EVALUATION OF THE LICENSE PLATE RECOGNITION SYSTEM

1. Overview of the License Plate Recognition System

The main function of the license plate recognition (LPR) system is to identify the entry and exit times of vehicles traveling through a targeted highway segment (e.g., Figure 1-1), based on license plate images captured by the system. These images along with the associated data strings (i.e., time, date, and license plate number) are then encrypted and sent to a central processing computer for travel time estimation and prediction.

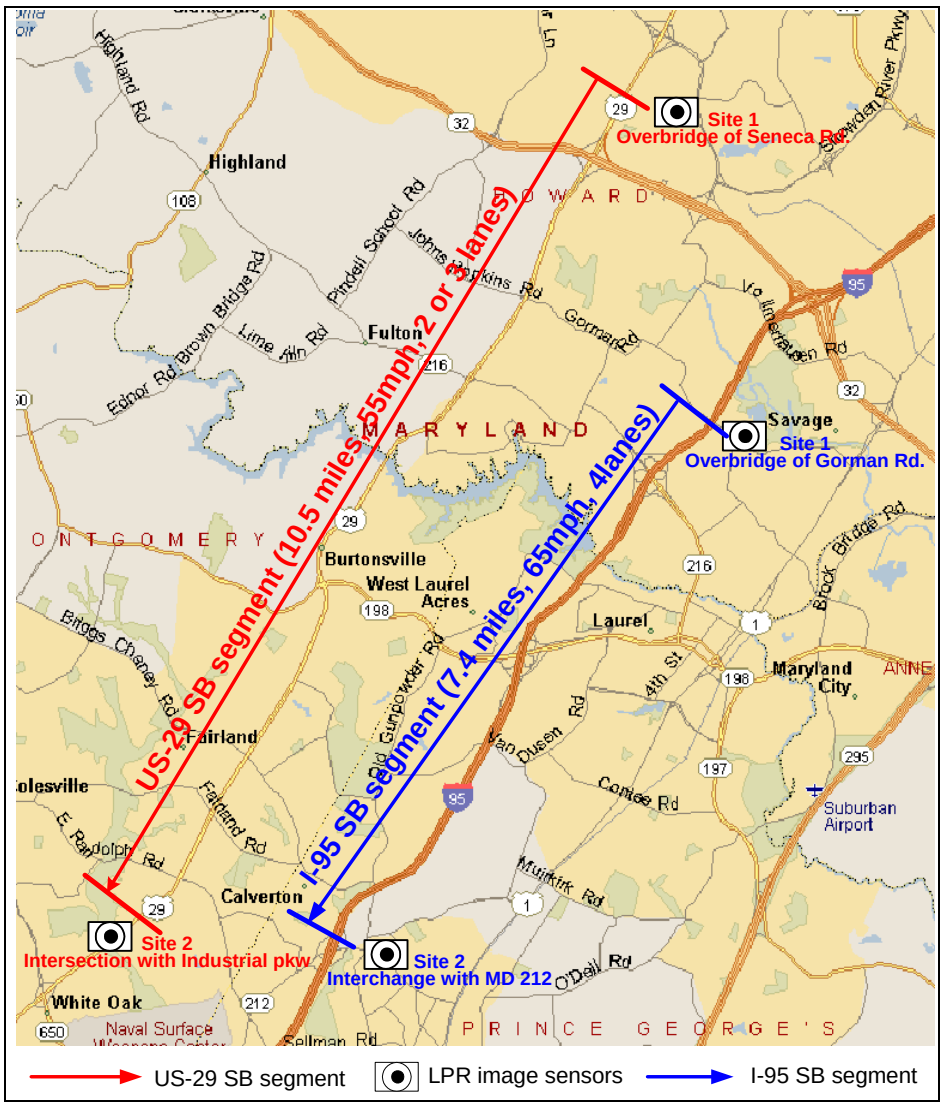


Figure 1-1: LPR deployment sites

1.1 LPR system deployment

The LPR system tested by MSHA (Maryland State Highway Administration) and ADDCO Association Inc. was deployed on a segment of I-95 SB and a segment of US-29 SB (see Figure 1-1).

The targeted segment of I-95 SB stretches 7.4 miles, as shown in Figure 1-2, and has four lanes on its mainline, but only two lanes (Lanes 1 and 2) were covered by LPR cameras. Figure 1-3 illustrates the targeted US-29 SB site, which is about 10.5 miles along. All its travel lanes were covered by the LPR system.

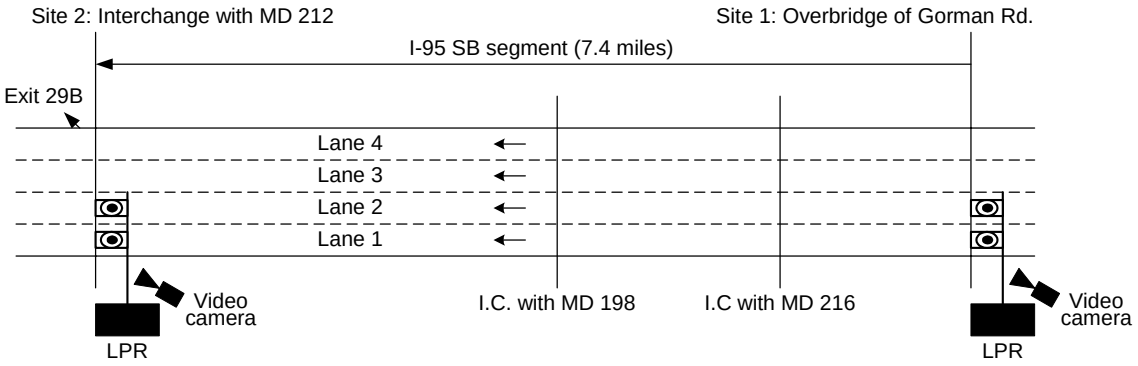


Figure 1-2: Deployment of LPR system on I-95 SB segment

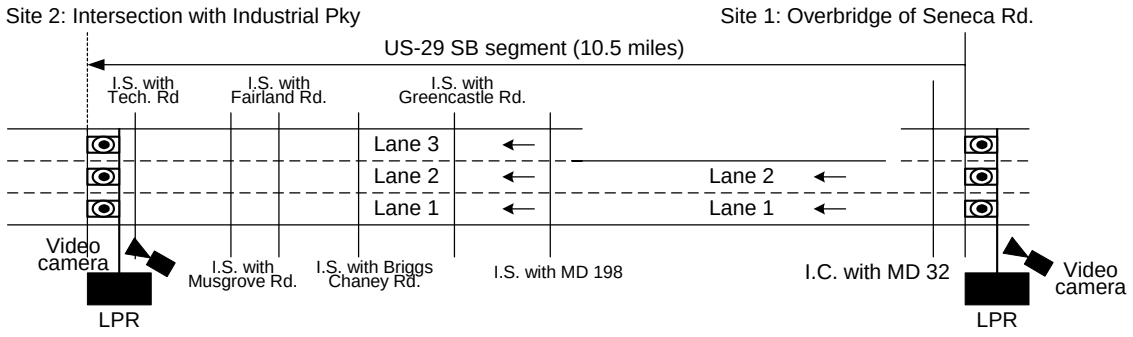


Figure 1-3: Deployment of LPR system on US-29 SB segment

2. Data Collection Summary

2.1 Data collection design

To obtain reliable travel time data, the research team took the following steps:

- Step-1: Select a fleet of probe vehicles whereby each vehicle departs every 10 to 15 minutes over the targeted highway segment.
- Step-2: Create a time-series database of travel times based on data recorded by each probe vehicle during experimental runs on each highway segment (Site 1 and Site 2, see Figure 1-2 and 1-3).
- Step-3: Repeat the above two steps at different peak periods and under various weather and traffic conditions.

In addition, the team used video camcorders to collect traffic volume data at locations outfitted with the LPR system (See Figures 1-2 and 1-3).

