

**NGSIM U.S. 101 Data Analysis
(8:20 a.m. to 8:35 a.m.)**

**summary
report**

prepared for

Federal Highway Administration

prepared by

Cambridge Systematics, Inc.

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December 2005

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■ 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 8:20 a.m. and 8:35 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.

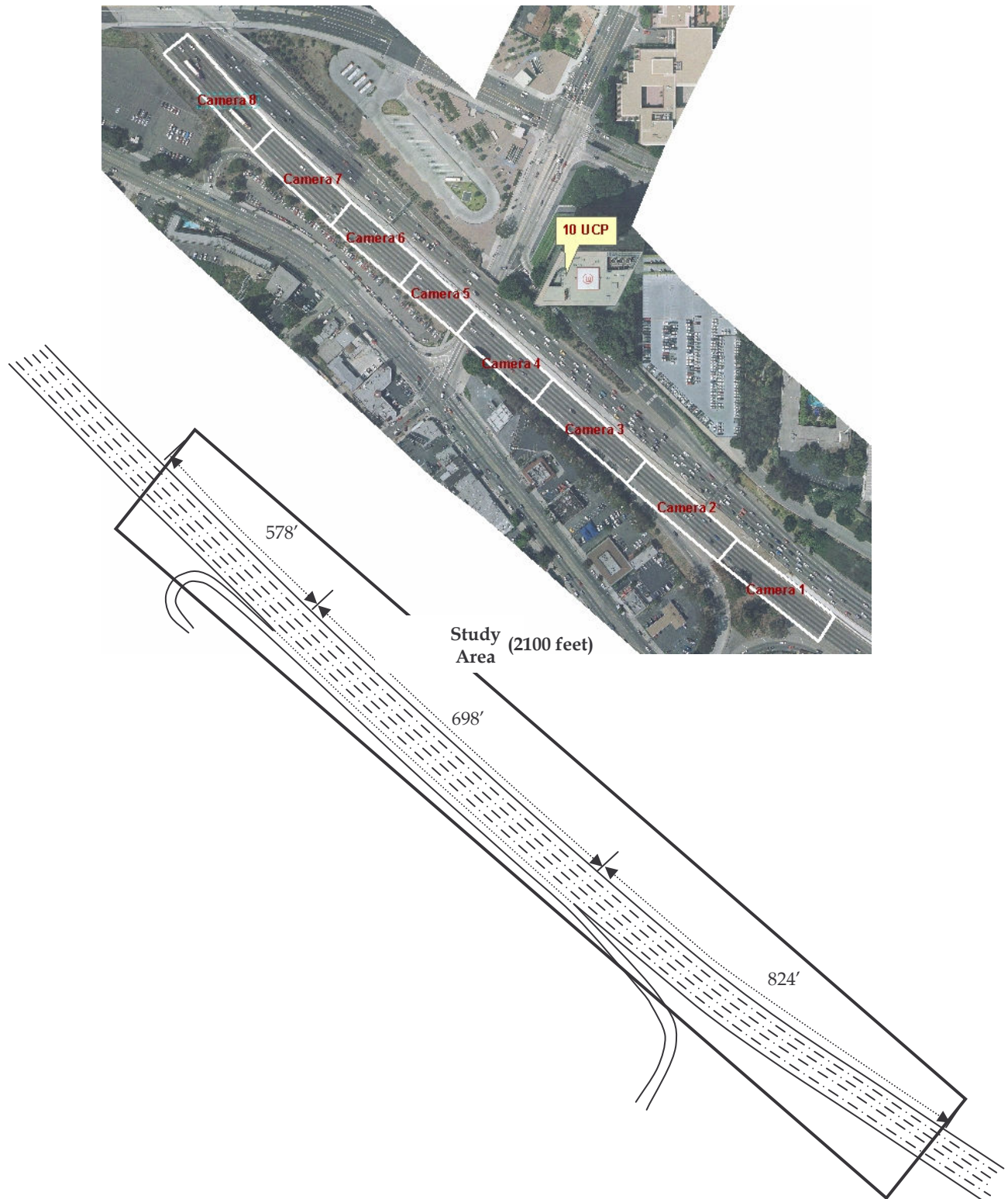
Study Area Description

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

