



**San Diego Association of Governments**

# **SANDAG 2022 COMMERCIAL VEHICLE SURVEY**

**November 22, 2023**



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## **LIST OF ABBREVIATIONS**

CA EDD	California Economic Development Department
CATI	Computer-Assisted Telephone Interviewing
CBP	County Business Pattern
CVS	Commercial Vehicle Survey
LCV	Light-Duty Commercial Vehicle
MUT	Multiunit Truck
NAICS	North American Industry Classification System
QA/QC	Quality Assurance/Quality Control
SANDAG	San Diego Association of Governments
SUT	Single-Unit Truck
TAZ	Transportation Analysis Zone
TNC	Transportation Network Company
VHT	Vehicle Hours Traveled
VMT	Vehicle Miles Traveled

## 1.0 EXECUTIVE SUMMARY

---

Commercial vehicle travel plays a significant role in model development and freight planning for the San Diego area. The region is a long-standing center of defense, high-tech manufacturing, and hosts some of the largest commercial vehicle border crossings in the United States.

Understanding the trip-making characteristics of these vehicles and the establishments (or businesses) that use the region's roads and highways is critical to properly planning and engineering for their needs. A commercial vehicle survey (CVS) helps meet this need by collecting data that helps staff use to develop forecasts.

Focusing on the movement of commercial vehicles rather than passengers, a CVS typically captures arrival and departure times, cargo details (load and type), trip purpose, and information about vehicles' origins and destinations. The data collected during the CVS will help the San Diego Association of Governments (SANDAG) and its partners in several ways.

For instance, SANDAG staff members can use the data to better understand commercial vehicle operators' travel decision-making processes by more accurately modeling their travel. This improved understanding will help inform which infrastructure prioritization and operational investments merits attention to enhance the overall quality of life for residents in the region.

Beginning in the spring of 2022 and continuing through January of 2023, ETC Institute, in coordination with RSG, worked with SANDAG to conduct a multistep CVS in San Diego County. RSG and ETC Institute worked with SANDAG to design and administer the CVS. Regional planning and modeling needs dictated the two types of surveys deployed:

- An **establishment survey** collected data about business operations that lead to truck movements. This survey collected information on business characteristics (e.g., industry, employment), shipping and receiving behavior, vehicle fleet composition, and the extent of commercial vehicle operations.
- A **truck travel diary survey** collected data about the vehicles' drivers, such as the types of businesses they are employed by and their daily travel. This survey featured multiple data retrieval options, including an app-based option installed on ETC Institute smart devices to collect data about truck driver behavior. The data included vehicle type, where vehicles start and end their day, and the details of each individual trip and stops made over the course of a day (e.g., activity at each stop, trip route, and stop duration).

The sampling plan was developed around the following goals:

- **Goals by Vehicle Class.** Goals by vehicle class were allocated to one of the following groups:
  - Light commercial vehicle (LCV), including passenger cars or motorcycles, pickup trucks (4 wheels), and vans (cargo/minivan) (4 wheels).
  - Medium commercial vehicle (SUT), including single-unit trucks and buses.

- Heavy commercial vehicle (MUT), including semis (all tractor-trailer combinations).
- **Goals by Industry Type and Size.** Goals for industry type were established using the North American Industry Classification System (NAICS) codes for each establishment. Establishments were sampled according to twelve industry categories:
  1. Agriculture/Mining.
  2. Manufacturing.
  3. Industrial/Utilities.
  4. Retail.
  5. Wholesale.
  6. Construction.
  7. Transportation.
  8. Info/Finance/Insurance/Real Estate/Professional services (Info/FIRE/Professional services).
  9. Education/Public/Other services.
  10. Medical/Health Services.
  11. Leisure/Accommodations and Food.
  12. Transportation Network Company (TNC).

During the travel diary phase of this project, certain organizations were targeted. These included TNCs operating commercial vehicles. These TNCs typically offer prearranged or on-demand delivery services for payment. They primarily use an online application or platform to facilitate communication between the seller of goods and the buyer.

Once the survey instruments and sampling plan were completed, ETC Institute conducted a pilot test to ensure the survey would run smoothly once the full administration began. After the pilot, all data gathered was analyzed by ETC Institute who then recommended minor modifications to the instrument to enhance the full administration tasks.

On completion of the main survey administration tasks, the data were expanded by the ETC Institute team, and the findings were presented to SANDAG. Key findings and characteristics of the dataset are explored in Chapter 9.0 of this report, which includes a comprehensive analysis of all collected data for the main commercial vehicle and TNC samples.

## Data Collected

The data collected revealed several insights into the operating habits of local establishments and the traffic patterns of their vehicles. Out of 104,122 unique establishments in the area, gleaned from a composite estimate of US Census Bureau and county-level data, 2,697 participated in the establishment survey. This amounts to about 2.6% of the total establishments in the region.

The goal and actual number of completed surveys, separated by type, are illustrated in Figure 1. A total of 1,751 vehicles completed the comprehensive 24-hour CVS travel diary. This effort produced a rich origin-destination dataset of 12,261 records. These records offered detailed

insights into both the origins and destinations of each journey undertaken by these commercial vehicles.

TNC completes also exceeded goals in the region, albeit at slightly lower rates than seen in other categories. A total of 411 TNC drivers completed the 24-hour TNC travel diary. The resulting dataset contained 5,253 records that traced the origins and destinations of their journeys. However, this sample did not include on-demand peer-to-peer rideshare services that carry passengers, such as Uber or Lyft.

The comprehensive approach to data collection for this project generated a significant volume of valuable information about commercial vehicle and TNC travel patterns. This, in turn, provides an in-depth understanding of travel behavior in the San Diego region, which will be crucial for future transportation planning and policy-making decisions.

**FIGURE 1: SUMMARY OF SURVEY GOALS AND COLLECTED**



Additional key findings from the surveys include the following:

- **CVS Trip Time and Distance.** Light and medium vehicles have similar trip characteristics, with average trip distances and times of approximately 8 miles and 11 minutes, respectively, while heavy trucks have longer trips, averaging 14 miles and 19 minutes (Table 17).
- **CVS Trip Vehicle Miles Traveled and Vehicle Hours Traveled.** Light vehicles traveled approximately 8 million miles and logged 200,000 hours of travel time, representing 54% of the total commercial vehicle mileage (VMT) and hours traveled (VHT) (Table 19).
- **CVS Trips by Origin-Destination Segment.** Most trips, 98% for light and medium vehicles and 90% for heavy trucks, started and ended within the San Diego region (Figure 20).
- **CVS tour patterns.** The most common (35.2%) tour pattern is one that started and ended at a base location within the same transportation analysis zone (TAZ) and that had multiple stops (Figure 29).
- **Number of Stops for CVS Tours.** As the number of tours per vehicle per day increased, there is a tendency for tours to have fewer stops. Additionally, as vehicle size increases, the



distribution of the number of stops per tour, categorized by vehicle type, becomes more likely to be single stop tours (Figure 24 and Figure 25).

- **TNC Trip Time and Distance.** The median trip distance and time for these trips in the TNC sample are 1.8 miles and 6.7 minutes, respectively, while the mean trip distance and time are 4.7 miles and 8.9 minutes (Table 24). The TNC sample is not weighted or expanded.

Table 1 summarizes key information about the trips and tours sampled in the CVS and TNC survey samples.

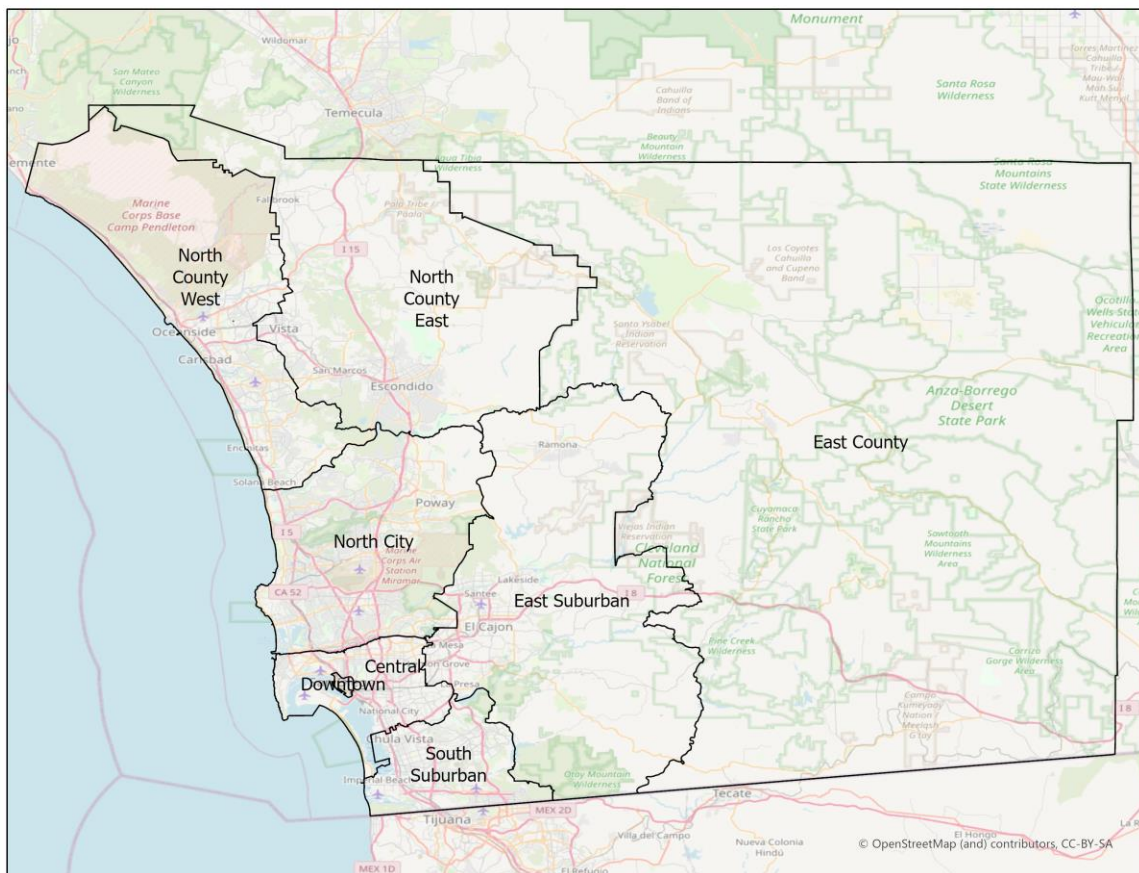
**TABLE 1: TRIP AND TOUR SUMMARY TABLE FOR CVS AND TNC SAMPLE**

VARIABLE	STATISTIC	CVS SURVEY	TNC SURVEY
Trips: Distance	Mean (Miles)	9.5	4.7
Tours: Distance	Mean (Miles)	47.2	51.3
Tours: Number of Stops (Excluding Return to Base)	Mean (# Stops)	4.0	10.4
Tours: Single Stop Tours (vs. Multistop)	Proportion	0.28	0.02
Trips: Stop Duration	Mean (Minutes)	37.9	32.8
Tours: Tour Duration	Mean (Minutes)	225.8	427.4
Tours/Employee/Day	Proportion	0.25	N/A
Trips/Tour/Day (Stops/Tour/Day)	Proportion	4.0	10.4

In addition to this report that documents the design, administration, and results of the CVS, five appendices are also included:

- **Appendix A: Survey Questionnaires.** Copies of the establishment and truck travel diary surveys and screenshots of the online version of the establishment survey.
- **Appendix B: Survey Tabulations.** Cross tabs of each question posed in the establishment and truck travel diary surveys.
- **Appendix C: Weighting and Expansion Memorandum.** A copy of ETC Institute's memorandum, which documents their process for developing sample targets and data-weighting procedures for vehicle and trip data.
- **Appendix D: Cover Letter.** The letter mailed to the establishments that were randomly selected to participate in the survey.

**FIGURE 2: SAN DIEGO REGION, INCLUDING ADJUSTED MSA BOUNDARIES**



Several data elements are needed for the development of the model, including but not limited to:

- Information about regional activity centers that are a driver for commercial vehicle activity. This includes industrial locations, retail centers, and special generators such as ports.
- Data pertaining to cross-regional trade that influences freight travel and movement of large trucks.
- Data pertaining to truck movements in serving employment and consumption centers. These data are obtained through a combination of sources such as anonymized GPS data as well as establishment surveys, truck diaries, and origin-destination surveys.

The data collected during this project will help SANDAG better understand commercial vehicle operators' travel decision-making processes. The data will also improve the region's ability to model commercial vehicle travel patterns, which will improve the region's prioritization efforts around infrastructure and operational investments to enhance residents' quality of life.

Prior to the start of this project, SANDAG, in close coordination with the project team (ETC Institute and RSG), assembled data from several sources to prepare for the project. These sources included:

- Employment information from the US Census Bureau and commercial sources.
- Freight activity data through commodity flow databases.
- Establishment data from a database of all establishments in the county, including the County Business Pattern (CBP) Survey and the California Economic Development Department (CA EDD).

In addition to the data sources listed above, the project team conducted an establishment survey as the first phase of this commercial vehicle survey (CVS). The establishment survey collected data about the number of trips at each location, the number of employees, the types of trips arriving and departing from the location, and the types of facilities where trips began and ended.

## 2.1 SURVEY ORGANIZATION AND PROJECT MANAGEMENT

This section describes ETC Institute's approach to the management of project task execution and deliverables.

### Project Team Meetings

Open and frequent communication between SANDAG and the project team was essential to the success of the project and helped to reduce confusion and duplication of efforts. The project team met as needed to discuss and coordinate upcoming tasks. Each project team member was responsible for disseminating information during the meeting to others in their respective organization. During the project, ETC Institute, RSG, and SANDAG conducted frequent progress meetings via conference calls. These meetings covered key activities and tasks to

ensure the project was progressing as desired and within budget and on schedule. Identified issues were addressed quickly and efficiently.

### Reports

ETC Institute submitted monthly status reports during the development of the survey materials and sampling plan. The monthly status reports documented the following:

- Work completed during the month.
- Work planned for the upcoming month.
- Problems/issues that need to be addressed.

ETC Institute's project manager emailed these reports to SANDAG's project manager. Once the administration of the survey began, ETC Institute submitted a weekly report that included the following:

- Goal for completed surveys.
- The number of establishments/vehicles recruited.
- The number of usable surveys completed.

### Key Personnel

The key members of the team and their role in the project are listed below:

- Chris Tatham (ETC Institute): Principal
- Aaron Hekele (ETC Institute): Project Manager
- Liz Corber (ETC Institute): Assistant Project Manager
- Andrew Kolcz (ETC Institute): Systems Manager (Lead Programmer and App Developer)
- Nick Jones (ETC Institute): Data Manager
- Jason Jones (ETC Institute): QAQC Manager
- Henry Danneberg (ETC Institute): Field Manager (Travel App Deployment)
- Kevin Arnold (ETC Institute): TNC Field Recruitment
- Norma Rosales, Mary Wirtz, and Barb Guinn (ETC Institute): Lead Recruiters
- Tristan Cherry, Colin Smith, and Rachel Li (RSG): Responsible for analysis and reporting of the CVS results.

## **Project Process and Report Structure**

The following sections further detail planning and implementation of the data collection process. This process necessitated developing a sampling plan, which the project team used to test and revise the survey design. Following testing and revisions, a final administrative plan and process was developed. This included a description of the data quality control process. Following the survey and collection of data, the project team summarized the findings.

The remainder of this report is structured as follows:

- Chapter 3.0: Survey Design
- Chapter 4.0: Survey Administration Procedures
- Chapter 5.0: Survey Sampling and Administration
- Chapter 6.0: Pilot Test
- Chapter 7.0: Quality Assurance and Control (QA/QC)
- Chapter 8.0: Data Expansion Procedures
- Chapter 9.0: Characteristics of Datasets
- Chapter 10.0: Conclusion

## 3.0 SURVEY DESIGN

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ETC Institute worked with SANDAG and RSG staff to develop the CVS instruments that could be completed as a mail-out survey, an online web survey, or via smartphone app. The survey was designed to be a 24-hour commercial vehicle activity travel diary that was kept by drivers/employees from recruited establishments. The CVS recruitment script and travel diary were structured and worded to allow participants to answer the questions easily. A complete data dictionary itemizing each survey question is included in Appendix A.

Two separate instruments were developed to collect all required data:

- **Establishment Survey.** A questionnaire that collected company details and vehicle fleet information from a randomly selected sample of commercial establishments in the SANDAG study area in 2022. A copy of the establishment survey questionnaire is included in Appendix A along with screenshots of the online instrument.
- **Truck Travel Diary Survey.** A smartphone-app-based travel diary survey that was installed on ETC Institute's smart devices to collect data about truck driver behavior. The survey included two main sections that collected information on drivers and vehicles, and a third section that recorded the details of driver trips. The app collected data about the drivers such as the types of businesses they are employed by and their daily travel. The data included vehicle type, where vehicles start and end their day, and the details of each individual trip and stops made over the course of a day (e.g., activity at each stop, trip route, and stop duration). A copy of the vehicle and travel diary survey questionnaires are also included in Appendix A.

## 4.0 SURVEY ADMINISTRATION PROCEDURES

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ETC Institute worked with SANDAG and RSG to develop the prenotification letter and survey materials. Copies of the letter, survey instruments, and supporting materials are provided in Appendix A.

### Pilot Survey

ETC Institute conducted the pilot in May 2022 using the same approach/methodology that was used in the main survey. The pilot requirements were to fully complete 50 establishment and CVSs. The pilot survey included a complete pretest and evaluation of the full survey, including:

- Sample generation.
- Telephone recruitment.
- Reminder call.
- Retrieval call.
- Data entry.
- Trip geocoding.
- Edit checks.

### Recruitment Procedure

ETC Institute used a sample of establishments from the SANDAG modeling region to recruit businesses to participate in the establishment survey and CVS during the pilot and the main surveys.

After an establishment was recruited, they went through a short qualification process to determine if their business was eligible to participate in the survey. This process was based on various sampling requirements (e.g., business type, employee size, location, industry). If all information determined they were qualified to participate in the survey, they were informed their participation would be incentivized. Participants were informed that all incentives were being offered solely by ETC Institute.

### Conducting the Commercial Vehicle Travel Survey

Given that routing decisions and commercial vehicle movements are often considered by companies as proprietary data, public awareness of the project sponsor was an important factor in the success of the survey. People who participated in the pilot survey indicated that the initial letter from SANDAG was important because they knew the survey was legitimate.

ETC Institute worked with SANDAG to develop and administer an awareness campaign to inform the community about the survey. The campaign involved a two-tiered strategy:

- **Tier 1—General Awareness.** This first tier involved building general awareness about the study on social media, SANDAG's website, and in other general media sources.



- **Tier 2—Detailed Awareness.** The second tier involved direct communication with each of the establishments that were recruited to participate in the study. ETC Institute worked with SANDAG to design a series of direct mailings that included reminder letters and advance letters. In addition, ETC Institute established local and toll-free numbers that allowed establishments in the study area to contact ETC Institute if they had questions about the study.

Each of the major elements of the survey administration process are briefly described below:

- **Prenotification Letter.** ETC Institute mailed a prenotification letter on SANDAG letterhead to all establishments that were randomly selected to participate in the survey. The letter was in both English and Spanish.
- **Initial Solicitation.** A few days after the prenotification letters were mailed, ETC Institute called each of the establishments that received a prenotification letter from the sample to confirm their address and collect establishment-level data. If it was determined that the establishment also qualified for the travel survey component of the study, call center interviewers recruited them to participate further by providing travel information via the travel diary app installed on a smartphone device.

Establishments that agreed to participate in the travel survey component were assigned a travel day for the diary/app survey. These establishments were also given instructions regarding how the information would be retrieved. Prior to traveling, additional data was retrieved to understand the type of vehicle that would be traveling, how it is used, and driver information. These data included, but were not limited to, the following:

- **Vehicle Information.** Number owned, number available, make, model, and commercial or private use.
- **Driver Information.** Age, sex, ethnicity, employment status, and contact information.

Information that was gathered from each of the participating establishments was entered into a database as soon as the establishment was recruited. Each establishment that was recruited was assigned a unique identifying number to monitor the establishment's participation in the survey throughout the survey administration process.

To ensure that participating establishments received all the necessary information to complete the survey, the following communications were also employed:

**Instructional Email.** ETC Institute emailed instructions for how to participate in the travel survey by using one of the three following methods: 1) participating via the travel diary application on a device delivered directly by ETC Institute field representatives; 2) over-the-phone collection with an ETC Institute call center employee; or 3) online, where the participating establishment could go online and fill out the information. Spanish versions of the online survey instrument and app were provided for drivers who did not speak English.

**Reminder Calls.** ETC Institute placed a reminder call to each establishment the day before they were scheduled to begin the travel survey. The pretravel day reminder call was used to confirm the establishment's participation. The call was also used to: 1) review the procedures for



recording travel information to ensure participants understood the importance of recording specific addresses; 2) answer any questions that the establishment/driver had regarding the survey; 3) schedule a callback time for the data-retrieval call; 4) stress the importance of the survey; and 5) emphasize the anonymity of the data provided.

**Data Retrieval.** ETC Institute placed a follow-up call at a prearranged callback time within two days after travel diary activity was scheduled. This call was used to retrieve travel activity and trip data. Every attempt was made to personally interview each of the employees/drivers who completed a travel diary. In some cases, a proxy provided information for employee members who were unavailable. These data-retrieval calls were arranged for all establishments participating in the survey regardless of methodology for completion to either confirm trip data or complete with the responding establishment over the phone.

**Thank-You Email.** After ETC Institute had received all completed surveys from an establishment, an email to contacts thanked them for participating and informed them they were done with the survey at that time.

## 5.0 SURVEY SAMPLING AND ADMINISTRATION

This chapter of the report documents the sampling goals that were used to guide the implementation and administration results of the establishment survey and truck travel diary surveys. A more-detailed rendering of the sample goals, including a discussion of statistical precision and level of confidence, can be found in the SANDAG Data Expansion Technical Memorandum prepared by ETC Institute and included in Appendix C.

### Establishment Survey

ETC Institute administered the establishment survey to commercial establishments in the San Diego region between June 2022 and October 2022. Establishments could participate by completing the survey and returning it via postage paid envelopes, online via the link within the letter, or by follow-up phone call. In total, 15,287 advance notification letters were sent (with an accompanying paper version of the survey) with business addresses obtained by the third-party vendor Data Axle. During the administration, 2,697 businesses completed the establishment survey. Of those, 467 had one or more vehicles participate in the travel diary. Of the 1,751 vehicles included in the survey, 1,394 used the travel diary application and 357 used the online form or paper diary.

The sample universe of establishments in the SANDAG model region is shown in Table 2. The distribution of the completed surveys by firm size and industry type is provided in Table 3; the table also shows the portion of each establishment group in San Diego County that participated in the research. The goal was to obtain a sample from at least 30 establishments in each cell of the sampling plan to support data expansion and weighting procedures. This was accomplished, except for the industrial/utilities group. Although ETC Institute did not complete the industrial/utilities group's minimum targets, surveys were collected from 22% of the establishments in this industry category.

**TABLE 2: SAMPLE UNIVERSE OF COMMERCIAL ESTABLISHMENTS IN THE SANDAG MODEL REGION**

GROUP	NAICS CODES	0-9 EMP.	10+ EMP.	TOTAL
Agriculture/Mining	11, 21	334	88	421
Manufacturing	31-33	2,723	1,664	4,387
Industrial/Utilities	22	115	77	191
Retail	44, 45	7,124	3,272	10,396
Wholesale	42	3,355	990	4,345
Construction	23	6,162	1,586	7,748
Transportation	48, 49	1,371	496	1,867
Info/FIRE/Professional services	51-55	24,539	4,310	28,849

## SANDAG 2022 Commercial Vehicle Survey

GROUP	NAICS CODES	0-9 EMP.	10+ EMP.	TOTAL
Education/Public/Other services	56, 61, 81, 92	11,416	3,233	14,649
Medical/Health Services	62	19,634	2,404	22,038
Leisure/Accommodations and Food	71, 72	4,742	4,492	9,234
<b>Total</b>		<b>81,512</b>	<b>22,610</b>	<b>104,122</b>

Source: CA EDD 2020, CBP Survey, San Diego County, 2019

**TABLE 3: COMPLETED ESTABLISHMENT SURVEYS, BY FIRM SIZE**

GROUP	NAICS CODES	0-9 EMP.	10+ EMP.	TOTAL	% OF IND. GROUP SURVEYED
Agriculture/Mining	11, 21	61	35	96	22.8%
Manufacturing	31-33	122	126	248	5.7%
Industrial/Utilities	22	16	26	42	22.0%
Retail	44, 45	147	128	275	2.6%
Wholesale	42	138	91	229	5.3%
Construction	23	146	108	254	3.3%
Transportation	48, 49	81	51	132	7.1%
Info/FIRE/Professional services	51-55	302	125	427	1.5%
Education/Public/Other services	56, 61, 81, 92	224	120	344	2.3%
Medical/Health Services	62	223	165	388	1.8%
Leisure/Accommodations and Food	71, 72	134	128	262	2.8%
<b>Total</b>		<b>1,594</b>	<b>1,103</b>	<b>2,697</b>	<b>2.6%</b>

## Truck Travel Diary Surveys

A total of 1,751 vehicles from 467 establishments participated in the commercial diary/travel app portion of the CVS, which involved having the vehicle's driver(s) track all the locations and activities for the vehicle for at least one 24-hour period. An average of 3.75 vehicles per participating establishment provided 24 hours of travel data. Data from trips made by 1,303 light-duty commercial vehicles (LCV), 228 single-unit trucks (SUT), and 220 multiunit trucks (MUT) were collected in the survey. Table 5 through Table 8 show vehicle, industry type, and industry size for each of the cells in the sampling plan as well as the number of completed surveys by vehicle class, establishment type, and firm-size category.

### *Transportation Network Company Travel App Survey*

Transportation network company (TNC) vehicles were sampled due to their important and growing contributions to commercial vehicle activity. A TNC vehicle, often referred to as part of the "gig economy," provides prearranged or on-demand delivery service for compensation and use an online application or platform to communicate between the seller of goods and the buyer. Table 4 shows the number of completed TNC surveys. The sample did not include on-demand peer-to-peer ride-hailing services to carry passengers (e.g., Uber or Lyft).

ETC Institute recruited 1,511 TNC drivers who agreed to participate in the travel diary survey, all using the smartphone app. Little reliable data exists to characterize the existing fleet and composition of TNC operations in the SANDAG study region, so no specific sample targets by vehicle or establishment type could be generated. Instead, ETC Institute sought to target a diverse sample of TNC types recruited throughout the study region. Of the 1,511 drivers recruited, 411 completed 24 hours of trip surveys using the smartphone app.

