

**NGSIM U.S. 101 Data Analysis
(7:50 a.m. to 8:05 a.m.)**

**summary
report**

prepared for

Federal Highway Administration

prepared by

Cambridge Systematics, Inc.

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Table of Contents

Introduction	1
Study Area Description	1
Vehicle Detection and Tracking	3
Data Analysis	4
Description	4
Vehicle Type	6
Aggregation by Time	6
Aggregation by Lane.....	6
Input-Output Analysis.....	8
Lane Change Analysis	9
Sectional Analysis.....	11
Analysis by Section and Time Period	13
Analysis by Starting Lane.....	15
Headway and Gap Analysis	18

List of Tables

1. Vehicle Type.....	6
2. Aggregate Results Summary for the Entire Section	6
3. Aggregate Flow and Speed for Each Lane.....	7
4. Input-Output Analysis.....	8
5. Input-Output Analysis by Lane and Time Period	9
6. Time Mean Speed and Space Mean Speed by Section	11
7. Time Mean Speed by Section and Time Period (Feet Per Second)	13
8. Space Mean Speed by Section and Time Period (Feet Per Second)	14
9. Lane Changes by Section and Time Period	15
10. Number of Vehicles by Starting Lane.....	16
11. Number of Lane Changes by Starting Lane.....	16
12. Average Lane Changes by Starting Lane	17
13. End Lane Distribution by Starting Lane (in Vehicles).....	17
14. Percent End Lane Distribution by Starting Lane	18
15. Average Headway by Time Period and Lane (in Seconds).....	18
16. Average Accepted Lead and Lag Gaps During Lane Changes	19
17. Average Accepted Lead and Lag Gaps During Lane Changes by Time Period ...	19

List of Figures

1. Study Area Schematic and Camera Coverage.....	2
2. Vehicle Detection and Tracking Process	3
3. Flow by Time Period	5
4. Time Mean Speed and Space Mean Speed by Time Period	5
5. Flow by Lane	7
6. Speed by Lane	8
7. Lane Change Analysis	10
8. Number of Lane Changes by Lane	10
9. Flow by Section.....	12
10. Time Mean Speed and Space Mean Speed by Section	12

■ Introduction

This report summarizes a data collection and processing effort undertaken to provide a dataset of vehicle trajectory data completed as part of the Federal Highway Administration's (FHWA) Next Generation Simulation (NGSIM) project, and provides a detailed analysis of a subset of the data. The data analyzed in this report represent vehicle trajectories on a segment of U.S. Highway 101 (Hollywood Freeway) in Los Angeles, California collected between 7:50 a.m. and 8:05 a.m. on June 15, 2005. Aggregate summaries of flow and speed of the vehicles, number of lane changes, headway and gap analysis, and an input-output analysis of flows are provided. The results are aggregated by time, distance (100 feet), and lane.