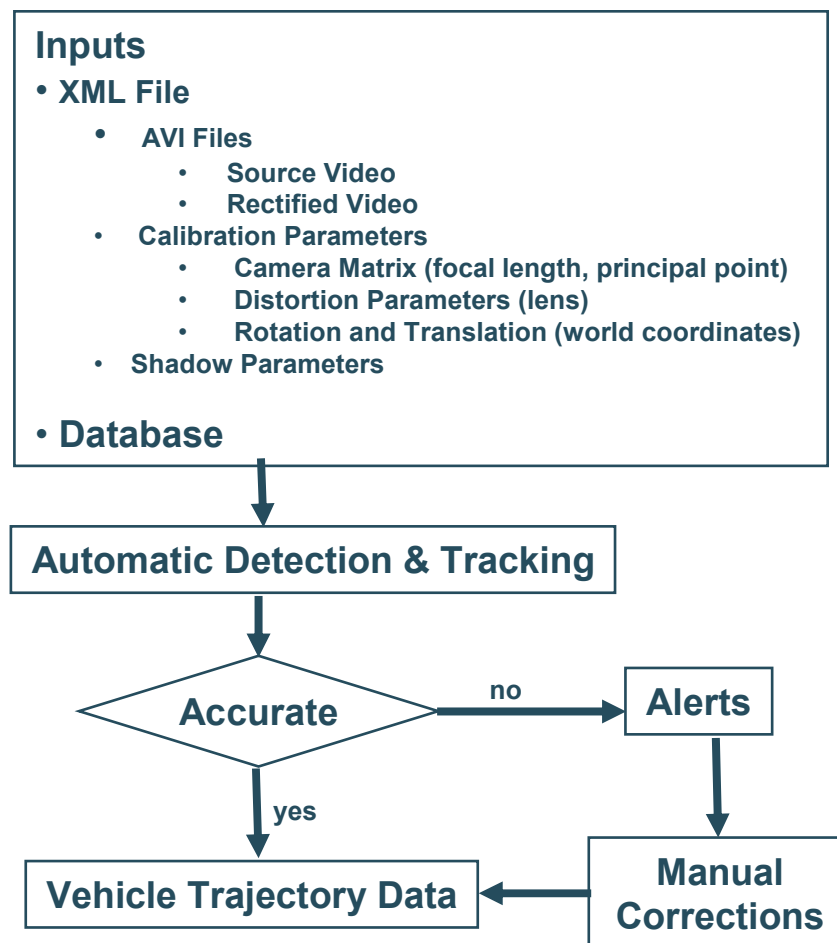


Vehicle Detection and Tracking

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 8:20 a.m. to 8:35 a.m. Immediately after 8:35 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 8:35 a.m. and traced back to 8:20 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 8:20 a.m. to 8:35 a.m., the actual tracking time is from 8:19:17 a.m. to 8:35:53 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 8:20 a.m. to 8:35 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;