2.2 Data collection summary

Most of the surveys were conducted during morning peak hours to evaluate the LPR system's performance under fluctuating traffic conditions. Table 2-1 displays a schedule of dates when travel times and traffic volumes were collected:

Table 2-1: Dates of data collection

Peak periods *	Travel time data		Traffic volume data	
	I-95	US-29	I-95	US-29
Morning Peak (MP)	11/18/04 11/19/04 11/23/04 11/30/04 12/02/04	12/21/04 12/22/04 01/05/05 01/06/05 01/07/05	11/18/04 (Sites 1&2) 11/19/04 (Sites 1&2) 11/23/04 (Sites 1&2) 11/30/04 (Sites 2) 12/02/04 (Sites 2)	12/13/04 (Sites 1) 12/14/04 (Sites 2) 12/15/04 (Sites 1) 12/16/04 (Sites 2) 12/17/04 (Sites 1)
Evening Peak (EP)		12/20/04		

Note (*): MP - 06:00AM to 10:00AM, EP - 15:00PM to 19:00PM

3. LPR System Evaluation Criteria

Evaluation of the LPR system focused on the following critical issues:

- The number of vehicles captured by the LPR system, defined as "**capture-ability**", under various traffic conditions;
- The number of correctly recognized license plates, defined as the **recognition rate** of the LPR system; and
- **Performance accuracy**, defined as the ratio between the number of actual sample travel times and the correctly predicted travel times provided by the LPR system.

4. LPR Reliability Evaluation

Analysis of each collected data set yields the following information:

- *Traffic and environmental conditions:* includes work zone activities, weather conditions, accidents or not, and a brief description of traffic flow conditions.
- *System capture-ability:* the ratio between the number of vehicle images captured by the system in relation to the observed volume.
- *System recognition rate:* the ratio between the identifiable license plate numbers to the total license plate numbers captured by the LPR system.

4.1 System reliability on the I-95 segment

System reliability on 11/18/04 (Thursday)

Traffic and Environmental conditions

- Weather: sunny (sunrise at 6:30AM)
- No work zone activities and no accidents
- Traffic conditions:
  - Traffic congestion on Site 1 at 7:10 AM, but clear by 7:50 AM.
  - Traffic congestion on Site 2 at 6:30AM, with traffic queue extending beyond Site 2 at 6:50AM, but clear by 8:20 AM.

System capture-ability

- Tables 4-1 (a) and (b) present the system's capture-ability at Site 1 (25.9 %) and at Site 2 (33.2 %), respectively.

Table 4-1(a): System capture-ability at Site 1 (6 AM to 10 AM, 11/18/04)

	Volume count(veh/5min)			Captured volume (veh/5min)	
	Cars	Trucks	Total (A)	# of captured vehicles (B)	Capture-ability, (B/A)*100
Ave.	286	20	305	78	25.9 %
Min	186	10	208	51	14.0 %
Max	389	36	412	132	41.8 %

Table 4-1(b): System capture-ability at Site 2 (6 AM to 10 AM, 11/18/04)

	Volume count (veh/5min)			Captured volume (veh/5min)	
	Cars	Trucks	Total (A)	# of captured vehicles (B)	Capture-ability, (B/A)*100
Ave	226	21	247	78	33.2 %
Min	151	10	176	39	10.5 %
Max	343	38	381	148	63.2 %

- Figures 4-1 (a) and (b), respectively, show the actual volume count by vehicle type (car or truck) compared to vehicle images captured by LPR at an interval of 5 minutes over the entire observation period.
- As shown in Figure 4-1(b), it appears that the LPR system performs better at capturing the license plate images when traffic flows are moving at relatively lower speeds.

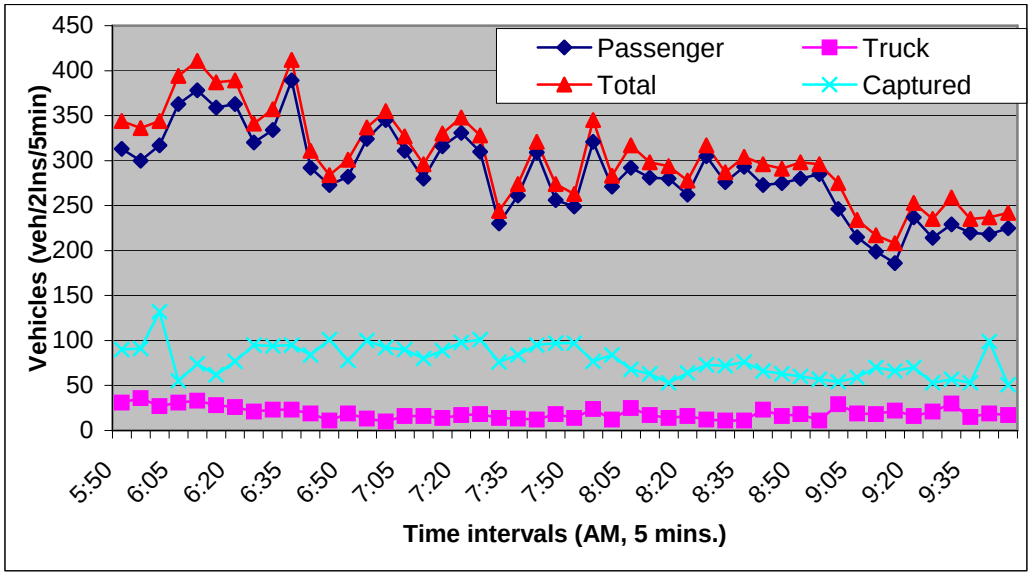


Figure 4-1(a)**:** Comparison of actual volume and LPR captured images at Site 1 (11/18/04)

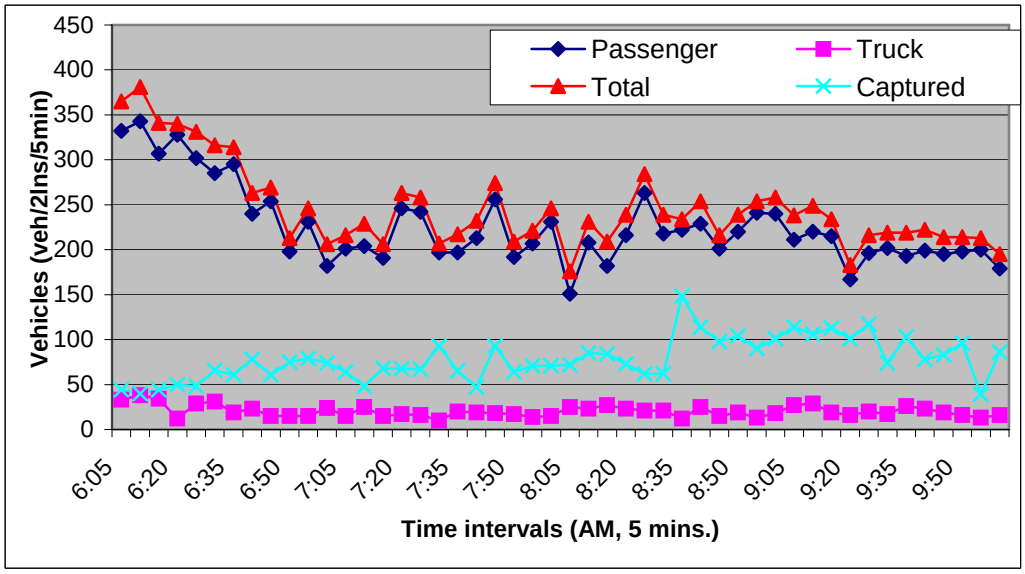


Figure 4-1(b): Comparison of actual volume and LPR captured images at Site 2 (11/18/04)

System reliability on 11/19/04 (Friday)

Traffic and environmental conditions

- Weather: cloudy
- No work zone activities and no accidents
- Traffic conditions:
  - No traffic congestion on Site 1
  - Moderate congestion on Site 2 at 6:50 AM, but clearing quickly.

System capture-ability

- Tables 4-2 (a) and (b) present the system capture-ability at Site 1 (25.9 %) and at Site 2 (21.1 %), respectively. Figures 4-2 (a) and (b), respectively, illustrate the actual volume versus captured vehicle images over the two sites.

Table 4-2(a)**:** System capture-ability at Site 1 (6AM to 10AM, 11/19/04)

	Volume count (veh/5min)			Captured volume (veh/5min)	
	Cars	Trucks	Total (A)	# of captured vehicles (B)	Capture-ability, (B/A)*100
Ave.	295	18	313	79	25.9 %
Min	108	8	118	47	15.3 %
Max	380	34	402	153	52.5 %

Table 4-2(b): System capture-ability at Site 2 (6AM to 10AM, 11/19/04)

	Volume count (veh/5min)			Captured volume (veh/5min)	
	Cars	Trucks	Total (A)	# of captured vehicles (B)	Capture-ability, (B/A)*100
Ave	247	22	269	56	21.1 %
Min	191	9	206	26	8.5 %
Max	327	36	357	110	45.8 %

- Note that capture-ability at Site 2 on 11/18/04 (33.2 %) is lower than that on 11/19/04 (21.1 %) because no congestion occurred during the observation period at Site 2 on 11/19/04.