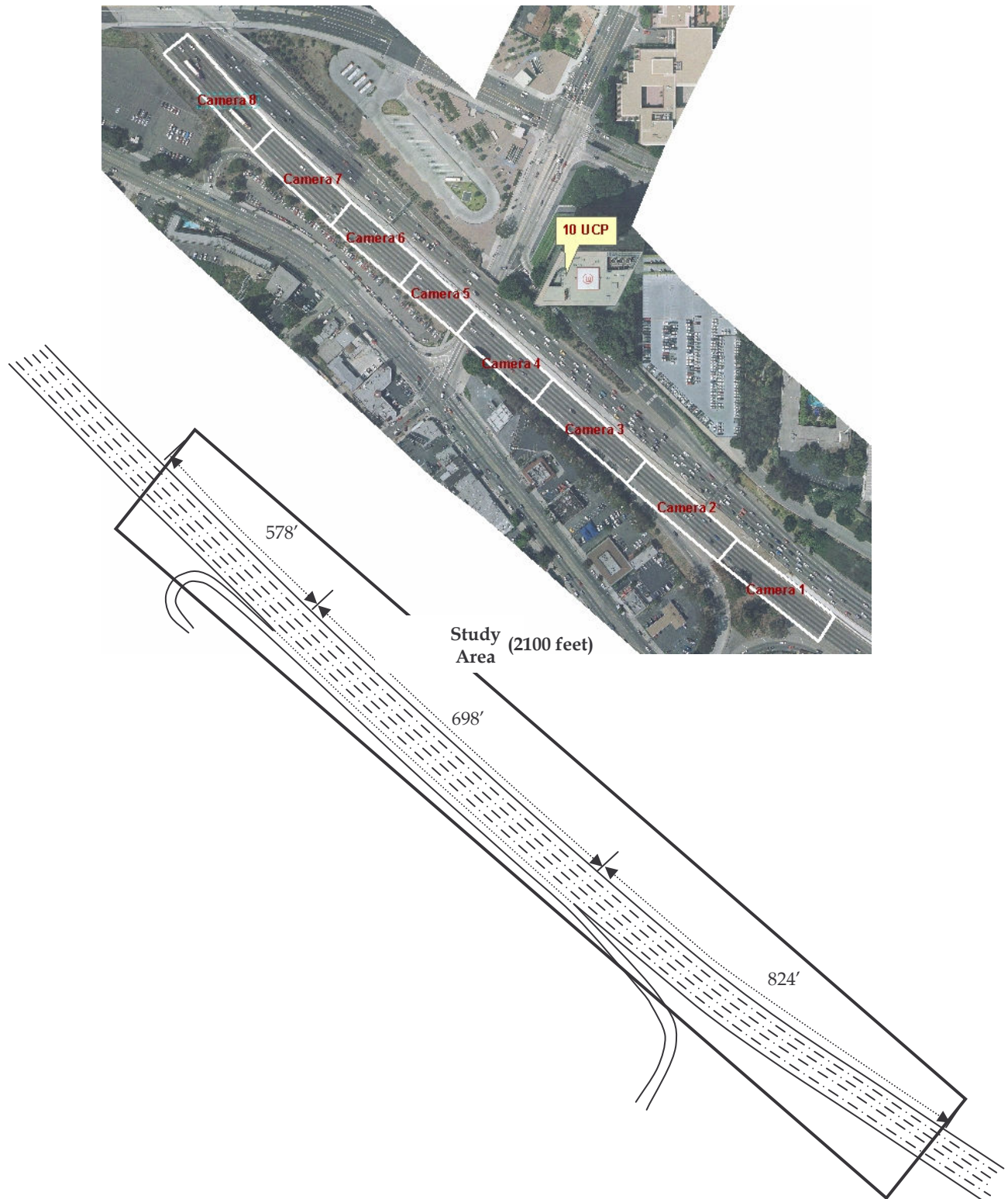
Study Area Description

Data presented in this report represent travel on the southbound direction of U.S. Highway 101 (Hollywood Freeway) in Los Angeles, California. This data was collected using video cameras mounted on a 36-story building, 10 Universal City Plaza, which is located adjacent to the U.S. Highway 101 and Lankershim Boulevard interchange in the Universal City neighborhood.

Figure 1 provides a schematic illustration of the location for the vehicle trajectory dataset. The site was approximately 2,100 feet in length, with five mainline lanes throughout the section. An auxiliary lane is present through a portion of the corridor between the on-ramp at Ventura Boulevard and the off-ramp at Cahuenga Boulevard. Lane numbering is incremented from the left-most lane.

Video data were collected using eight video cameras, cameras 1 through 8, with camera 1 recording the southernmost, and camera 8 recording the northernmost section of the study area, as shown in Figure 1. Digital video images were collected over an approximate nine-hour period from 7:00 a.m. to 12:00 p.m. and from 3:00 p.m. to 7:00 p.m. on June 15, 2005. Complete vehicle trajectories were transcribed at a resolution of 10 frames per second.

Figure 1. Study Area Schematic and Camera Coverage

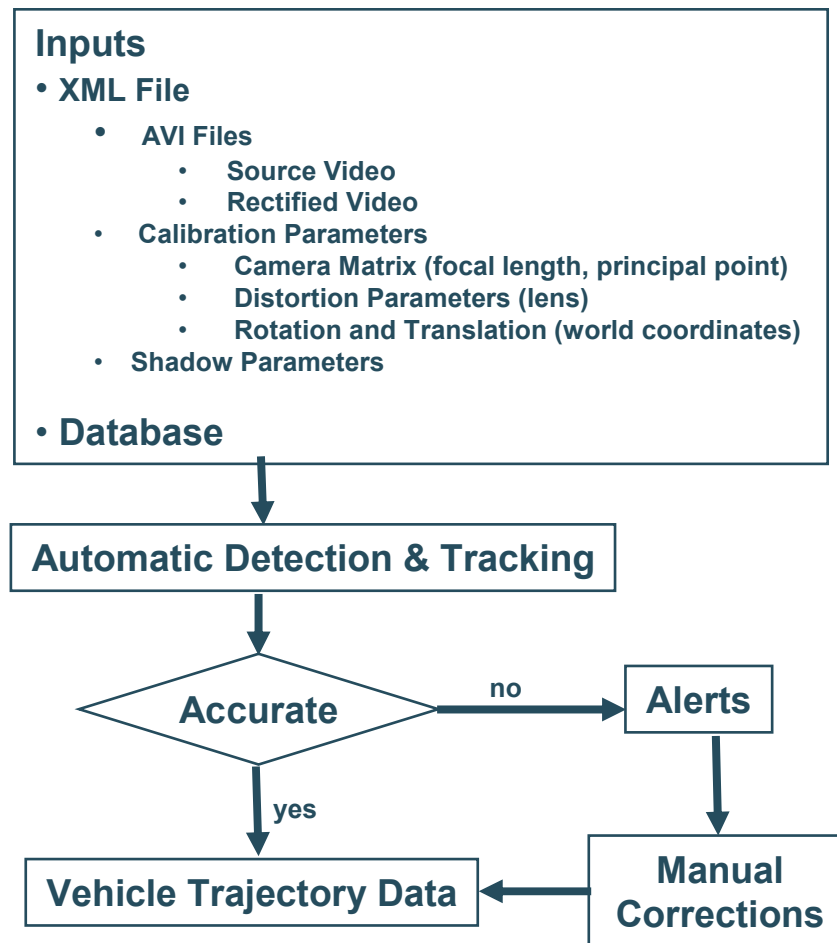


Vehicle Detection and Tracking

Vehicle trajectory data were transcribed from the video data using a customized software application developed for NGSIM. This program automatically detects and tracks most vehicles from video images and transcribes the trajectory data to a database.

The flow process for the vehicle transcription is shown in Figure 2. The software detects vehicles in a user-defined detection zone, which is usually set in the camera that is looking straight down from the building, and then tracks vehicles both upstream and downstream from the point of detection. Hence, vehicle tracking progress was divided into two major parts: a) forward (cameras 5, 4, 3, 2, and 1); and b) reverse (cameras 5, 6, 7, and 8).

Figure 2. Vehicle Detection and Tracking Process



Forward tracking was first performed for the data from 7:50 a.m. to 8:05 a.m. Immediately after 8:05 a.m., vehicle detection was stopped; however, to account for full vehicle trajectories, tracking continued to allow the vehicles which were already detected to be tracked completely to the end of the study area (camera 1). For reverse tracking, vehicle informa-

tion was retrieved from the database generated by the forward tracking. Thus, reverse tracking started from 8:05 a.m. and traced back to 7:50 a.m. Similar as in forward tracking, vehicles which have entered into the tracking system were tracked completely to the beginning of the study area (camera 8). Therefore, for the vehicle trajectory data of 7:50 a.m. to 8:05 a.m., the actual tracking time is from 7:49:39 a.m. to 8:05:34 a.m.