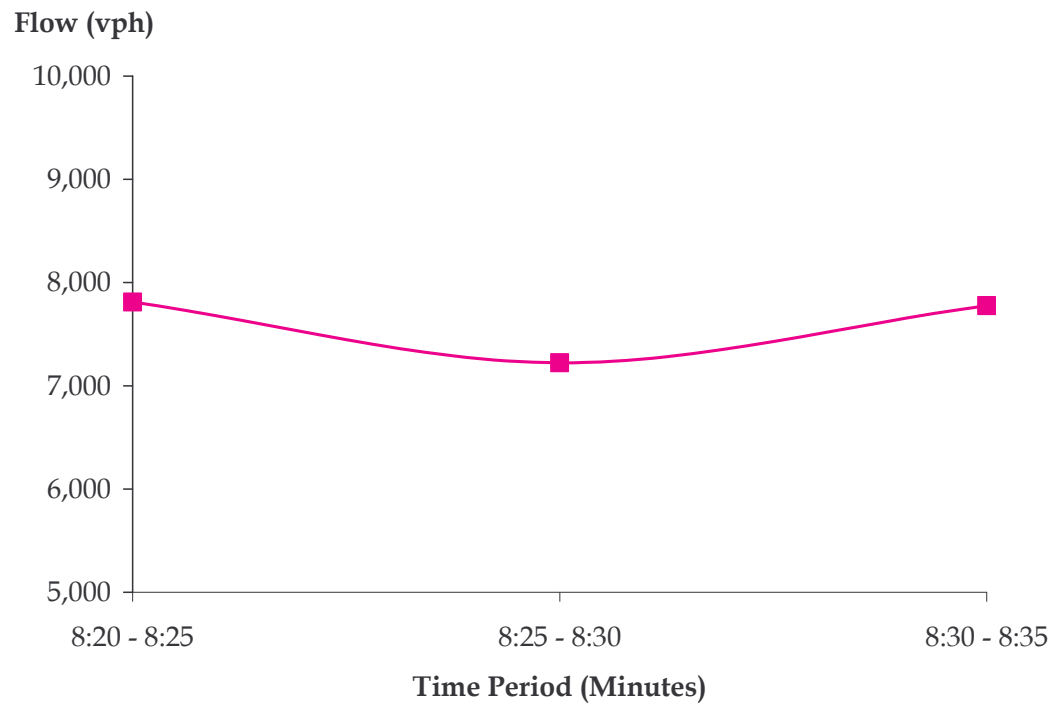
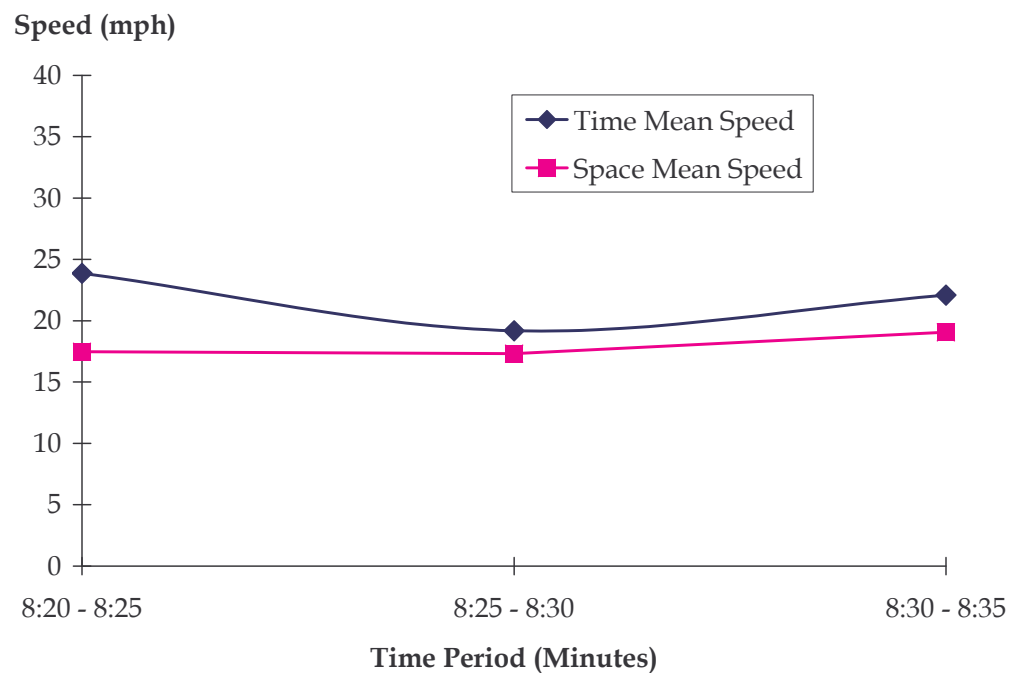
$SMS(t,s)$ – Space Mean Speed in section s during time period t ;

$v(t,s)_i$ – 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	5	0.3%
Automobile	1,870	97.6%
Truck and Buses	40	2.1%
Sum	1,915	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
8:20 a.m. – 8:25 a.m.	7,812	35.01	23.87	25.64	17.48
8:25 a.m. – 8:30 a.m.	7,224	28.14	19.19	25.38	17.30
8:30 a.m. – 8:35 a.m.	7,776	32.39	22.08	27.96	19.06
Average	7,604	31.94	21.78	26.35	17.96

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	1,394	29.36	20.02	24.04	16.39
2	1,460	30.54	20.82	24.79	16.90
3	1,390	30.42	20.74	25.04	17.07
4	1,374	31.10	21.20	24.96	17.02
5	1,490	31.76	21.65	28.68	19.55
Auxiliary Lane	496	50.52	34.45	46.37	31.62
Average	7,604	31.95	21.78	26.90	18.34

