type.

Land Use	Cargo			Service			All Vehicles		
	Number of Trips	Avg. Travel Time (min)	Avg. Travel Speed (mph)	Number of Trips	Avg. Travel Time (min)	Avg. Travel Speed (mph)	Number of Trips	Avg. Travel Time (min)	Avg. Travel Speed (mph)
Office	153	17.5	41.5	213	16.8	40.6	366	17.1	41.0
Retail	236	14.8	40.8	131	16.3	40.2	367	15.3	40.6
Industrial	398	23.5	43.2	70	25.1	43.3	468	23.7	43.2
Medical	22	15.8	40.5	18	17.0	40.5	40	16.4	40.5
Education	64	11.1	37.1	62	12.6	40.0	126	11.8	38.6
Government	43	9.8	37.2	135	9.2	38.0	178	9.3	37.8
Residential	114	18.0	40.9	435	14.4	39.0	549	15.1	39.4
Other	589	20.5	42.0	436	14.3	40.1	1,025	17.9	41.3
Unknown	31	21.6	41.3	97	19.3	42.0	128	19.9	41.8
Total	1,650	19.3	41.9	1,597	15.1	40.2	3,247	17.2	41.2

Table 27 shows the average travel time and speed to destinations by commodity group for trips made by cargo vehicles only. Trips transporting raw materials had the longest average trip duration of 25.5 minutes, with an average travel speed of 43.2 mph. Secondary commodity groups had the highest number of trips, and had an average travel time of 19.6 minutes and an average travel speed of 42.0 mph.

Table 27. Average Travel Time and Speed to Destinations by Commodity Group.

Commodity Group	Cargo		
	Number of Trips	Average Travel Time (minutes)	Average Travel Speed (mph)
Agriculture	22	19.7	45.9
Raw Materials	108	25.5	43.2
Food	126	9.9	36.9
Textiles	18	6.5	30.8
Wood	31	15.0	40.5
Building Materials	22	16.2	41.9
Machinery	217	18.1	41.9
Miscellaneous	128	18.2	40.6
Secondary	635	19.6	42.0
Unknown	275	24.6	43.0
Empty	68	13.6	39.4
Total	1,650	19.3	41.9

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. However, those cases where a vehicle did not report a base location (i.e., all of the reported trips were non-base) were considered on a case-by-case basis. In cases where the beginning and ending non-base zone were the same, a tour was considered to be made. In a handful of cases where only non-base trips were reported, the trip tour was determined to have an open start or end, with a trip tour happening as well.

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 end or return to the study area. Therefore, to exclude external trips in the analysis could result in not capturing those trips that occur outside the study area that take place within the trip tour.

There were 3,701 trips observed in the H-GAC 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 ends (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. Such instances were treated separately from those vehicles with at least one trip involving a base, in determining whether the trip tour could be considered “all open,” “completely closed,” “before a closed tour,” or “after a closed tour.” Rather than simply labeling such trips as “all open,” each case was considered individually. If the trips started or ended at the same zone number, the trips for this vehicle were classified as “completely closed.” Similar logic was used in determining if a “trip before the tour” or a “trip after the tour” had occurred.

As Table 28 shows, approximately 60 percent of the total trips generated by cargo vehicles were non-base trips and 40 percent were base trips. For trips made by service vehicles, 56 percent were non-base trips and 44 percent were base trips.

Table 28. 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	745	40.1	811	44.0	1,556	42.0
Non-Base	1,111	59.9	1,034	56.0	2,145	58.0
Total	1,856	100.0	1,845	100.0	3,701	100.0

Table 29 shows the distribution of trip tours for cargo and service vehicles. There were 742 trip tours generated by 465 vehicles making at least one trip tour. Cargo vehicles made 334 tours and service vehicles produced 408 tours. The number of tours varied from 1-to-6 tours for cargo vehicles, and 1-to-9 tours for service vehicles. Over two-thirds (69 percent) of the cargo and service vehicles making a tour made only one trip tour. For those cargo and service vehicles making only one trip tour, they averaged 5.8 trips and 4.1 trips within the tour, respectively. For all vehicles combined, the average number of tours per vehicle was 1.6 and the average number of trips per tour was 3.5.