A total of 45 minutes vehicle trajectories are being processed from the video data collected on June 15, 2005. These data represent the periods from 7:50 a.m. to 8:05 a.m. (representing a transitional traffic period in the build up to congestion) and from 8:05 a.m. to 8:35 a.m. (representing primarily congested conditions). The data was divided into three 15-minute periods for processing and analysis.

Subsequent sections of this report provide analysis of the transcribed data. This report provides data analysis for the period from 7:50 a.m. to 8:05 a.m. Separate reports are available providing the same performance statistics for the remaining periods.

■ Data Analysis

Description

Flows and Time Mean Speed (TMS) are calculated at the midpoint of each study section (stretch of roadway), while Space Mean Speed (SMS) is calculated by dividing the sum of trajectory lengths traversed in a section by all the vehicles by the sum of time taken to transverse these section. Temporal variation of traffic flows during the 15-minute period is shown in Figure 3, while Figure 4 presents the variation in TMS and SMS.

$$TMS(t,s) = \frac{\sum_i v(t,s)_i}{n(t,s)} \qquad SMS(t,s) = \frac{\sum_i d(t,s)_i}{\sum_i tt(t,s)_i}$$

$TMS(t,s)$ – Time Mean Speed in section s during time period t measured at midsection;

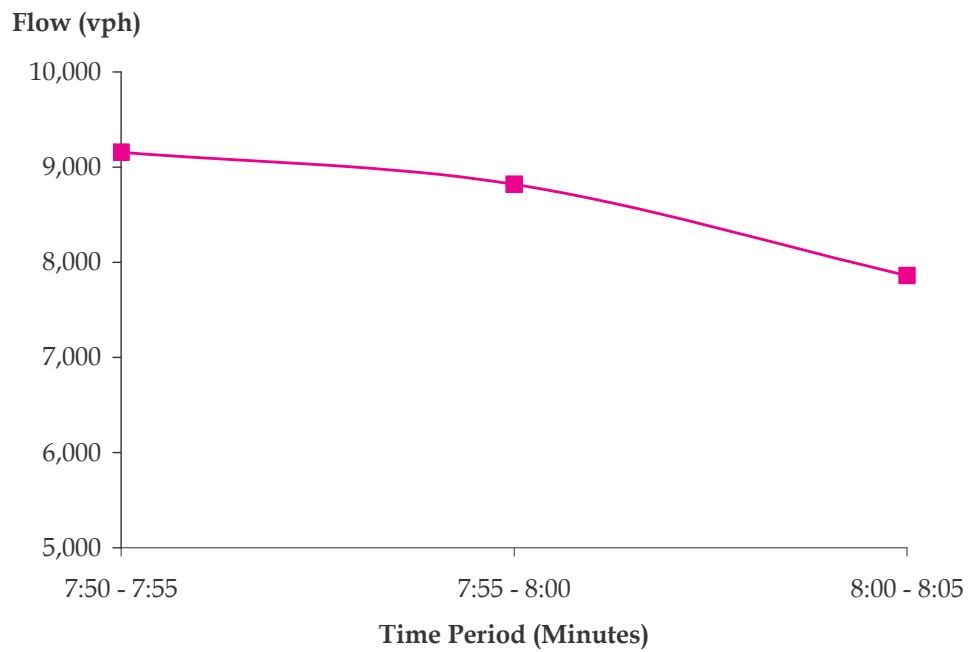
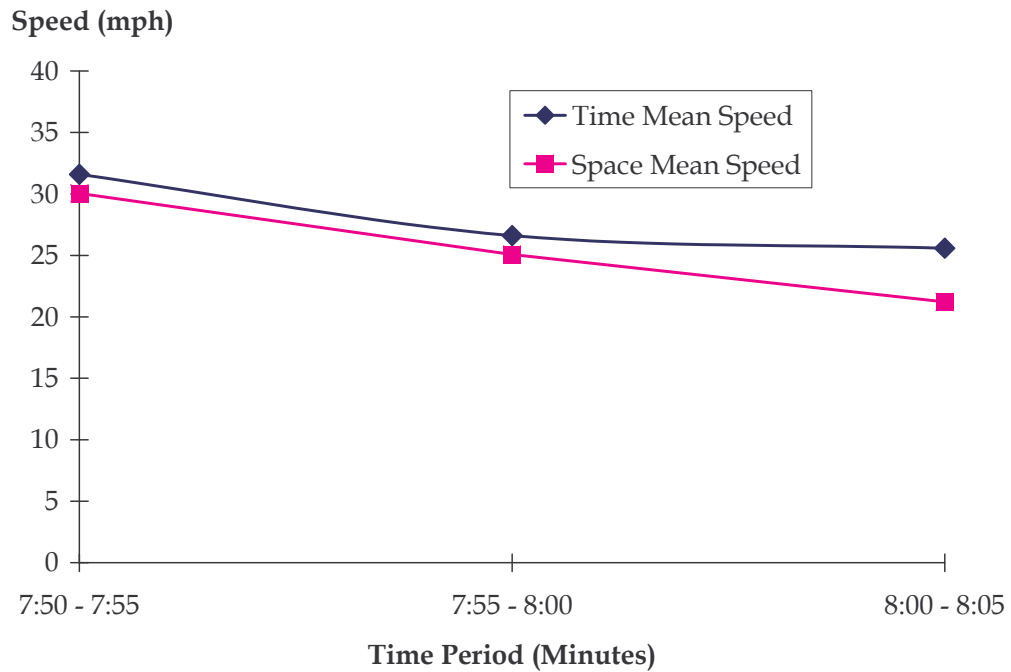
$SMS(t,s)$ – Space Mean Speed in section s during time period t ;

$v(t,s)_i$ – Instantaneous speed of a vehicle i in section s during time period t measured at midsection;

$n(t,s)$ – Number of vehicles traversing section s during time period t ;

$d(t,s)_i$ – Distance traveled by vehicle i in section s during time period t ; and

$tt(t,s)_i$ – Travel time of vehicle i in section s during time period t .