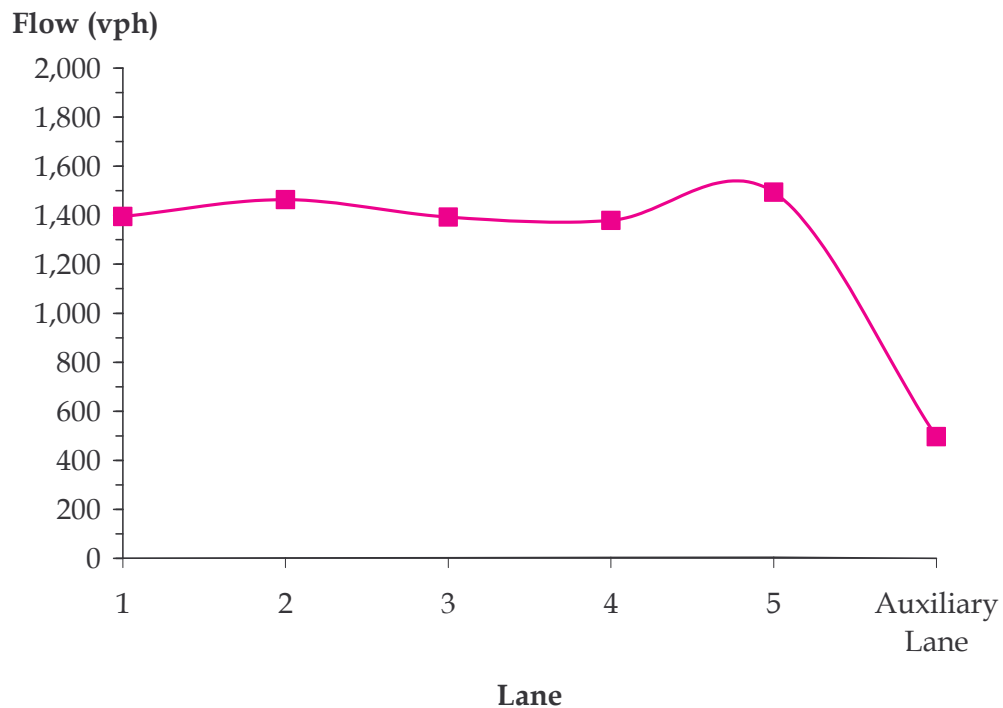
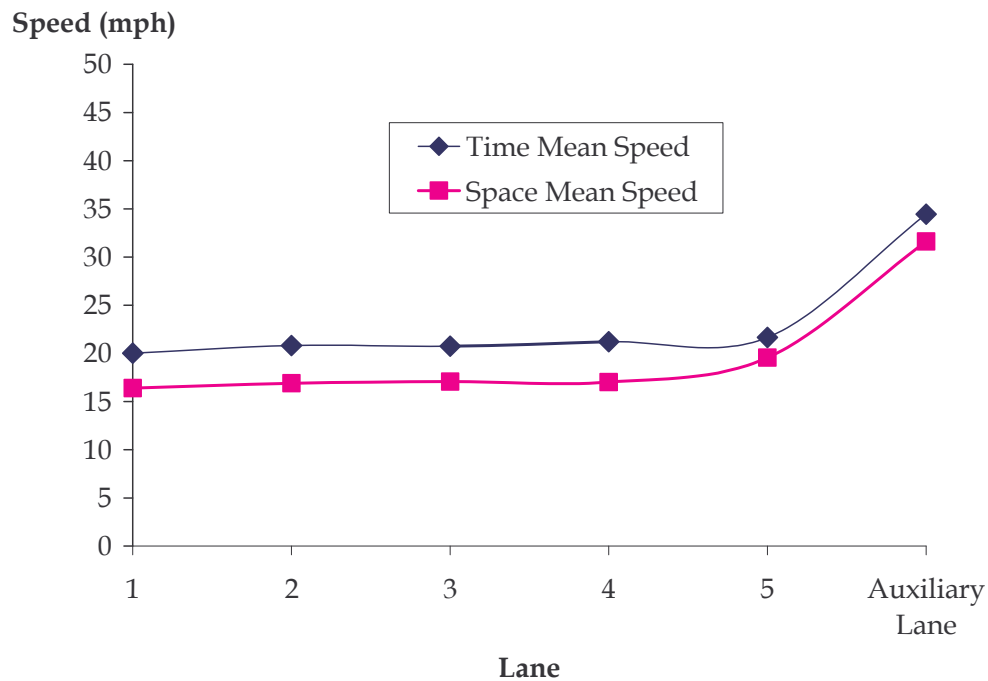
Figure 5. Flow by Lane