Table 29. Trip Tours per Vehicle.

Cargo Vehicles				
Total Number of Trip Tours	Number of Vehicles	Number of Tours	Number of Trips	Average Trips per Tour
1	152	152	877	5.8
2	41	82	248	3.0
3	11	33	95	2.9
4	10	40	95	2.4
5	3	15	22	1.5
6	2	12	30	2.5
7	0	0	0	0.0
8	0	0	0	0.0
9	0	0	0	0.0
Cargo Total	219	334	1,367	4.1
Service Vehicles				
Total Number of Trip Tours	Number of Vehicles	Number of Tours	Number of Trips	Average Trips per Tour
1	169	169	686	4.1
2	41	82	238	2.9
3	17	51	128	2.5
4	6	24	74	3.1
5	4	20	44	2.2
6	5	30	50	1.7
7	1	7	10	1.4
8	2	16	24	1.5
9	1	9	10	1.1
Service Total	246	408	1,264	3.1
Grand Total	465	742	2,631	3.5

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 2,631 trips observed within the total 742 trip tours. For all vehicles, 83 were external trips (3 percent), 2,358 were inter-zonal trips (90 percent), and 190 were intra-zonal trips (7 percent). Table 30 shows the distribution of these trips for cargo and service vehicles.

Table 30. 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	64	13	786	630	27	43	877	686
2	0	0	237	210	11	28	248	238
3	4	0	84	111	7	17	95	128
4	2	0	92	74	1	0	95	74
5	0	0	20	35	2	9	22	44
6	0	0	28	31	2	19	30	50
7	0	0	0	5	0	5	0	10
8	0	0	0	13	0	11	0	24
9	0	0	0	2	0	8	0	10
Total	70	13	1,247	1,111	50	140	1,367	1,264

Table 31 shows the number of non-base trips within trip tours separately since non-base 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 31. 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	568	353	921	877	64.2	686	54.3	1,563	59.4
2	111	115	226	248	18.1	238	18.8	486	18.5
3	35	50	85	95	6.9	128	10.1	223	8.5
4	19	29	48	95	6.9	74	5.9	169	6.4
5	5	14	19	22	1.6	44	3.5	66	2.5
6	10	20	30	30	2.2	50	4.0	80	3.0
7	0	2	2	0	0.0	10	0.8	10	0.4
8	0	14	14	0	0.0	24	1.9	24	0.9
9	0	8	8	0	0.0	10	0.8	10	0.4
Total	748	605	1,353	1,367	100.0	1,264	100.0	2,631	100.0

Figure 13 and Figure 14 show the percentage distribution of non-base trips, external trips, inter-zonal trips, and intra-zonal trips within trip tours for cargo vehicles and service vehicles, respectively.