**TABLE 4: SURVEY COMPLETION COUNT, BY TNC**

TNC	COUNT	PERCENT
Amazon	34	8.3%
Amazon Flex	15	3.6%
Amazon Fresh	1	0.2%
Axle Hire	4	1.0%
Door Dash	90	21.9%
Fantuan	1	0.2%
Go Puff	2	0.5%
Grub Hub	43	10.5%
Instacart	47	11.4%
Point Pick Up	20	4.9%
Postmates	12	2.9%

## SANDAG 2022 Commercial Vehicle Survey

TNC	COUNT	PERCENT
Return Mates	5	1.2%
Return to Runway	2	0.5%
Roadie	28	6.8%
Senpex	7	1.7%
Shipt	16	3.9%
Spark	9	2.2%
Uber Eats	75	18.2%
<b>Total</b>	<b>411</b>	<b>100.0%</b>

**TABLE 5: TOTAL SAMPLING GOALS AND COMPLETED VEHICLE SURVEYS, BY FIRM SIZE AND INDUSTRY TYPE**

GROUP	SAMPLE TARGETS			COMPLETED SURVEYS		
	0-9 EMPLOYEES	10+ EMPLOYEES	ALL SIZES	0-9 EMPLOYEES	10+ EMPLOYEES	ALL SIZES
1. Agriculture/Mining	—	—	55	20	31	51
2. Manufacturing	34	61	95	39	81	120
3. Industrial/Utilities	—	—	75	5	80	85
4. Retail	60	80	140	59	86	145
5. Wholesale	63	62	125	66	91	157
6. Construction	150	115	265	116	169	285
7. Transportation	60	110	170	46	171	217
8. Info/FIRE/Professional Services	165	110	275	119	125	244
9. Education/Public/Other Services	70	115	185	59	160	219
10. Medical/Health Services	60	66	126	64	80	144
11. Leisure/Accommodations & Food	40	50	90	44	40	84
<b>Total</b>	<b>745</b>	<b>855</b>	<b>1,600</b>	<b>637</b>	<b>1,114</b>	<b>1,751</b>

**TABLE 6: LCV SAMPLING GOALS AND COMPLETED VEHICLE SURVEYS, BY FIRM SIZE AND INDUSTRY TYPE**

GROUP	SAMPLE TARGETS			COMPLETED SURVEYS		
	0-9 EMPLOYEES	10+ EMPLOYEES	ALL SIZES	0-9 EMPLOYEES	10+ EMPLOYEES	ALL SIZES
1. Agriculture/Mining	—	—	45	18	20	38
2. Manufacturing	20	40	60	34	49	83
3. Industrial/Utilities	—	—	60	5	59	64
4. Retail	40	60	100	43	54	97
5. Wholesale	45	45	90	45	64	109
6. Construction	90	85	175	77	126	203
7. Transportation	30	50	80	31	70	101
8. Info/FIRE/Professional Services	150	100	250	112	108	220
9. Education/Public/Other Services	60	100	160	47	137	184
10. Medical/Health Services	45	55	100	51	71	122
11. Leisure/Accommodations & Food	35	45	80	42	40	82
<b>Total</b>	<b>550</b>	<b>650</b>	<b>1,200</b>	<b>505</b>	<b>798</b>	<b>1,303</b>

**TABLE 7: SUT SAMPLING GOALS AND COMPLETED VEHICLE SURVEYS BY FIRM SIZE AND INDUSTRY TYPE**

GROUP	SAMPLE TARGETS			COMPLETED SURVEYS		
	0-9 EMPLOYEES	10+ EMPLOYEES	ALL SIZES	0-9 EMPLOYEES	10+ EMPLOYEES	ALL SIZES
1. Agriculture/Mining	–	–	5	0	8	8
2. Manufacturing	4	6	10	5	10	15
3. Industrial/Utilities	–	–	10	0	15	15
4. Retail	10	5	15	11	6	17
5. Wholesale	8	7	15	9	15	24
6. Construction	15	15	30	9	23	32
7. Transportation	15	15	30	12	30	42
8. Info/FIRE/	15	10	25	4	17	21
9. Education/Public/	10	15	25	7	23	30
10. Medical/Health Services	15	10	25	13	9	22
11. Leisure/Accommodations & Food	5	5	10	2	0	2
<b>Total</b>	<b>102</b>	<b>98</b>	<b>200</b>	<b>72</b>	<b>156</b>	<b>228</b>

**TABLE 8: MUT SAMPLING GOALS AND COMPLETED VEHICLE SURVEYS BY FIRM SIZE AND INDUSTRY TYPE**

GROUP	SAMPLE TARGETS			COMPLETED SURVEYS		
	0-9 EMPLOYEES	10+ EMPLOYEES	ALL SIZES	0-9 EMPLOYEES	10+ EMPLOYEES	ALL SIZES
1. Agriculture/Mining	–	–	5	2	3	5
2. Manufacturing	10	15	25	0	22	22
3. Industrial/Utilities	–	–	5	0	6	6
4. Retail	10	15	25	5	26	31
5. Wholesale	10	10	20	12	12	24
6. Construction	45	15	60	30	20	50
7. Transportation	15	45	60	3	71	74
8. Info/FIRE/	0	0	0	3	0	3
9. Education/Public/	0	0	0	5	0	5
10. Medical/Health Services	0	0	0	0	0	0
11. Leisure/Accommodations & Food	0	0	0	0	0	0
<b>Total</b>	<b>93</b>	<b>107</b>	<b>200</b>	<b>60</b>	<b>160</b>	<b>220</b>

## 6.0 PILOT TEST

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ETC Institute conducted a pilot test for the SANDAG CVS in May 2022. The pilot test was conducted to assess the methodology for administering both the establishment survey and travel application components of the truck travel diary survey application. The activities and outcomes for each task are described below.

### Task 1: Survey Design

The initial survey design took place prior to the pilot and involved several rounds of edits with both RSG and SANDAG, and ETC Institute's own internal testing. After edits and internal testing were completed, the materials were ready for full pilot testing, which occurred in May 2022. Based on the results of the pilot test, ETC Institute worked with SANDAG and RSG to refine the survey materials. Those materials were officially finalized in early June of 2022.

A random sample of 100 organizations were selected for the pilot test. The completion goals for the pilot test were as follows:

- To obtain at least 10 establishment surveys (including one TNC).
- To obtain one-day travel surveys from at least 40 commercial vehicles of which at least 30 would participate using the smartphone app.

### Task 2: Stakeholder Participation in Pilot

Select members of the SANDAG project team participated in the pilot test to facilitate a greater understanding of the recruitment process and the travel application functions.

### Task 3: Administration

The pilot test was administered as follows:

1. **Design of the Survey Materials.** The design of the survey materials, including the advance notification letter, was completed in May 2022.
2. **Advance Notification Letter.** Advance notification letters were mailed to representatives of each of the 100 establishments that were selected for the pilot test.
3. **Administration of the Establishment Survey.** ETC Institute began contacting representatives from each of the organizations that had been selected for the pilot test and attempted to contact each establishment to schedule a time to complete the survey. Of the 100 organizations that were selected, ETC Institute was able to reach a representative of 13 organizations by phone. Nine organizations who participated in the establishment survey also agreed to complete one or more travel apps over a 24-hour period. A total of 9 of the 13 (75%) organizations who agreed to participate in the travel application completed it by the date scheduled.



4. **Administer the Truck Travel Diary.** Drivers from 9 organizations and one Uber Eats driver completed the 24 hours of trips surveys using the survey application retrieval method.

### Task 4: Prepare Databases

The data from the establishment survey and travel diary application were compiled into three databases:

- **Establishment Database.** Contains the location of the participating organization, number of employees, number of vehicles, and other data about the company.
- **Vehicle Database.** Contains the location where the vehicle is normally based, make/model/year of vehicle, and other information about the vehicle.
- **Trip Database.** Contains each of the destinations that were visited by vehicle on the assigned travel day along with the types of places visited, times of travel, and type/amount of cargo, if applicable.

Each of these databases were submitted to SANDAG and RSG for review to ensure the format and content of the databases will support the modeling requirements for the region.

## 6.1 ENHANCEMENTS FROM THE PILOT

The following changes were made to CVS based on the results of the pilot test:

### *Changes to Survey Collateral and Website*

- ETC Institute worked with SANDAG's project team to update the color scheme to match SANDAG's new logo on all survey collateral material.
- ETC Institute worked with SANDAG's project team to update the color scheme to match SANDAG's new logo on the project website.

### *Changes to the Establishment Survey*

- During the administration of the pilot test, ETC Institute noted minor issues with respect to methodology, programming, and survey wording. ETC Institute provided recommendations to SANDAG to resolve any identified issues and were given approval to update the survey and the methodology prior to moving into the main survey.
- A TYPE-SIZE code was added to the beginning of the survey to simplify the ability to track the goals in the sampling plan.
- Sample size codes were changed from A, B, C to 1, 2, 3 to match the codes in the sample.
- A question regarding the point of contact's preferences for being contacted by phone or email was added.

### ***Changes to the Vehicle Data Collection***

- A question was added to the vehicle portion of the diary survey to ask if the vehicle's travel date was rescheduled because the vehicle did not travel on the date that was originally assigned. This helped assess the percentage of commercial vehicles that travel on an average day, which is needed for data expansion.
- ETC Institute also clarified instructions related to whether the vehicle was used for commercial purposes on its assigned travel day (rather than just being used for commercial purposes in general).

### ***Changes to the Travel App***

- ETC Institute worked with SANDAG's project team to update the color scheme to match SANDAG's new logo.

## 7.0 QUALITY ASSURANCE AND CONTROL

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The project team employed a comprehensive quality assurance/quality control (QA/QC) program that began with the survey instrument design. Both ETC Institute and RSG ensured that every data element was appropriately addressed and that each survey question was crafted to maximize respondent comprehension and accuracy of response. The final survey instrument was designed to follow a logical progression of data collection to avoid question-order bias and to elicit all required information effectively.

Another critical step in the QA/QC process was conducting all surveying in-house with surveyors, supervisors, and managers that have a comprehensive understanding of surveying through project-specific training. The ETC Institute team also ensured representative samples and established quota controls. The final step in the QA/QC process was tracking, coding, correcting, and validating survey results. ETC Institute used several techniques in this area to maximize data quality, including:

- Observed surveys in progress to ensure that surveyors asked all questions consistently and in a neutral fashion during phone interviews.
- Conducted phone interviews using a computer-assisted telephone interviewing (CATI) technique, where the interviewer followed a preprogrammed script, which is included in Appendix C. This process enabled proper skips and branching patterns. The CATI program included supplementary text to help the interviewer to assist the respondent with their responses.
- The CATI program also included reasonableness and logical checks to improve data quality. These checks were programmed into the survey instrument and brought to the surveyor's attention so that they could be resolved with the respondent on a real-time basis, eliminating the need for a subsequent callback. Some examples of automated checks included, but were not limited to, the following:
  - If a respondent indicated there were trucks located at their facility, but then subsequently indicated that none of the trucks left the facility, the interviewer would clarify or correct the responses to these two questions.
  - Respondents were asked to indicate what percentage of all trucks leaving the facility left full, empty, or partially full. The same questions were asked about arriving trucks. The automated program would add the results for each of these series of questions to ensure that the responses were balanced. If the responses were not balanced, such as when the total percentage of all trucks did not add up to 100%, then the interviewer would revisit the responses to those questions.
  - If the respondent indicated more than 50% of all trucks go outside the San Diego region, the respondents would be asked to provide information about their product and destination to discern a logical reason for this travel pattern.
  - Establishments that were within a predetermined list of NAICS codes were asked to provide the type and percentage of each commodity type that they ship out or

deliver. The automated program ensured that the percentage of the primary product was larger or equal to the percentage of the secondary product. Otherwise, the primary and secondary product categories and percentages were reversed. This check enforced accurate and consistent data collection.

- To respect the respondent's time, each QA/QC check included a comment field, so the interviewer could record the respondent's clarification, if needed, and complete the survey in a timely manner, and then later go back and correct the responses, as needed.
- "Other" establishment category responses that do not clearly fit into one of the predetermined categories in the survey were reviewed through a combination of internet searches and callbacks to determine the appropriate category for the survey.
- During survey transcription, a visual review of each completed survey was conducted by an analyst to ensure that all skip patterns functioned correctly. In addition, all open-ended and "other" responses were checked to ensure that they were logical and sufficiently met the needs of the survey.

After completing the survey administration tasks, some records were excluded from the final analysis. In the establishment survey, 186 establishments provided incomplete data. Of those, all but 47 were successfully retrieved during follow-up calls with the contacts. During the travel app component of the study, 64 vehicles were excluded due to the following reasons:

- Noncooperative drivers who turned off the device or experienced connectivity issues.
- Inability of ETC Institute data review team to confirm the stops during the follow-up interview.
- Travel was completed on a weekend.

### **GPS Probe Data QA/QC Checks**

The project team employed a series of QA/QC checks designed specifically for travel behavior surveys. These checks focus on trip rates, trip-length distributions by vehicle type, and key industry type. These checks were customized for each of the data types. In addition, a set of checks on spatial and temporal consistency of reported and inferred trips was established to assure that vehicle travel diaries and outputs from vehicle probe data processing reasonably matched. This comparative analysis helped impute missing information in one survey by utilizing information from a different survey. In some instances, a well-filled-out trip diary may help impute GPS traces with gaps, or vice versa.

More specifically, the types of checks applied to the GPS traces included the following:

- GPS trace data can include noise in the form of varying speeds. A new smoothed speed was calculated using a 15-second rolling mean.
- A speed threshold of 2.5 mph was applied, and the vehicle was imputed to have stopped any time it fell below this threshold for at least 120 seconds after having been above this threshold.

- Since noisy GPS data caused an overabundance of imputed stops, an additional distance threshold was applied such that if any stop was < 0.07 miles from the previous stop, it was filtered out as a likely spurious stop. This threshold was chosen by examination of several particularly noisy records such that it removed nearly all spurious stops without inadvertently removing legitimate stops that happen to be located near one another.
- These various thresholds (1-3 above) still leave room for error such as if a legitimate stop lasts less than two minutes, if a vehicle is stuck in slow traffic for a significant time, or if a vehicle drives to different locations on the same site. To address this concern, ETC Institute visually examined every record in which diary stops and imputed stops were observed. This was done to remove spurious imputed stops and (less frequently) add “imputed” stops for cases where there was a diary stop without a matching imputed stop due to not exceeding the time threshold. Table 9 shows the percentage of trips that traveled under two minutes by vehicle and sample type (unweighted).

**TABLE 9: PERCENTAGE OF TRIPS UNDER 2 MINUTES, BY VEHICLE AND SAMPLE TYPE**

VEHICLE TYPE	CVS SAMPLE (UNWEIGHTED)			TNC SAMPLE (UNWEIGHTED)		
	TRIPS < 2 MIN	TOTAL TRIPS	PERCENT	TRIPS < 2 MIN	TOTAL TRIPS	PERCENT
Light	705	7,971	8.8%	781	5,253	14.9%
Medium	177	1,588	11.1%	N/A	N/A	N/A
Heavy	117	1,128	10.4%	N/A	N/A	N/A
<b>All Vehicles</b>	<b>999</b>	<b>10,687</b>	<b>9.3%</b>	<b>781</b>	<b>5,253</b>	<b>14.9%</b>

## 8.0 DATA EXPANSION PROCEDURES

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This chapter describes the steps taken by ETC Institute to develop weight factors used to expand the commercial vehicle and trip data collected from the truck travel diary survey. Data weighting and expansion was not carried out for the TNC dataset since there is no reliable target data describing the sample universe of these vehicles to base weighting on. This section is a summary of the SANDAG Data Expansion Technical Memorandum (Appendix C), which contains a complete step-by-step breakdown of the data expansion procedures. This breakdown also includes additional information on how industry classifications were collapsed in cases with low survey sample. The memorandum contains the complete list of 66 individual factors developed to expand the vehicle and trip databases.

As detailed in the memorandum, ETC Institute developed upper, most likely, and lower weighting factors corresponding to different assumptions of the number of qualifying commercial establishments in the San Diego region. This report does not discuss these considerations and uses the “most likely” weight factor for all expansion and analysis purposes.

### ***Step 1: Commercial Establishments in the San Diego Region***

The first step included gathering an estimate of the number of establishments operating in the study area. ETC Institute gathered establishment data from two sources to estimate the number of establishments in the San Diego region:

1. **CBP Survey Data.** These data were developed and published by the US Census Bureau for San Diego County in 2019. These data estimate there were 92,564 establishments in the county. Although the CBP is considered the benchmark for understanding establishment activity with paid employees, its coverage is not complete and excludes crop and animal production; rail transportation; Postal Service; pension, health, welfare, and vacation funds; trusts, estates, and agency accounts; office of notaries; private households; and public administration.
2. **CA EDD.** The estimates from the CA EDD exclude “nonclassified” records, and there were 115,679 establishments in the SANDAG planning area in 2020.

Due to the inherent limitations within each data source and the substantial variations in the estimates, ETC Institute created a composite estimate based on the average of the two data sources. The composite distribution of commercial establishments in the San Diego region is shown in Table 10.

**TABLE 10: ESTIMATE OF COMMERCIAL ESTABLISHMENTS IN SAN DIEGO COUNTY, BY NUMBER OF EMPLOYEES**

GROUP	0-9 EMPLOYEES	10+ EMPLOYEES	TOTAL
1. Agriculture/Mining	334	88	421
2. Manufacturing	2,723	1,664	4,387
3. Industrial/Utilities	115	77	191
4. Retail	7,124	3,272	10,396
5. Wholesale	3,355	990	4,345
6. Construction	6,162	1,586	7,748
7. Transportation	1,371	496	1,867
8. Info/FIRE/Professional Services	24,539	4,310	28,849
9. Education/Public/Other Services	11,416	3,233	14,649
10. Medical/Health Services	19,634	2,404	22,038
11. Leisure/Accommodations and Food	4,742	4,492	9,234
<b>Total</b>	<b>81,512</b>	<b>22,610</b>	<b>104,122</b>

***Step 2: Apply Mean Number Light-Duty Commercial Vehicles, Single-Unit Trucks, and Multiunit Trucks, by Establishment Type***

The mean number of LCVs, SUTs, and MUTs in the SANDAG modeling region were estimated, by industry type group, based on the results of the 2,697 organizations that completed the establishment survey. Table 11 shows the average number of vehicles, by vehicle type, and industry group. On average, industrial/utility establishments have the largest fleets of LCVs, with approximately seven vehicles. Transportation establishments reported having the largest fleets of MUTs on average. Leisure and accommodation and retail establishments had on the smallest vehicle fleets across all classes on average.

**TABLE 11: AVERAGE VEHICLE FLEET SIZE, BY VEHICLE TYPE AND INDUSTRY GROUPS**

GROUP	AVERAGE FLEET SIZE PER ESTABLISHMENT		
	LCV	SUT	MUT
1. Agriculture/Mining	1.29	0.33	0.32
2. Manufacturing	1.16	0.54	0.29
3. Industrial/Utilities	6.98	1.69	1.36
4. Retail	0.65	0.56	0.32
5. Wholesale	1.83	0.62	0.57

GROUP	AVERAGE FLEET SIZE PER ESTABLISHMENT		
	LCV	SUT	MUT
6. Construction	2.92	0.98	2.23
7. Transportation	4.23	1.35	2.36
8. Info/FIRE/Professional Services	1.71	0.96	0.26
9. Education/Public/Other Services	4.03	2.11	0.84
10. Medical/Health Services	1.69	0.29	0.01
11. Leisure/Accommodations and Food	0.95	0.15	0.02

Next, the average vehicle fleet size in Table 11 were multiplied by the number of establishments in the region by industry group shown in Table 10. The resulting estimated number of vehicles by industry group and vehicle type operating in the San Diego region are shown in Table 12. The expansion process estimated there were 248,595 commercial vehicles operating in the San Diego region.

**TABLE 12: ESTIMATED NUMBER OF COMMERCIAL VEHICLES IN THE SAN DIEGO REGION, BY VEHICLE TYPE AND INDUSTRY GROUP**

INDUSTRY GROUP	AVERAGE FLEET SIZE PER ESTABLISHMENT		
	LCV	SUT	MUT
1. Agriculture/Mining	455	104	92
2. Manufacturing	4,450	2,161	1,188
3. Industrial/Utilities	934	213	197
4. Retail	6,061	5,582	3,140
5. Wholesale	6,171	2,447	1,975
6. Construction	16,758	5,295	12,385
7. Transportation	6,149	1,969	3,193
8. Info/FIRE/Professional Services	34,584	20,801	5,019
9. Education/Public/Other Services	41,254	20,641	8,122
10. Medical/Health Services	21,652	5,159	132
11. Leisure/Accommodations and Food	8,801	1,337	176
<b>Total</b>	<b>147,268</b>	<b>65,708</b>	<b>35,619</b>

### ***Step 3: Determining the Expansion Factors***

The expansion factors for LCVs, SUTs, and MUTs were calculated by dividing the estimated number of vehicles within each industry group by the number of commercial vehicle travel surveys completed in each establishment size cell. In this way, the expansion factors were estimated to account for:

- Three vehicle classes (LCV, SUT, MUT).
- Eleven industry groups (see the “Group” column in Table 12).
- Two establishment size classifications (0-9 employees, 10+ employees).



Aggregation was completed to collapse industry group and firm-size categories with limited survey sample size. In general, categories containing fewer than 15 completed CVSs were aggregated to create the expansion factors. For example, as shown in Table 6, only 5 surveys were collected for Group 3 (industrial/utilities) for establishments with 0-9 employees. For expansion purposes, the undersampled cell collapsed with the 10+ employee category so that only a single-weight factor was developed for LCVs in Group 3.

Aggregating data for expansion can reduce the negative impact of unreasonably high expansion factors on data analysis. The negative impact of aggregating cells is that it can cause shifts in the distribution of the sample toward industries that were over- or underrepresented. For example, retail and accommodations were combined for the expansion of SUTs because only two SUTs were obtained from the accommodations group.

Since industries with similar characteristics were combined, the overall impact of the aggregations should be limited. However, users of the data should be aware that the weighting could be responsible for unusual industry-specific findings.

## 9.0 CHARACTERISTICS OF DATASETS

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This chapter of the report details characteristics for each of the datasets that were collected during the project. The CVS comprised three parts:

1. An establishment survey that was designed to understand the number and type of commercial vehicles that are operated by business establishments in the region.
2. A passive GPS survey that collected GPS data for the trips made by a subset of the vehicles that participated in the establishment survey.
3. A GPS survey that obtained passively collected trip data from TNC drivers in the San Diego region. Because this group represents a special population distinct from regular commercial vehicle travel and does not have a reliable census to benchmark activity or incidence, it is presented as a stand-alone chapter following analysis of regular commercial vehicle data.

The final data was provided in a spreadsheet with tabs containing establishment data, vehicle data, trip data, and a data dictionary. The datasets contain the following:

- 2,697 responses from establishments to the establishment survey.
- The vehicle information for 1,751 vehicles (but only 1,543 vehicles that completed the truck diary survey).
- Data on 12,261 truck stops were collected from the 1,543 vehicles that completed the truck diary survey.
- Data on 5,664 stops made by 411 TNC vehicles.

This CVS dataset represents one of the primary sources of information used in this project to understand business establishment activities and truck travel characteristics in the San Diego region. This chapter of the report describes the establishment-level findings, followed by the truck diary survey findings, and concludes with an analysis of the TNC data.

### 9.1 ESTABLISHMENT CHARACTERISTICS

During the data collection effort for this project, 2,697 establishments provided information about their business and vehicle fleet operations. The following sections contain observations from the unweighted data.

#### Location of Establishments

The maps below and on the following pages (Figure 3) show the heat map of establishment locations within the SANDAG modeling region that participated in the establishment portion of the survey. Figure 3 shows most of the establishments are in San Diego proper, as well as east of the city in the El Cajon area. Firm participation geographically aligns to areas with higher concentrations of population and commercial activity. Figure 4, Figure 5, and Figure 6 show in greater detail three areas in the region with higher participation.