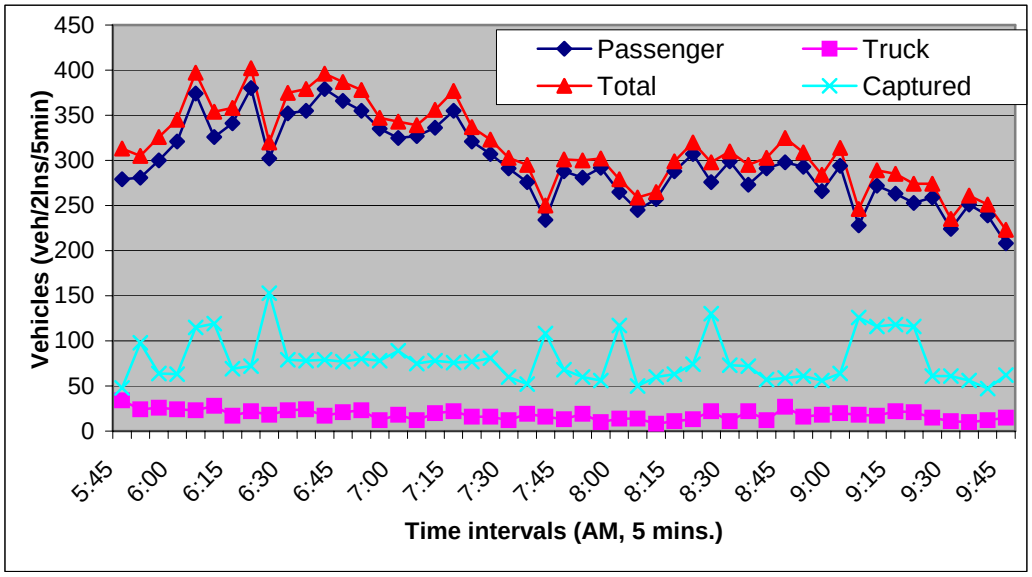


Figure 4-2(a)**:** Comparison of actual volume and LPR captured images at Site 1 (11/19/04)

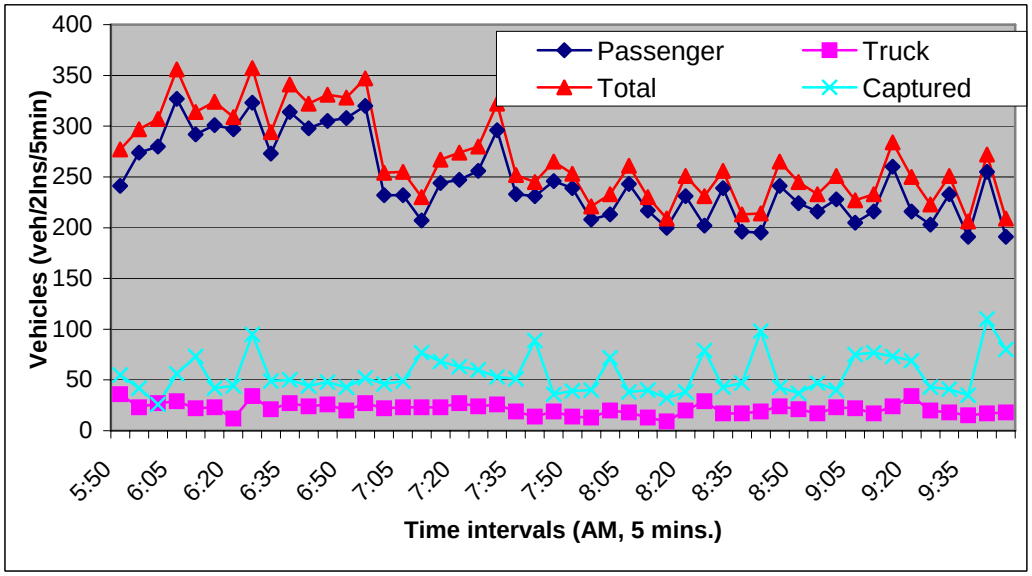


Figure 4-2(b): Comparison of actual volume and LPR captured images at Site 2 (11/19/04)

System reliability on 11/23/04 (Tuesday)

Traffic and environmental conditions

- Weather: cloudy and foggy
- No work zone activities
- Traffic accident near Exit 29 (around Site 2): left lane closed at 6:30 AM.
- Traffic conditions:
  - Moderate congestion on Site 1 between 6:50 AM and 7:30 AM
  - Traffic congestion on Site 2 began before 6:50 AM, and continued until 9:00 AM.

System capture-ability

- Tables 4-3 (a) and (b) present the system capture-ability at Site 1 and at Site 2, respectively.

Table 4-3(a): System capture-ability at Site 1 (6AM to 10AM, 11/23/04)

	Volume count (veh/5min)			Captured volume (veh/5min)	
	Cars	Trucks	Total (A)	# of captured vehicles (B)	Capture-ability, (B/A)*100
Ave.	280	19	299	75	26.1 %
Min.	171	6	179	49	14.4 %
Max.	395	39	423	167	54.2 %

Table 4-3(b): System capture-ability at Site 2 (6AM to 10AM, 11/23/04)

	Volume count (veh/5min)			Captured volume (veh/5min)	
	Cars	Trucks	Total (A)	# of captured vehicles (B)	Capture-ability, (B/A)*100
Ave.	222	23	244	99	41.7 %
Min.	113	14	130	28	9.6 %
Max.	314	46	342	233	80.8 %

- As reflected in Figures 4-3 (a) and (b), the relatively high capture-ability (41.7 %) at Site 2 was due to the nearby accident, which resulted in slow traffic flow speed. In contrast, the capture-ability (26.1 %) at Site 1 under accident-free conditions was still relatively low, and similar to that on 11/18/04 (25.9 %) and 11/19/05 (25.9 %).

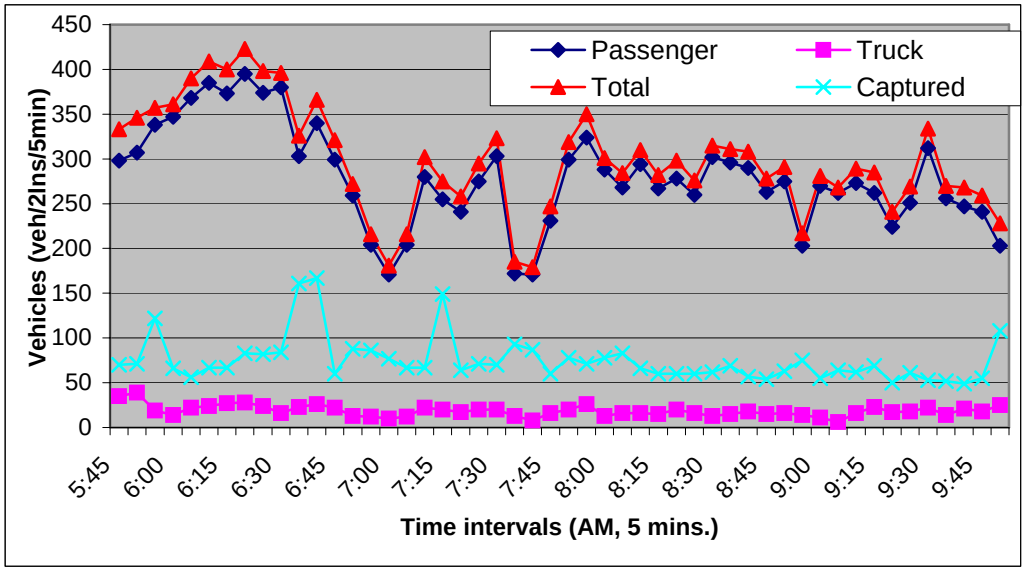


Figure 4-3(a)**:** Comparison of actual volume and LPR captured images at Site 1 (11/23/04)