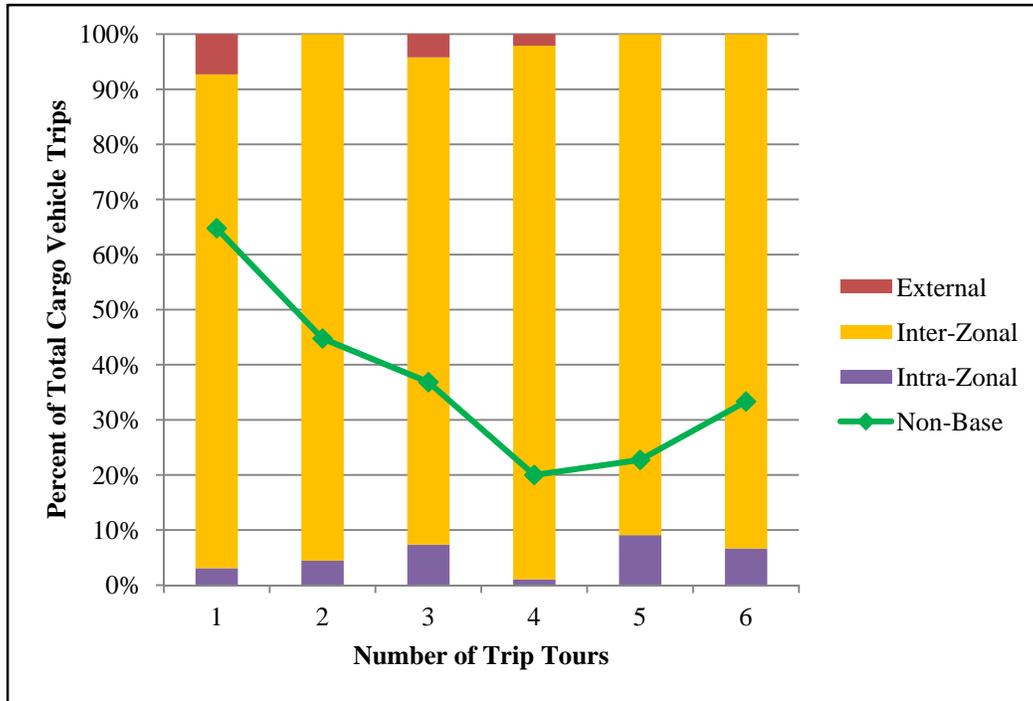


Figure 13. Cargo Vehicle Trips within Trip Tours by Trip Type.

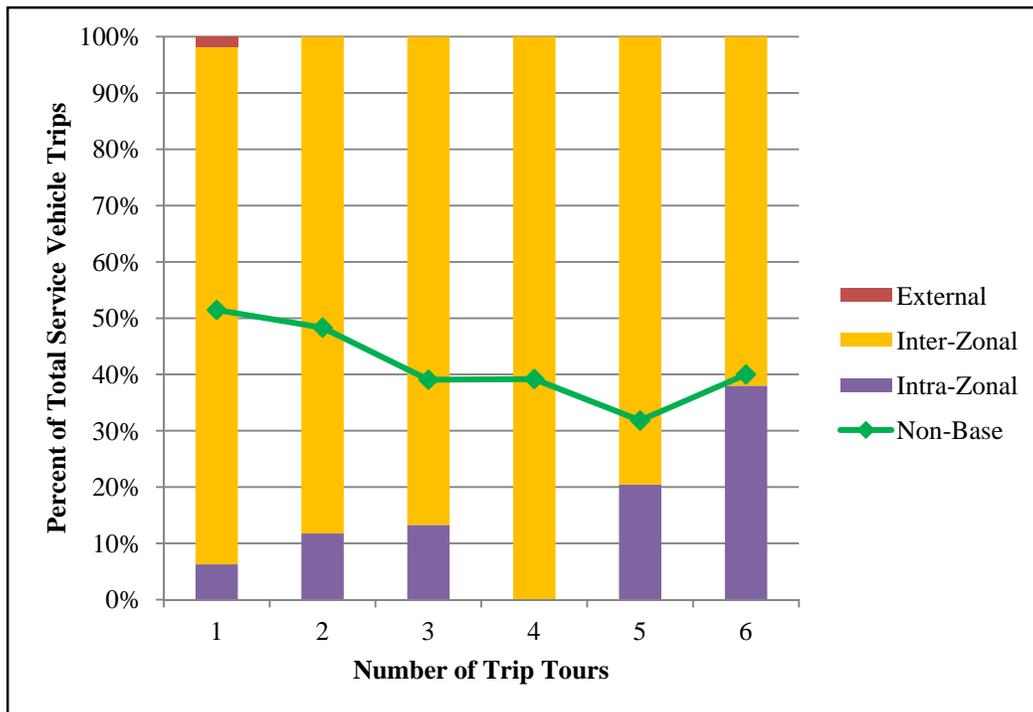


Figure 14. Service Vehicle Trips within Trip Tours by Trip Type.

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 trip chains that did not start and/or end at their base location, as well as those that only went to the base one time on the survey day, were considered open tours (except in the case of all non-base trips). In the case of non-base trips, if the trips were determined to contain completely closed tours under the criteria described earlier. They were labeled as completely closed tours. Due to the number of trips that were made in open tours, a review of when these trips occurred was performed. Table 32 provides an overview of when trips that are not part of tours were made relative to trip tours. Roughly 4 percent of the trips made by cargo and service vehicles combined were before the first trip tour or after the last completed trip tour. Nearly 15 percent of the trips made by surveyed vehicles did not have any trip tours. A total of 69 trips (29 cargo trips and 40 service trips) were not associated with any tours.