FIGURE 3: ESTABLISHMENT LOCATIONS HEAT MAP

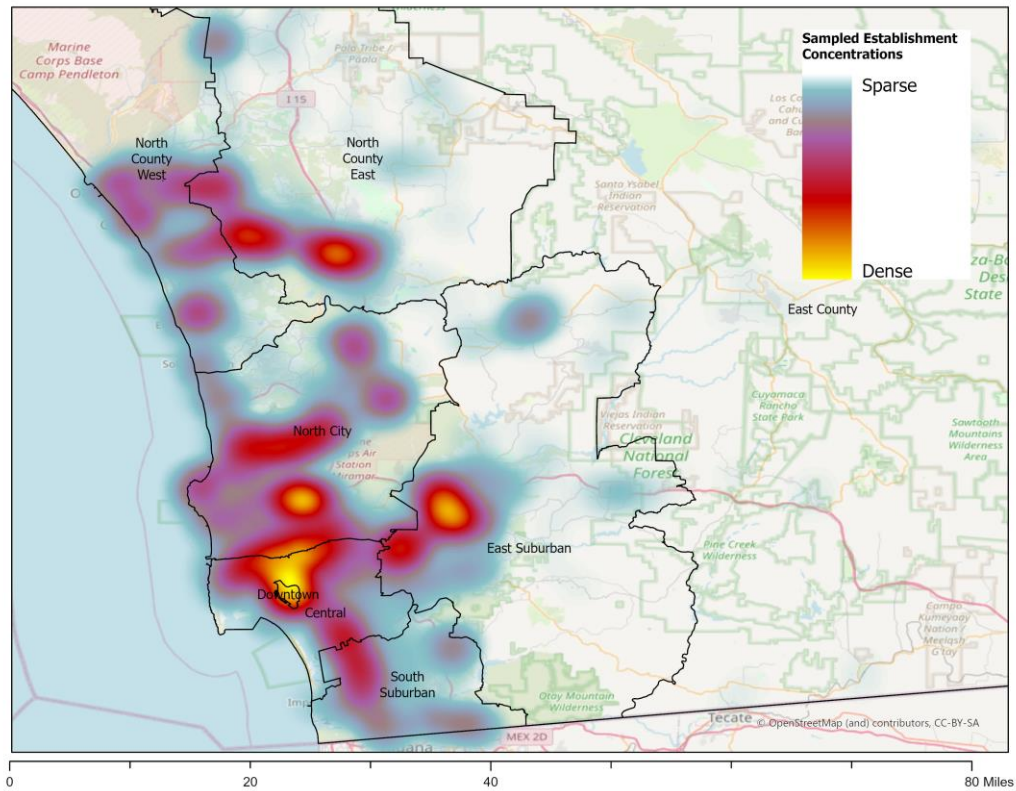
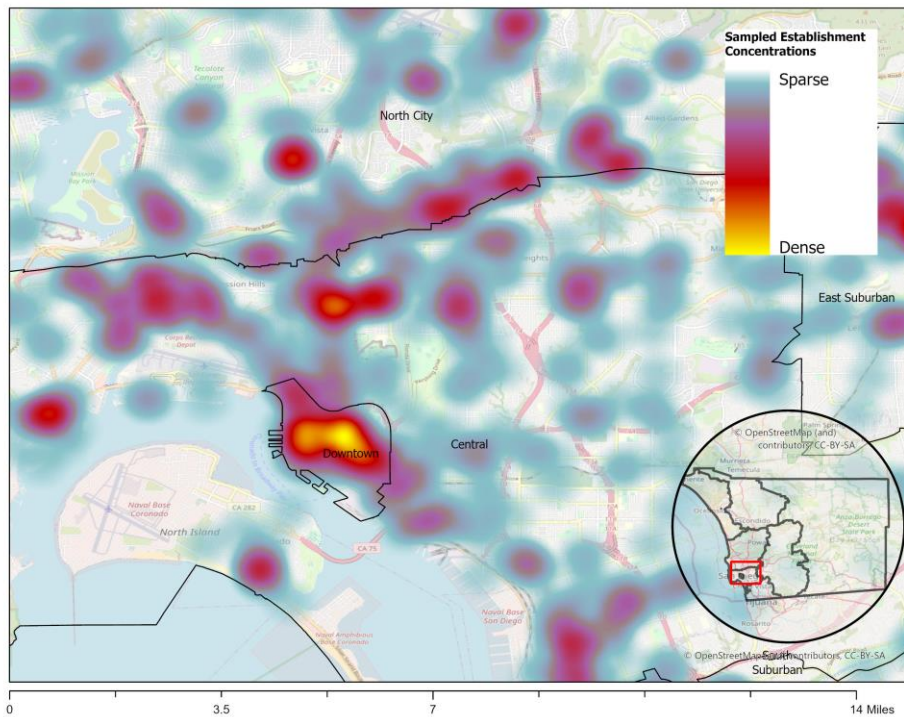
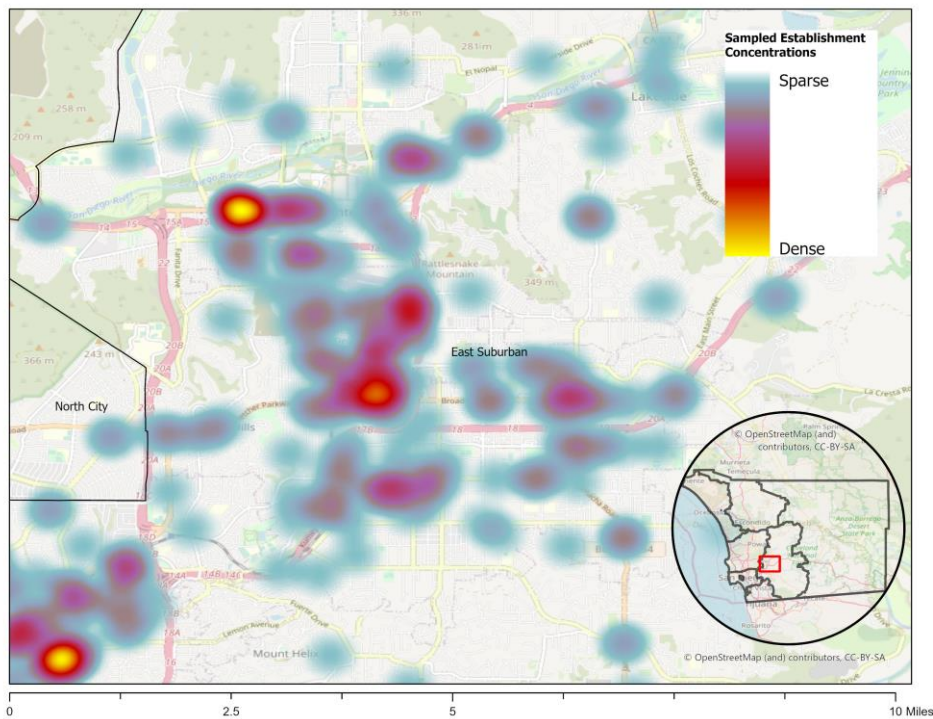


FIGURE 4: ESTABLISHMENT LOCATIONS HEAT MAP (SAN DIEGO)



**FIGURE 5: ESTABLISHMENT LOCATIONS HEAT MAP (EL CAJON AREA)**



**FIGURE 6: ESTABLISHMENT LOCATIONS HEAT MAP (ESCONDIDO AREA)**

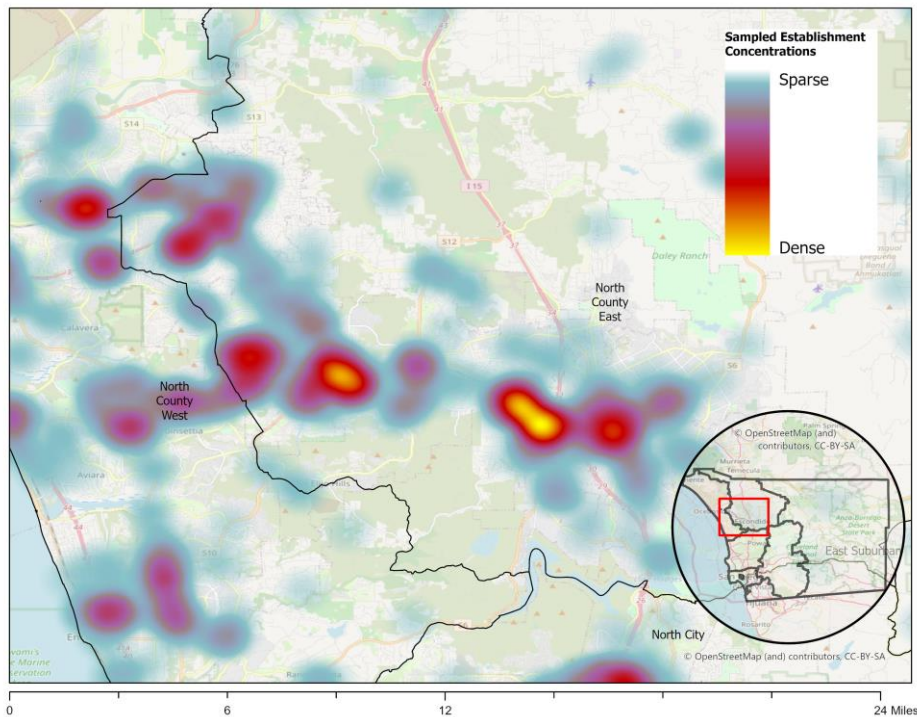


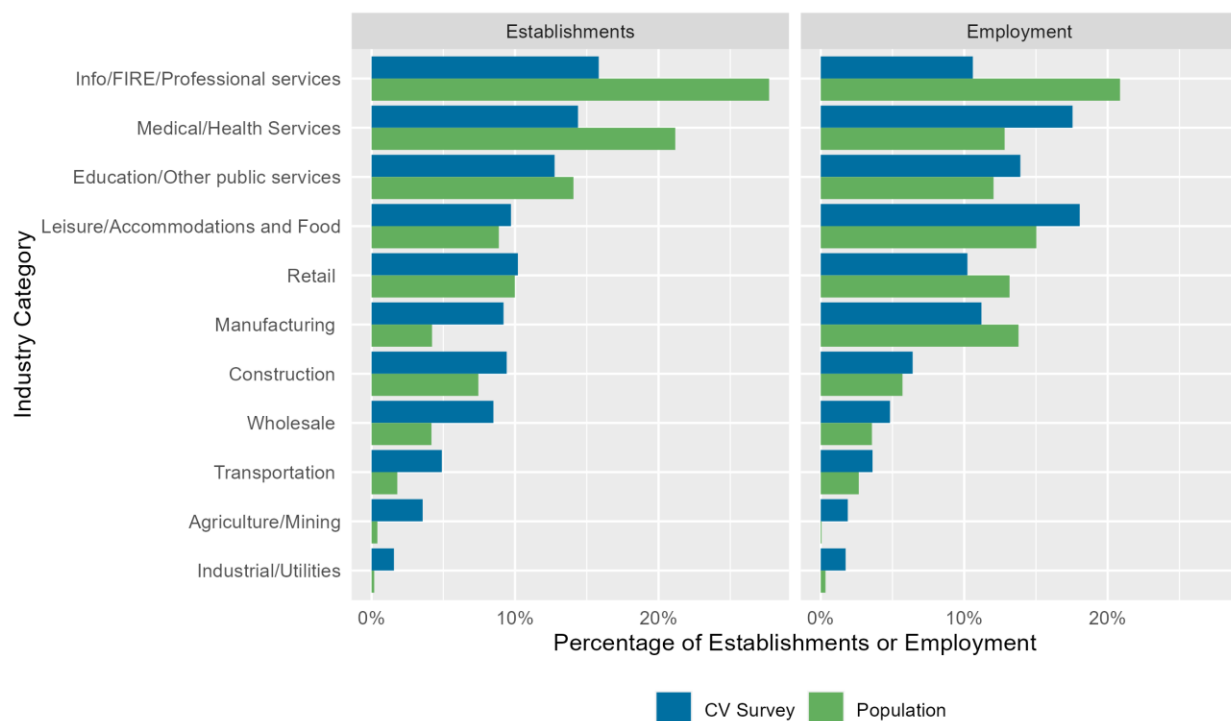
Figure 7 demonstrates the alignment between the unweighted establishment sample from the CVS and the complete set of business establishments in the region. This compares the percentage of establishments and employment by industry category in the CVS with the



population of San Diego County establishments and employment. The sample universe of establishments is the average value of two sources: CBP data for San Diego County in 2019 and CA EDD data in 2020. Employment estimates use the CBP data for San Diego County.

Figure 7 shows the largest sectors include services, such as FIRE; professional, medical/health services; and education/other public services. Additionally, agriculture/mining, utilities, and manufacturing establishments are overrepresented in the CVS sample, and info/finance/insurance/real estate/professional establishments are underrepresented. The distribution of employees in the CVS sample more closely tracks to the overall employment distribution in the region. Info/finance/insurance/real estate/professional employment are underrepresented in the CVS.

**FIGURE 7: COMPARISON BETWEEN CVS SAMPLE AND ESTABLISHMENTS AND EMPLOYMENT DATA**



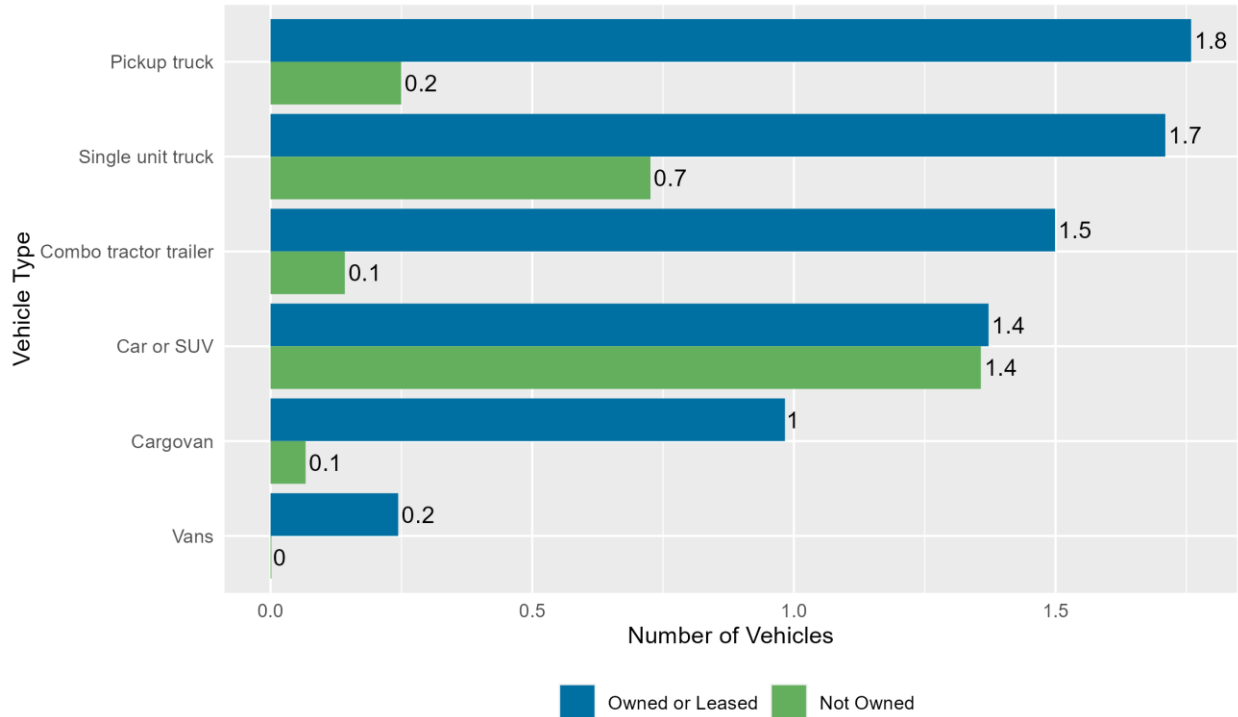
Source: SANDAG 2022 Commercial Vehicle Survey (unweighted), CBP Data, CA EDD data

Establishments reported their ownership and use of commercial vehicles in the unweighted sample as follows:

- 39.3% of the establishments owned or leased vehicles (from cars to trucks or other large vehicles) that are used for business purposes.
- Employees at 23.1% of the establishments used their personal vehicles for business purposes.
- 22.7% of the establishments used at least one nonowned or leased vehicle for commercial purposes.

Combining the responses to these three questions, 55% of establishments in the unweighted sample used vehicles for commercial purposes. Figure 8 shows how many vehicles of each type were available, on average, to those establishments that used commercial vehicles. Larger vehicles are almost always owned or leased by the business, while smaller vehicles such as cars, SUVs, and SUTs are often owned by others such as their employees.

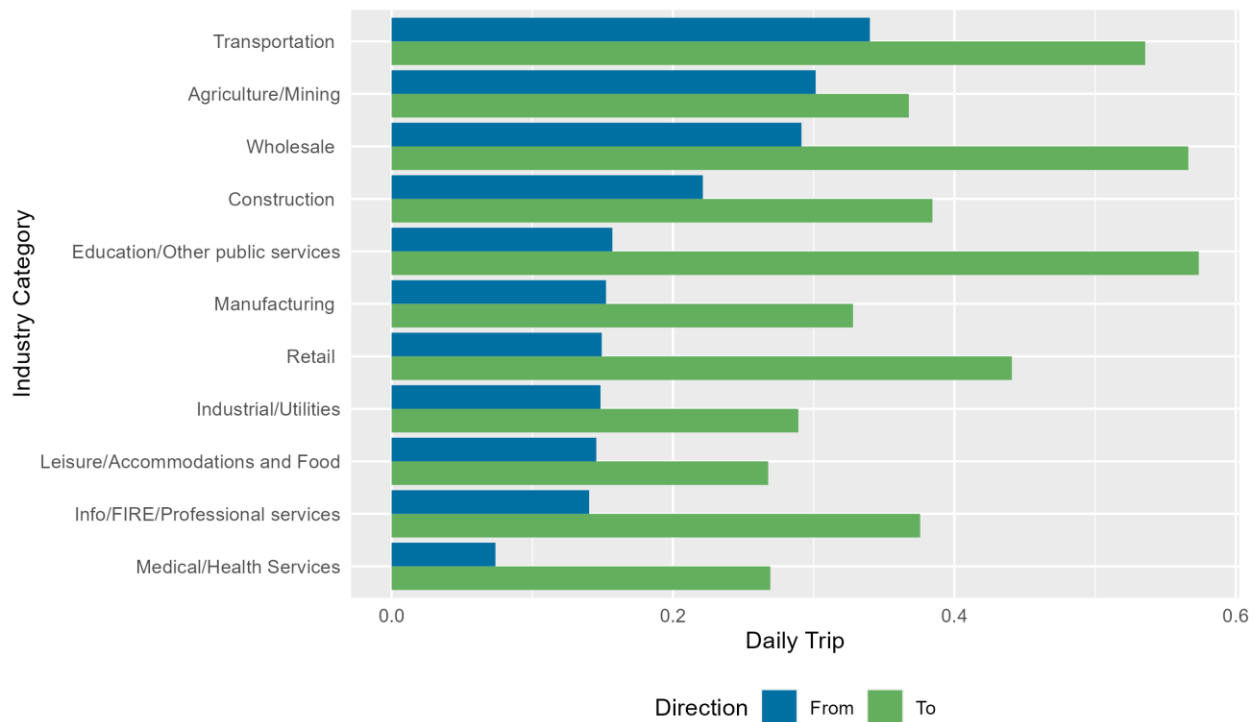
**FIGURE 8: COMMERCIAL VEHICLE AVERAGE AVAILABILITY IN THE CVS SAMPLE**



Source: SANDAG 2022 Commercial Vehicle Survey (unweighted)

Figure 9 shows the results in terms of average number of daily trips by direction per employee by employment categories. Four data points with over 10 daily trips have been removed from the plot, leaving a truncated X axis. Direction “To” refers to the average number of vehicles that deliver cargo or services to the establishment’s location per employee on a normal weekday. Direction “From” refers to the average number vehicles per employee that deliver cargo or services from the establishment’s location on a normal weekday. The chart indicates that, on balance, establishments tend to attract more trips than they generate on a per-employee basis. Certain industries have higher trip rates on a per-employee basis, such as transportation and agriculture. The results for employment categories with few responses in the survey, such as medical facilities, should be treated with caution as they have a high margin of error.

**FIGURE 9: AVERAGE DAILY TRIPS PER EMPLOYEE TO AND FROM ESTABLISHMENTS IN THE CVS SAMPLE**



Source: SANDAG 2022 Commercial Vehicle Survey (Unweighted)

Table 13 shows the average number of daily deliveries received by establishments within each industry group, categorized by origin type. Excluding the "Other" category, warehouses emerge as the primary source of shipment origins, contributing an average of approximately 1.2 vehicles per establishment per day. Among all industry groups, retail establishments receive the highest average daily deliveries at 5.5 trips, followed closely by industrial/utilities establishments at 5.1 trips.

Table 14 presents the average number of daily shipments delivered by establishments within each industry group, categorized by destination type. Excluding the "Other" category, service-type businesses stand out as the largest recipients of shipments, averaging about 0.9 vehicles per establishment per day. However, it is worth noting that transportation establishments report the highest average daily shipments at 14.4, indicating their significant role in the distribution network.

TABLE 13: AVERAGE WEEKDAY DELIVERIES BY SHIPMENT ORIGIN

INDUSTRY GROUP	SHIPMENT ORIGIN						Total
	Warehouse	Port/Airport/Terminal	Manufacturing	Retail Outlet	Service Business	Other	
Agriculture/Mining	1.0	0.0	0.2	0.1	0.2	1.0	2.6
Retail	1.5	0.1	0.3	0.2	0.2	3.2	5.5
Manufacturing	1.2	0.2	0.6	0.1	0.1	1.2	3.4
Education/Other public services	1.0	0.0	0.1	0.2	0.4	1.7	3.5
Medical/Health Services	0.5	0.0	0.1	0.0	0.1	2.1	2.8
Leisure/Accommodations and Food	1.9	0.0	0.2	0.1	0.4	0.8	3.2
Info/FIRE/Professional services	0.7	0.0	0.1	0.2	0.2	1.5	2.8
Industrial/Utilities	2.2	0.2	0.9	0.3	0.1	1.3	5.1
Wholesale	1.3	0.2	0.6	0.1	0.1	1.2	3.6
Transportation	1.6	0.9	0.3	0.1	0.2	1.4	4.5
Construction	1.4	0.0	0.8	0.3	0.0	1.3	3.9
<b>Total</b>	<b>1.2</b>	<b>0.1</b>	<b>0.3</b>	<b>0.2</b>	<b>0.2</b>	<b>1.6</b>	<b>3.6</b>

<sup>1</sup> Other options include 'I don't know' and 'Other'.



TABLE 14: AVERAGE WEEKDAY SHIPMENTS BY DELIVERY DESTINATION

INDUSTRY GROUP	DELIVERY DESTINATION						
	Warehouse	Port/Airport/Terminal	Manufacturing	Retail Outlet	Service Business	Other	Total
Agriculture/Mining	0.4	0.0	0.4	0.3	1.0	0.6	2.8
Retail	0.3	0.0	0.1	0.6	0.6	1.6	3.2
Manufacturing	0.6	0.1	0.5	0.2	0.3	1.3	3.0
Education/Other public services	0.1	0.1	0.1	0.1	0.8	6.1	7.3
Medical/Health Services	0.0	0.0	0.0	0.0	0.5	1.8	2.3
Leisure/Accommodations and Food	0.1	0.0	0.0	0.1	2.3	1.5	4.0
Info/FIRE/Professional services	0.3	0.1	0.1	0.2	0.4	2.0	3.2
Industrial/Utilities	0.5	0.5	0.6	0.1	3.0	4.9	9.6
Wholesale	1.5	0.1	0.5	0.5	0.7	1.2	4.4
Transportation	2.6	1.2	2.0	1.5	3.0	4.2	14.4
Construction	0.7	0.1	0.8	0.3	0.7	1.9	4.6
<b>Total</b>	<b>0.6</b>	<b>0.1</b>	<b>0.4</b>	<b>0.3</b>	<b>0.9</b>	<b>2.2</b>	<b>4.6</b>

<sup>2</sup> Other options include 'I don't know' and 'Other'.

## 9.2 VEHICLE CHARACTERISTICS

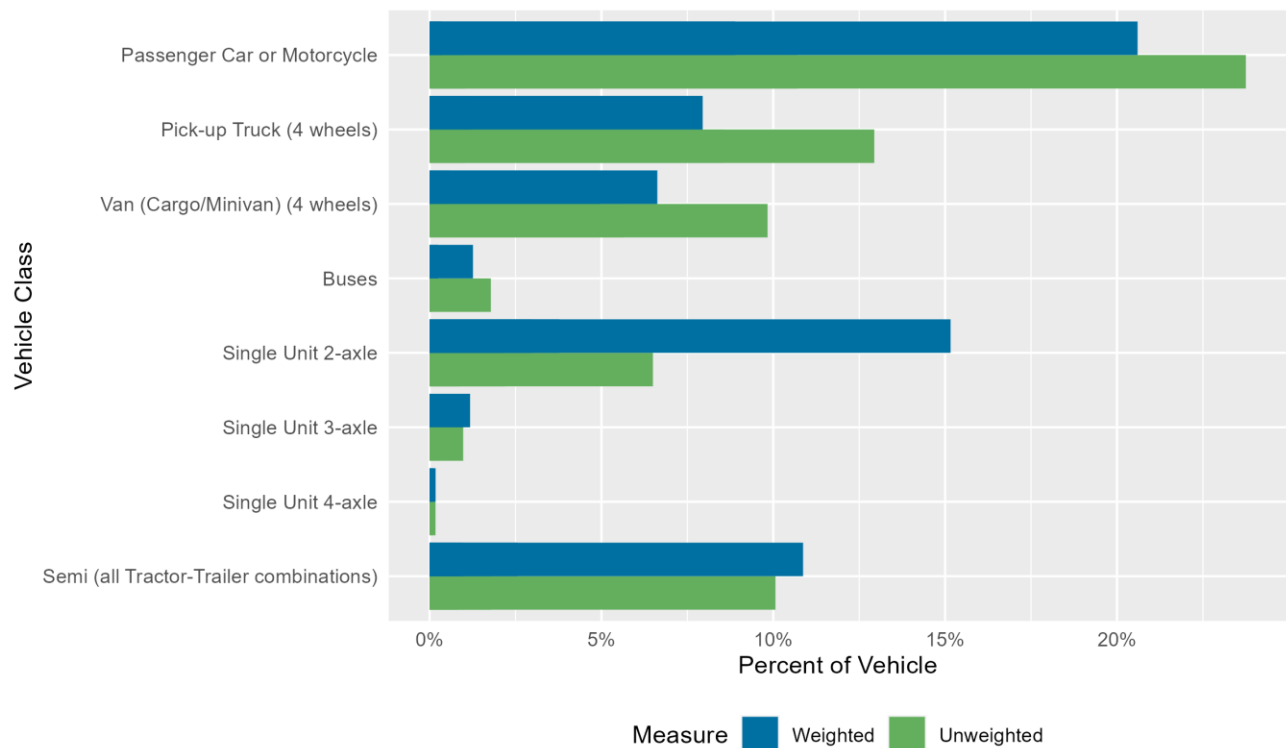
The vehicle table contains one record for each vehicle that participated in the truck diary survey and includes information about the vehicle and aggregate statistics about the vehicle's travel during the survey day. Table 15 shows the range of vehicle classes included in the sample and the more aggregated grouping used for expansion of the CVS, along with sample sizes for each group.

**TABLE 15: VEHICLE CLASSIFICATIONS USED IN THE CVS**

CVS CLASS #	CVS VEHICLE CLASS NAME	CVS SAMPLE SIZE	EXPANSION CLASS	CVS SAMPLE SIZE (GROUPED)
1	Passenger Car or Motorcycle	626	Light	1,303
2	Pickup Truck (4 Wheels)	395		
3	Van (Cargo or Minivan) (4 Wheels)	282		
4	Buses	32	Medium	228
5	Single-Unit 2-Axle	166		
6	Single-Unit 3-Axle	25		
7	Single-Unit 4-Axle	5		
8	Semi (All Tractor-Trailer Combinations)	220	Heavy	220

Figure 10 shows the distribution in the sample of vehicles by vehicle class, weighted to represent the full population of commercial vehicles at business establishments in the region. Most vehicles are either passenger cars or single units with two axles. Relatively few three-axle and four-axle SUTs were present in the sample.