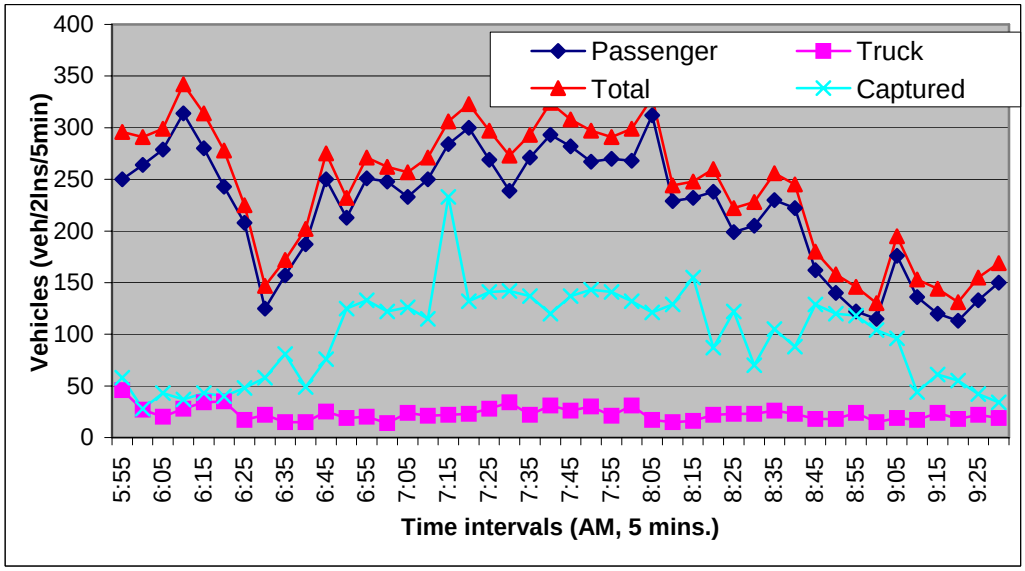


Figure 4-3(b): Comparison of actual volume and LPR captured images at Site 2 (11/23/04)

System reliability at Site 2 on 11/30/04 (Tuesday)

Traffic and environmental conditions

- Weather: sunny
- No work zone activities and no accidents
- Traffic conditions: light traffic congestion around Site 2 before 6:40AM, and around Site 1 before 7:20AM.

System capture-ability

- Table 4-4 presents the system capture-ability at Site 2, which is about 25.7 %, and similar to the results at Site 1 on 11/18/04 and 11/19/04. Figure 4-4 shows the corresponding traffic flow patterns during the observation period.

Table 4-4: System capture-ability at Site 2 (6AM to 10AM, 11/30/04)

	Volume count (veh/5min)			Captured volume (veh/5min)	
	Cars	Trucks	Total (A)	# of captured vehicles (B)	Capture-ability, (B/A)*100
Ave.	248	21	269	68	25.7 %
Min.	176	8	198	26	10.2 %
Max.	351	33	374	130	58.1 %

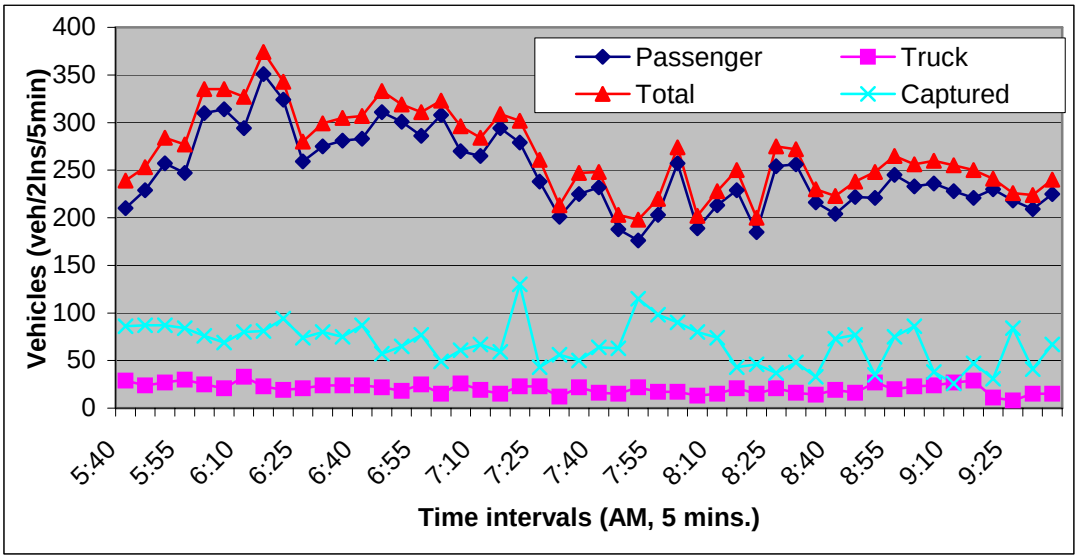


Figure 4-4: Comparison of actual volume and LPR captured images at Site 2 (11/30/04)

System reliability at Site 2 on 12/02/04 (Thursday)

Traffic and environmental conditions

- Weather: sunny, but very windy
- No work zone activities and no accidents
- Traffic conditions: moderate congestion near Site 2 before 7:30AM

System capture-ability

- Table 4-5 indicates that system capture-ability is relatively high (45.5 %), similar to the result (41.7 %) on 11/23/04 under congested traffic conditions. Figure 4-5 shows the corresponding traffic flow patterns and the number of vehicle images captured by the LPR system.

Table 4-5: System capture-ability at Site 2 (6AM to 10AM 12/02/04)

	Volume count (veh/5min)			Captured volume (veh/5min)	
	Cars	Trucks	Total (A)	# of captured vehicles (B)	% of capture-ability (B/A)
Ave.	244	22	266	119	45.5 %
Min.	160	11	177	80	30.7 %
Max.	356	39	378	185	71.4 %

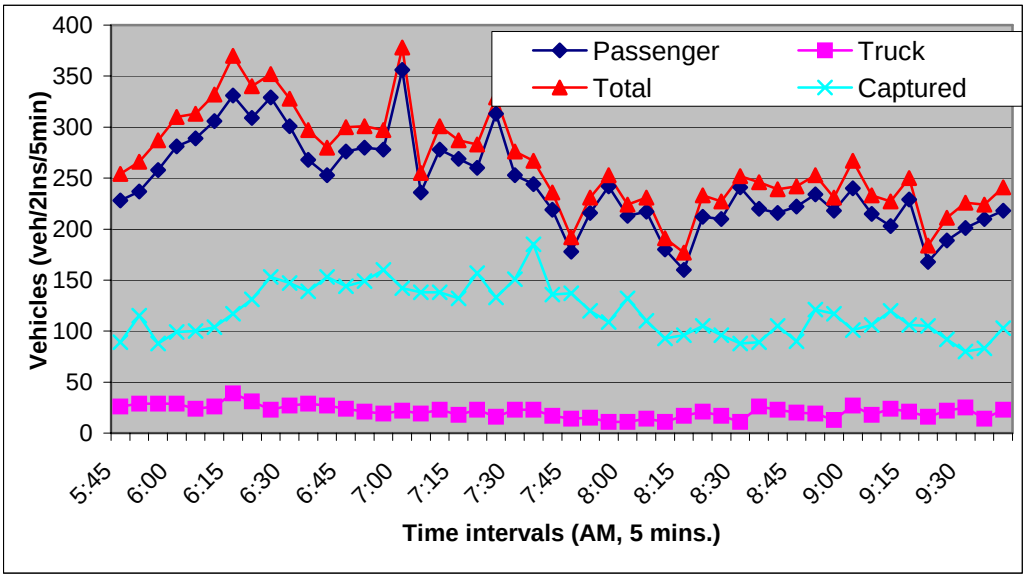


Figure 4-5: Comparison of actual volume and LPR captured images at Site 2 (12/02/04)

4.2 System reliability on the US-29 segment

System reliability at Site 1 on 12/13/04 (Monday)

Traffic and environmental conditions

- Weather: light rain in the early morning, and sunny later.
- Work zone activities near the MD 198 interchange
- Traffic conditions: no congestion

System capture-ability

- Table 4-6 presents the system's capture-ability (21.4 %) at Site 1, and Figure 4-6 shows the corresponding traffic flow patterns compared to those captured by the LPR system.

Table 4-6: System capture-ability at Site 1 (6AM to 10AM, 12/13/04)

	Volume count (veh/5min)			Captured volume (veh/5min)	
	Cars	Trucks	Total (A)	# of captured vehicles (B)	Capture-ability, (B/A)*100
Ave.	277	7	284	59	21.4 %
Min.	126	0	130	37	12.8 %
Max.	389	14	403	79	35.3 %

- It should be noted that the roadway around Site 1 is near a segment of the freeway. Therefore, its average flow speed is higher than the posted speed limit (55mph).