Table 32. Summary of Open Tour Trips.

Trip Type	Cargo		Service		All Vehicles	
	# of Trips	% of Total	# of Trips	% of Total	# of Trips	% of Total
Before Closed	6	0.3	54	2.9	60	1.6
After Closed	31	1.7	72	3.9	103	2.8
Only Open	255	13.7	296	16.0	551	14.9
Within Closed	1,564	84.3	1,423	77.2	2,987	80.7
Total	1,856	100.0	1,845	100.0	3,701	100.0
No Tours	29	NA	40	NA	69	NA

*Total does not include the “No Tours” category; NA: Not Applicable

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. However, in the

H-GAC commercial vehicle survey analysis, information on registered trucks has been included 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 contain annual average daily traffic (AADT) estimates of the total VMT by 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 average weekday VMT by functional classification. Table 33 provides the adjusted 2008 HPMS VMT estimates for the H-GAC study area.

Table 33. 2008 HPMS Estimates of Weekday VMT in the H-GAC Study Area.

Functional Classification	Total Weekday VMT
Freeway	68,409,493
Arterial	51,060,431
Collector	15,845,101
Local	5,733,168
Total	141,048,192

The percentages of commercial and non-commercial vehicles by functional classification were determined by utilizing vehicle classification counts for the H-GAC area that were obtained from TxDOT. Normally, the percentage of commercial vehicles for internal sites for each functional classification were combined with the corresponding percentage for external sites based on the percentage of regional VMT estimated as external travel. However, for H-GAC there were no external vehicle classification count data to utilize. Therefore, estimates derived from an analysis of external count data for the Dallas/Fort Worth (DFW) area were utilized and an assumption was made that the percentage of commercial vehicles by each functional classification would be similar in the H-GAC area. Based on the DFW results, the external VMT for that study area was approximately eight percent of the total HPMS VMT for the area. Therefore, it was assumed that

eight percent of the total VMT in the H-GAC area was external-related. These percentages were applied to obtain the weighted average for each functional classification.

Table 34 provides the internal, external, and weighted percentages of commercial and non-commercial vehicles by functional classification. The weighted percentages were applied to the HPMS estimated weekday VMT shown in Table 33 to estimate the total commercial and non-commercial VMT. Table 35 shows the estimated VMT for commercial and non-commercial vehicles. There were no count data for local roadways, and as a result the percentages obtained in DFW were utilized for that road classification.

Table 34. Percentage of Commercial and Non-Commercial Vehicles by Functional Classification.

Functional Classification	Percent of Commercial Vehicles			Percent of Non-Commercial Vehicles		
	Internal Sites (92%)	External Sites (8%)	Weighted Average	Internal Sites (92%)	External Sites (8%)	Weighted Average
Freeway	7	33	9	93	67	91
Arterial	9	17	9	91	83	91
Collector	8	7	8	92	93	92
Local	N/A	N/A	4	N/A	N/A	96

Table 35. Estimated VMT for Commercial and Non-Commercial Vehicles.

Functional Classification	Commercial VMT	Non-Commercial VMT	Total VMT
Freeway	6,364,566	62,044,927	68,409,493
Arterial	4,764,210	46,296,221	51,060,431
Collector	1,239,261	14,605,840	15,845,101
Local	229,327	5,503,841	5,733,168
Total	12,597,363	128,450,829	141,048,192

The total commercial VMT of 12,597,363 miles represents all commercial vehicles that traveled within the H-GAC study area. To properly expand the survey data and determine the total internal commercial vehicle trips generated in the study area, external VMT estimates had to be subtracted from the total commercial VMT. The external commercial VMT was estimated to be 3,498,106 miles. Therefore, the internal commercial VMT estimate was 9,099,258 miles.