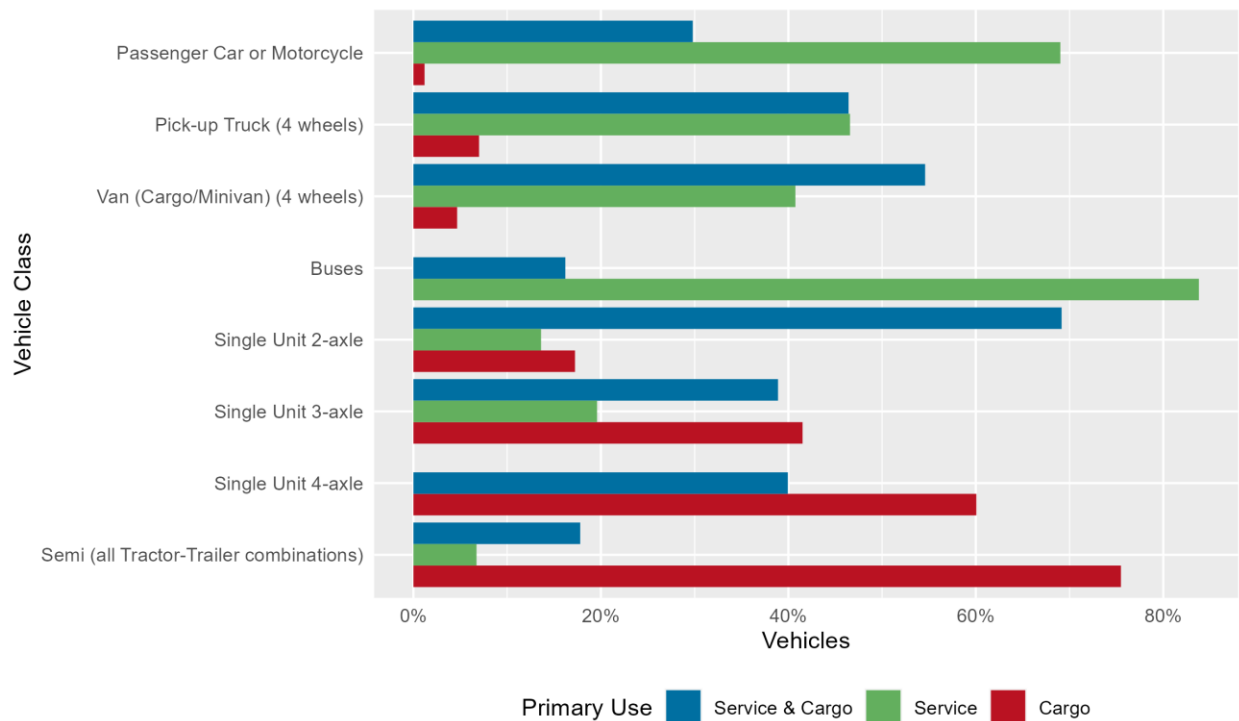
**FIGURE 10: NUMBER OF VEHICLES IN THE CVS SAMPLE, BY VEHICLE CLASS**



Source: SANDAG 2022 Commercial Vehicle Survey

Figure 11 shows how vehicles contained in the sample are primarily used (for cargo delivery, commercial service, or both) for each of the eight vehicle classifications (from autos to tractor-trailer combinations). Among the light vehicles (autos, pickup trucks, buses, and vans), most vehicles are being used for commercial services. Almost all heavy trucks (tractor-trailer combinations) are used for cargo delivery only.

**FIGURE 11: VEHICLE PRIMARY USE, BY VEHICLE CLASS, CVS SAMPLE**



Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

Figure 12 shows the distribution of the number of stops those vehicles in the sample (n = 1,543) made on the diary day, by vehicle class. In the box plot, the thick vertical bar shows the median number of stops, while the boxes show the 25th and 75th percentile ranges. Each whisker extends 1.5X the interquartile range. Outlier data points are represented by the dots. The highest median number of stops was for single-unit four-axle trucks, but since there were only five diaries completed by these vehicles, this result is not statistically valid.

In general, the plot shows that many of the most common vehicle classes, such as passenger vehicles, have relatively low variability in stop frequencies with a roughly symmetrical number of stops occurring with the 25th and 75th percentiles. Vans and single-unit two-axle trucks demonstrate variability skewed toward more stops. Furthermore, 21 vehicles made over 30 stops. Among these vehicles, the majority consist of vans (accounting for nine) and passenger cars or motorcycles (accounting for five). The plot shows that although outliers exist among the categories, these comprise only a small portion of overall commercial vehicle activity, and the overall tendency of these data are relatively consistent across vehicle types.

**FIGURE 12: REPORTED DAILY STOPS ON DIARY DAY, CVS SAMPLE**

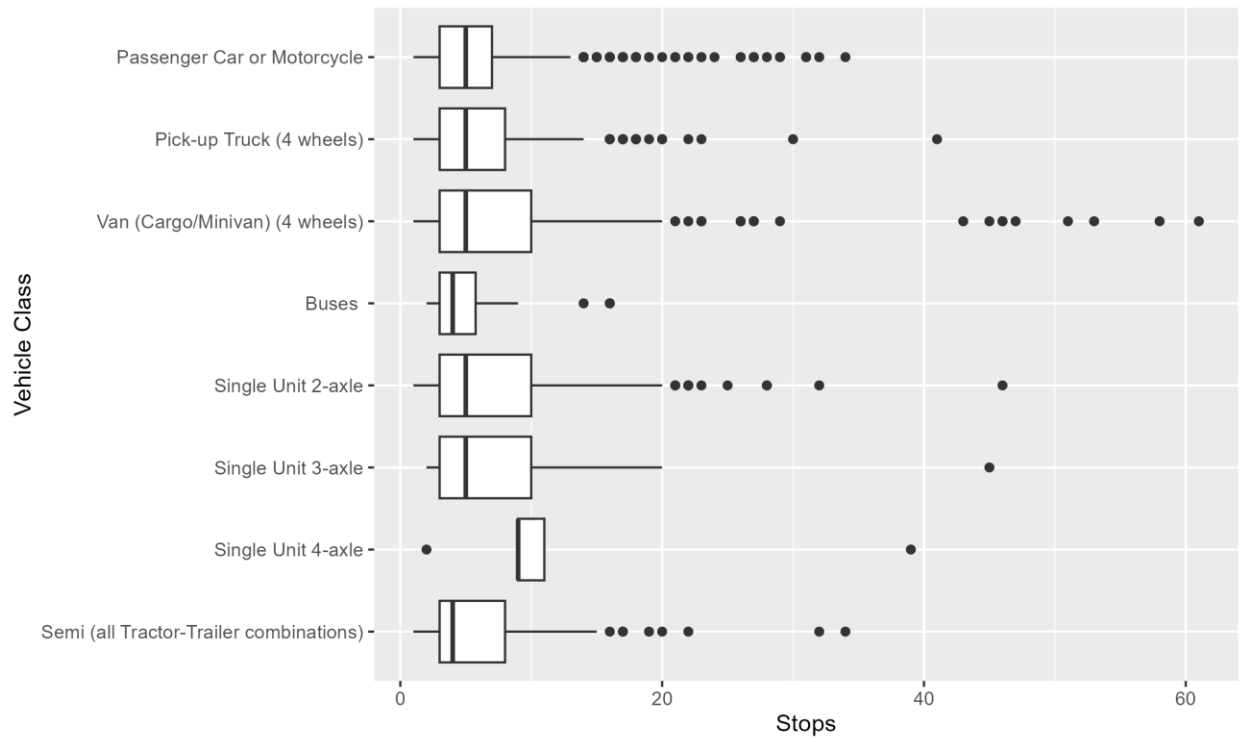


Table 16 presents summary statistics for reported daily stops on the diary day, categorized by vehicle class. The table includes mean, median, and 25th and 75th percentile statistics.

**TABLE 16: SUMMARY STATISTICS OF REPORTED DAILY STOPS ON DIARY DAY**

VEHICLE CLASS	MEDIAN	MEAN	25TH PERCENTILE	75TH PERCENTILE
Passenger Car or Motorcycle	5	6.4	3	7
Pickup Truck (4 Wheels)	5	6.2	3	8
Van (Cargo/Minivan) (4 Wheels)	5	8.7	3	10
Buses	4	5.5	3	5.8
Single-Unit 2-axle	5	7.8	3	10
Single-Unit 3-axle	5	8.0	3	10
Single-Unit 4-axle	9	14.0	9	11
Semi (All Tractor-Trailer Combinations)	4	6.1	3	8
<b>Total (All Vehicle Classes)</b>	<b>5</b>	<b>6.9</b>	<b>3</b>	<b>8</b>

### 9.3 TRIP CHARACTERISTICS

The trip database contains a record for each stop reported in the truck diary survey, totaling 12,261 records (10,687 trips) from 1,543 vehicles that reported travel. Each record includes information about the stop's location, such as its address, coordinates, place type, arrival, and departure times, and any activity that took place at the stop, including a description of any cargo delivery related to the stop. Additionally, each record is processed using a driving direction algorithm tool to estimate network travel time and distance for each stop. After expansion, the database included 1,665,038 stops. Figure 13 shows the number of stops by stop place type. The most common place types are residential/home and office building.

**FIGURE 13: NUMBER OF STOPS, BY STOP PLACE TYPE, CVS SAMPLE**

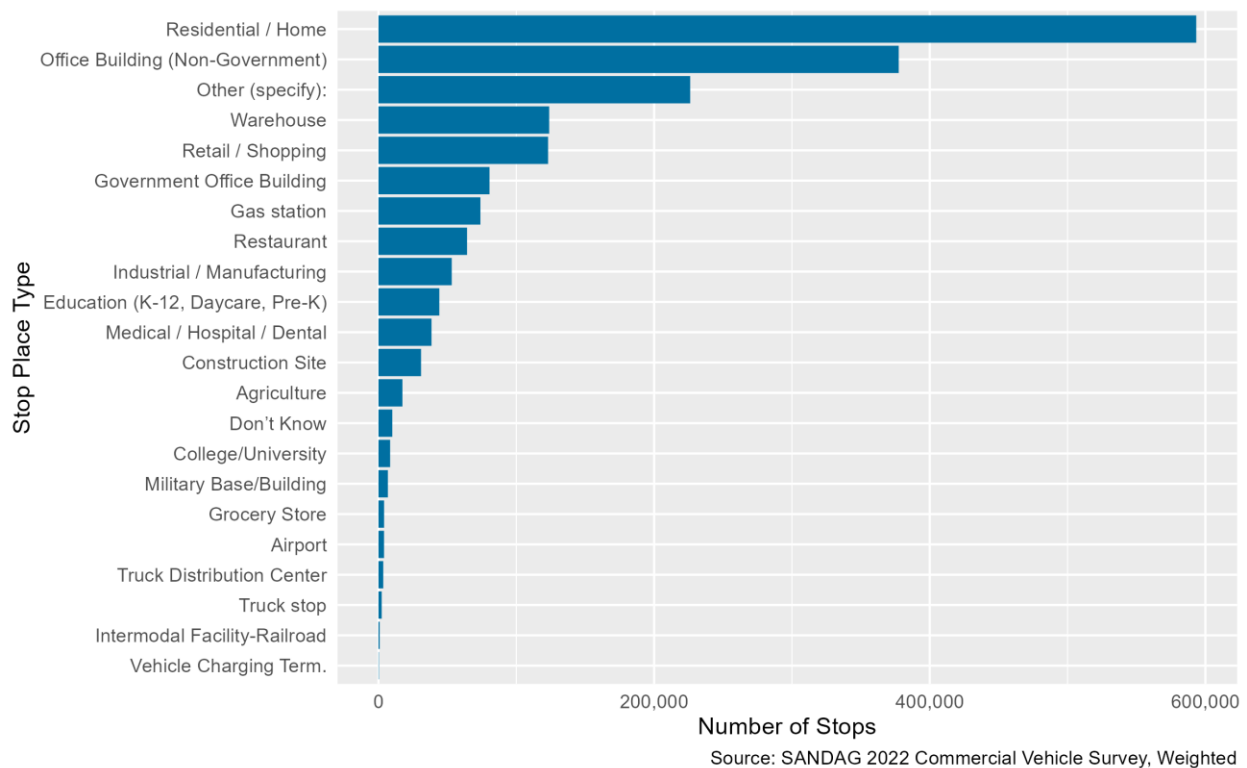
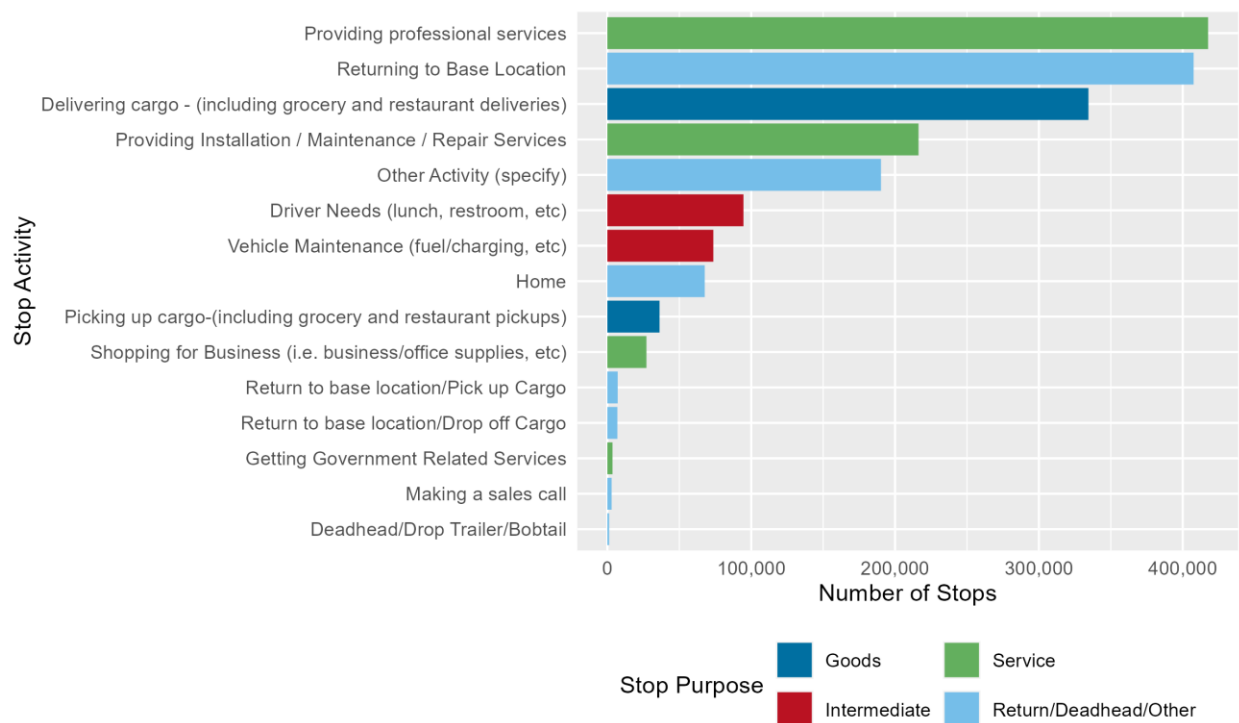


Figure 14 presents the distribution of stop purposes in the sample. The most common stop activity is the provision of professional services. This includes businesses that provide various services, including but not limited to catering, HVAC, movers, and related on-site service providers. Following this, returning to the base location at the end of a tour is the second-most-common activity, which is expected given that tours typically involve only a few stops on average. The sample also includes a significant number of other types of stops, such as driver breaks and vehicle maintenance.

**FIGURE 14: NUMBER OF STOPS, BY STOP ACTIVITY, CVS SAMPLE**



Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

Figure 15 displays the distribution of stop activities by vehicle type, which have been grouped into three vehicle classes. All three vehicle classes have approximately one-fifth of their stops as returning to base location, indicating a similar average number of stops per tour by vehicle type (as discussed in more detail in the Tours section below). However, the distribution of stop activities for the remaining stops differs by vehicle type.

**FIGURE 15: PERCENTAGE OF STOPS, BY STOP ACTIVITY AND VEHICLE TYPE, CVS SAMPLE**



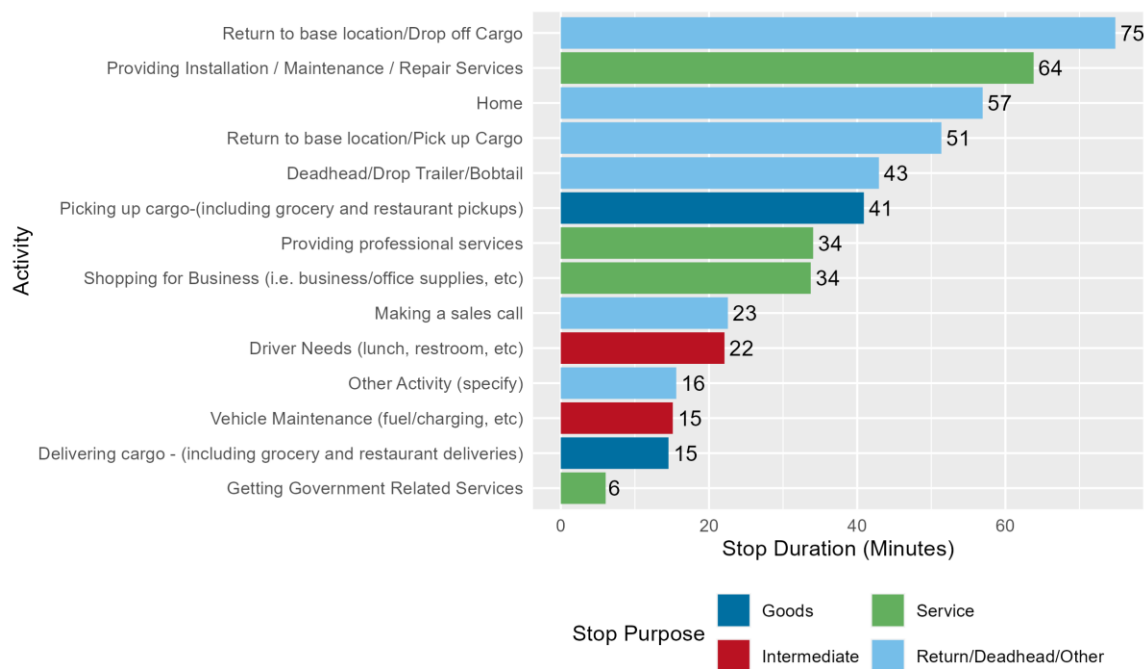
Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

In terms of stop purposes, LCV trips reported relatively high numbers of stops for driver needs and service stops, but relatively few stops for cargo pick up. Medium trucks (SUT) reported a similar distribution of stop purposes compared to light vehicles but comprised a lower proportion of goods delivery and pickup stops than heavy vehicles (around 17% of medium truck stops). On the other hand, most heavy-truck (MUT) stops were for goods delivery and pickup (around 29%), with few service stops. Only approximately 8% of heavy-truck stops were for driver needs and vehicle maintenance, which is fewer than for medium trucks and light vehicles.

Figure 16 displays the average stop duration, which varies by stop activity. A total of 26 stops were not included in the stop duration calculation or analysis because their arrival and departure times were the same. Return/deadhead/other stops (e.g., returning to base location, dropping off cargo, picking up cargo, and being at home) tend to be longer than service stops (e.g., sales calls, professional services, and installation/maintenance/repair). Conversely, most stops for getting government-related service are relatively brief, averaging approximately six minutes.



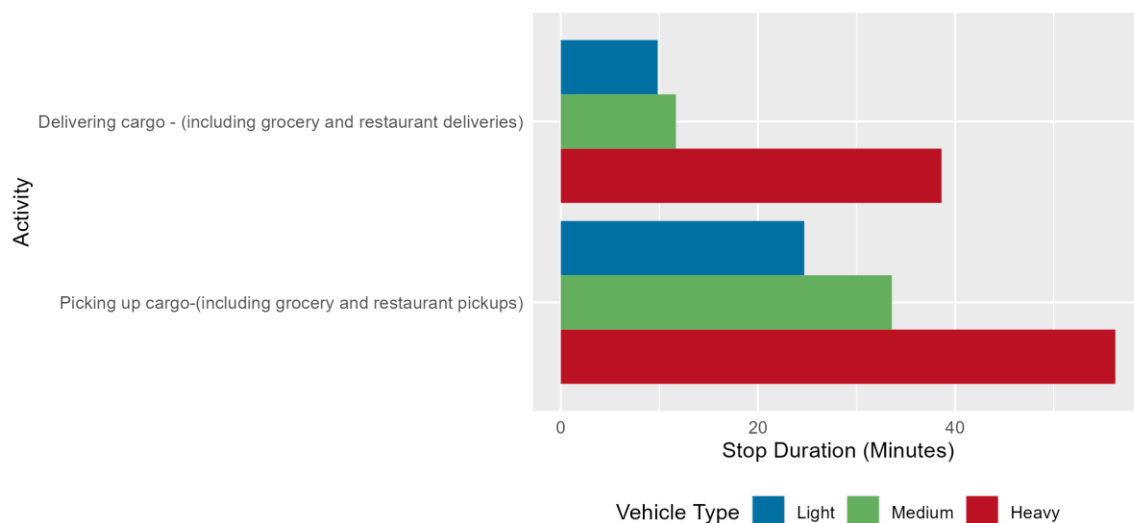
**FIGURE 16: AVERAGE STOP DURATION, BY STOP ACTIVITY**



Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

Figure 17 displays the average stop duration for goods stops (delivery and pickup) broken down by vehicle type. For both delivery and pickup stops, heavy vehicles stop on average for longer periods than medium or light vehicles, with durations ranging from 39 to 56 minutes on average, compared to 10 to 34 minutes on average.

**FIGURE 17: AVERAGE STOP DURATION FOR GOOD STOPS, BY VEHICLE TYPE**



Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

The stops in the trips database were arranged into 10,687 trips. Table 17 shows the number of trips (unweighted and weighted), the median distance and travel time (unweighted), and the mean distance and travel time (unweighted and weighted) broken out by vehicle type and for all vehicles. Trip characteristics for light vehicles and medium trucks are similar (mean weighted distances of approximately 8 miles and mean weighted travel times of approximately 11 minutes), while heavy-truck trips are longer in terms of distance and time (14 miles and 19 minutes, respectively).

**TABLE 17: AVERAGE TRIP DISTANCE AND TRAVEL TIME, BY VEHICLE TYPE**

VEHICLE CLASS	SURVEY TRIPS	TRIPS*	MEDIAN DIST. (MI)	MEAN DIST. (MI)	MEAN DIST. (MI)*	MEDIAN TIME (MIN)	MEAN TIME (MIN)	MEAN TIME (MIN)*
Light	7,971	906,609	3.8	9.1	8.6	9.7	13.4	12.8
Medium	1,588	567,656	3.7	8.0	7.0	9.6	12.4	11.0
Heavy	1,128	190,773	7.3	15.0	14.0	13.2	19.0	18.6
<b>All Vehicles</b>	<b>10,687</b>	<b>1,665,038</b>	<b>4.1</b>	<b>9.5</b>	<b>8.7</b>	<b>10.0</b>	<b>13.8</b>	<b>12.8</b>

*\*Indicates a weighted field*

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Table 18 shows the number of trips (unweighted and weighted), the median distance and travel time (unweighted), and the mean distance and travel time (unweighted and weighted) broken out by industry segment. Only the manufacturing and wholesale industries have a mean weighted trip distance of over 13 miles, accompanied by an average weighted travel time of approximately 19 minutes.

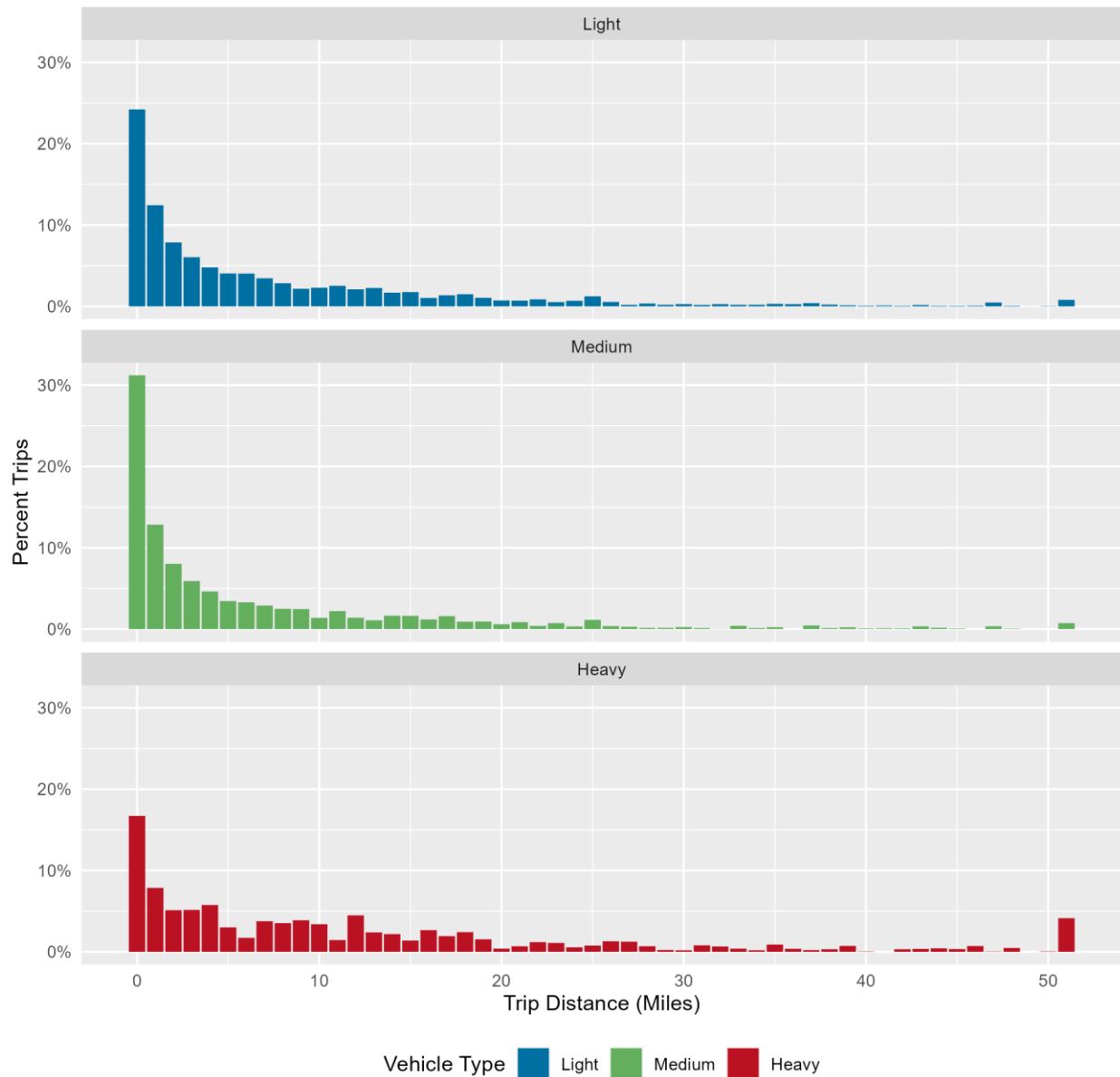
**TABLE 18: AVERAGE TRIP DISTANCE AND TRAVEL TIME, BY INDUSTRY SEGMENT**

INDUSTRY SEGMENT	SURVEY TRIPS	TRIPS*	MEDIAN DISTANCE (MI)	MEAN DISTANCE (MI)	MEAN DISTANCE (MI)*	MEDIAN TIME (MIN)	MEAN TIME (MIN)	MEAN TIME (MIN)*
Agriculture/Mining	248	9,829	5.8	9.9	9.6	11.3	15.2	15.4
Construction	1,370	168,813	5.6	12.4	11.8	11.9	16.8	16.4
Education/Other Public Services	1,368	483,684	2.9	6.6	5.9	8.1	10.8	9.9
Industrial/Utilities	666	17,881	3.1	5.2	5.3	8.5	10.7	11.2
Info/FIRE/Professional Services	1,193	218,508	5	9	9.2	10.8	13.5	13.7
Leisure/Accommodations and Food	314	31,605	4.7	7.8	8.1	10.8	12.5	12.6
Manufacturing	773	106,340	4.8	10.3	13.7	10.4	14.8	18.4
Medical/Health Services	1,343	385,094	4.6	8.6	8.4	10.1	12.4	12.2
Retail	767	81,389	4.7	8.4	8.1	10.3	12.8	12.3
Transportation	1,678	92,882	2.6	8.8	8.1	8.4	12.7	12.1
Wholesale	967	69,012	5.2	16.7	15.3	11.8	20.4	19.1
<b>All Industry</b>	<b>10,687</b>	<b>1,665,038</b>	<b>4.1</b>	<b>9.5</b>	<b>8.7</b>	<b>10</b>	<b>13.8</b>	<b>12.8</b>