Figure 3. Flow by Time Period**Figure 4. Time Mean Speed and Space Mean Speed by Time Period**

Vehicle Type

Vehicles are classified into three categories: (1) motorcycle, (2) automobile, and (3) truck and buses. The distribution of vehicle types is shown in Table 1.

Table 1. Vehicle Type

Vehicle Type	Vehicles	Percentage
Motorcycle	30	1.4%
Automobile	2,086	96.2%
Truck and Buses	53	2.4%
Sum	2,169	100.0%

Aggregation by Time

Aggregation results by time for flow and speed are provided in Table 2.

Table 2. Aggregate Results Summary for the Entire Section

Time Period	Flow (vph)	Time Mean Speed		Space Mean Speed	
		fps	mph	fps	mph
7:50 a.m. – 7:55 a.m.	9,156	46.34	31.60	44.05	30.03
7:55 a.m. – 8:00 a.m.	8,820	39.02	26.60	36.76	25.06
8:00 a.m. – 8:05 a.m.	7,860	37.53	25.59	31.12	21.22
Average	8,612	41.16	28.06	37.63	25.66

Aggregation by Lane

Aggregation of flow and speeds were conducted for each lane as shown in Table 3.

Table 3. Aggregate Flow and Speed for Each Lane

Lane	Flow (vph)	Time Mean Speed		Space Mean Speed	
		fps	mph	fps	mph
1	1,528	34.85	23.76	31.46	21.45
2	1,676	40.08	27.33	37.32	25.45
3	1,660	40.00	27.27	39.13	26.68
4	1,620	41.98	28.62	38.53	26.27
5	1,664	43.61	29.73	40.62	27.70
Auxiliary Lane	464	58.31	39.76	54.93	37.45
Average	8,612	41.16	28.06	38.44	26.21

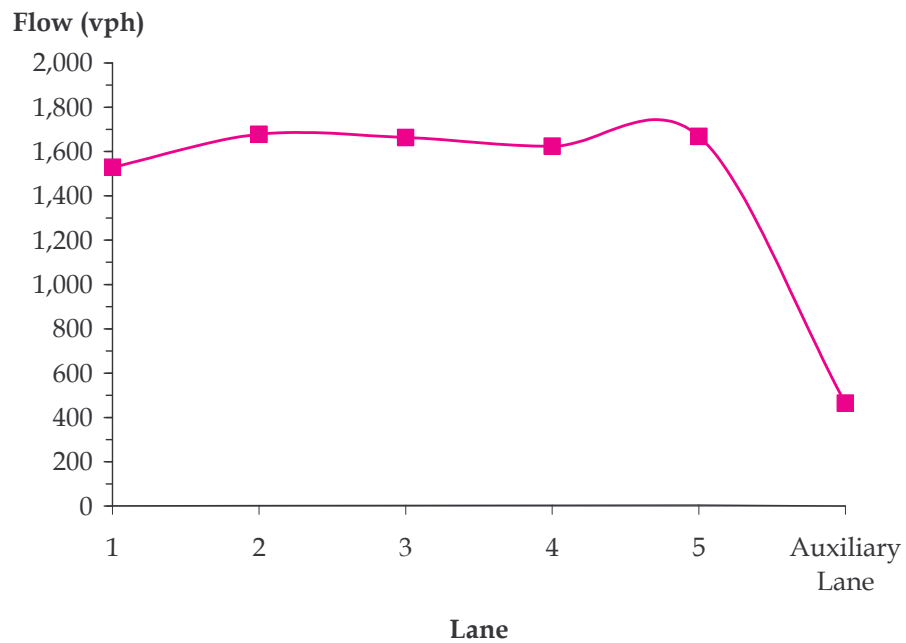
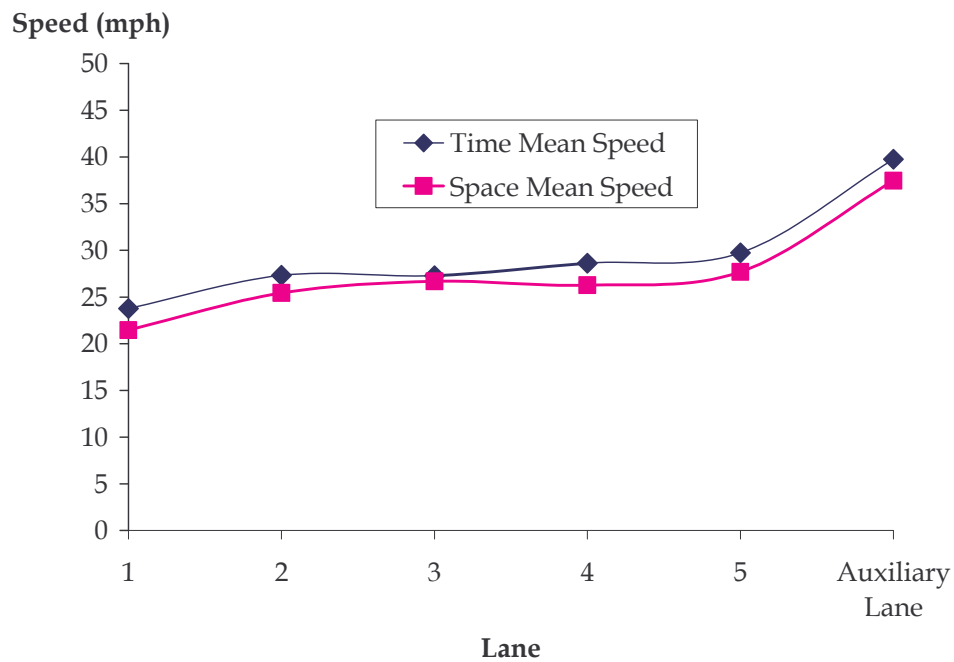
Figure 5. Flow by Lane

Figure 6. Speed by Lane

Input-Output Analysis

The following section summarizes the input-output analysis conducted on the section as shown in the tables below.