The total internal VMT observed from the commercial vehicle survey was 39,721 miles, of which 22,311 miles were cargo VMT and 17,410 miles were service VMT. This estimate was based on 3,277 inter-zonal trips (1,665 cargo vehicle trips and 1,612 service vehicle trips), multiplied by the average trip length (13.4 miles for cargo and 10.8 miles for service vehicles). The total internal commercial VMT (39,721 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 56 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 44 percent of the commercial vehicles belonged to Class 3 (pick-up, van, or two-axle four-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 5,111,038 miles for cargo vehicles and 3,988,219 miles for service vehicles.

An expansion factor was derived based on the quotient between total internal VMT and observed internal VMT (from the survey) for each commercial vehicle type. The expansion factor (229.08 for both cargo and service vehicles) was then multiplied by the observed number of inter-zonal trips to estimate the total vehicle trips. The resulting inter-zonal trip estimates were approximately 381,421 cargo vehicle trips and 369,279 service vehicle trips. Based on the average number of inter-zonal trips per day of 6.3 trips for cargo vehicles and 5.6 trips for service vehicles, 126,486 commercial vehicles (60,543 cargo vehicles and 65,943 service vehicles) were estimated to be operating within the H-GAC study area on a daily basis. This estimate is 1.35 times more than the approximate 93,600 trucks registered in the study area in 2009. Table 36 provides a summary of key results from the H-GAC commercial vehicle survey and data expansion.

Table 36. Key Survey Results and Expanded Trip and VMT Data.

Indicator	Cargo Vehicles	Service Vehicles	All Vehicles
Sample Size	264	287	551
Total Inter-zonal Trips	1,665	1,612	3,277
Total Intra-zonal Trips	102	212	314
Total Internal Trips	1,767	1,824	3,591
Total External Trips	89	21	110
Total Internal and External Trips	1,856	1,845	3,701
Average Total Trips per Vehicle	7.03	6.43	6.72
Average Total Internal Trips per Vehicle*	6.30	5.60	5.95
Average Trip Length	13.4	10.8	12.1
Observed Internal VMT	22,311	17,410	39,721
Total Internal Commercial VMT	5,111,039	3,988,219	9,099,258
Survey Expansion Factor	229.08	229.08	229.08
Total Expanded Inter-Zonal Commercial Vehicle Trips	381,421	369,279	750,700
Total Expanded Intra-Zonal Commercial Vehicle Trips	23,366	48,565	71,932
Total Expanded Commercial Vehicle Trips	404,787	417,845	822,632
Number of Commercial Vehicles Operating on a Daily Basis	60,543	65,943	126,486
Attraction Rate to Households	--	--	0.075

*Based on internal trips of 551 surveyed commercial vehicles (264 cargo vehicles and 287 service vehicles).

One final calculation was the determination of the commercial vehicle attraction rate to households. In the survey, approximately 18 percent of the trips went to residential land use types. This percentage was applied to the total, expanded commercial vehicle trips within the study area to obtain an estimated 147,531 trips to residential locations. The residential trip estimate was divided by the estimated number of households in the H-GAC area (1,976,775) to obtain an attraction rate of 0.075.

SURVEY SUMMARY

This section provides a summary of vehicle and trip characteristics of 551 commercial vehicles that participated in the 2010 H-GAC 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 7.7 years compared to 6.7 years for service vehicles. The odometer readings reported by cargo vehicles indicated an average mileage of 201,000 miles, which was nearly double the reported average mileage of 107,000 miles by service vehicles. In terms of fuel use, around 71 percent of cargo vehicles used diesel and 29 percent used unleaded gasoline, while 78 percent of service vehicles used unleaded gasoline and 22 percent used diesel.

The analyses of trip characteristics included in-depth examination of trip frequency, trip type, average trip length, trip purpose, and land use activity at trip destinations by commercial vehicle type. Surveyed cargo vehicles made an average of 7.0 total trips per day, compared to 6.4 trips per day for service vehicles. Excluding the trips made outside of the study area (external trips), cargo vehicles produced 6.7 internal trips per day, with average travel distance of 13.5 miles, compared to service vehicles which made 6.4 internal trips per day, with average trip length of 10.1 miles. The average travel time per trip for cargo vehicles was 19.3 minutes and for service vehicles the average travel time per trip was 15.1 minutes.