\*Weighted field

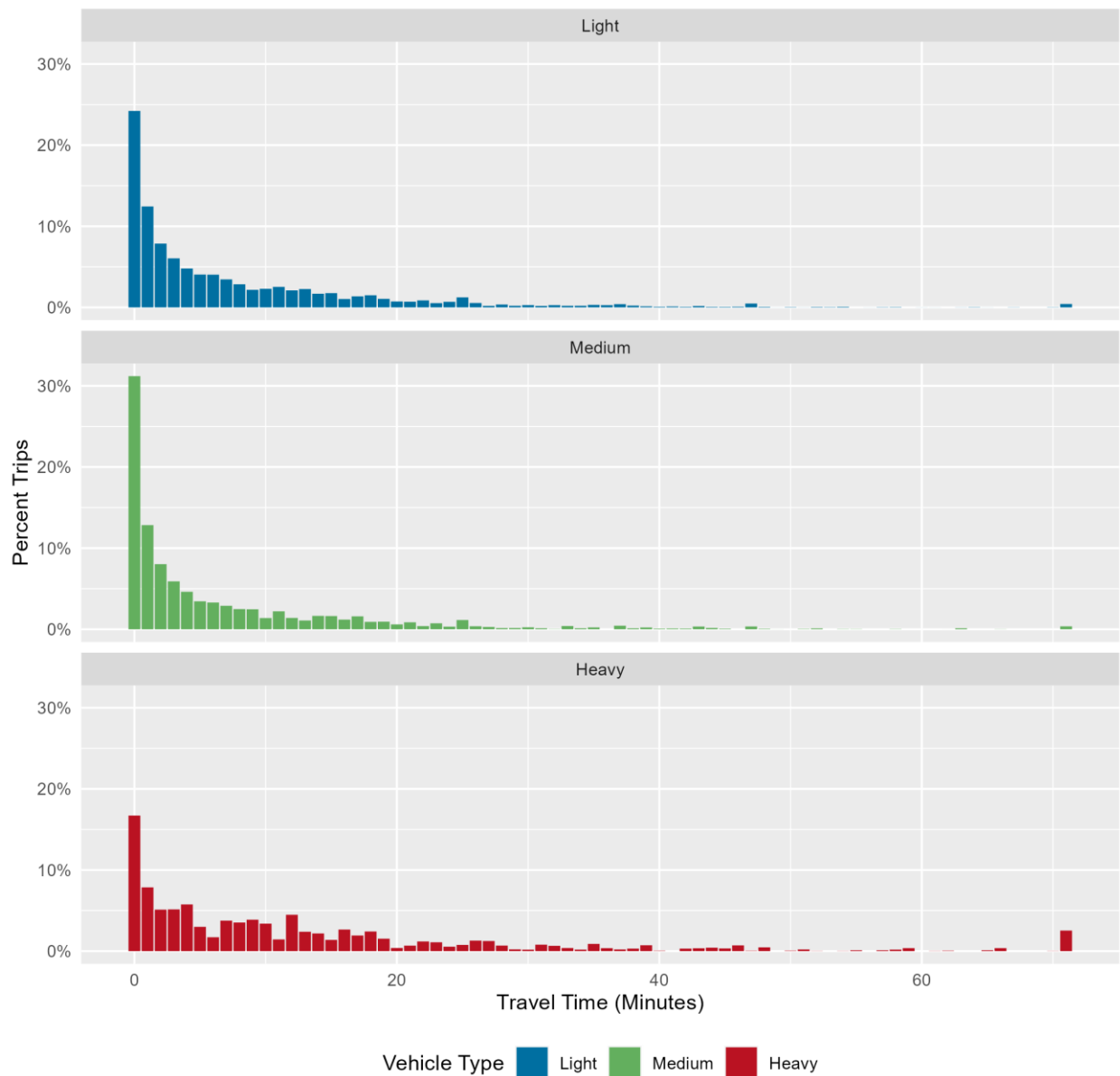
Figure 18 and Figure 19 show detailed trip-length distributions using one-mile bins for travel distance and one-minute bins for travel time. The final bin (51 miles and 71 minutes) includes all remaining trips over those thresholds. Nearly 30% of both light and medium truck trips are binned in the zero- to one-mile trip-length range. Heavy-truck trip distributions are far more skewed toward longer-distance and longer-duration trips.

**FIGURE 18: TRIP DISTANCE DISTRIBUTION, BY VEHICLE TYPE, 1-MILE BINS FOR TRIPS**



Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

**FIGURE 19: TRIP TRAVEL TIME DISTRIBUTION, BY VEHICLE TYPE, 1-MINUTE BINS FOR TRIPS**



Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

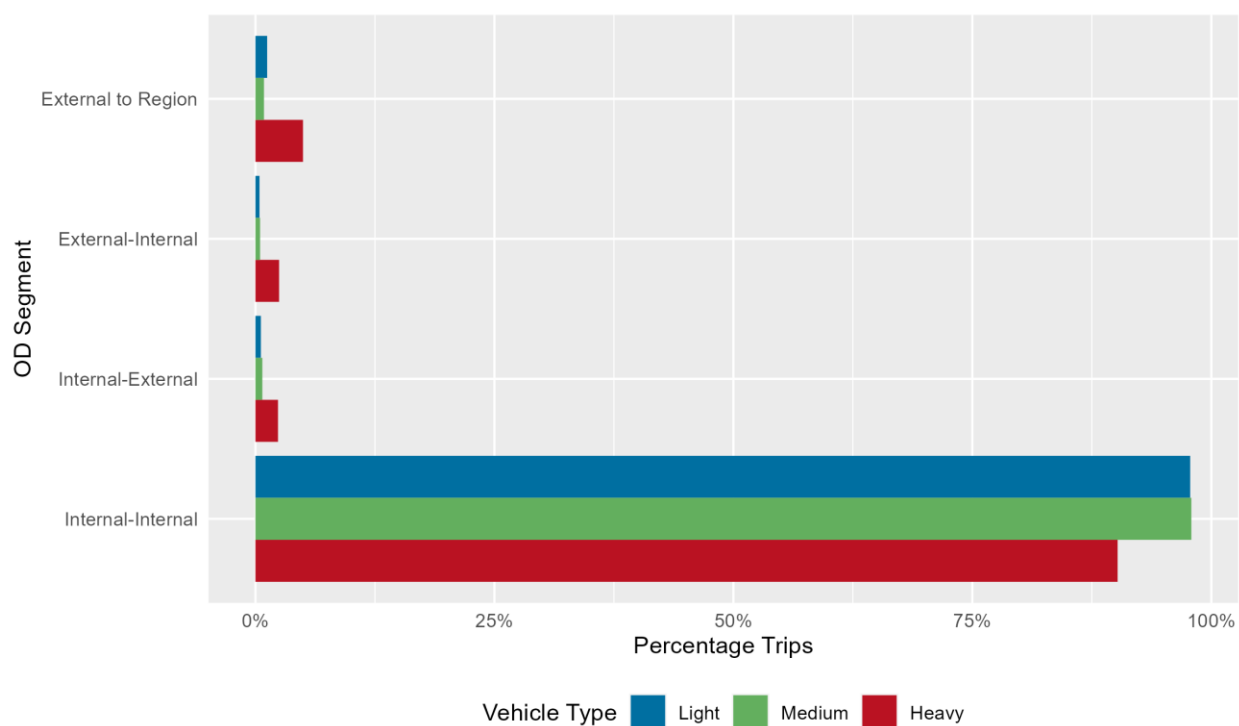
Table 19 summarizes the total vehicle miles traveled (VMT) and vehicle hours traveled (VHT) for the trips in the expanded dataset. This includes all trips in the sample at this stage, including trips to and from stops that were reported in the survey but were located outside of the San Diego region (analysis of stops external to the region is presented later in this section). Light vehicle VMT is approximately 8 million miles and accounts for 54% of total commercial vehicle VMT.

**TABLE 19: SUMMARY OF VEHICLE MILES AND VEHICLE HOURS, BY VEHICLE TYPE IN THE CVS SAMPLE**

VEHICLE CLASS	TRIPS	PERCENT TRIPS	VEHICLE MILES	PERCENT MILES	VEHICLE HOURS	PERCENT HOURS
Light	906,609	54.4%	7,810,220	54.2%	193,042	54.2%
Medium	567,656	34.1%	3,945,884	27.4%	103,950	29.2%
Heavy	190,773	11.5%	2,666,863	18.5%	59,178	16.6%
<b>All Vehicles</b>	<b>1,665,038</b>	<b>100.0%</b>	<b>14,422,967</b>	<b>100.0%</b>	<b>356,170</b>	<b>100.0%</b>

As shown in Figure 20, the breakdown of trips by origin-destination segment is displayed by vehicle type. Trips with neither trip end inside the region are labeled “external to region.” A map of the San Diego region is shown in Figure 2. Although sampled establishments included only those with business locations inside the San Diego region, the survey recorded stops made outside the region by the vehicles that those establishments operate. In such cases, external-to-region trips may not involve any travel that is within the San Diego region. For all vehicle types, most trips are internal to internal, accounting for 98% of trips made by light and medium vehicles and 90% of trips made by heavy trucks. All other light- and medium-vehicle origin-destination segments account for only 1 to 2% of all trips, while less than 5% of heavy-truck trips are either external-internal or internal-external, and the remaining 5% are external to the region.

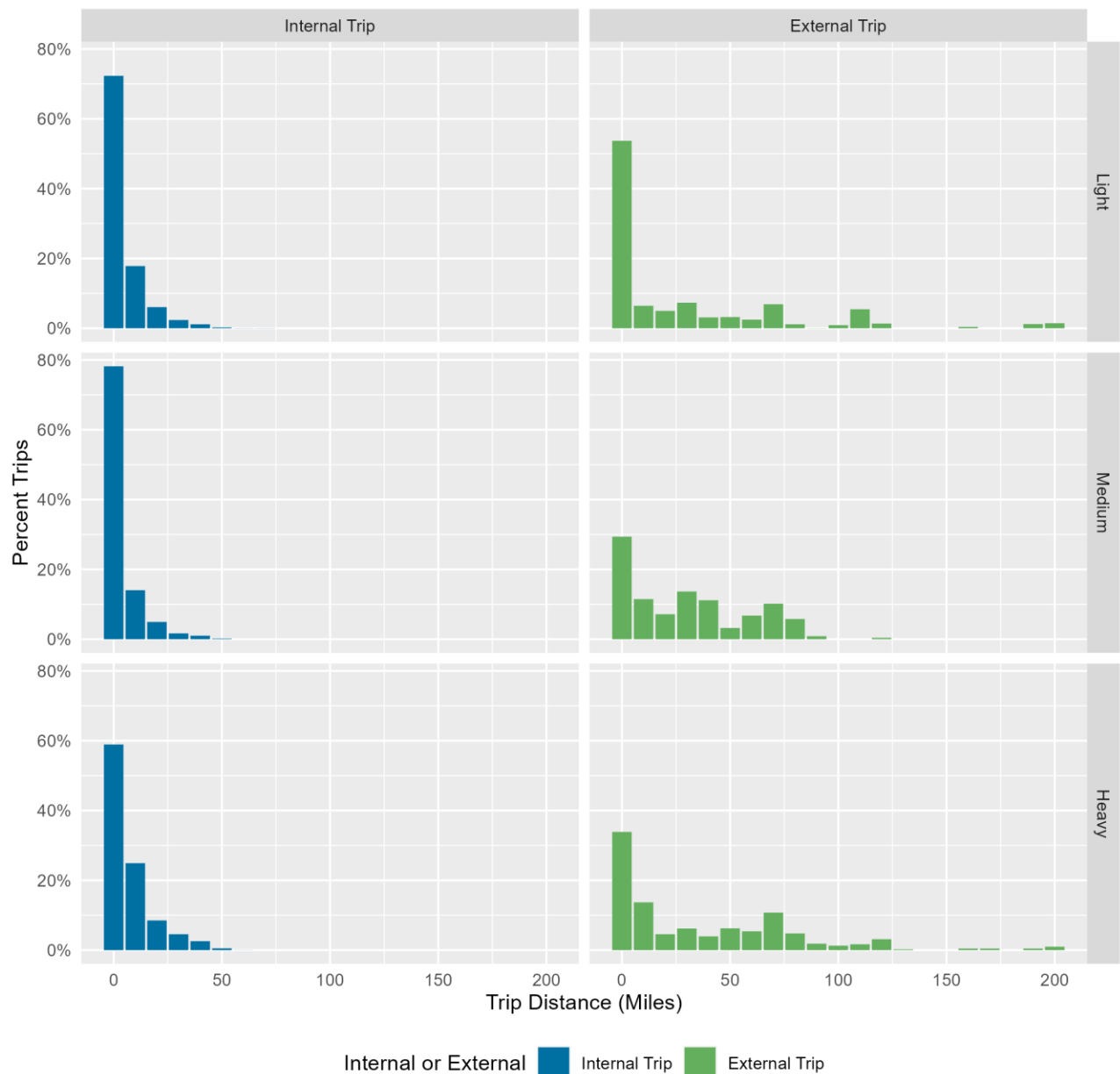
**FIGURE 20: TRIPS, BY ORIGIN-DESTINATION SEGMENT AND VEHICLE TYPE**



Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

Figure 21 splits the trip distance distributions by vehicle type shown in Figure 20 between internal trips and all three types of external trips grouped together into a single external trip class. Heavy-truck internal trips are now more closely aligned with the internal trip distributions for light and medium vehicles, in comparison to the larger differences in the overall trip distributions by vehicle type. However, the external trip distributions become skewed toward longer trips as vehicle size increases.

**FIGURE 21: TRIP DISTANCE DISTRIBUTION, BY VEHICLE TYPE AND INTERNAL OR EXTERNAL TRIP, 10 MILE BINS**



Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

Table 20 presents the average travel distance and time for both internal and external trips, broken down by vehicle type. External trips refer to all trips that have at least one end point outside the San Diego region. On average, internal heavy-truck trips are 1.5 times longer than internal medium truck and light vehicle trips. Of the 4 trips that exceeded 1,000 miles, all were completed using light vehicles. These few exceedingly long-distance trips skew average travel time (51 minutes) and distance (52 miles) for this category compared to the heavier vehicle classes.

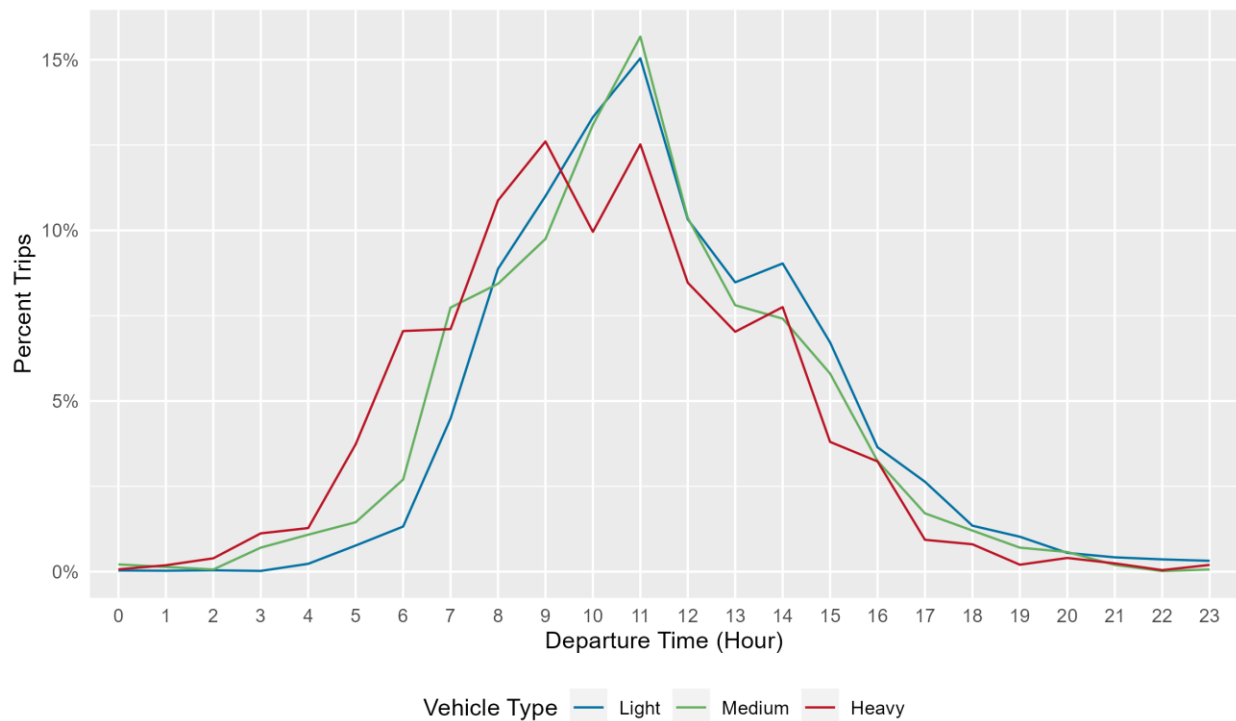
**TABLE 20: AVERAGE TRIP DISTANCE AND TRAVEL TIME, BY VEHICLE TYPE FOR INTERNAL AND EXTERNAL TRIPS**

VEHICLE TYPE	INTERNAL TRIPS				EXTERNAL TRIPS			
	TRIPS	TRIPS*	MEAN DISTANCE*	MEAN TIME*	TRIPS	TRIPS*	MEAN DISTANCE*	MEAN TIME*
Light	7,749	886,538	7.6	11.9	222	20,072	51.9	51
Medium	1,543	555,775	6.4	10.5	45	11,880	34	35.4
Heavy	968	172,066	10.8	15.8	160	18,707	43.5	44.5
<b>All Vehicles</b>	<b>10,260</b>	<b>1,614,379</b>	<b>7.5</b>	<b>11.8</b>	<b>427</b>	<b>50,659</b>	<b>44.6</b>	<b>44.9</b>

\*Weighted data

Figure 22 shows the departure time distribution for all trips by vehicle type. Heavy trucks are more likely than smaller vehicles to start trips during the night and in the early morning. In the afternoon, light and medium vehicles are the most likely vehicle classes to make trips.

**FIGURE 22: TRIP DEPARTURE TIME DISTRIBUTION, BY VEHICLE TYPE**



Source: SANDAG 2022 Commercial Vehicle Survey, Weighted



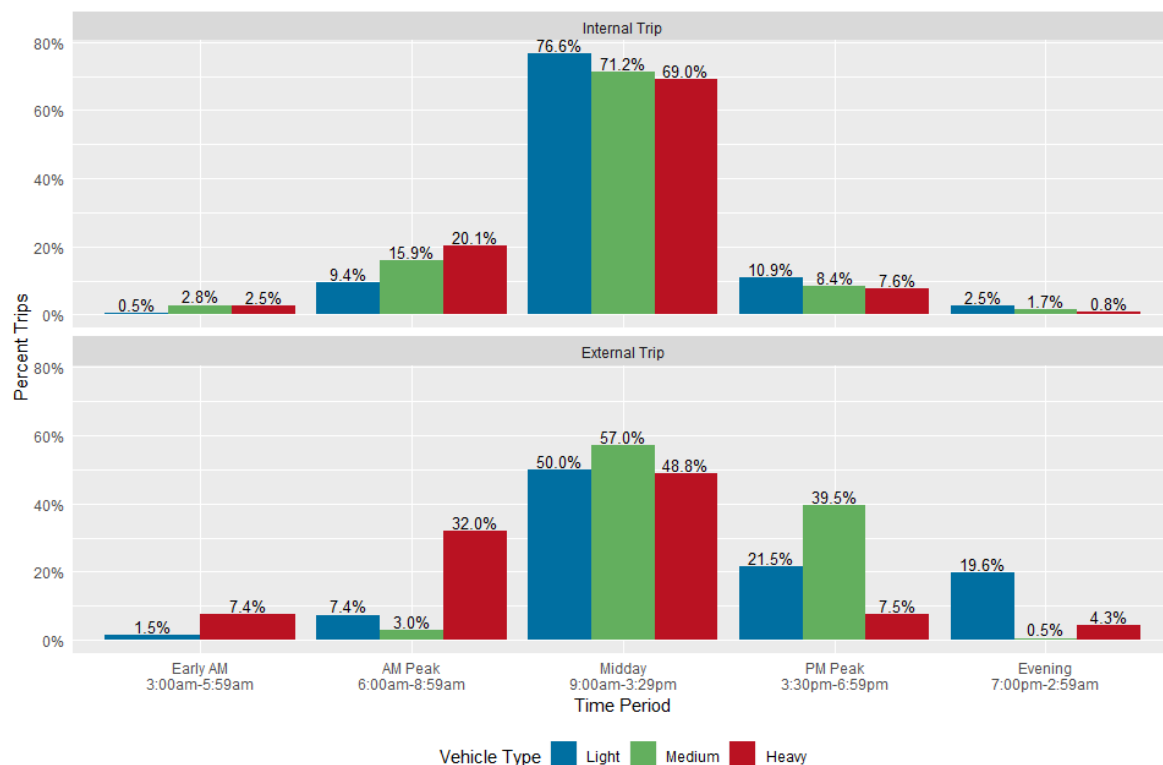
## SANDAG 2022 Commercial Vehicle Survey

Figure 23 depicts the departure time distributions grouped by the five SANDAG model time periods. The time periods are defined as follows:

- Early AM: 3:00 a.m. to 5:59 a.m.
- AM Peak: 6:00 a.m. to 8:59 a.m.
- Midday: 9:00 a.m. to 3:29 p.m.
- PM Peak: 3:30 p.m. to 6:59 p.m.
- Evening: 7:00 p.m. to 2:59 a.m.

The graph illustrates that the internal trip departure time distribution is relatively consistent across all vehicle types, with no large differences. However, heavy-truck trips are more likely to commence during the early AM and AM peak periods, and less likely during the PM peak and evening periods, compared to other vehicle types. It is worth noting that over half of all trips take place in the midday period between 9:00 a.m. and 3:29 p.m. In contrast, the external trip distributions exhibit greater variability, as anticipated due to the smaller sample size. Nevertheless, the pattern by time is similar to internal trips.

**FIGURE 23: TRIP DEPARTURE TIME PERIOD DISTRIBUTION, BY VEHICLE TYPE AND INTERNAL OR EXTERNAL TRIPS**



Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

Table 21 summarizes VMT in the expanded CVS sample by SANDAG model time periods, for internal and external trips. The statistics align to the distributions of trips by the time period shown in Figure 23, with heavy trucks having a slightly flatter distribution with more VMT in the Early AM and AM Peak periods compared to smaller vehicles (for both internal and external trips).

**TABLE 21: VMT, BY TIME PERIOD AND VEHICLE TYPE FOR INTERNAL AND EXTERNAL TRIPS**

TIME PERIOD	INTERNAL TRIPS			EXTERNAL TRIPS		
	LIGHT	MEDIUM	HEAVY	LIGHT	MEDIUM	HEAVY
Early AM	0.8%	1.8%	4.5%	1.7%	0.0%	16.6%
AM Peak	14.8%	15.6%	23.9%	20.2%	4.0%	42.0%
Midday	70.1%	70.1%	64.0%	51.4%	57.1%	32.1%
PM Peak	11.8%	10.7%	6.7%	11.5%	36.8%	2.9%
Evening	2.4%	1.8%	0.9%	15.2%	2.0%	6.4%

## 9.4 TOUR CHARACTERISTICS

A tour for this analysis refers to a sequence of trips made by a vehicle and driver within the 24-hour survey period. Tours typically include multiple stops or activities while completing each trip within the larger tour. Tours are defined by collapsing individual trip records from the truck trip diary. Each tour includes extra break records at the beginning of each that distinguishes it from the end of the preceding one. The steps identifying and defining tours include the following:

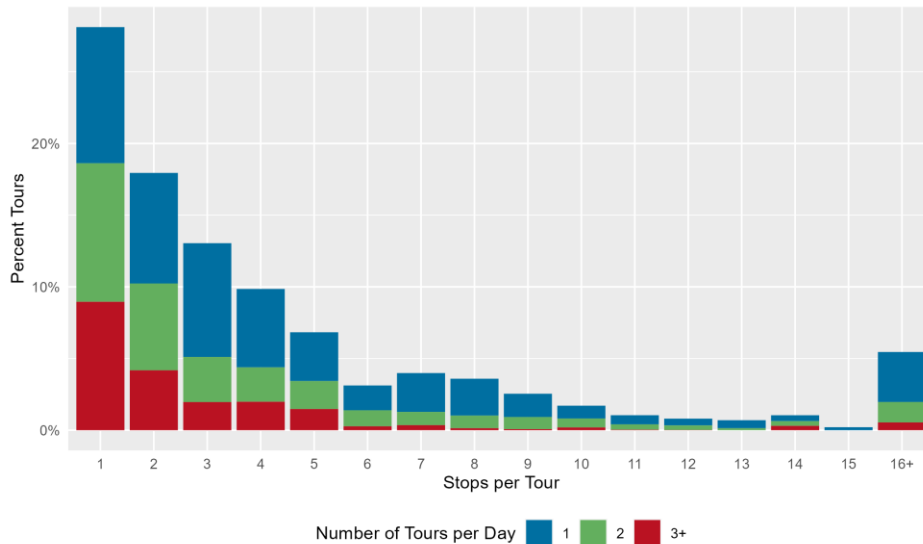
1. The trips dataset comprises a row for each stop, including an initial record for each vehicle specifying a start location; each subsequent stop is represented a "trip\_number" id.
2. To construct the tour table, the row representing the stop where the truck returns to the base location is duplicated. This duplication creates a departure stop row that marks the beginning of the next tour, when applicable.
3. The tour table assigns a tour number (TOUR\_NUM) to each tour conducted by a particular vehicle. Within each tour, a stop sequence (STOP\_SEQ) is assigned to number each stop accordingly.