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

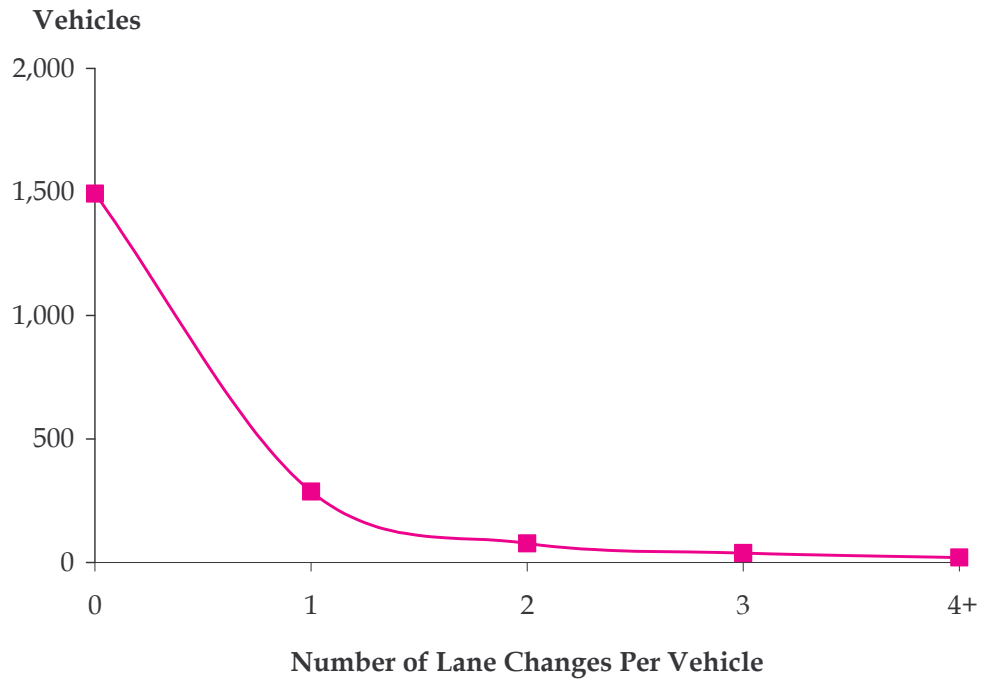
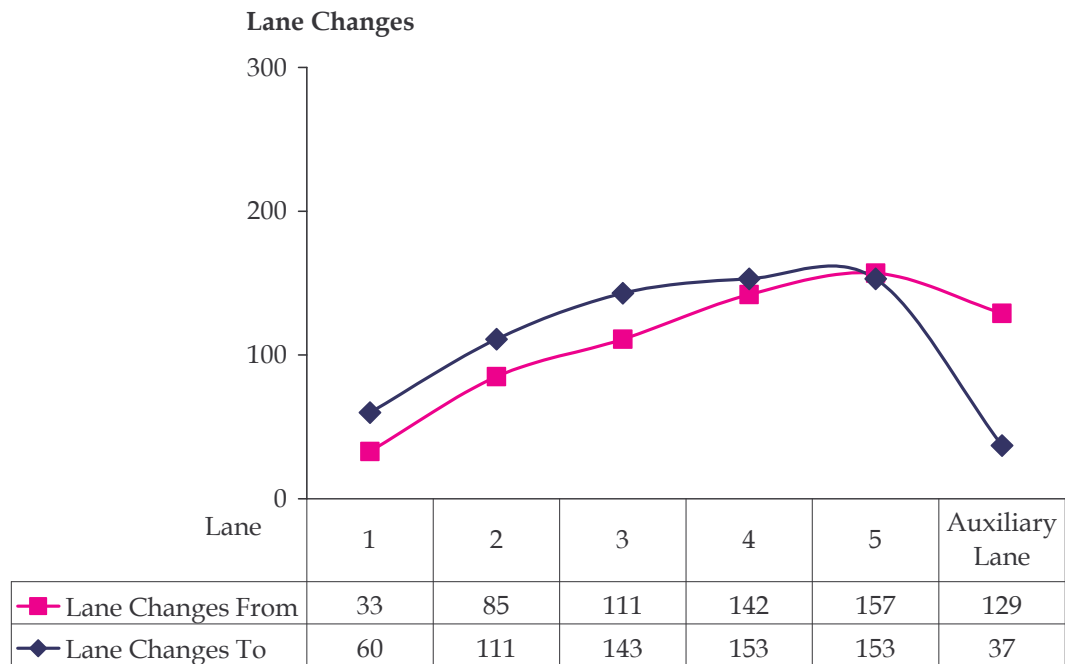
	Time Period (p.m.)					Sum	Volume (Vehicles)
	8:19:17 - 8:20	8:20 - 8:25	8:25 - 8:30	8:30 - 8:35	8:35 - 8:35:53		
On-Ramp Flow (vehicles)	2	46	52	47	0	147	
Entering - Freeway Lanes (vehicles)	33	607	562	566	0	1,768	1,915
Exiting - Freeway Lanes (vehicles)	0	632	607	634	42	1,915	1,915
Entering Vehicles	35	653	614	613	0		1,915
Exiting Vehicles	0	-632	-607	-634	-42		-1,915

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

		Time Period (p.m.)					Sum (Vehicles)
		8:19:17 - 8:20	8:20 - 8:25	8:25 - 8:30	8:30 - 8:35	8:35 - 8:35:53	
Vehicles Entering (Vehicles)	Lane 1	7	121	105	109	0	342
	Lane 2	6	124	118	121	0	369
	Lane 3	6	122	109	104	0	341
	Lane 4	7	116	114	110	0	347
	Lane 5	7	124	116	122	0	369
	On-Ramp	2	46	52	47	0	147
	Sum	35	653	614	613	0	1,915
Vehicles Exiting (Vehicles)	Lane 1	0	119	108	111	7	345
	Lane 2	0	128	122	128	8	386
	Lane 3	0	121	113	117	10	361
	Lane 4	0	108	120	119	8	355
	Lane 5	0	122	119	138	8	387
	Off-Ramp	0	34	25	21	1	81
	Sum	0	632	607	634	42	1,915