Table 4. Input-Output Analysis

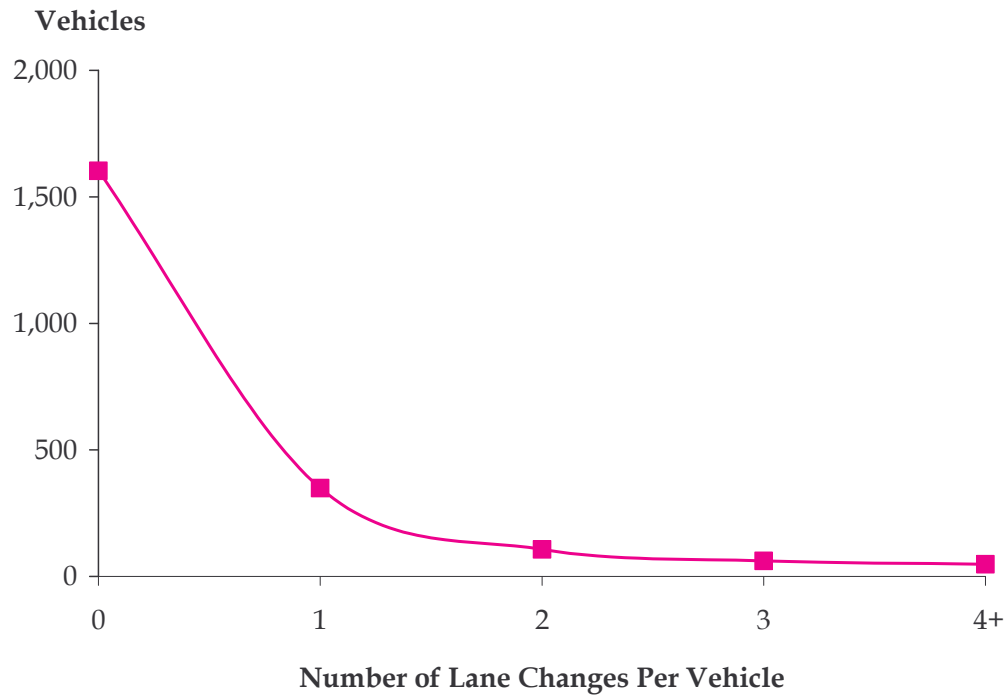
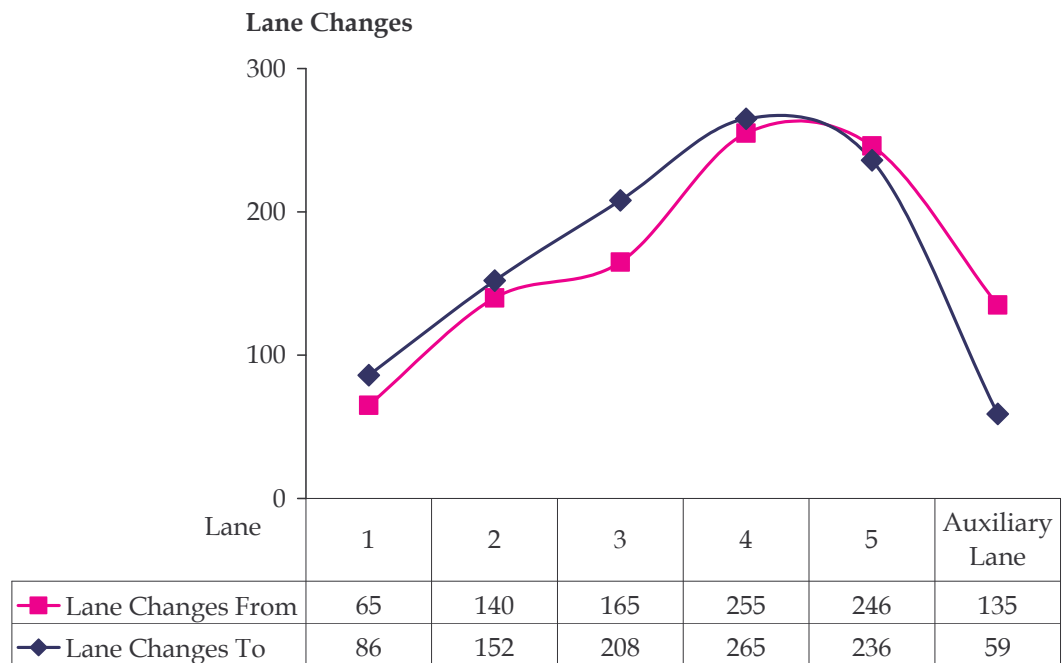
	Time Period (p.m.)					Sum	Volume (Vehicles)
	7:49:39 - 7:50	7:50 - 7:55	7:55 - 8:00	8:00 - 8:05	8:05 - 8:05:34		
On-Ramp Flow (vehicles)	4	53	41	39	0	137	
Entering - Freeway Lanes (vehicles)	27	717	710	578	0	2,032	2,169
Exiting - Freeway Lanes (vehicles)	0	746	735	655	33	2,169	2,169
Entering Vehicles	31	770	751	617	0		2,169
Exiting Vehicles	0	-746	-735	-655	-33		-2,169