This process formats each tour with a starting record, a record for each stop on the tour, and a closing record for the final stop. This final stop can either be a return to the starting location or a stop at the tour's destination.

The tours dataset includes 12,900 start and stop records comprising 2,213 tours. Each record, except the start record, provides details of the preceding trip and stop. This section analyzes the tour characteristics, such as the number of stops per tour, the distribution of tours starting and ending in the sampled area, tour distance and time duration, and the time of day when tours occur. The tour table uses the same weighting scheme as the trip data.

Figure 24 shows the distribution of the number of stops per tour, excluding the stops that denote the return stop at the end of a tour where present. (As discussed below, not all tours are closed-loop tours, or tours that end in the same location that they started.) The final bin (16 stops) includes all remaining trips over these thresholds. Some vehicles made more than one tour during the survey day, and the number of tours per vehicle is categorized into one tour per day, two tours, and three or more. Single-stop tours are the most common, accounting for almost one-quarter of tours, and approximately 95% of tours have 15 or fewer stops. As the number of tours per vehicle per day increases, the tours themselves tend to have fewer stops.

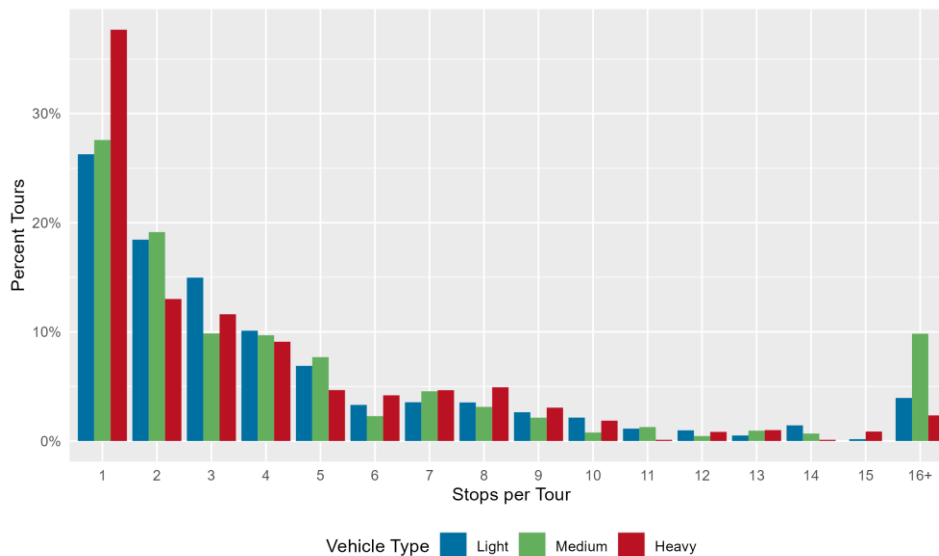
**FIGURE 24: NUMBER OF STOPS PER TOUR, BY NUMBER OF TOURS PER DAY**



Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

Figure 25 shows the distribution of the number of stops per tour split by vehicle type. As vehicle size increases, the distribution is more skewed toward single-stop tours.

**FIGURE 25: NUMBER OF STOPS PER TOUR, BY VEHICLE TYPE**



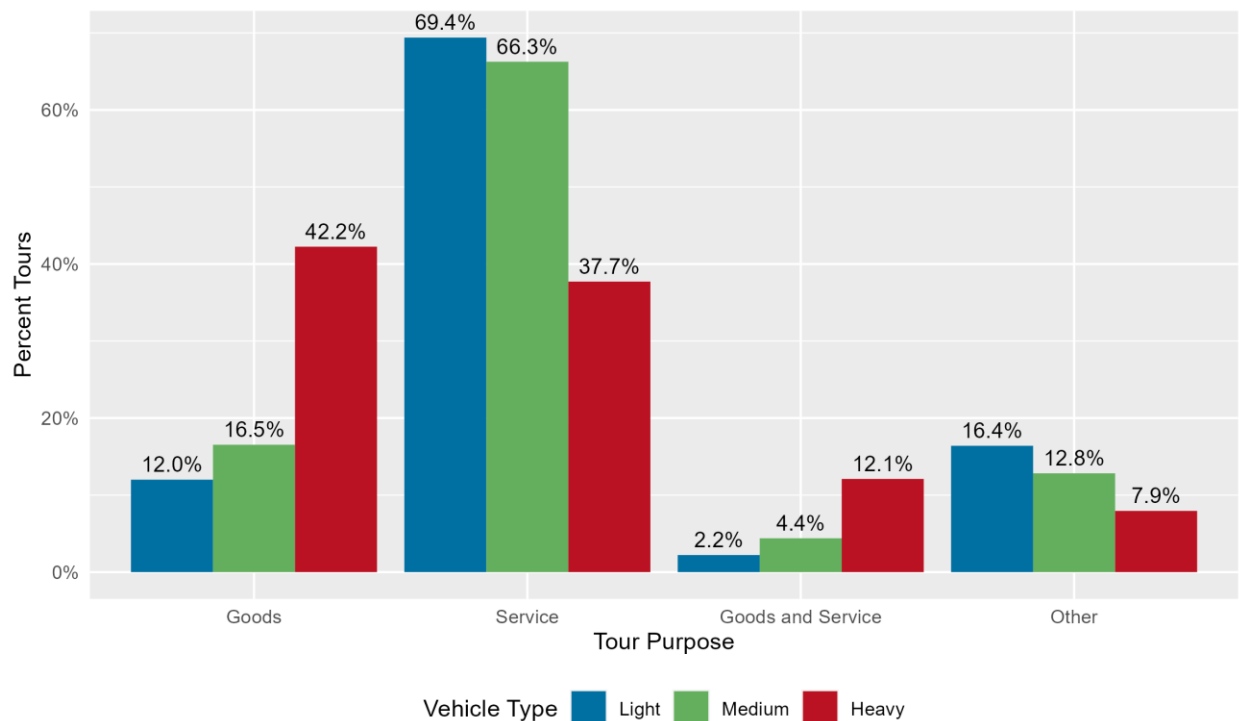
Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

Each stop within a tour includes a purpose/activity variable, allowing an overall tour purpose to be characterized based on the combination of stop purposes. Tours were allocated to four tour purpose types:

1. **Goods Tours.** One or more goods stops, no service stops, and 0 or 1+ other stops.
2. **Service Tours.** One or more service stops, no goods stops, and 0 or 1+ other stops.
3. **Goods and Service Tours.** Both goods and service stops, and 0 or 1 + other stops.
4. **Other Tours.** No goods or service stops, only other stops such as driver needs or vehicle refueling.

Figure 26 shows the distribution of tour purposes by vehicle type. Most light and medium truck tours are for service delivery. Heavy-truck tours are roughly split between goods or service delivery.

**FIGURE 26: TOUR PURPOSE DISTRIBUTION, BY VEHICLE TYPE**



Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

Tours can be classified by several characteristics, including whether a tour starts and ends in the same location, by the number of stops on the tour, and the type of location at the start and end of the tour. The following composite classification, or tour typology, of these three measures was created to group the observed tours:

- Tour starts and ends in the same transportation analysis zone (TAZ) or a different TAZ.
- Tour starts and ends at the vehicle's base location or a nonbase location.

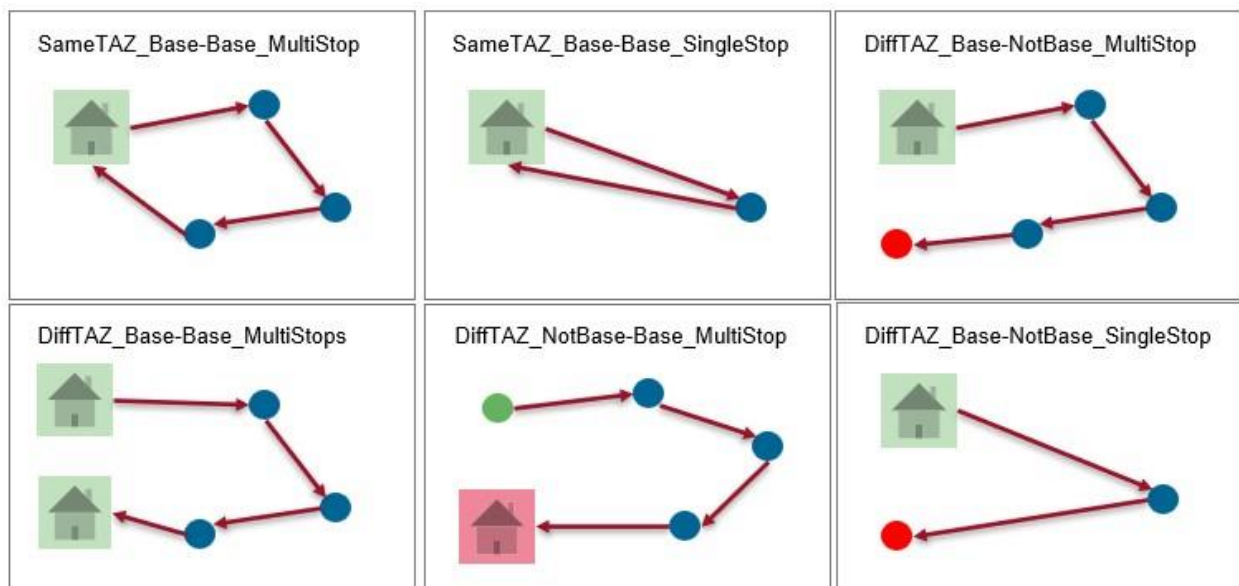
- Tour includes a single stop in addition to the return stop or the tour includes multiple stops before the return stop.

Below are the main six tour typologies, each representing more than 3% of the tours in the survey data. These are listed below and depicted in Figure 27:

1. SameTAZ\_Base-Base\_MultiStop.
2. SameTAZ\_Base-Base\_SingleStop.
3. DiffTAZ\_Base-NotBase\_MultiStop.
4. DiffTAZ\_Base-Base\_MultiStop.
5. DiffTAZ\_NotBase-Base\_MultiStop.
6. DiffTAZ\_Base-NotBase\_SingleStop.

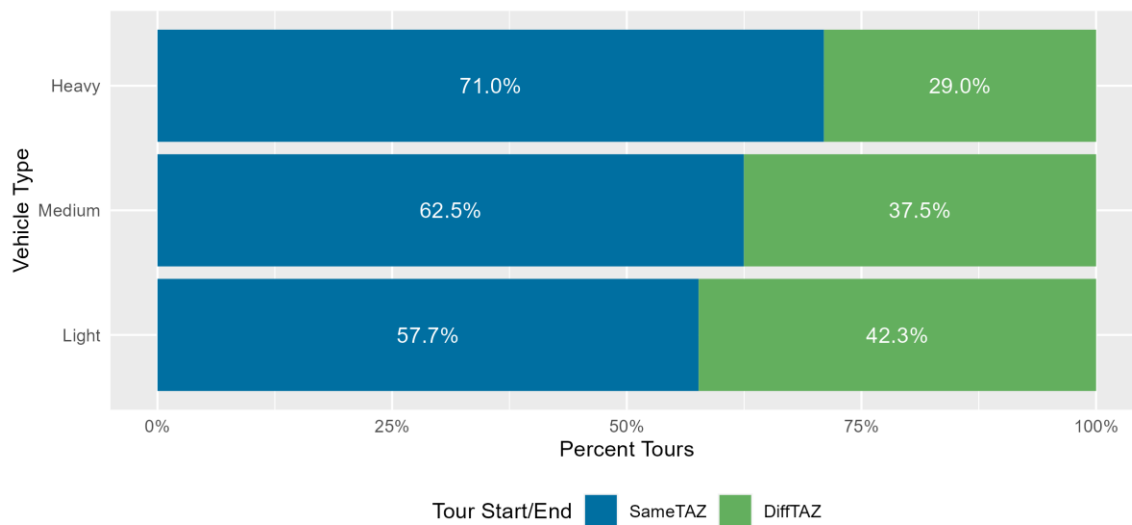
The first two classifications, which account for approximately 54% of the tours, both start and end at the same base location in the same TAZ. They are differentiated by the first classification by having multiple stops, and the second having just a single stop on the tour. The other four classifications are all different types of incomplete tours, with all either starting or ending at the vehicle's base location.

**FIGURE 27: TOUR TYPOLOGY**



A significant number of tours recorded by the survey start and end in different TAZs, a consistent finding across vehicle classes. Figure 28 shows the split between complete and incomplete tours (those trips that start or end in different TAZs) by vehicle class. For heavy vehicles, approximately 30% of tours started and ended in different TAZ, while for light and medium vehicles it was approximately 40%.

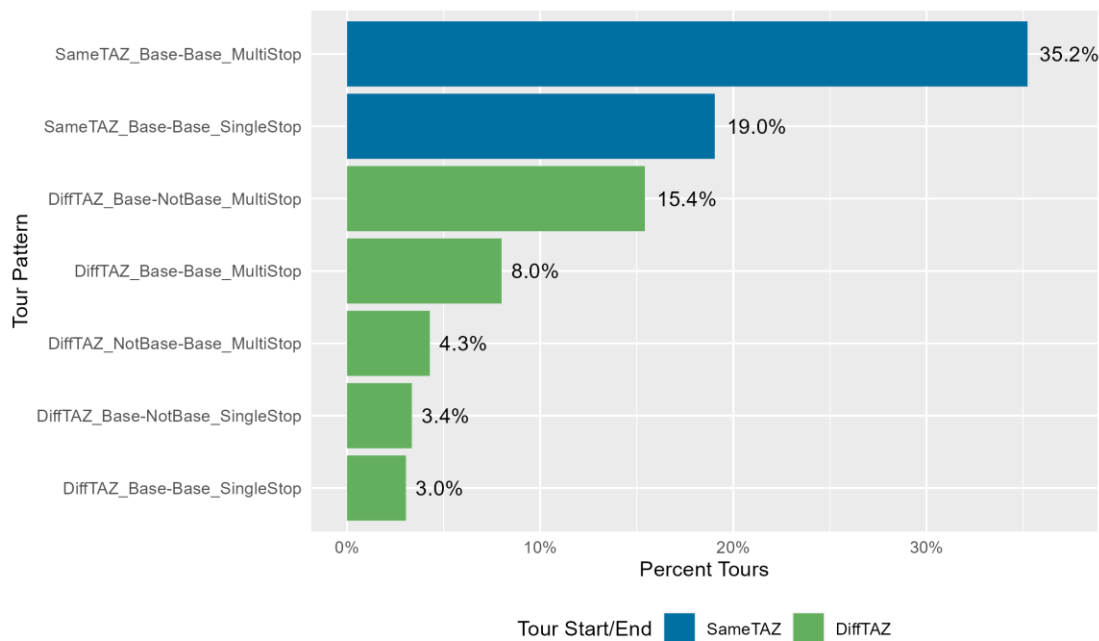
**FIGURE 28: PROPORTION OF COMPLETE AND INCOMPLETE TOURS, BY VEHICLE CLASS**



Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

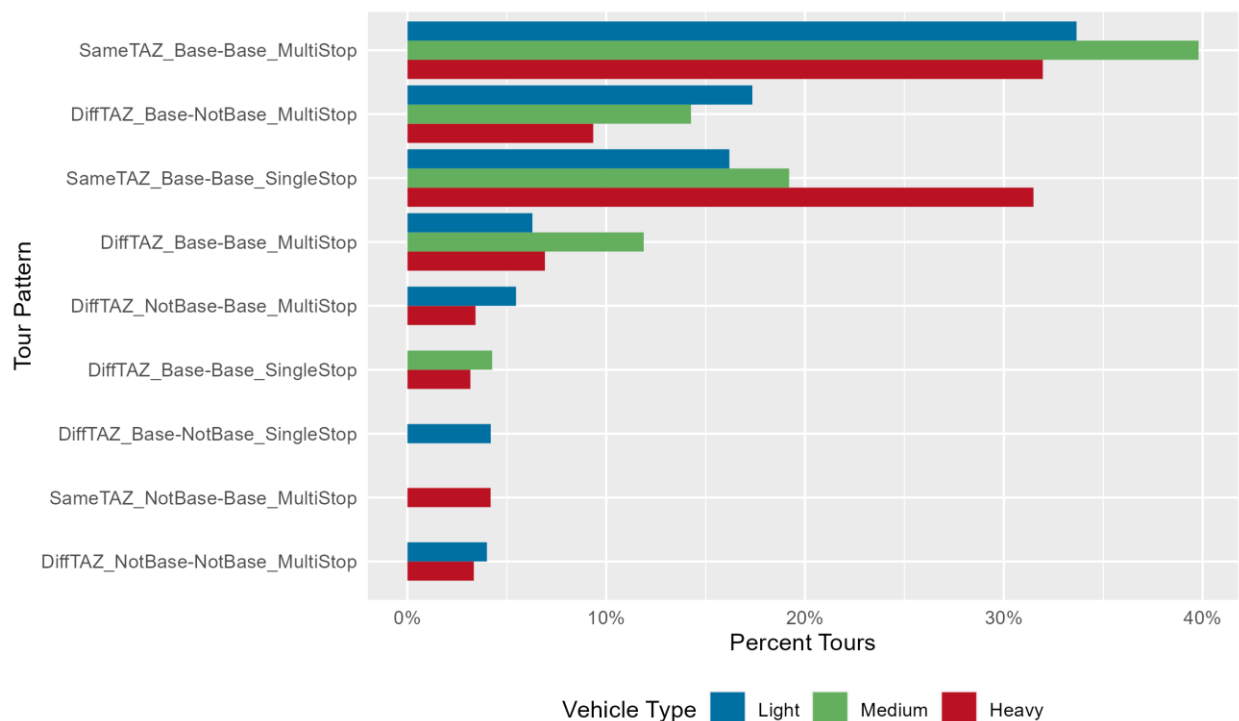
Figure 29 summarizes the share of seven tour types in the survey data. Figure 30 shows the difference in the prevalence of the different tour types by vehicle type. For all three vehicle classes, the first tour typology (SameTAZ\_Base-Base\_MultiStop) is the most common.

**FIGURE 29: TOURS, BY PATTERN**



Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

**FIGURE 30: TOUR PATTERNS, BY VEHICLE CLASS**

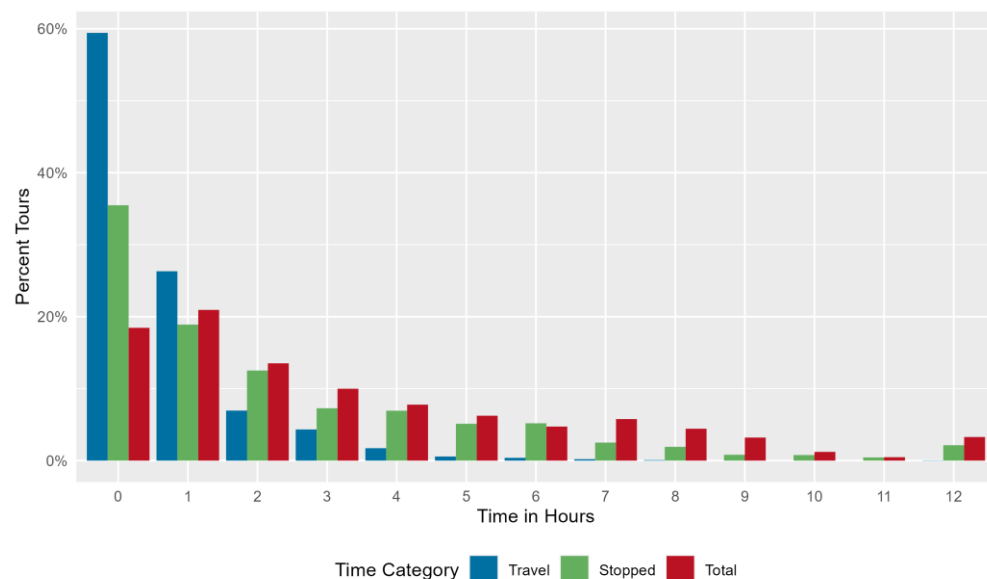


Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

For all tours classified, few start or end external to the region. The only exception are the heavy-vehicle tours that start and end in different locations, where a significant proportion of those tours either start or end outside the San Diego region. Overall, 4% of heavy-truck tours start or end outside of the region. For light vehicles and medium vehicles, approximately 2% of tours have a start or end point outside of the region.

Tour lengths can be defined in terms of time (which comprises travel time between stops and time at stops) and travel distance. Figure 31 shows the distribution of tour travel time, stopped time, and total time, binned by hours for all tours. The distributions show that approximately 60% of tours have less than an hour of travel time, around 25% of tours have between one and two hours, and the remainder of tours are two or more hours. Total tour time (travel time plus stopped time) tracks more closely with the stopped-time distribution, which is the larger contributor to total time. Just under 20% of tours are less than an hour in total.

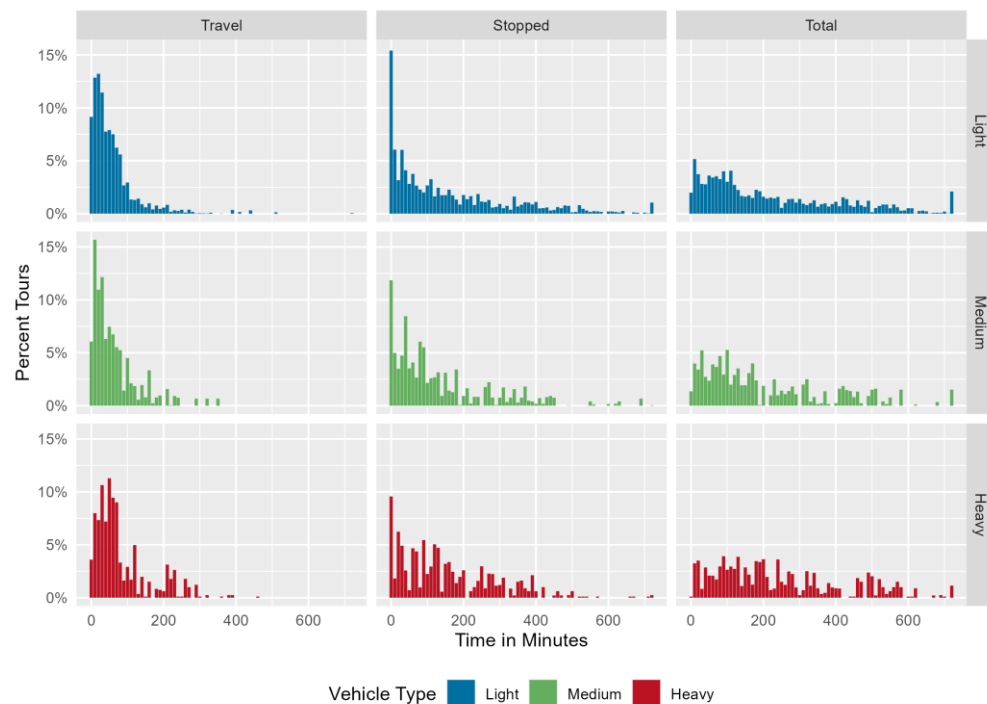
**FIGURE 31: TOUR TIME DISTRIBUTION FOR TRAVEL TIME, STOPPED TIME, AND TOTAL TIME**



Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

Figure 32 shows the breakdown by vehicle type, with more-detailed time bins (10-minute increments, up to 720 minutes or 12 hours) for total time. Tours lasting over 720 minutes were included in the 720-minute time bin. Heavy trucks tended to have more travel time on their tours than smaller vehicles. The stopped-time distributions vary by vehicle type, with heavy vehicles skewing slightly shorter (indicating a balance toward more travel and less time at stops than smaller vehicles).

**FIGURE 32: TOUR TIME DISTRIBUTION FOR TRAVEL TIME, STOPPED TIME, AND TOTAL TIME**

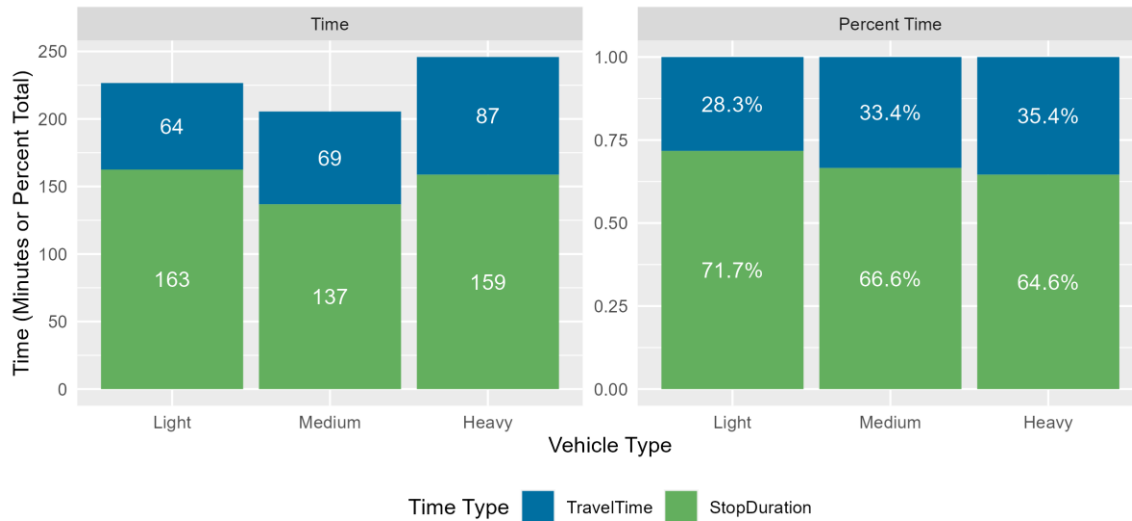


Source: SANDAG 2022 Commercial Vehicle Survey, Weighted



Figure 33 plots the mean tour lengths split between travel time and stop duration, in minutes and as a percentage of the total tour time by vehicle type. Twenty-six stops were not included in the stop duration calculation or analysis because their arrival and departure times were the same. The average total stop duration decreases as vehicle size increases.