Lane Change Analysis

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

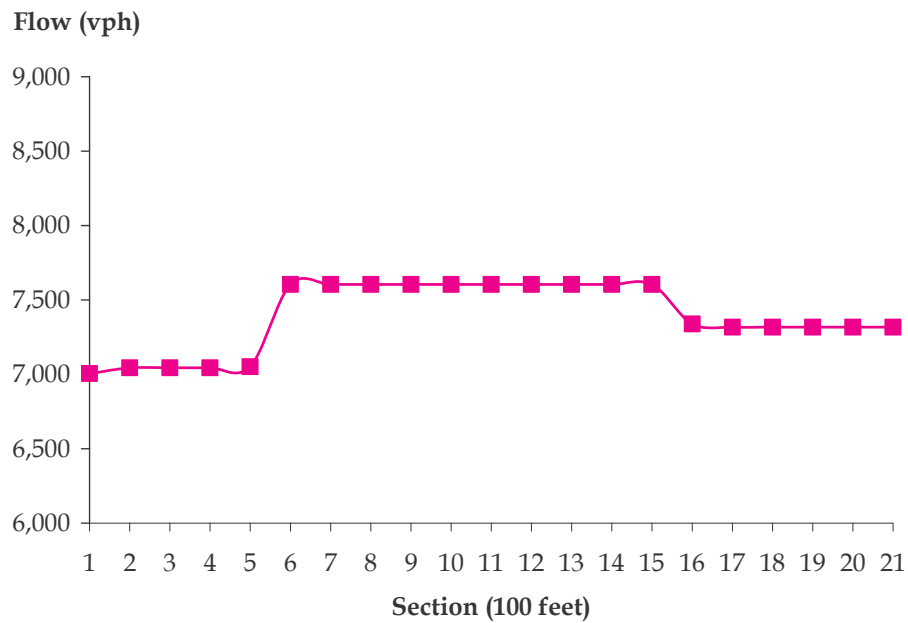
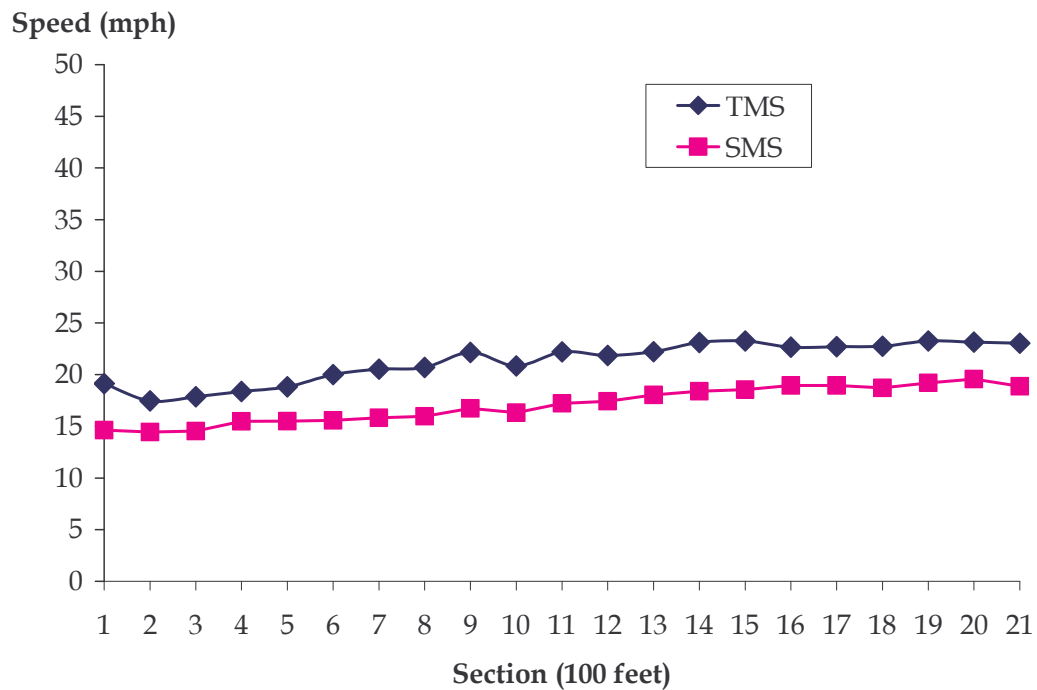
Figure 7. Lane Change Analysis**Figure 8. Number of Lane Changes by Lane**