Table 5. Input-Output Analysis by Lane and Time Period

		Time Period (p.m.)					Sum (Vehicles)
		7:49:39 - 7:50	7:50 - 7:55	7:55 - 8:00	8:00 - 8:05	8:05 - 8:05:34	
Vehicles Entering (Vehicles)	Lane 1	6	138	127	106	0	377
	Lane 2	6	156	141	122	0	425
	Lane 3	3	145	144	117	0	409
	Lane 4	7	137	144	120	0	408
	Lane 5	5	141	154	113	0	413
	On-Ramp	4	53	41	39	0	137
	Sum	31	770	751	617	0	2,169
Vehicles Exiting (Vehicles)	Lane 1	0	137	122	113	8	380
	Lane 2	0	155	143	134	5	437
	Lane 3	0	138	154	126	6	424
	Lane 4	0	144	139	132	8	423
	Lane 5	0	134	152	129	5	420
	Off-Ramp	0	38	25	21	1	85
	Sum	0	746	735	655	33	2,169

Lane Change Analysis

An analysis of lane changes occurring in the study area is provided here as shown in Figures 7 and 8 below.

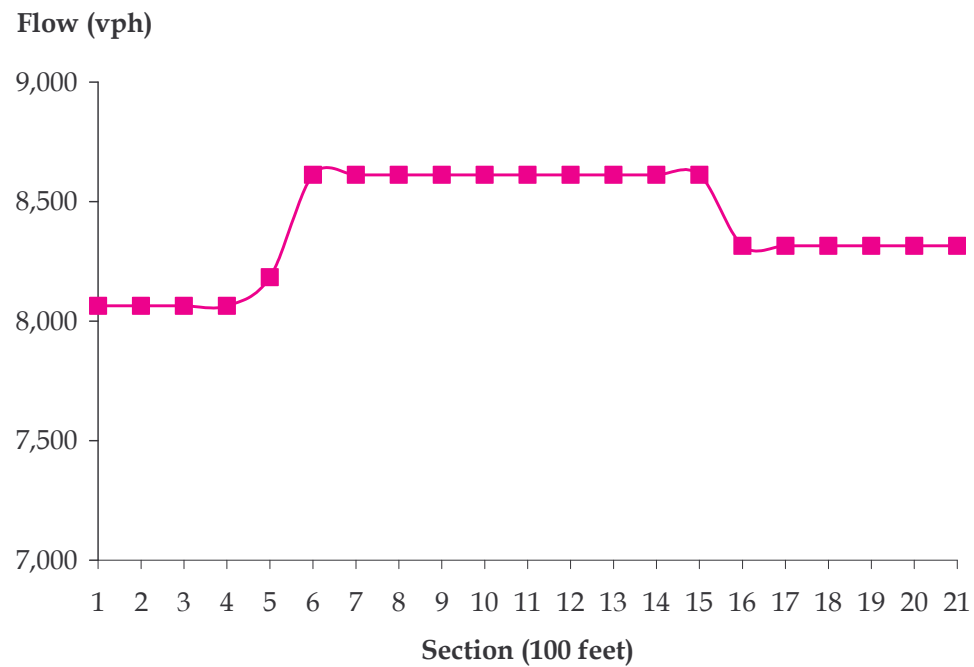
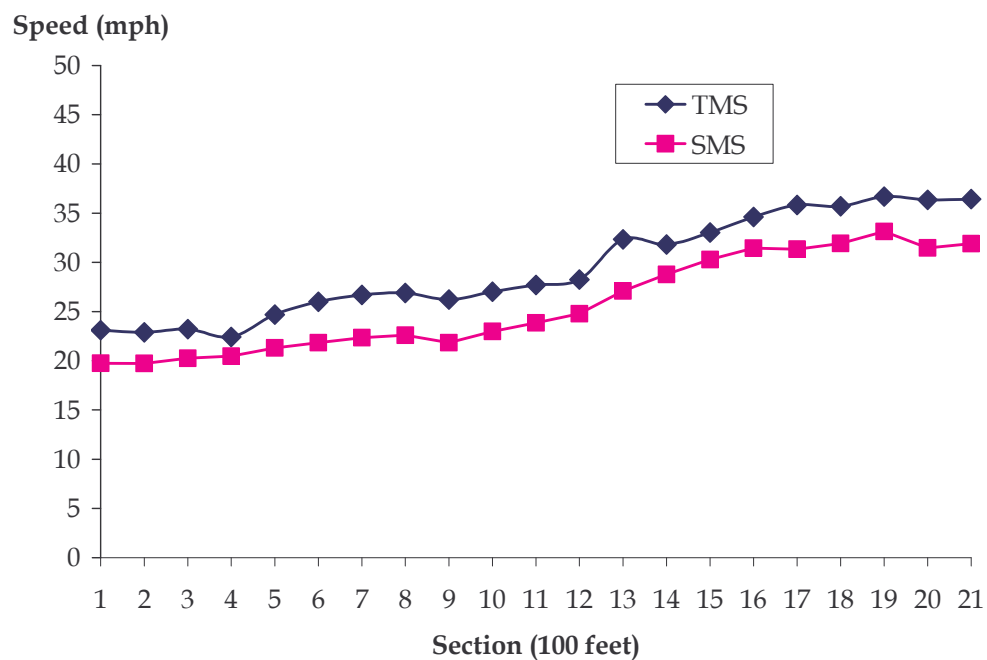
Figure 7. Lane Change Analysis**Figure 8. Number of Lane Changes by Lane**

Sectional Analysis

The data collection effort tracked vehicles over a length of 2,100 feet. Data analysis was conducted every 100 feet on the 21 sections (0'-100', 100'-200', ... 1,900'-2,000', and >2,000') in the study area and is provided in Table 6. The analysis for each section was conducted at its midpoint.