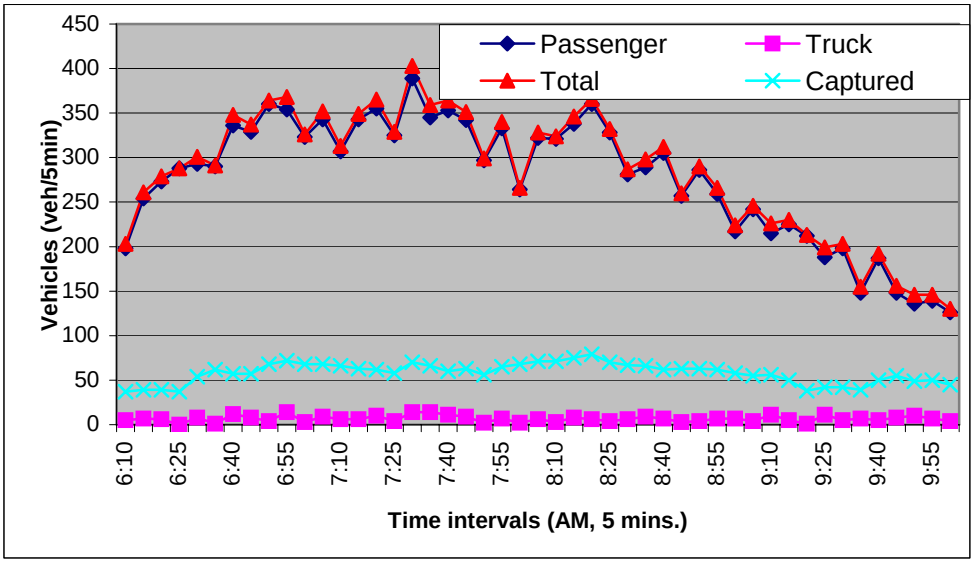


Figure 4-6: Comparison of actual volume and LPR captured images at Site 1 (12/13/04)

System reliability at Site 2 on 12/14/04 (Tuesday)

Traffic and environmental conditions

- Weather: sunny
- Work zone activities near the MD 198 interchange
- Traffic conditions: spillback from the MD 650 exit

System capture-ability

- Table 4-7 shows that the LPR system has high capture-ability (58.7%) at Site 2.
- The main reasons that the LPR system appears to capture more vehicle images at Site 2 is due to its location (near a signalized intersection) and slow moving traffic flows. In addition, traffic conditions at Site 2 were congested due to the spillback from the MD 650 exit during the observation period.

Table 4-7: System capture-ability at Site 2 (6AM to 10AM, 12/14/04)

	Volume count (veh/5min)			Captured volume (veh/5min)	
	Cars	Trucks	Total (A)	# of captured vehicles (B)	Capture-ability, (B/A)*100
Ave	220	8	228	133	58.7 %
Min	152	1	156	60	38.0 %
Max	327	15	334	203	85.0 %

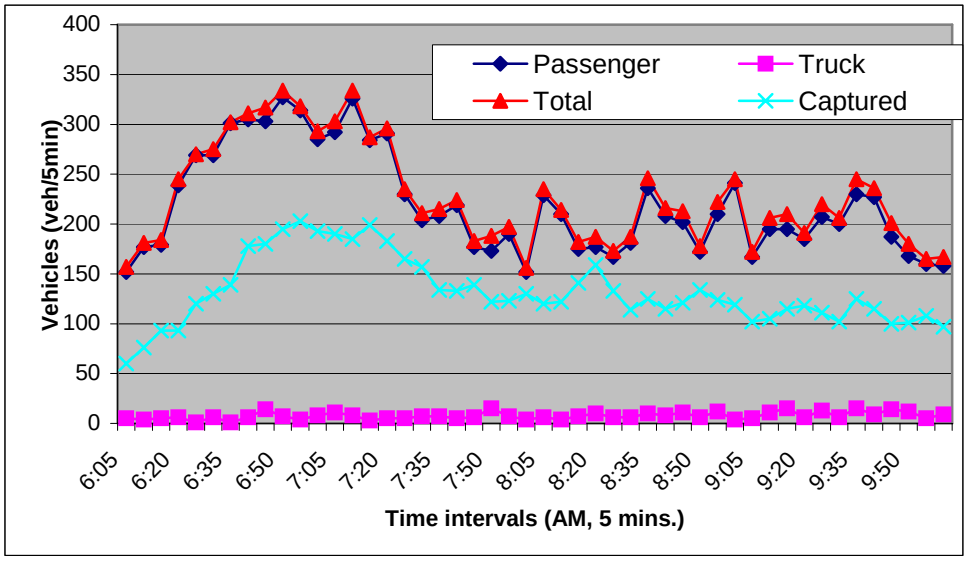


Figure 4-7: Comparison of actual volume and LPR captured images at Site 2 (12/14/04)

System reliability at Site 1 on 12/15/04 (Wednesday)

Traffic and environmental conditions

- Weather: sunny
- Work zone activities near the MD 198 interchange
- Traffic conditions: no congestion

System capture-ability

- Table 4-8 shows the system capture-ability, which is about 7.8% and is lower than that at Site 1 (21.4%) on 12/13/04. Figure 4-8 indicates that its traffic volume is lower than that on 12/13/04.

Table 4-8: System capture-ability at Site 1 (6AM to 10AM, 12/15/04)

	Volume count (veh/5min)			Captured volume (veh/5min)	
	Cars	Trucks	Total (A)	# of captured vehicles (B)	Capture-ability, (B/A)*100
Ave.	260	5	267	20	7.8 %
Min.	134	0	141	5	1.7 %
Max.	390	17	396	36	19.1 %

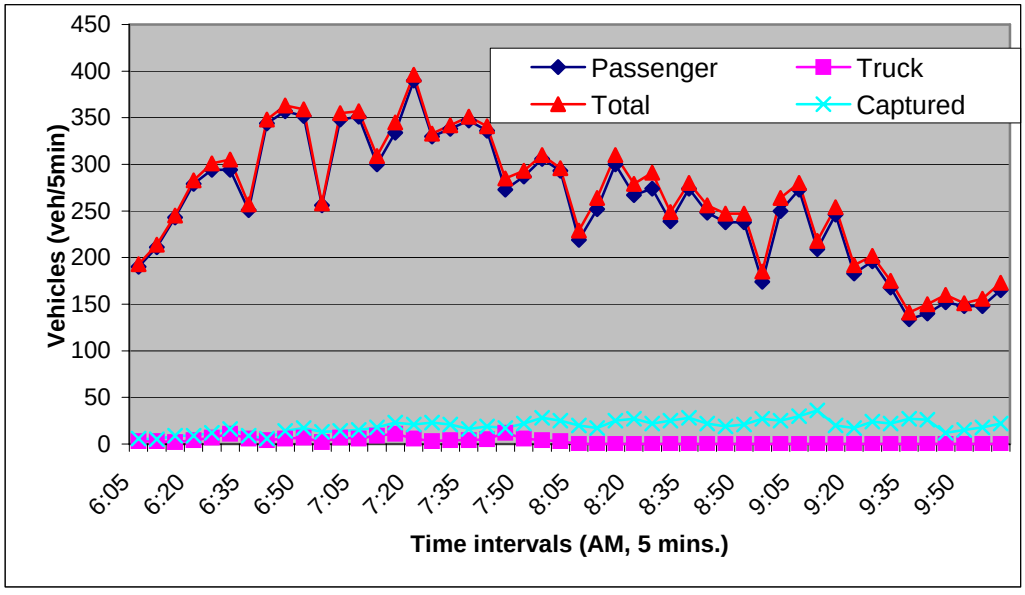


Figure 4-8: Comparison of actual volume and LPR captured images at Site 1 (12/15/04)

System reliability at Site 2 on 12/16/04 (Thursday)

Traffic and environmental conditions

- Weather: sunny
- Work zone activities near the MD 198 interchange
- Traffic conditions: heavy spillback from the MD 650 exit

System capture-ability

- Table 4-9 indicates that system capture-ability is 63.4 %, which is higher than the result (58.7 %) on 12/14/04 at Site 2 due to the lower level of traffic volume. Figure 4-9 shows the traffic flow patterns and their comparison with the images captured by the LPR system.