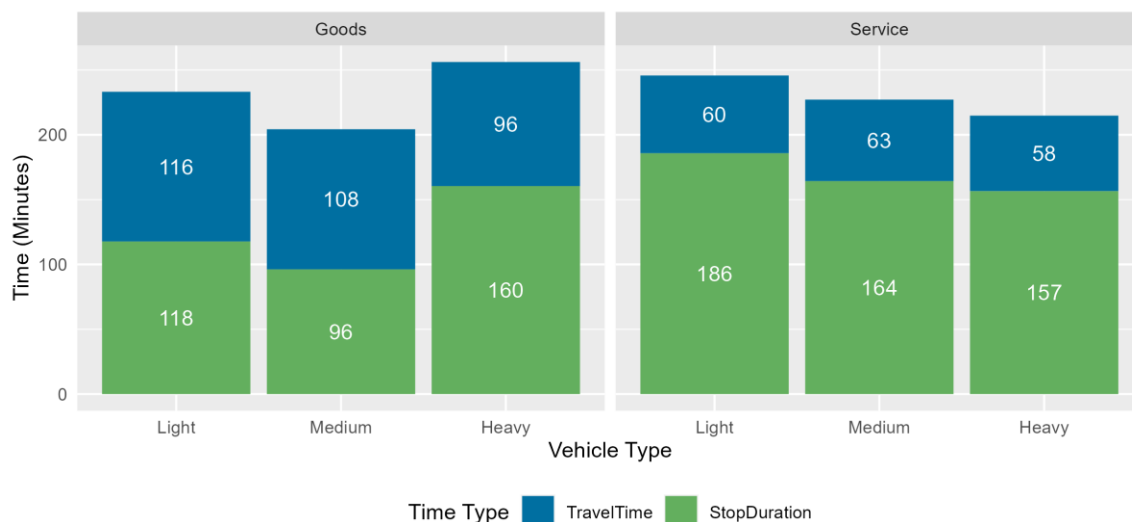
**FIGURE 33: TOUR TIME AVERAGES FOR TRAVEL TIME AND STOPPED TIME, BY VEHICLE TYPE**



Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

Figure 34 refines the analysis of average tour times by excluding the small number of tours that start and end outside of the San Diego region and presenting the goods tours and the service tours separately by vehicle type. The figure shows that within goods tours, heavy vehicles have the longest stop duration, while medium vehicles tend to have shorter stop durations. For service tours, the average total stop duration and total time decreases as vehicle size increases.

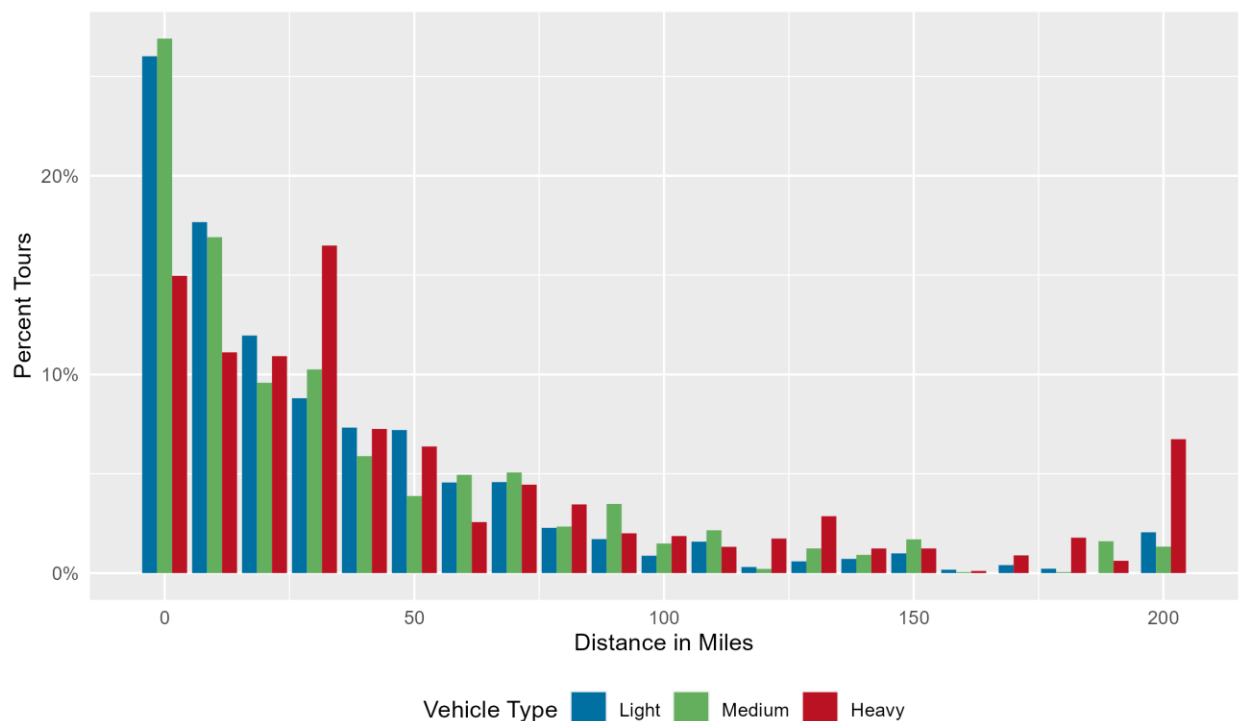
**FIGURE 34: TOUR TIME AVERAGE FOR INTERNAL TOURS, BY TRAVEL TIME AND STOPPED TIME, BY VEHICLE TYPE AND TOUR PURPOSE**



Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

Figure 35 shows the tour distance distribution by vehicle type (the sum of all the trip distances for the trips that comprise each tour). The figure shows the percentage of tours in 10-mile distance bins. Tours with distances over 200 miles were included in the 200-mile distance bins. As with the travel time for tours, the heavy-vehicle tours are longer than the tours for smaller vehicles. For light and medium vehicles, slightly more than one-quarter of the tours are under 10 miles long.

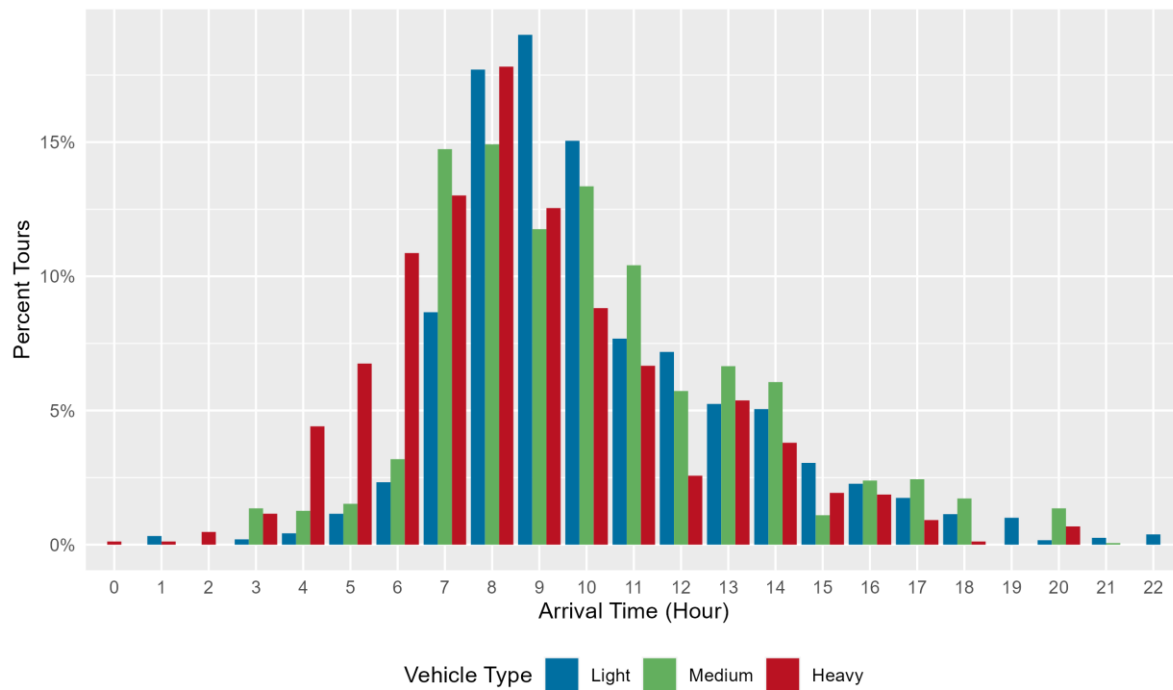
**FIGURE 35: TOUR TOTAL DISTANCE DISTRIBUTION, BY VEHICLE TYPE**



Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

One facet of the tour, often incorporated into commercial vehicle designs to schedule tours and their respective trips, is the arrival time at the first "scheduled" stop. This refers to the initial stop intended for delivering goods or providing services. Figure 36 shows the distribution of the hour in which the arrival at the first stop takes place by vehicle type. The first stop for heavy vehicles peaks between 8:00 a.m. and 9:00 a.m., with noticeably more tours starting in the early morning before 7:00 a.m. compared to smaller vehicle types. Light and medium vehicles peak slightly later in the morning, between 8:00 a.m. and 10:00 a.m.

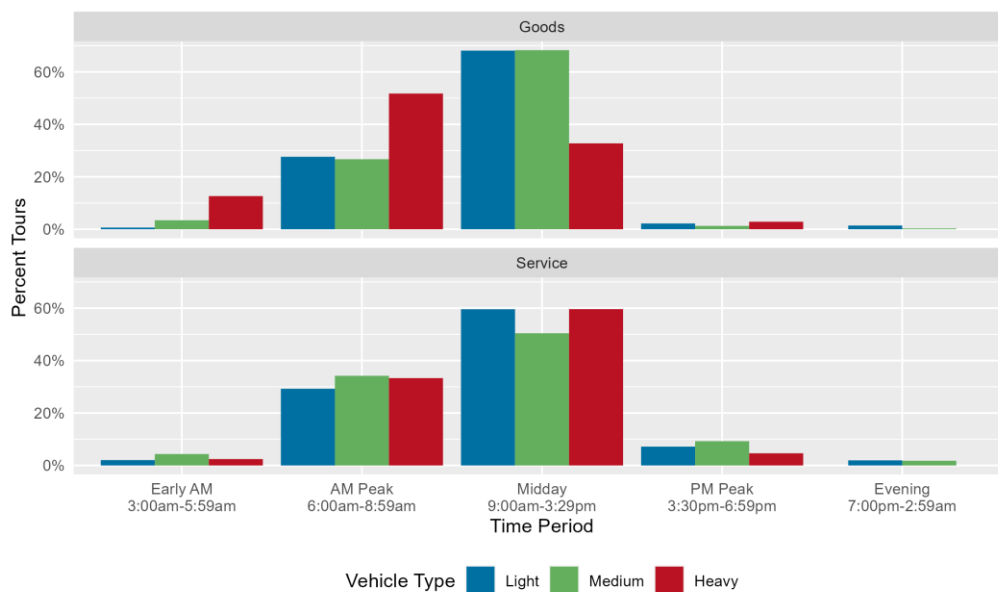
**FIGURE 36: DISTRIBUTION OF TOUR ARRIVAL TIME AT FIRST STOP, BY VEHICLE TYPE**



Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

Figure 37 groups the arrival times into the five SANDAG model time periods and splits the distributions by tour purpose into goods tours and service tours. For goods tours, heavy vehicles are more likely than smaller vehicles to begin their tours in the early AM and AM peak periods and less likely to begin them in the middle of the day. Service and goods tours by light and medium vehicles have similar distributions to one another.

**FIGURE 37: TOUR ARRIVAL TIME PERIOD AT FIRST STOP DISTRIBUTION, BY VEHICLE TYPE AND TOUR PURPOSE**



Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

Figure 38 collapses tours into length categories of short (less than three hours), medium (between three and six hours), and long (more than six hours in total) tours. The shortest tours are more likely than others to begin in the midday and PM peak times, with about 60% starting in that period. Long tours are the most likely to start in the early AM or AM peak time periods.

**FIGURE 38: TOUR ARRIVAL TIME PERIOD AT FIRST STOP DISTRIBUTION, BY VEHICLE TYPE AND TOUR LENGTH CATEGORY**



Source: SANDAG 2022 Commercial Vehicle Survey, Weighted

## 9.5 TNC DATA ANALYSIS

The following section details the 411 TNC vehicles that completed the trip diary survey. The data were provided in a spreadsheet with tabs containing vehicle data, trip data, and a data dictionary. The dataset contains data on 5,664 records that were collected from the 411 vehicles that completed the truck diary survey. As detailed in the weighting section, weighting and expansion was not carried out for the TNC dataset as there is no reliable set of target data to base weighting on. The data in this section is, therefore, presented as unweighted.

## 9.6 TNC VEHICLE CHARACTERISTICS

The vehicle table contains one record for each vehicle that participated in the TNC diary survey and includes information about the vehicle and aggregate statistics about the vehicle's travel during the survey day. Table 22 shows the sample size by vehicle classifications.

**TABLE 22: NUMBER OF VEHICLE CLASSIFICATIONS, TNC DATA**

CLASS #	VEHICLE TYPE	SAMPLE SIZE
1	Passenger Car or Motorcycle	362
2	Pickup Truck	16
3	Van (Cargo or Minivan)	19
4	Bus	14
<b>Total</b>		<b>411</b>

Table 23 shows the number of vehicles and stops by primary use for all 411 TNC vehicles. Approximately 80% of these vehicles were used for both service and cargo.

**TABLE 23: NUMBER OF VEHICLES AND STOPS, BY PRIMARY USE, TNC DATA**

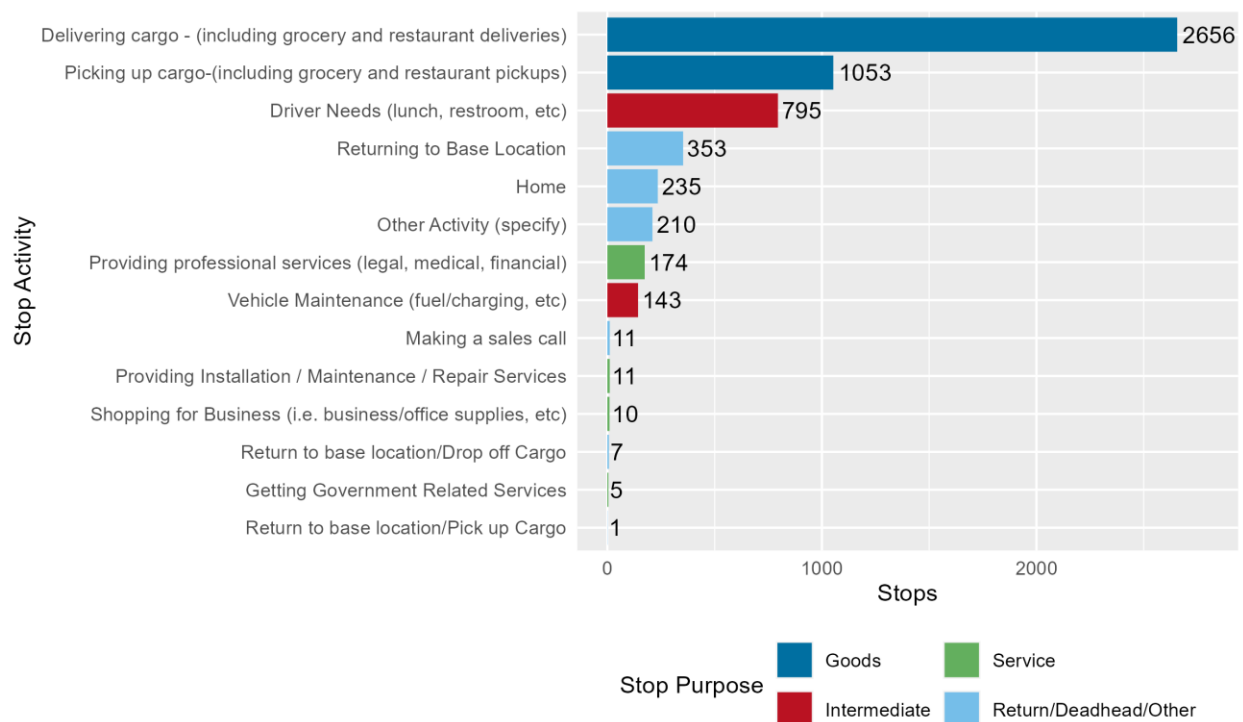
PRIMARY USE	NUMBER OF VEHICLES	PERCENTAGE	AVERAGE NUMBER OF STOPS	MEDIAN NUMBER OF STOPS
Cargo	31	7.5%	16.0	12
Service	52	12.7%	9.6	7
Service & Cargo	327	79.6%	13.0	10
Refuse to Answer	1	0.2%	3.0	3
<b>Total</b>	<b>411</b>	<b>100.0%</b>	<b>13</b>	<b>10</b>

## 9.7 TNC TRIP CHARACTERISTICS

The trips table contains a record for each stop reported in the TNC diary survey, totaling 5,664 records from 411 vehicles. The table includes information on the stop's location, such as its address, coordinates, place type, arrival and departure times, and any activity conducted at the stop. If the stop's activity involved cargo delivery, the shipment is described. Additionally, each record is processed using a driving direction algorithm tool to estimate network travel time and distance for each stop.

Figure 39 shows the distribution of stop activities in the sample. As expected, the largest two stop purposes are for delivering cargo and picking up cargo (including grocery and restaurant deliveries).

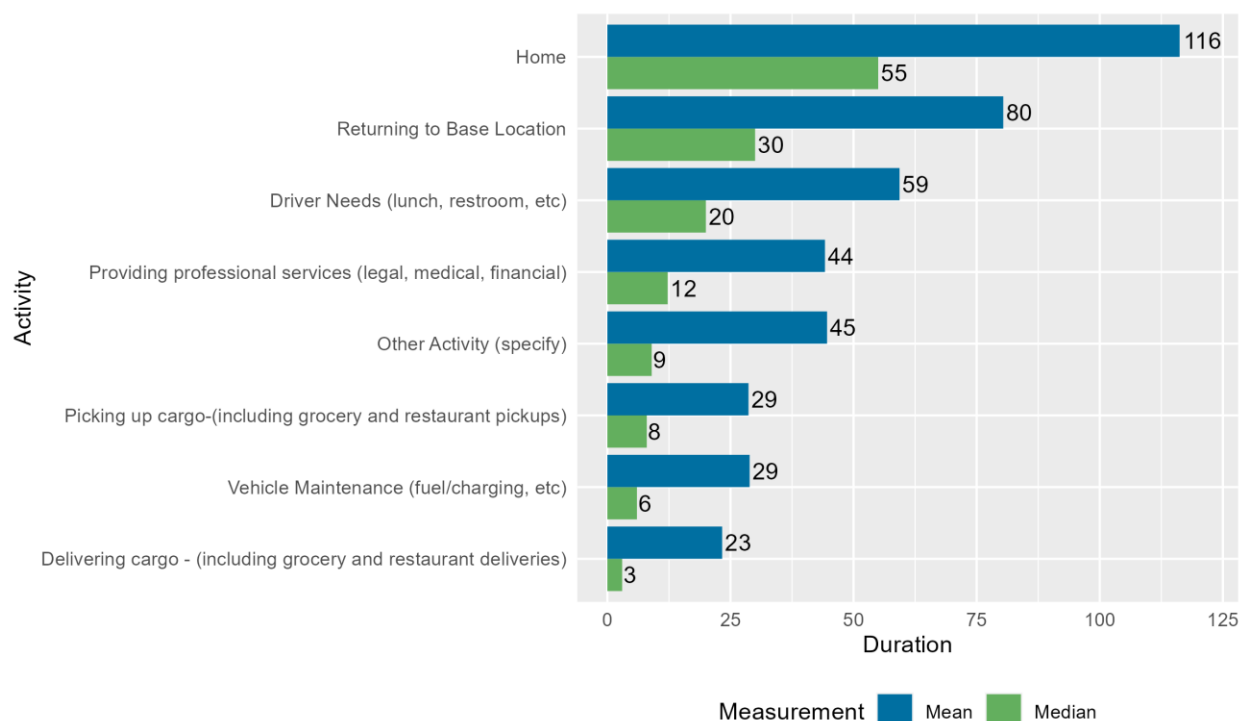
**FIGURE 39: NUMBER OF STOPS, BY STOP ACTIVITY, TNC DATA**



Source: SANDAG 2022 TNC Data, Unweighted

Figure 40 shows how the average and median stop duration reported in the diary surveys varies by stop activity. The results show that the mean stop duration is significantly longer than the median stop duration in all types of stop activity. The longest stops generally occurred when drivers returned home, to a base location, or to attend to a personal need.

**FIGURE 40: STOP DURATION IN MINUTES, BY STOP ACTIVITY, TNC DATA**



Source: SANDAG 2022 TNC Data, Unweighted

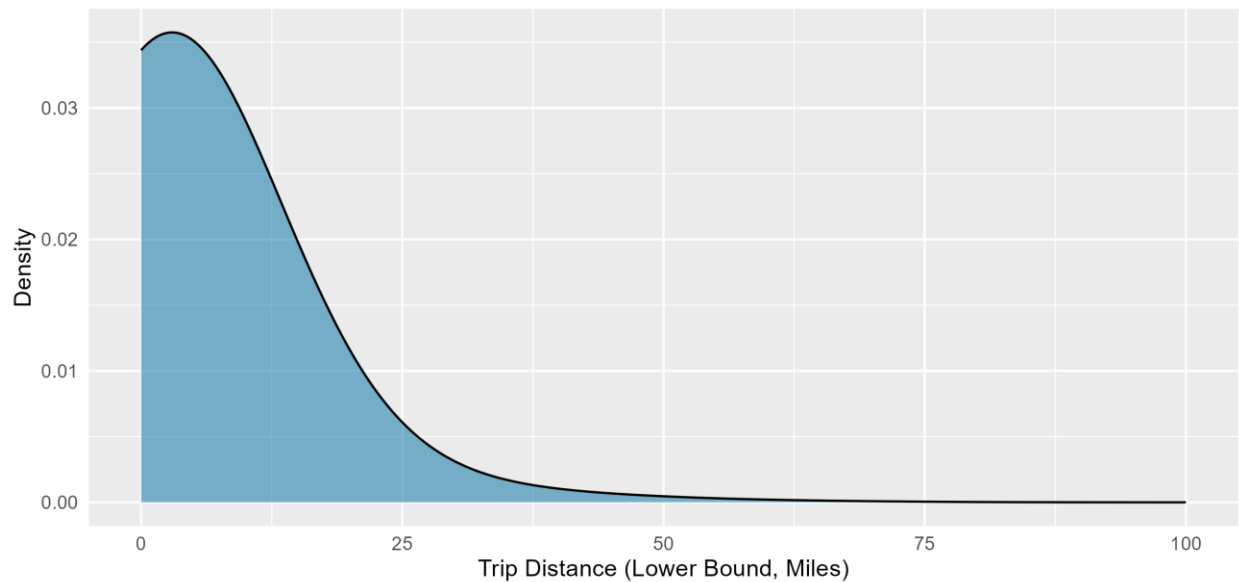
Table 24 shows the number of trips, the median distance and travel time, and the mean distance and travel time for all TNC trip data. The median trip distance and time are 1.8 miles and 6.7 minutes, respectively, while the mean trip distance and time are 4.7 miles and 8.9 minutes.

**TABLE 24: TRIP STATISTICS FOR ALL TNC TRIPS**

NUMBER OF TRIPS	MEDIAN DISTANCE	MEAN DISTANCE	MEDIAN TIME	MEAN TIME
5,253	1.8	4.7	6.7	8.9

Figure 41 and Figure 42 show the distributions of trip length by distance and travel time, respectively. Figure 41 does not include 4 trips with distances over 100 miles and Figure 42 does not include 2 trips with travel time over 100 minutes. Trip distance density is highest within a 1- to 10-mile range, with a sharp decrease in density as the distance increases, with few trips over 50 miles. Similarly, for the travel time distribution, a high density of trips is observed within the 0- to 10-minute range, with a more gradual decline in density as the travel time increases.

**FIGURE 41: TRIP DISTANCE DISTRIBUTION FOR TRIP UNDER 100 MILES (4 TRIPS OVER 100 MILES WERE EXCLUDED), TNC DATA**



**FIGURE 42: TRIP TRAVEL TIME DISTRIBUTION FOR TRIP UNDER 100 MINUTES, (2 TRIPS OVER 100 MIN WERE EXCLUDED), TNC DATA**

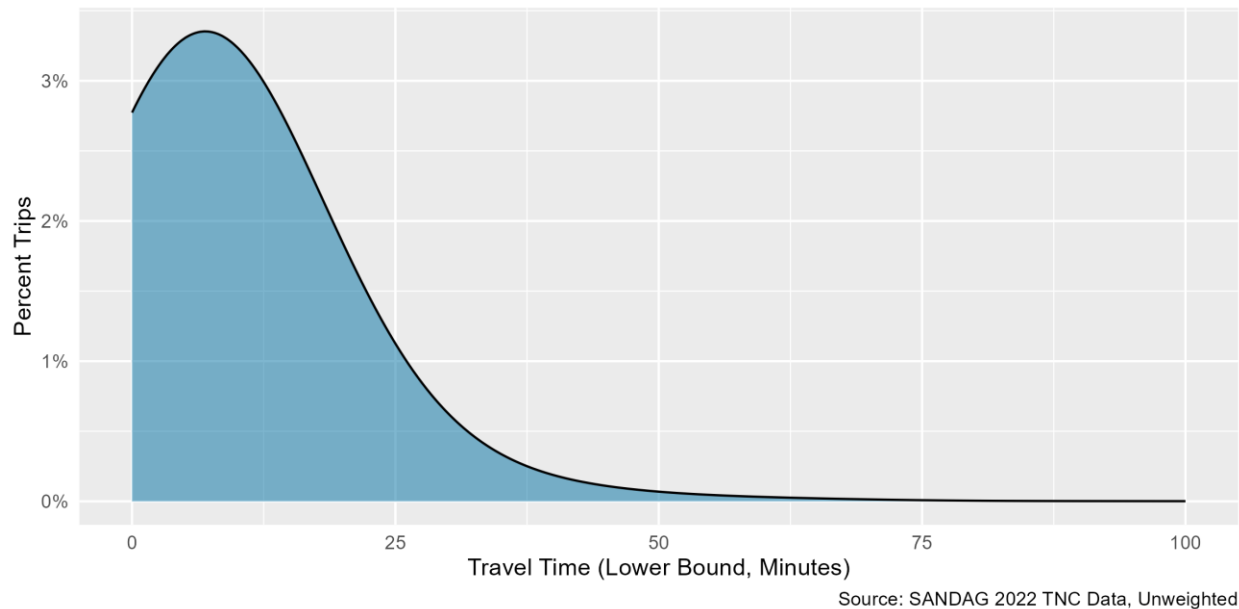
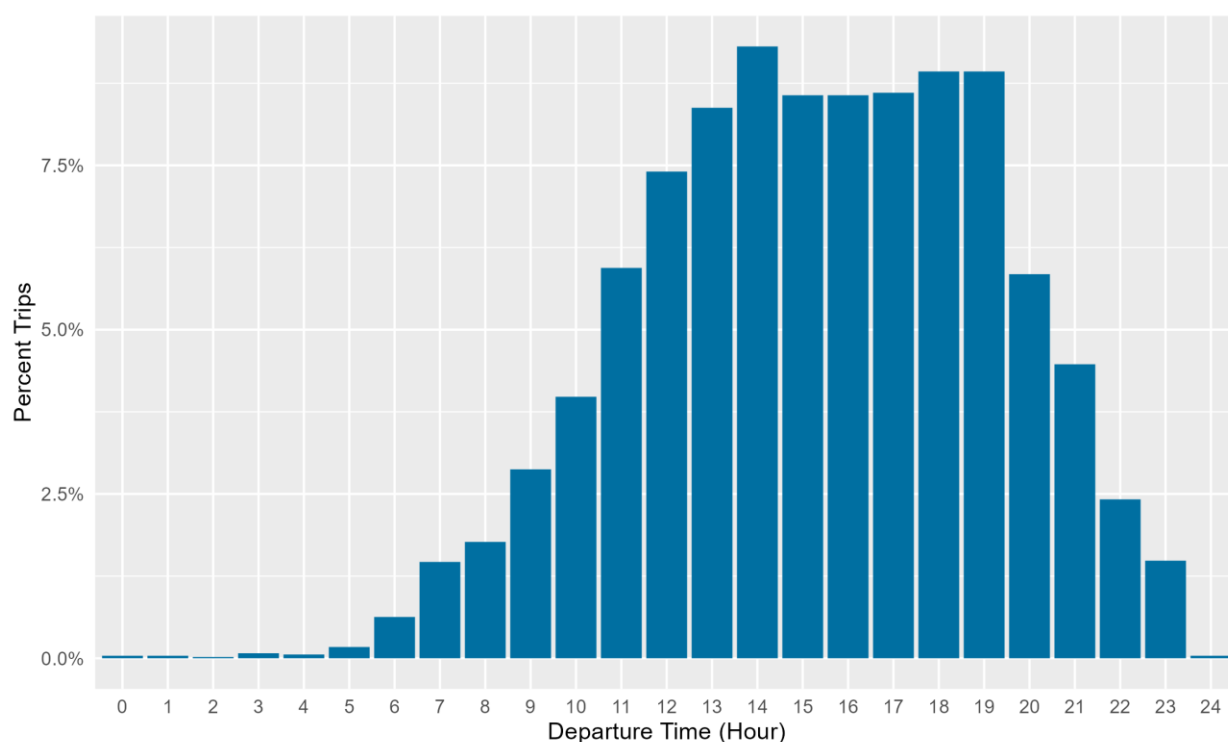


Figure 43 shows the departure time distribution for trips. Most of the trips departed during the afternoon and early evening between 13:00 to 19:00.