Table 6. Time Mean Speed and Space Mean Speed by Section

Id	Section	Flow (vph)	TMS		SMS	
			fps	mph	fps	mph
1	0-100'	8,064	33.89	23.11	28.96	19.75
2	100'-200'	8,064	33.58	22.90	28.93	19.73
3	200'-300'	8,064	34.06	23.22	29.72	20.26
4	300'-400'	8,064	32.89	22.43	30.04	20.48
5	400'-500'	8,182	36.22	24.70	31.26	21.31
6	500'-600'	8,612	38.14	26.00	32.03	21.84
7	600'-700'	8,612	39.15	26.69	32.77	22.34
8	700'-800'	8,612	39.44	26.89	33.15	22.60
9	800'-900'	8,612	38.46	26.22	32.03	21.84
10	900'-1,000'	8,612	39.63	27.02	33.70	22.98
11	1,000'-1,100'	8,612	40.63	27.70	34.98	23.85
12	1,100'-1,200'	8,612	41.43	28.25	36.36	24.79
13	1,200'-1,300'	8,612	47.43	32.34	39.74	27.10
14	1,300'-1,400'	8,612	46.67	31.82	42.21	28.78
15	1,400'-1,500'	8,612	48.45	33.03	44.43	30.29
16	1,500'-1,600'	8,316	50.75	34.60	46.13	31.45
17	1,600'-1,700'	8,316	52.54	35.82	45.97	31.34
18	1,700'-1,800'	8,316	52.36	35.70	46.82	31.92
19	1,800'-1,900'	8,316	53.81	36.69	48.61	33.14
20	1,900'-2,000'	8,316	53.31	36.35	46.15	31.47
21	>2,000'	8,316	53.44	36.44	46.80	31.91

Figure 9. Flow by Section**Figure 10. Time Mean Speed and Space Mean Speed by Section**

Analysis by Section and Time Period

Additional analysis by 100-foot sections of the study area for each five-minute period is provided below.

**Table 7. Time Mean Speed by Section and Time Period
(Feet Per Second)**

Section	Time Period (p.m.)			Average
	7:50 – 7:55	7:55 – 8:00	8:00 – 8:05	
0-100'	35.27	33.46	32.15	33.63
100'-200'	34.72	33.85	31.46	33.34
200'-300'	35.26	34.94	31.10	33.77
300'-400'	35.04	33.70	28.75	32.50
400'-500'	38.92	36.85	31.85	35.87
500'-600'	41.34	38.54	33.66	37.85
600'-700'	42.43	39.28	34.95	38.89
700'-800'	43.30	39.01	35.28	39.20
800'-900'	43.04	37.11	34.58	38.24
900'-1,000'	44.71	37.52	36.14	39.46
1,000'-1,100'	45.65	38.32	37.42	40.46
1,100'-1,200'	45.71	39.85	38.31	41.29
1,200'-1,300'	51.63	46.99	43.09	47.24
1,300'-1,400'	50.88	47.15	41.36	46.46
1,400'-1,500'	52.80	50.00	41.92	48.24
1,500'-1,600'	55.23	53.45	42.90	50.53
1,600'-1,700'	57.49	55.91	43.46	52.29
1,700'-1,800'	58.19	56.25	41.68	52.04
1,800'-1,900'	60.70	58.04	41.61	53.45
1,900'-2,000'	61.43	57.56	39.92	52.97
>2,000'	61.85	57.73	39.87	53.15
Average	47.41	44.07	37.21	42.90

**Table 8. Space Mean Speed by Section and Time Period
(Feet Per Second)**

Section	Time Period (p.m.)			Average
	7:50 – 7:55	7:55 – 8:00	8:00 – 8:05	
0-100'	33.72	29.65	29.82	31.06
100'-200'	33.79	30.27	29.36	31.14
200'-300'	34.40	32.08	29.18	31.89
300'-400'	35.38	32.79	27.16	31.78
400'-500'	36.75	33.99	27.33	32.69
500'-600'	37.54	35.42	27.51	33.49
600'-700'	37.51	36.66	27.46	33.88
700'-800'	39.03	36.71	27.09	34.28
800'-900'	39.42	35.39	27.37	34.06
900'-1,000'	40.59	34.70	27.87	34.39
1,000'-1,100'	42.90	34.99	28.80	35.56
1,100'-1,200'	43.38	37.58	29.92	36.96
1,200'-1,300'	47.02	42.88	31.53	40.48
1,300'-1,400'	49.65	46.28	32.75	42.89
1,400'-1,500'	52.29	50.05	33.04	45.13
1,500'-1,600'	54.67	53.14	33.61	47.14
1,600'-1,700'	56.01	54.67	31.78	47.49
1,700'-1,800'	57.45	55.75	32.55	48.58
1,800'-1,900'	60.71	57.86	33.69	50.75
1,900'-2,000'	60.64	54.90	30.78	48.77
>2,000'	61.35	53.70	32.07	49.04
Average	45.44	41.88	30.03	39.12