Table 4-9: System capture-ability at Site 2 (6AM to 10AM, 12/16/04)

	Volume count (veh/5min)			Captured volume (veh/5min)	
	Cars	Trucks	Total (A)	# of captured vehicles (B)	Capture-ability, (B/A)*100
Ave.	182	13	194	122	63.4 %
Min.	99	4	110	53	38.2 %
Max.	241	25	258	184	94.3 %

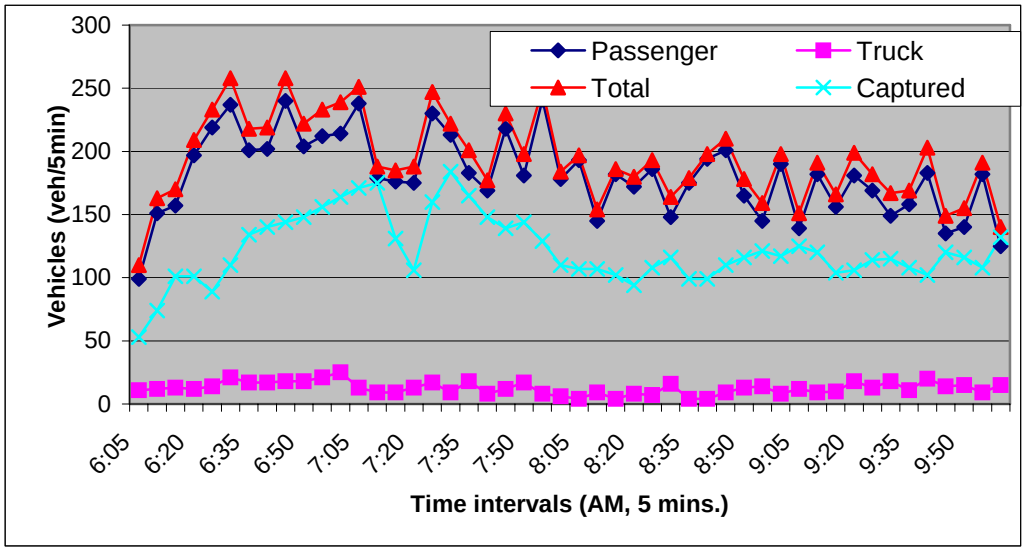


Figure 4-9: Comparison of actual volume and LPR captured images at Site 2 (12/16/04)

System reliability at Site 1 on 12/17/04 (Friday)

Traffic and environmental conditions

- Weather: sunny
- Work zone activities near the MD 198 interchange
- Traffic conditions: no congestion

System capture-ability

- Table 4-10 shows the system's capture-ability at Site 1, which is about 11.8 %, and lies between those on 12/13/04 and 12/15/04. Figure 4-10 illustrates observed traffic flow patterns compared to those captured by the system.

Table 4-10: System capture-ability at Site 1 (6AM to 10AM, 12/17/04)

	Volume count (veh/5min)			Captured volume (veh/5min)	
	Cars	Trucks	Total (A)	# of captured vehicles (B)	Capture-ability, (B/A)*100
Ave.	229	8	237	24	11.8 %
Min.	107	1	116	7	2.9 %
Max.	332	15	346	54	46.6 %

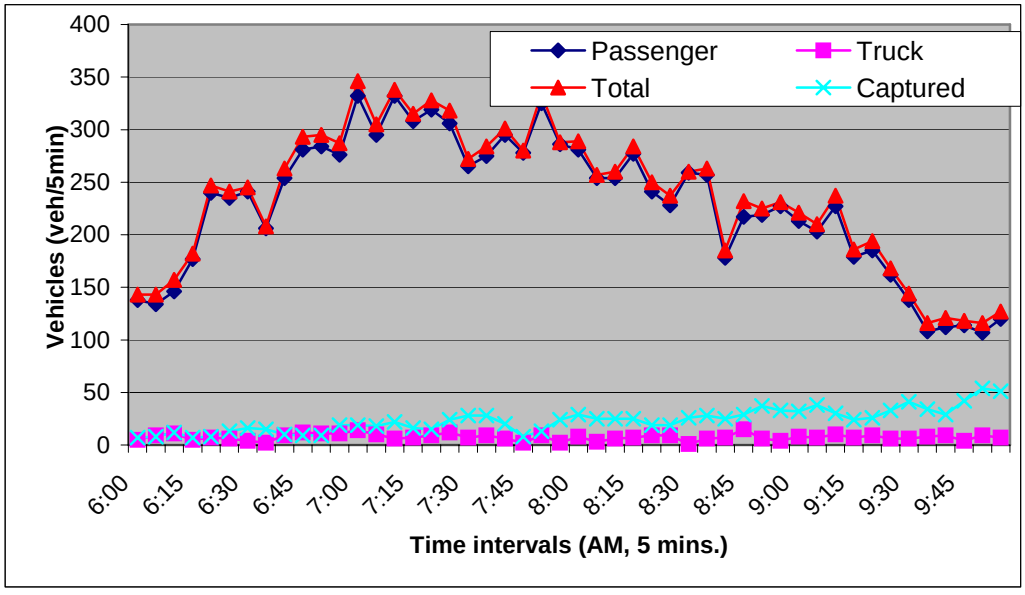


Figure 4-10: Comparison of actual volume and LPR captured images at Site 1 (12/17/04)

4.3 System recognition rate

The system recognition rate is defined as the ratio between the number of correctly recognized license plates and the total license plate images captured by the LPR. Table 4-11 shows examples of incorrectly recognized plate numbers, and based on this sample data set, the system yields a 67.19 % recognition rate. Table 4-12 summarizes the main characters commonly misread by the LPR system. The difficulty in recognizing some characters may cause the system to yield incorrect travel time estimates.

Table 4-11: Examples of the inaccurately recognized plate numbers

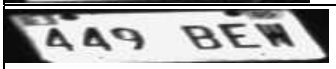
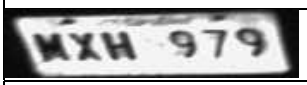
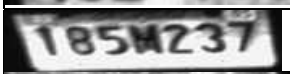
Actual captured license images	JPG image	OCR read	Characters		(A/B)* 100	Characters misread
			Read #(A)	Total #(B)		
	GJB315	6JB315	5	6	83.33%	G=6
	449BEW	449BEM	5	6	83.33%	W=M
	MXH979	MXW979	5	6	83.33%	H=W
	165M575	16SW575	5	7	71.43%	5=S, M=W
	LWD556	LWO556	5	6	83.33%	D=O
	M175538	MI75538	6	7	85.71%	1=I
	YHU3357	YMW3357	5	7	71.43%	H=M, U=W
	40L190	4OL790	4	6	66.67%	0=O, 1=7
	185M237	1BSM237	5	7	71.43%	8=B, 5=S
	FFY538	FFV538	5	6	83.33%	Y=V
	ZPP626	PP624	4	6	66.67%	Z=Nothing, 6=4
	LG66116	J66116	5	7	71.43%	L=Nothing, G=J

Table 4-12: Characters misread by the system

Actual characters	W (M)	H	G	5	1	D, 0	U	Y	8	L, Z
Misread characters	M (W)	W, M	6, J	S	I or 7	O	W	V	B	N/A

5. LPR Accuracy Evaluation

Due to the insufficient number of license plate matches on the US-29 segment, the evaluation of LPR's performance in regard to travel time estimation focuses on the I-95 segment, based on the following two statistics (see Table 5-1):

- *Matching rate:* defined as the ratio (MR) between the number (M) of matched license plates over Sites 1 & 2 and the number (S2) of vehicle images captured at Site 2 by the system.
  - This ratio is calculated at intervals of 5 minutes during the observation period (i.e., 6AM to 10AM), and the average of such rations (AR) is defined as the average matching rate.

- *System accuracy:* defined as the percentage (SA) of travel times (TT 1) correctly estimated by LPR over the total sample of actual travel times (TT 2) collected by the probe vehicles during the observation period (i.e., 6AM to 10AM).
  - 'Correct' or 'Incorrect' estimation is determined by the pre-specified acceptable deviations (i.e., within the intervals of $\pm$ 1, 2, and 3 minutes).

Table 5-1: Sample data set for LPR performance accuracy (*)

I-95 segment	System					Survey	
	TT 1 (sec)	veh/5min			MR	TT 2 (sec)	TT1 *vs*. TT2 ($\leq \pm$ 2 min.)
		M	S1	S2			
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
7:35AM	987	10	76	65	15.4	971	Correct
7:40AM	1014	7	84	47	14.9		
7:45AM	1074	12	95	93	12.9	882	Incorrect
7:50AM	1088	20	97	64	31.3		
7:55AM	1021	14	77	71	19.7	840	Correct
8:00AM	994	14	84	71	19.7		
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
Average					18.1 % (AR)		66.6 % (SA)

(*) Notations:
TT1 – Travel time estimated by the LPR system; TT2 – Travel time collected by probe vehicle
M – Number of matched vehicles between Sites 1 and 2.
S1 and S2 – Number of vehicles captured by the LPR system at Sites 1 and 2, respectively.
MR – Matching rate, i.e., MR = (M/S2)*100, AR – Average matching rate during the observation period.
SA – System accuracy, i.e., SA = {(# of Correct) / (# of Incorrect)}*100 during the observation period.