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'	7,004	28.07	19.14	21.44	14.62
2	100'-200'	7,044	25.60	17.45	21.19	14.45
3	200'-300'	7,044	26.19	17.86	21.33	14.54
4	300'-400'	7,044	26.93	18.36	22.71	15.48
5	400'-500'	7,052	27.60	18.82	22.73	15.50
6	500'-600'	7,604	29.35	20.01	22.84	15.57
7	600'-700'	7,604	30.10	20.52	23.21	15.83
8	700'-800'	7,604	30.36	20.70	23.42	15.97
9	800'-900'	7,604	32.48	22.15	24.54	16.73
10	900'-1,000'	7,604	30.56	20.84	23.94	16.32
11	1,000'-1,100'	7,604	32.56	22.20	25.27	17.23
12	1,100'-1,200'	7,604	32.07	21.87	25.55	17.42
13	1,200'-1,300'	7,604	32.58	22.21	26.46	18.04
14	1,300'-1,400'	7,604	33.89	23.11	26.96	18.38
15	1,400'-1,500'	7,604	34.11	23.26	27.20	18.55
16	1,500'-1,600'	7,338	33.23	22.66	27.80	18.95
17	1,600'-1,700'	7,316	33.31	22.71	27.80	18.95
18	1,700'-1,800'	7,316	33.36	22.75	27.45	18.72
19	1,800'-1,900'	7,316	34.12	23.26	28.16	19.20
20	1,900'-2,000'	7,316	33.96	23.15	28.71	19.58
21	>2,000'	7,316	33.79	23.04	27.68	18.87

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
	8:20 - 8:25	8:25 - 8:30	8:30 - 8:35	
0-100'	28.08	28.57	27.88	28.18
100'-200'	25.62	26.49	25.06	25.72
200'-300'	26.67	26.80	25.66	26.38
300'-400'	28.38	26.48	26.28	27.05
400'-500'	28.82	26.66	27.35	27.61
500'-600'	30.37	28.03	29.54	29.31
600'-700'	31.38	28.23	30.57	30.06
700'-800'	32.67	27.65	30.55	30.29
800'-900'	35.53	29.32	32.33	32.39
900'-1,000'	33.48	27.08	30.91	30.49
1,000'-1,100'	35.49	29.22	32.96	32.56
1,100'-1,200'	34.65	29.43	32.40	32.16
1,200'-1,300'	34.64	30.22	33.29	32.72
1,300'-1,400'	35.55	31.61	35.03	34.06
1,400'-1,500'	36.15	32.57	34.39	34.37
1,500'-1,600'	34.85	32.68	32.80	33.44
1,600'-1,700'	34.94	32.56	32.70	33.40
1,700'-1,800'	34.95	32.08	33.01	33.35
1,800'-1,900'	36.54	32.24	33.33	34.04
1,900'-2,000'	37.13	31.29	32.97	33.80
>2,000'	37.12	30.33	32.97	33.47
Average	33.00	29.50	31.05	31.18

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

Section	Time Period (p.m.)			Average
	8:20 - 8:25	8:25 - 8:30	8:30 - 8:35	
0-100'	20.79	26.71	21.03	22.84
100'-200'	20.49	26.54	21.68	22.90
200'-300'	21.09	26.83	22.30	23.41
300'-400'	23.39	26.51	23.46	24.45
400'-500'	23.16	26.08	23.14	24.13
500'-600'	23.29	25.83	23.61	24.24
600'-700'	23.39	24.93	24.70	24.34
700'-800'	23.97	23.79	24.71	24.16
800'-900'	25.06	23.82	25.41	24.76
900'-1,000'	24.24	23.01	25.13	24.13
1,000'-1,100'	25.33	23.32	27.36	25.34
1,100'-1,200'	25.90	23.64	28.80	26.11
1,200'-1,300'	26.63	24.24	33.63	28.17
1,300'-1,400'	27.46	25.40	35.39	29.42
1,400'-1,500'	26.83	25.56	34.65	29.01
1,500'-1,600'	28.11	26.44	35.59	30.05
1,600'-1,700'	28.60	26.35	36.11	30.35
1,700'-1,800'	27.90	25.88	34.24	29.34
1,800'-1,900'	29.41	26.34	32.44	29.40
1,900'-2,000'	29.95	26.85	31.54	29.45
>2,000'	29.61	25.14	29.71	28.15
Average	25.46	25.39	28.32	26.39