In terms of trip purpose at trip destinations, approximately 53 percent of the cargo vehicle trips were delivery, 14 percent were pick-up, and 14 percent were “unknown”. For trips made by service vehicles, approximately 50 percent were service related, 16 percent were “unknown”, and nine percent were delivery.

In terms of land use activity, approximately 23 percent of the trips made by cargo vehicles occurred at industrial sites, followed by 14 percent to retail locations, and 13 percent at warehouses. For service vehicles, nearly 29 percent of the trips took place at residential sites, followed by nearly 16 percent at locations classified as “other”, and 12 percent at office locations.

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 trip destinations, the trip purposes and land use activity at each stop, and the net weight of cargo being picked-up and/or dropped off for each trip. Overall, the average net cargo weight per trip was around 2,000 pounds. Raw materials showed the highest average net cargo weight of around 9,000 pounds per trip, but the most frequently transported commodity was secondary materials with a net cargo

weight of 2,900 pounds per trip. The land use “industrial” showed the highest average net cargo weight of around 3,700 pounds per trip, but the land use “other” had the most number of trips and an average cargo weight of approximately 2,600 pounds per trip. Delivery trip purpose had the highest average net cargo weight of around 3,100 pounds per trip and it had the highest number of trip occurrences.

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. A total of 742 trip tours were generated by the surveyed vehicles, with cargo vehicles making 334 tours and service vehicles producing 408 tours. The number of trip tours per vehicle varied from one to six tours for cargo vehicles and one to nine tours for service vehicles. The average number of trips tours for all vehicles was 1.6 and the average number of trips per tour was 3.5. Trips made as part of trip tours accounted for 2,631 trips (1,367 trips by cargo vehicles and 1,264 trips by service vehicles). Within the trip tours, approximately 90 percent were inter-zonal trips, seven percent were intra-zonal trips and the remaining three percent were external trips. Non-base trips (which were not mutually-exclusive of the other trip types) made up approximately 50 percent of the trips within the tours.

Lastly, the expansion of commercial vehicle survey data were based on vehicle miles of travel (VMT) estimates and vehicle classification counts for the H-GAC study area. The commercial VMT estimates represented all commercial vehicles and do not distinguish by cargo and service vehicle types. Therefore, the estimation of VMT and volume of cargo and service vehicles operating within the study area were mainly based on key findings from the survey, such as the total number of internal cargo and service vehicle trips, the average number of trips per cargo and service vehicle, and the average trip lengths per cargo and service vehicle. Based on these findings, approximately 126,500 commercial vehicles (60,500 cargo vehicles and 65,000 service vehicles) were estimated to be operating within the H-GAC study area on a daily basis, roughly 1.35 times the volume of trucks registered in the study area in 2010.

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) <input type="checkbox"/> Passenger Car | 5) <input type="checkbox"/> Single Unit 2-axle (6 wheels) |
| 2) <input type="checkbox"/> Pick-up | 6) <input type="checkbox"/> Single Unit 3-axle (10 wheels) |
| 3) <input type="checkbox"/> Van (Cargo or Mini) | 7) <input type="checkbox"/> Single Unit 4-axle (14 wheels) |
| 4) <input type="checkbox"/> Sport Utility Vehicle (SUV) | 8) <input type="checkbox"/> Semi (all Tractor-Trailer combinations) |
| 9) <input type="checkbox"/> 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: _____ a.m./p.m.

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		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)
<i>NAME of Place:</i>	<i>Address including city, state, and zip OR Nearest street intersection or Landmark</i>						
PLACE 1		Arrive: _____ am/pm Depart: _____ am/pm					Delivery Picked Up
		Arrive: _____ am/pm Depart: _____ am/pm					Delivery Picked Up
		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

Commercial Vehicle Survey Travel (continued)

VEHICLE LICENSE #: _____

	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 Picked Up
PLACE 11		Arrive: _____ am/pm Depart: _____ am/pm					Delivery Picked Up
PLACE 12		Arrive: _____ am/pm Depart: _____ am/pm					Delivery Picked Up
PLACE 13		Arrive: _____ am/pm Depart: _____ am/pm					Delivery Picked Up
PLACE 14		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