5.1 Matching rates

- Table 5-2 summarizes average matching rates during each day's observation period (i.e., 6AM to 10AM). In general, the average matching rate (12.2 %) lies expectedly between the maximum (16.0 %) and minimum (10.1 %) rates over the five survey days.
- The matching rates and reported capture-abilities do not reveal any consistent pattern.

Table 5-2: Summary of average matching rates (6AM to 10AM)

Dates	11/18/04	11/19/04	11/23/04	11/30/04	12/02/04
Matching rate	16.0 %	12.0 %	10.8 %	12.3 %	10.1 %
Average	12.2 %				

5.2 System performance accuracy

System accuracy on 11/18/04

- Table 5-3 illustrates system performance accuracy (83.3 %) within the ± 2 min. acceptable time deviation.
- Figure 5-1 compares the actual and calculated travel times during the survey period.

Table 5-3: System performance accuracy (6AM to 10AM, 11/18/04)

Number of samples	# within acceptable time deviations		
	<= ± 1 min.	<= ± 2 min.	<= ± 3 min.
Correct estimates	12	15	16
Incorrect estimates	6	3	2
System accuracy	66.7 %	83.3 %	88.9 %

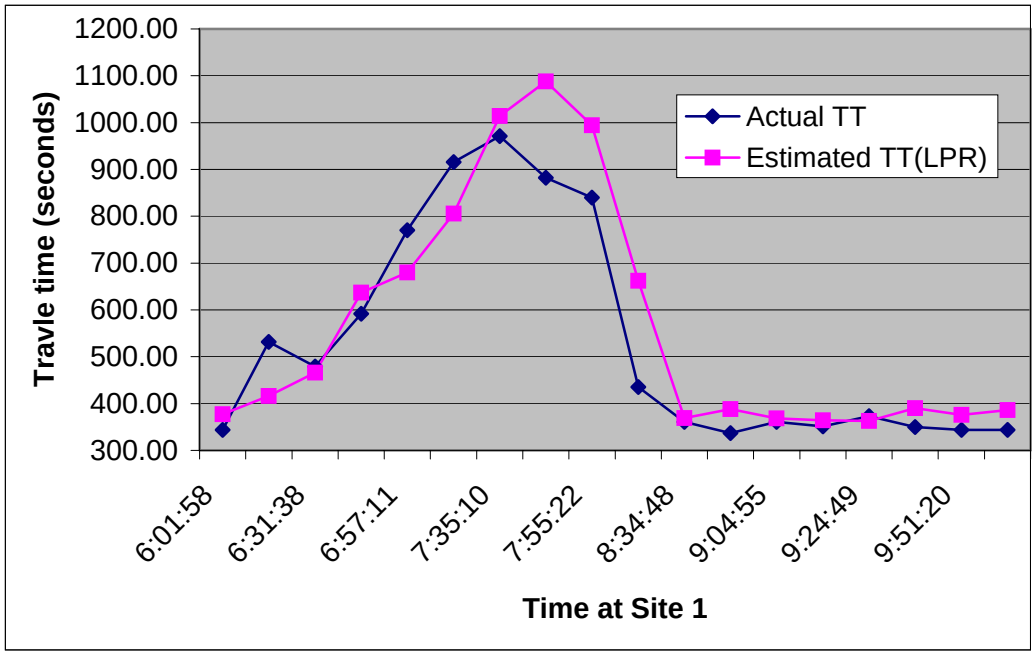


Figure 5-1: Comparison of actual and LPR estimated travel times (11/18/04)

System accuracy on 11/19/04

- Table 5-4 demonstrates that system accuracy is about 92.9 % and 100.0 %, respectively under the acceptable time deviations of ± 1 and 2 min.
- Such a high level of performance accuracy can be expected since traffic conditions are quite stable (see Figure 5-2).

Table 5-4: System performance accuracy (6AM to 10AM, 11/19/04)

Number of samples	# within acceptable time deviations		
	<= ± 1 min.	<= ± 2 min.	<= ± 3 min.
Correct estimates	13	14	14
Incorrect estimates	1	0	0
System accuracy	92.9 %	100.0 %	100.0 %

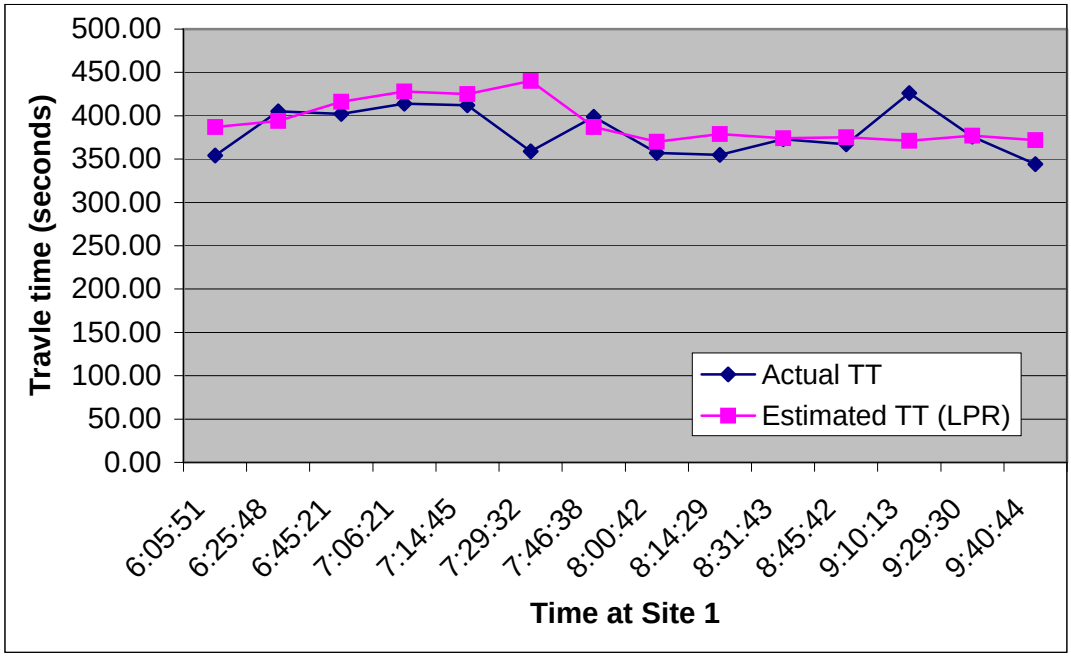


Figure 5-2: Comparison of actual and LPR estimated travel times (11/19/04)

System accuracy on 11/23/04

- Table 5-5 shows that the system accuracy is relatively low, at 50.0 % and 62.5 %, respectively under the acceptable time deviations of ± 1 and 2 min.
- Figure 5-3 compares the actual and LPR computed travel times during the survey period, which indicates a time lag between these two travel time measurements.

Table 5-5: System performance accuracy (6AM to 10AM, 11/23/04)

Number of samples	# within acceptable time deviations		
	<= ± 1 min.	<= ± 2 min.	<= ± 3 min.
Correct estimates	12	15	19
Incorrect estimates	12	9	5
System accuracy	50.0 %	62.5 %	79.2 %

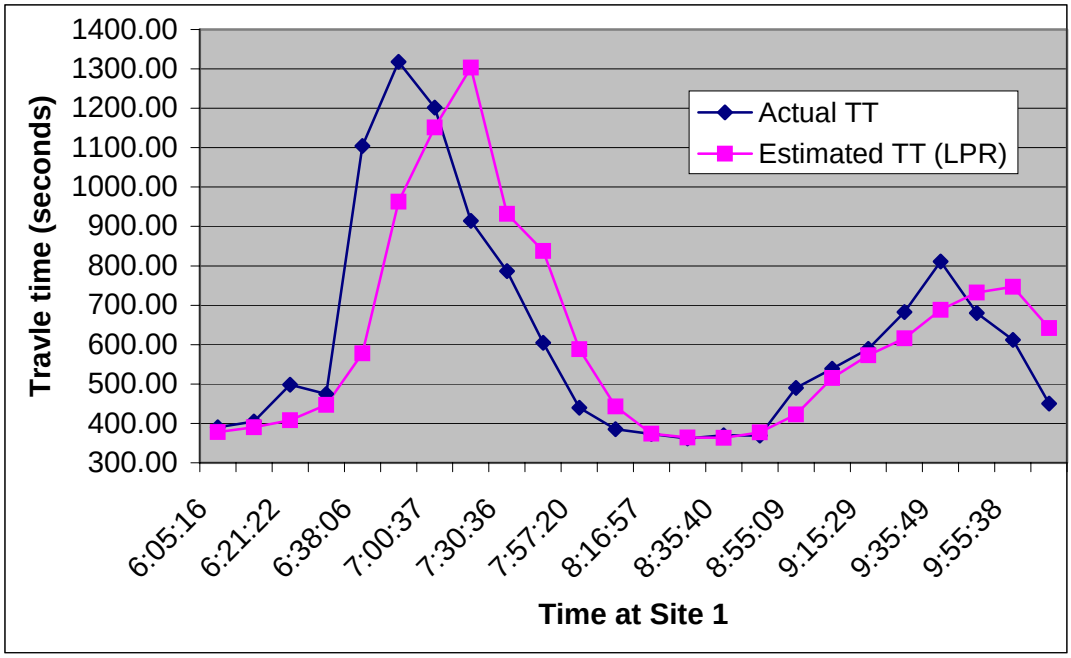


Figure 5-3: Comparison of actual and LPR estimated travel times (11/23/04)

System accuracy on 11/30/04

- Table 5-6 shows system accuracy of 62.5 % and 83.3 %, respectively under the criteria of ± 1 and 2 min. deviations.
- Figure 5-4 compares the actual and the LPR computed travel times during the survey period, which also indicates a time lag between the two travel time measurements.