Table 9. Lane Changes by Section and Time Period

Section	Time Period (p.m.)					Sum
	8:19:17 - 8:20	8:20 - 8:25	8:25 - 8:30	8:30 - 8:35	8:35 - 8:35:53	
0-100'	0	3	0	0	0	3
100'-200'	1	7	6	3	0	17
200'-300'	0	8	5	3	0	16
300'-400'	0	1	5	5	0	11
400'-500'	0	6	5	13	0	24
500'-600'	1	1	6	3	0	11
600'-700'	1	9	13	1	0	24
700'-800'	1	20	21	25	0	67
800'-900'	0	20	22	24	0	66
900'-1,000'	0	8	15	11	0	34
1,000'-1,100'	0	17	20	16	1	54
1,100'-1,200'	0	19	11	14	1	45
1,200'-1,300'	0	14	17	13	0	44
1,300'-1,400'	0	12	12	13	1	38
1,400'-1,500'	0	10	9	8	0	27
1,500'-1,600'	0	9	8	14	1	32
1,600'-1,700'	0	5	9	9	0	23
1,700'-1,800'	0	5	10	8	1	24
1,800'-1,900'	0	13	9	5	1	28
1,900'-2,000'	0	5	9	7	0	21
>2,000'	0	17	12	17	2	48
Sum	4	209	224	212	8	657

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		
8:19:17 – 8:20	7	6	6	7	7	2	35
8:20 - 8:25	121	124	122	116	124	46	653
8:25 - 8:30	105	118	109	114	116	52	614
8:30 - 8:35	109	121	104	110	122	47	613
8:35 - 8:35:53	0	0	0	0	0	0	0
Sum	342	369	341	347	369	147	1,915

Table 11. Number of Lane Changes by Starting Lane

Time	Starting Lane					On-Ramp	Sum
	1	2	3	4	5		
8:19:17 – 8:20	0	0	0	1	3	0	4
8:20 - 8:25	28	18	28	43	31	61	209
8:25 - 8:30	11	17	27	39	43	87	224
8:30 - 8:35	13	26	21	31	46	75	212
8:35 - 8:35:53	0	1	1	1	1	4	8
Sum	52	62	77	115	124	227	657

Table 12. Average Lane Changes by Starting Lane

Time	Starting Lane					On-Ramp	Sum
	1	2	3	4	5		
8:19:17 – 8:20	0.00	0.00	0.00	0.14	0.43	0.00	0.10
8:20 - 8:25	0.23	0.15	0.23	0.37	0.25	1.33	0.43
8:25 - 8:30	0.10	0.14	0.25	0.34	0.37	1.67	0.48
8:30 - 8:35	0.12	0.21	0.20	0.28	0.38	1.60	0.47
8:35 - 8:35:53	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	0.15	0.17	0.23	0.33	0.34	1.54	0.34

* 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	322	13	2	3	0	0	340
2	33	319	12	2	1	0	367
3	5	38	278	15	2	0	338
4	3	12	46	273	12	3	349
5	1	3	12	32	264	68	380
On-Ramp	3	8	20	35	74	1	141
Total	367	393	370	360	353	72	1,915

* 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	94.71%	3.82%	0.59%	0.88%	0.00%	0.00%	100%
2	8.99%	86.92%	3.27%	0.54%	0.27%	0.00%	100%
3	1.48%	11.24%	82.25%	4.44%	0.59%	0.00%	100%
4	0.86%	3.44%	13.18%	78.22%	3.44%	0.86%	100%
5	0.26%	0.79%	3.16%	8.42%	69.47%	17.89%	100%
On-Ramp	2.13%	5.67%	14.18%	24.82%	52.48%	0.71%	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		
8:19:17 – 8:20	3.75	2.76	2.60	2.65	2.25	1.20	2.92
8:20 – 8:25	3.20	3.44	2.81	3.35	3.09	3.55	3.19
8:25 – 8:30	3.59	3.26	3.10	3.83	3.10	4.05	3.39
8:30 – 8:35	3.22	3.38	3.81	3.04	2.39	4.12	3.20
8:35 – 8:35:53	2.85	4.55	3.25	2.58	3.10	N/A	3.34
Weighted Average	3.34	3.38	3.24	3.41	2.88	3.87	3.26

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

From Lane	To Lane	Lead Gap (Feet)	Lag Gap (Feet)
1	2	35.11	37.18
2	1	43.57	58.41
2	3	46.70	43.96
3	2	36.40	50.91
3	4	44.78	55.32
4	3	39.57	53.18
4	5	51.51	47.82
5	4	40.92	45.60
5	Auxiliary Lane	122.36	83.42
Auxiliary Lane	5	35.66	41.25
Weighted Average		41.13	48.65

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

	Time Period (Minutes)					Average
	8:19:17 – 8:20	8:20 – 8:25	8:25 – 8:30	8:30 – 8:35	8:35 – 8:35:53	
Lead Gap	15.52	44.68	39.45	40.22	32.16	41.13
Lag Gap	33.16	48.07	49.86	47.66	61.44	48.65