**FIGURE 43: TRIP DEPARTURE TIME DISTRIBUTION, TNC DATA**

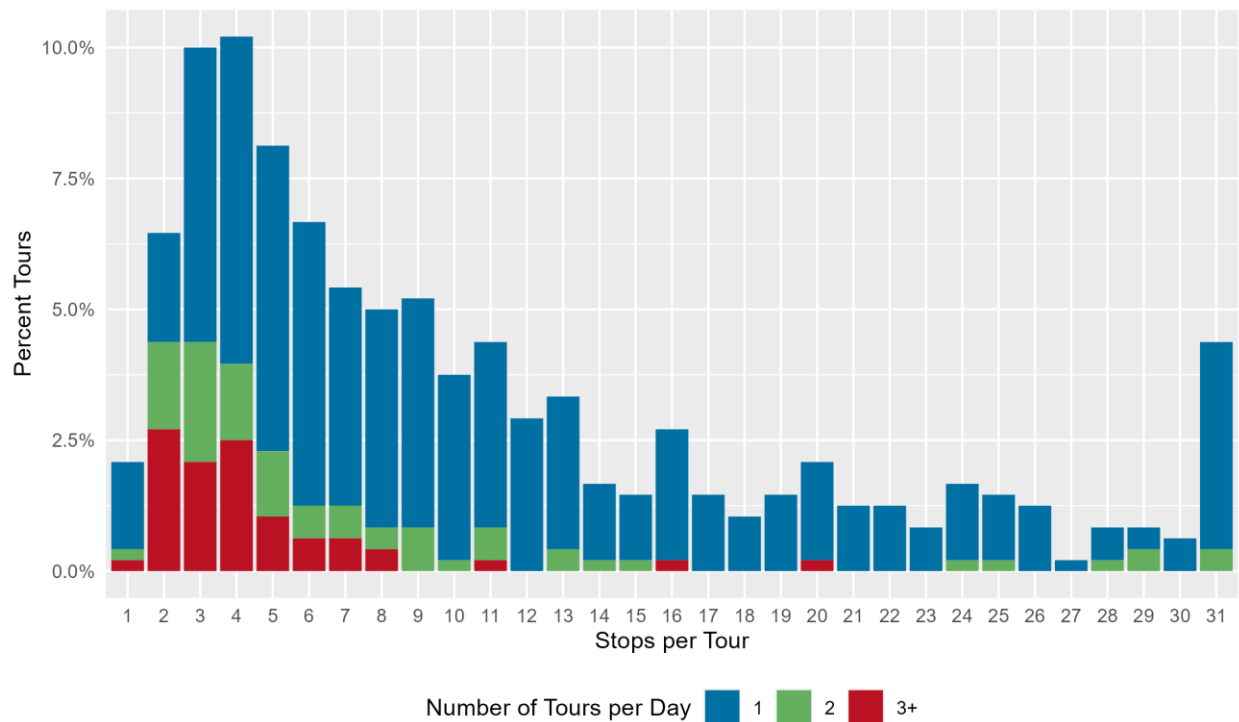
Source: SANDAG 2022 TNC Data, Unweighted

## 9.8 TNC TOUR CHARACTERISTICS

The tour table includes 5,733 records and, as with the trip table, each record after the start record describes details of the stop and preceding trip. The records are ordered within each individual vehicle by a tour number and stop sequence. There are a total of 483 tours. The summaries in this section entail analysis of tour characteristics, including number of stops per tour, the split between tours starting and ending in the sample place or not, tour length in terms of distance and time, and when during the day tours take place.

Figure 44 shows the distribution of the number of stops per tour, excluding the stops that denote the return stop at the end of a tour where that is present (as is discussed further below, not all tours are closed-loop tours, or tours that end in the same location that they started). The final bin (31 stops) includes all remaining trips over those thresholds. Some vehicles made more than one tour during the survey day, and the number of tours per vehicle is categorized into one tour per day, two tours, and three or more tours. Single-stop tours are uncommon, accounting for fewer than 2.5% of tours, and 95.6% of tours have 30 or fewer stops. Most drivers have multiple tours and stops per day.

**FIGURE 44: NUMBER OF STOPS PER TOUR, BY NUMBER OF TOURS PER DAY**



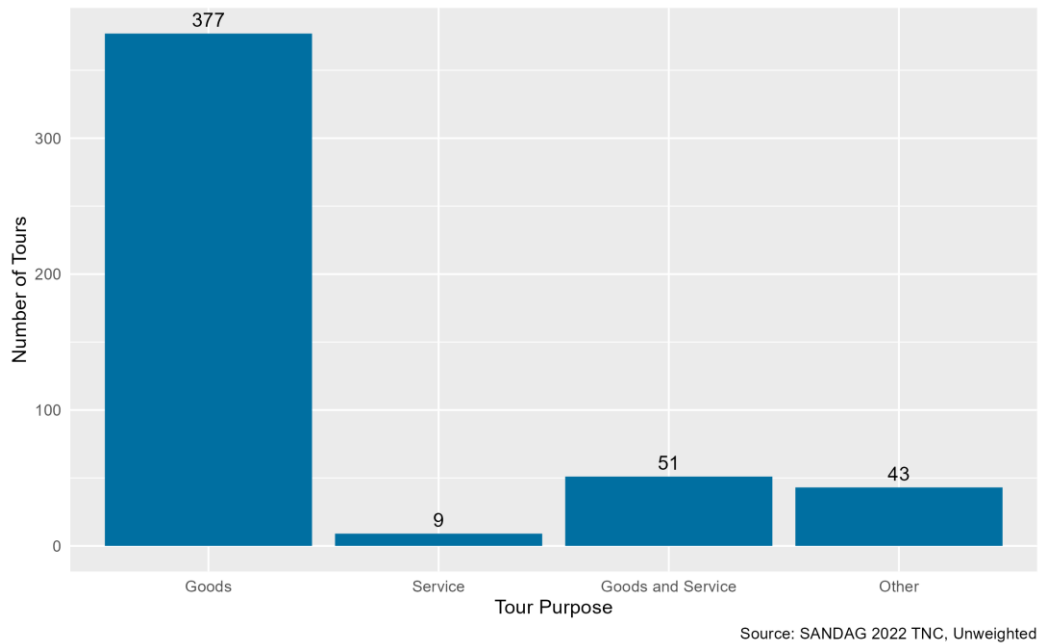
Source: SANDAG 2022 TNC Data, Unweighted

As with the regular CVS truck data, the stops within a tour each have a purpose, allowing an overall tour purpose to be characterized based on the combination of stop purposes. Tours were allocated to four tour purpose types:

- **Goods tours.** 1 + goods stops, 0 service stops, and 0 or 1 + other stops.
- **Service tours.** 1 + service stops, 0 goods stops, and 0 or 1 + other stops.
- **Goods and service tours.** Both goods and service stops, and 0 or 1 + other stops.
- **Other tours.** No goods or service stops, only other stops such as driver needs or vehicle refueling.

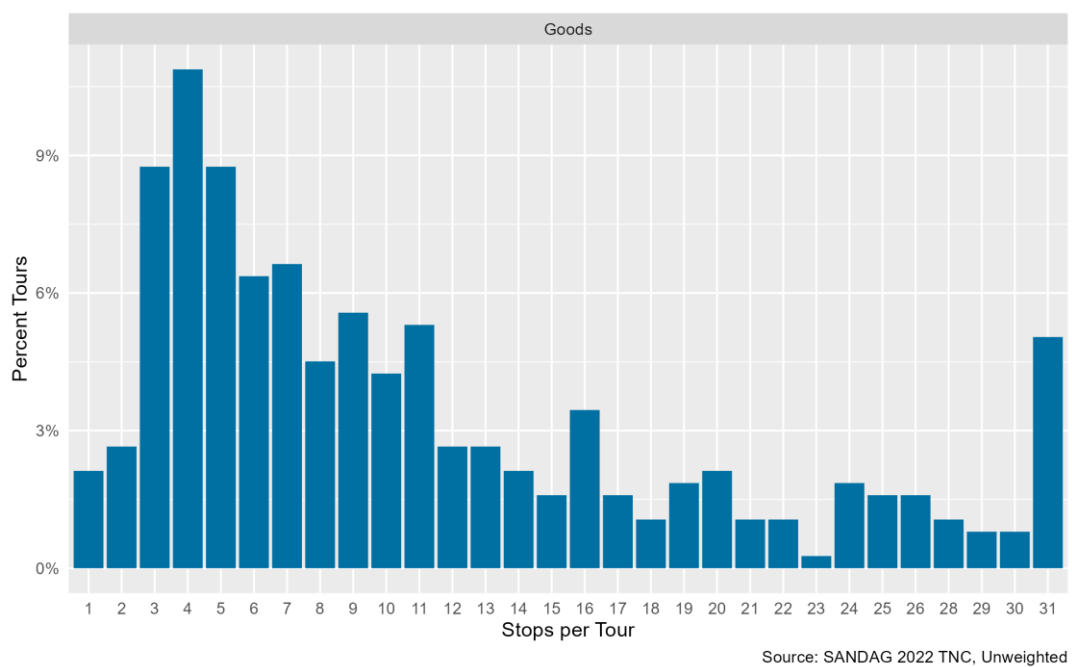
Figure 45 shows the distribution of tour purposes. Most sampled tours were goods tours.

**FIGURE 45: TOUR PURPOSE DISTRIBUTION**



For the most common tour purpose (goods stop tours), Figure 46 shows the distribution of the number of stops. The last bin includes all tours with 31 or more stops. Around 98% of tours have multiple stops, while 5% have 31 or more stops per tour. Most tours have between three to five stops.

**FIGURE 46: NUMBER OF STOPS PER TOUR FOR GOODS TOUR PURPOSE**

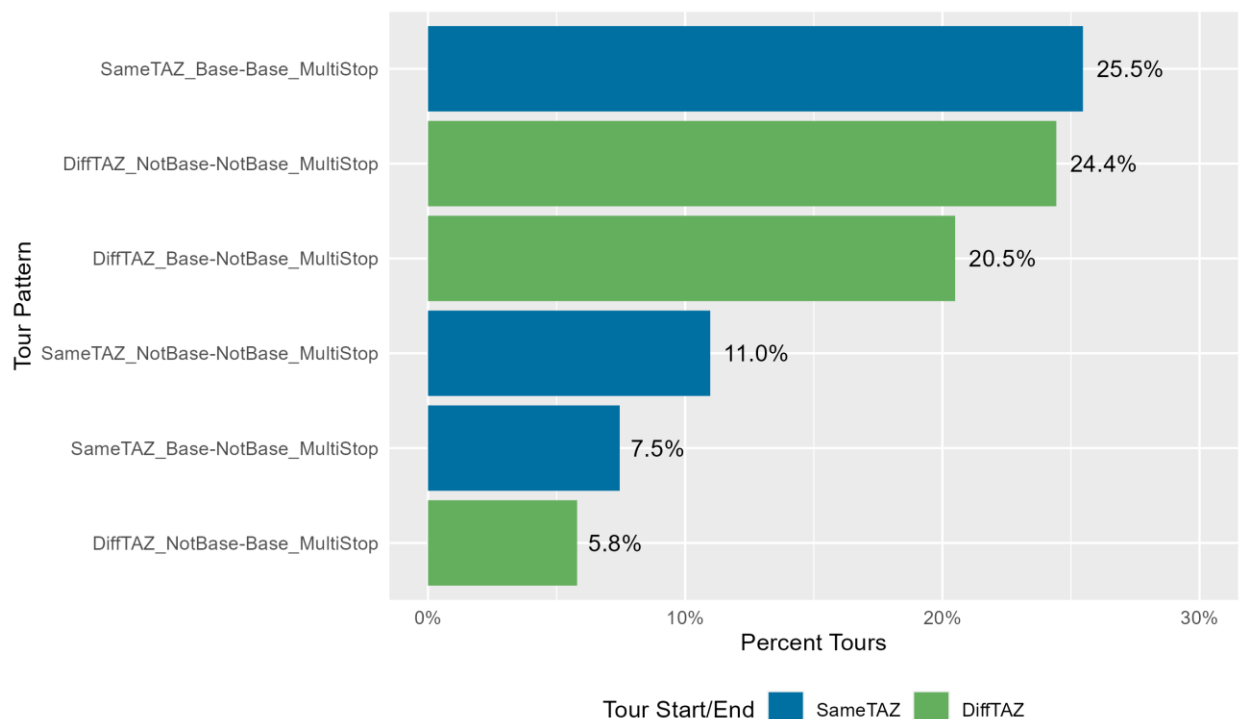


As with the CVS truck data, tours can be classified by several characteristics, including whether a tour starts and ends in the same location, by the number of stops on the tour, and the type of location at the start and end of the tour. The following composite classification, or tour typology, of these three measures was created to group the tours observed in the TNC data:

- Tours that start and end in the same TAZ or a different TAZ.
- Tours that start and end at the vehicle's base location or a nonbase location.
- Tours that include a single stop in addition to the return stop, or the tour includes multiple stops before the return stop.

Most tours recorded by the survey start and end in different TAZs. Specifically, 43.5% of tours start and end at the same TAZ, while the remaining 56.5% of tours start and end at a different TAZ. As with the regular CVS data, six tour typologies account for at least 3% of the tours in the survey data. The proportions of the most common tour types are shown in Figure 47. These tour types are defined and illustrated in Figure 27 in the previous chapter.

**FIGURE 47: TOURS, BY PATTERN, TNC DATA**

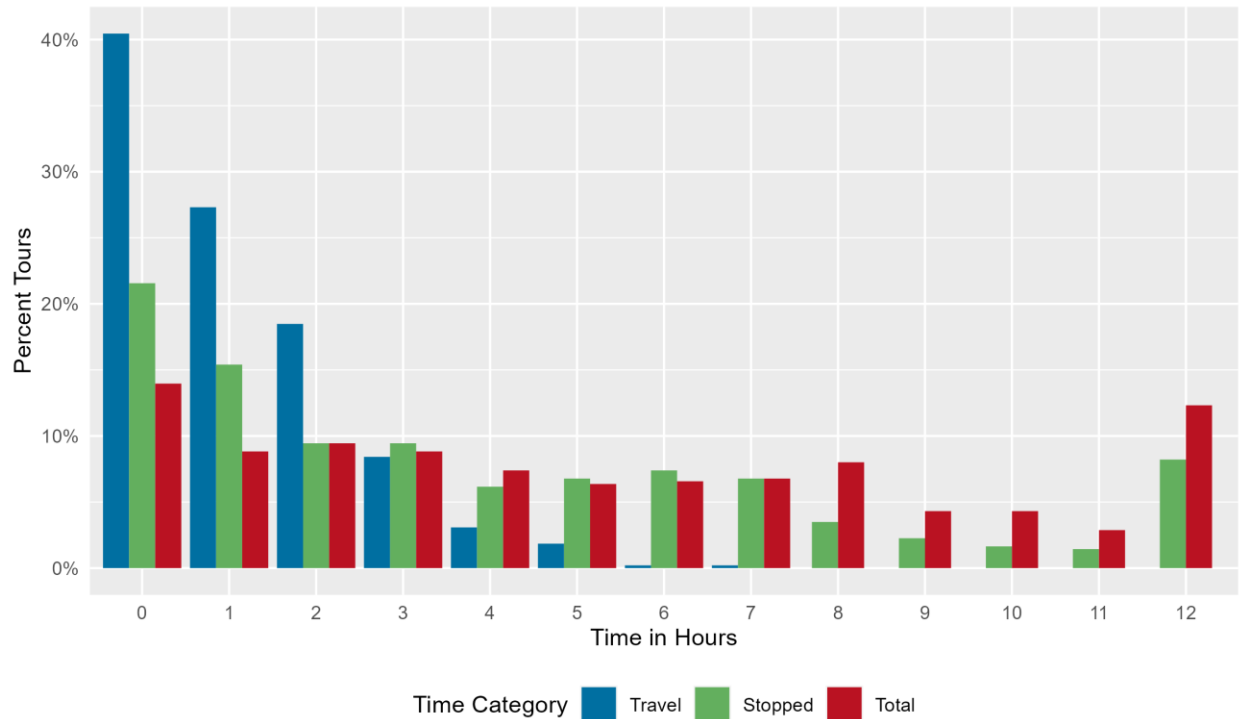


Source: SANDAG 2022 TNC Data, Unweighted

Tour lengths can be defined in terms of time (which comprises travel time between stops and time at stops) and travel distance. Figure 48 shows the distribution of tour travel time, stopped time, and total time, binned by hours for all tours. The distributions show that approximately 40% of tours have less than an hour of travel time, around 27% of tours have between one and two hours, and the remainder of tours are longer than two hours. The distribution of stopped time is less left skewed, with 22% of tours having less than an hour of stopped time. Total tour time (travel time plus stopped time) tracks more closely with the stopped-time distribution, which

is the larger component of total time, than with the travel time distribution. Approximately 14% of tours are less than an hour in total.

**FIGURE 48: TOUR TIME DISTRIBUTION FOR TRAVEL TIME, STOPPED TIME, AND TOTAL TIME, TNC DATA**



Source: SANDAG 2022 TNC Data, Unweighted

Table 25 presents a summary of travel time, stop duration, and tour time using both mean and median values. The mean values for travel time, stopped time, and tour time are higher than the median values, indicating the trip duration is skewed toward longer trips.

**TABLE 25: TRAVEL TIME, STOPPED TIME AND TOUR TIME SUMMARY (MINUTES), TNC DATA**

MEASUREMENT	TRAVEL TIME	STOP DURATION	TOUR TIME
Mean	97	332	429
Median	75	214	315

Figure 49 shows travel time and stop duration by tour purpose, plotting the mean tour lengths split between travel time and stop duration in minutes and as a percentage of the total tour time. Only nine service tours are in the TNC data, so analysis in this category should be interpreted with caution.

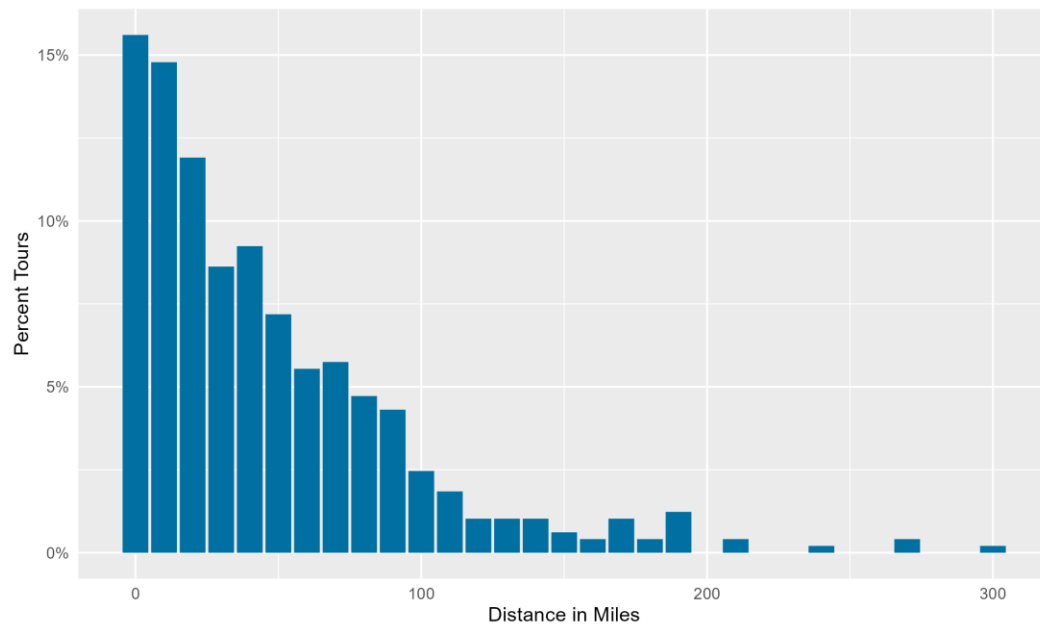
**FIGURE 49: TOUR TIME AVERAGES FOR TRAVEL TIME AND STOPPED TIME, BY TOUR PURPOSE, TNC DATA**



Source: SANDAG 2022 TNC Data, Unweighted

Figure 50 shows the distribution of the total tour distance (the sum of all the trip distances for the trips that comprise each tour). The chart shows the percentage of tours in each 10-mile distance bin. Most of the tours are under 50 miles, with approximately 30% of tours under 20 miles.

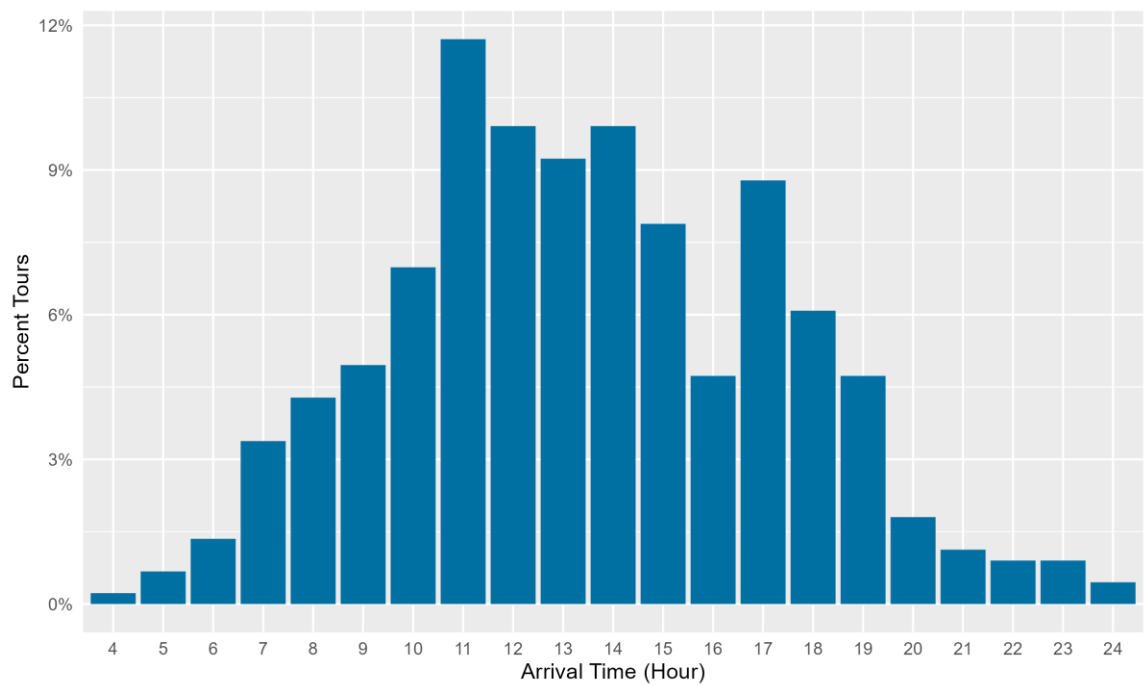
**FIGURE 50: TOUR TOTAL DISTANCE DISTRIBUTION, TNC DATA**



Source: SANDAG 2022 TNC Data, Unweighted

A common method used in commercial vehicle models is an aggregation approach, which schedules tours and their constituent trips based on the arrival time at the first "scheduled" stop. This initial stop is usually intended for delivering goods or providing services. Figure 51 shows the distribution of the hour in which the arrival at the first stop takes place by vehicle type. Most of the tours (about 40%) arrived at the first stop between 11:00 to 14:00.

**FIGURE 51: TOUR ARRIVAL TIME AT FIRST STOP DISTRIBUTION, TNC DATA**



## 10.0 CONCLUSION

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From June 2022 to January 2023, SANDAG, in collaboration with the ETC Institute and RSG, conducted a CVS in San Diego County. The survey included an establishment survey and a truck travel diary survey, collecting data such as arrival and departure times, cargo details, trip purpose, and origin and destination information.

The goal of the survey was to gather data on commercial vehicles, categorized by vehicle class, industry type, and size, and encompassing nontraditional entities like TNCs. The collected data comprised 2,697 completed surveys from establishments, information from 1,751 commercial vehicles associated with 464 unique establishments, and input from 411 TNC drivers from 18 unique TNCs. In total, 12,261 records (including 10,687 stops and 1,574 original) were collected from the 1,751 vehicles. For the 411 TNC drivers, a total of 5,664 records were compiled, including 5,253 stops and 411 original entries.

The data gathered through this survey will provide SANDAG and its partners with valuable insights into commercial vehicle operators' travel decision-making processes. This knowledge will enhance the region's capacity to accurately model commercial vehicle travel patterns.