Table 5-6: System performance accuracy (6AM to 10AM, 11/30/04)

Number of samples	# within acceptable time deviations		
	<= ± 1 min.	<= ± 2 min.	<= ± 3 min.
Correct estimates	15	20	23
Incorrect estimates	9	4	1
System accuracy	62.5 %	83.3 %	95.8 %

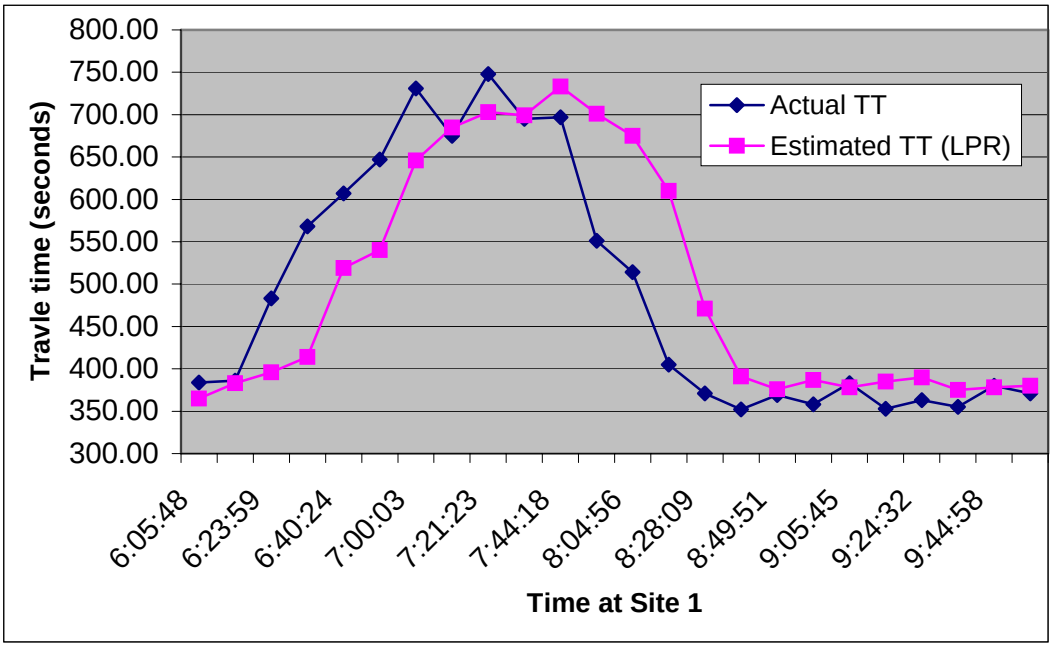


Figure 5-4: Comparison of actual and LPR estimated travel times (11/30/04)

System accuracy on 12/02/04

- Table 5-7 shows high system accuracy of 95.2 % and 100.0 %, respectively under the criteria of ± 1 and 2 min. deviations.
- Such a high level of system performance accuracy can be expected as traffic conditions are quite stable (see Figure 5-5).

Table 5-7: System performance accuracy (6AM to 10AM, 12/02/04)

Number of sample	# within acceptable time deviations		
	<= ± 1 min.	<= ± 2 min.	<= ± 3 min.
Correct estimates	20	21	21
Incorrect estimates	1	0	0
System accuracy	95.2 %	100.0 %	100.0 %

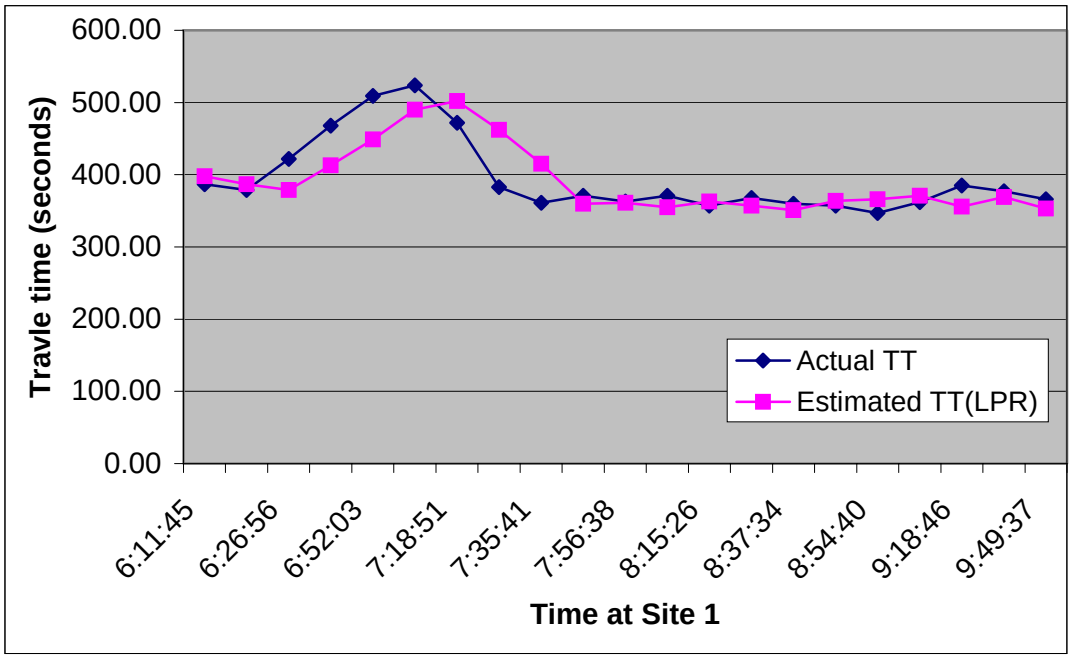


Figure 5-5: Comparison of actual and LPR estimated travel times (12/02/04)

6. Summary of LPR System Evaluations

Based on the above analysis, one may reach the following preliminary conclusions (see Table 6-1);

- On the I-95 segment, the percentages of captured vehicles are 26.0 % and 33.4 %, at Site 1 and Site 2, respectively. LPR's capture-ability is stable under normal traffic patterns (e.g., Site 1), but varies substantially under congested traffic conditions (e.g., Site 2).
- Although the matching rate is stable (e.g., 12.2 %) on the targeted freeway segment, it does not show any systematic relation to LPR's capture-ability.
- Since the system calculates travel time based on the average travel time of the matched vehicles in the last time interval, there exists a time lag between the travel times estimated by LPR and those collected from the probe vehicles. Such discrepancies become quite significant under congested traffic conditions (e.g., 11/23/04 and 11/30/04).

Table 6-1: Summary of LPR system evaluation on the I-95 SB segment (6AM to 10AM)

	Capture-ability		Matching rate	System accuracy ($\leq \pm$ 2 min.)
	Site 1	Site 2		
11/18/04	25.9 %	33.2 %	16.0 %	83.3 %
11/19/04	25.9 %	21.1 %	12.0 %	100.0 %
11/23/04	26.1 %	41.7 %	10.8 %	62.5 %
11/30/04		25.7 %	12.3 %	83.3 %
12/02/04		45.5 %	10.1 %	100.0 %
Average	26.0 %	33.4 %	12.2 %	85.8 %

- On the US-29 segment, the number of the matched vehicles is not sufficient to make any meaningful comparison. The poor performance of LPR is likely due to the traffic pattern, since a large number of vehicles did not travel through both detection sites to enable LPR to match their license plate numbers.

- Although the LPR system can attain a matching rate of 67.19 %, its difficulty in recognizing some characters may cause the system to yield incorrect travel time estimates.