Table 9. Lane Changes by Section and Time Period

Section	Time Period (p.m.)					Sum
	7:49:39 – 7:50	7:50 – 7:55	7:55 – 8:00	8:00 – 8:05	8:05 – 8:05:34	
0-100'	0	4	4	6	0	14
100'-200'	0	8	5	8	0	21
200'-300'	1	4	4	5	0	14
300'-400'	0	7	5	7	0	19
400'-500'	0	9	10	6	0	25
500'-600'	0	11	8	3	0	22
600'-700'	1	30	21	18	0	70
700'-800'	1	33	17	25	0	76
800'-900'	1	27	19	15	0	62
900'-1,000'	0	23	14	19	1	57
1,000'-1,100'	0	30	15	19	0	64
1,100'-1,200'	0	16	8	9	0	33
1,200'-1,300'	0	15	14	19	0	48
1,300'-1,400'	0	16	9	11	0	36
1,400'-1,500'	0	8	9	10	0	27
1,500'-1,600'	0	15	15	4	1	35
1,600'-1,700'	0	12	20	11	2	45
1,700'-1,800'	0	23	13	13	2	51
1,800'-1,900'	0	25	17	18	0	60
1,900'-2,000'	0	40	26	24	3	93
>2,000'	0	56	42	29	7	134
Sum	4	412	295	279	16	1,006

Analysis by Starting Lane

The tables in this section provide number of lane changes by the starting lane of the vehicle. The starting lane of a vehicle is the lane in which the vehicle was first tracked in the northernmost section of the study area.

Table 10. Number of Vehicles by Starting Lane

Time	Starting Lane					On-Ramp	Sum
	1	2	3	4	5		
7:49:39 – 7:50	6	6	3	7	5	4	31
7:50 – 7:55	138	156	145	137	141	53	770
7:55 – 8:00	127	141	144	144	154	41	751
8:00 – 8:05	106	122	117	120	113	39	617
8:05 – 8:05:34	0	0	0	0	0	0	0
Sum	377	425	409	408	413	137	2,169

Table 11. Number of Lane Changes by Starting Lane

Time	Starting Lane					On-Ramp	Sum
	1	2	3	4	5		
7:49:39 – 7:50	0	1	1	0	1	1	4
7:50 – 7:55	31	49	50	90	68	124	412
7:55 – 8:00	17	40	61	62	46	69	295
8:00 – 8:05	23	45	32	66	46	67	279
8:05 – 8:05:34	0	6	2	3	2	3	16
Sum	71	141	146	221	163	264	1,006

Table 12. Average Lane Changes by Starting Lane

Time	Starting Lane					On-Ramp	Sum
	1	2	3	4	5		
7:49:39 – 7:50	0.00	0.17	0.33	0.00	0.20	0.25	0.16
7:50 – 7:55	0.22	0.31	0.34	0.66	0.48	2.34	0.73
7:55 – 8:00	0.13	0.28	0.42	0.43	0.30	1.68	0.54
8:00 – 8:05	0.22	0.37	0.27	0.55	0.41	1.72	0.59
8:05 – 8:05:34	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	0.19	0.33	0.36	0.54	0.39	1.93	0.46

* Average lane changes are calculated by dividing the number of lane changes (Table 11) by the number of vehicles (Table 10).

Table 13. End Lane Distribution by Starting Lane (in Vehicles)

Starting Lane	Ending Lane					Off-Ramp	Total
	1	2	3	4	5		
1	346	26	3	1	0	0	376
2	43	348	25	4	1	0	421
3	4	36	334	30	2	0	406
4	1	8	61	300	36	2	408
5	1	4	11	40	295	73	424
On-Ramp	2	11	15	43	63	0	134
Total	397	433	449	418	397	75	2,169

* End lane is the lane in which the vehicle is last tracked in the southernmost section of the study area.

Table 14. Percent End Lane Distribution by Starting Lane

Starting Lane	Ending Lane					Off-Ramp	Total
	1	2	3	4	5		
1	92.02%	6.91%	0.80%	0.27%	0.00%	0.00%	100%
2	10.21%	82.66%	5.94%	0.95%	0.24%	0.00%	100%
3	0.99%	8.87%	82.27%	7.39%	0.49%	0.00%	100%
4	0.25%	1.96%	14.95%	73.53%	8.82%	0.49%	100%
5	0.24%	0.94%	2.59%	9.43%	69.58%	17.22%	100%
On-Ramp	1.49%	8.21%	11.19%	32.09%	47.01%	0.00%	100%

Headway and Gap Analysis

Table 15 provides average headways of the vehicles in the section during the study period. Tables 16 and 17 present the accepted lead and lag gaps by vehicles during lane-changing. The results are presented by lane and for each time period, respectively.

Table 15. Average Headway by Time Period and Lane (in Seconds)

Time Period (Minutes)	Lane					Auxiliary Lane	Weighted Average
	1	2	3	4	5		
7:49:39 – 7:50	1.55	1.97	2.64	1.71	1.75	1.70	1.86
7:50 – 7:55	2.73	1.96	2.15	2.14	2.21	3.35	2.26
7:55 – 8:00	2.97	2.24	2.06	2.13	2.07	3.90	2.32
8:00 – 8:05	3.65	3.05	3.04	2.98	2.85	4.19	3.12
8:05 – 8:05:34	2.33	2.21	2.30	1.80	2.17	3.92	2.16
Weighted Average	3.13	2.46	2.45	2.44	2.39	3.71	2.59

Table 16. Average Accepted Lead and Lag Gaps During Lane Changes

From Lane	To Lane	Lead Gap (Feet)	Lag Gap (Feet)
1	2	49.59	55.31
2	1	73.14	69.33
2	3	65.53	64.92
3	2	55.73	67.10
3	4	55.67	74.26
4	3	61.33	67.74
4	5	57.88	71.65
5	4	71.21	69.63
5	Auxiliary Lane	150.75	86.68
Auxiliary Lane	5	57.41	71.16
Weighted Average		63.37	69.04

Table 17. Average Accepted Lead and Lag Gaps During Lane Changes by Time Period

	Time Period (Minutes)					Average
	7:49:39 – 7:50	7:50 – 7:55	7:55 – 8:00	8:00 – 8:05	8:05 – 8:05:34	
Lead Gap	129.32	67.47	66.29	55.24	42.92	63.37
Lag Gap	42.94	72.99	72.19	59.26	94.14	69.04