Title

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Authors
Bloomberg, Loren D.
Bacon, Jr., Vinton W.
May, Adolf D.

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CALIFORNIA PATH PROGRAM
INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, BERKELEY

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Loren D. Bloomberg
Vinton W. Bacon, Jr.
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This work was performed as part of the California PATH Program of the University of California, in cooperation with the State of California Business, Transportation, and Housing Agency, Department of Transportation; and the United States Department of Transportation, Federal Highway Administration.

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This report is part of an effort to simulate various IVHS strategies on the Santa Monica Freeway corridor (I-10) in Los Angeles. This corridor is also known as the “Smart Corridor” because of the project of the same name that is currently underway on the corridor. While much of the data used for this report were obtained from the agencies involved in the Smart Corridor project, it should be made clear that this research was conducted at the University of California at Berkeley and is not a part of the Smart Corridor project itself. The results arrived at in this report do not necessarily reflect the views of any of the agencies involved in the Smart Corridor project.

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Section 1: Executive Summary

As part of the efforts for the Smart Corridor evaluation and simulation projects, a team at the University of California at Berkeley performed a pilot analysis of freeway detector data from the Santa Monica Freeway in Los Angeles. The study was undertaken to benefit two separate projects: an evaluation project investigating the benefits of Intelligent Vehicle-Highway Systems (IVHS) for the Smart Corridor, and a simulation project to model the Smart Corridor using INTEGRATION.

Caltrans provided Santa Monica freeway detector data on magnetic tapes for the week of December 7, 1992. The detector data on the tapes were transferred to PC files using an extraction program developed by a team at UC Irvine and modified by the UC Berkeley team. Data for the morning peak period (6 A.M. to 12 noon) on Tuesday December 8 was selected as the central focus of the analysis. Two spreadsheets were developed: one containing traffic volume for 15 minute periods at each of 7 1 zones along the freeway, and another with occupancy data. Each zone included 15 detector stations. The first 4 or 5 detectors were positioned on the mainline freeway (one per lane).

It was found that approximately 32 percent of all possible mainline freeway detectors appeared to return data that are appropriate for freeway traffic. (Note that Caltrans recognizes that many of these detectors are not working and some zones may in fact not have mainline detectors. Therefore, this percentage may be underestimated.) The working detectors were grouped roughly in the center portion of the freeway sections; there were also several large sections with no working detectors. While there is no guarantee as to the accuracy of the "working" detectors (32 percent), detailed traffic flow analysis on data from two zones of detectors (La Brea 2 and Crenshaw) give the appearance of reasonable results. Several charts are provided in the report that detail the results of the analysis.

It is suggested that Caltrans District 07 staff review this report and give consideration to efforts directed toward increasing the number of detectors which are operable and give reliable information. Otherwise, other means of freeway data collection will need to be undertaken for the evaluation and simulation of the Santa Monica Freeway. These other means of freeway data collection may be quite costly and time consuming, and not as comprehensive as the freeway detector system data.

Section 2: Rationale

Two separate projects are underway to analyze the benefits of Intelligent Vehicle-Highway System (IVHS) technology for the Smart Corridor in Los Angeles. As part of the PATH program, the Smart Corridor evaluation project is investigating the benefits of this technology by comparing field measurements of existing and future (after specific IVHS components are implemented) conditions along the Smart Corridor. A parallel effort is a simulation project that is applying the INTEGRATION model to the Smart Corridor in order to assess and refine individual and combined ATIS/ATMS strategies.

Both projects have substantial data requirements. The evaluation project is collecting data on existing conditions on the freeways and arterials within the Santa Monica Freeway corridor. In order to assess the benefits of IVHS, it is first necessary to develop a baseline model for comparison. Since demand data is critical for such a model, the evaluation project is investigating techniques for gathering traffic data.

The simulation project also requires demand data as an input to its model. The INTEGRATION model requires origin/destination data. These data can either be direct (i.e., gathered directly by means of surveys or other techniques), or synthesized (using traffic flow data at specific points). The simulation project will use the synthesized origin/destination data as the source of demand data. However, in order to build a useful model, it is critical for the team to have access to timely and accurate demand data.

Since both projects require these demand data, it was decided to undertake a pilot study of the available sources of data. Since Caltrans has developed a network of freeway detectors, determining the usefulness of the data from these detectors was considered to be an important first step. The study involved gathering and organizing the data from Caltrans and performing a series of analyses to assess the data. While the primary activities in the study involved analyzing the data from freeway detectors, the overall goal was to make a general assessment of the validity and usefulness of the freeway data in order to help define future work.

Section 3: Process

This section outlines the data collection and extraction process. The steps that were undertaken to prepare the data for analysis are described.

A. Caltrans Data Collection
At the request of the UC Berkeley team, Caltrans captured freeway detector data for the week of December 7, 1992. The data is automatically collected by Caltrans for detectors throughout the Los Angeles area (including a large set of detectors on the Santa Monica Freeway, both eastbound and westbound within the Smart Corridor area). For this project, the detector data for four days (Monday December 7 through Thursday December 10) were copied to magnetic tapes.

B. Initial Work at UC Berkeley
The data was received at UC Berkeley the following week on eight magnetic tapes, each containing 12 hours of freeway detector data (midnight to noon and noon to midnight) from all of the freeway detectors on the L.A. area. 2000 sets of detector data (numbered 1 to 2000) were collected, but a test indicated that only about 1300 of these contained any data.

The magnetic tapes were taken to Computing Services in Evans Hall (at UC Berkeley) for temporary storage. A simple program was used to transfer (via the campus Ethernet network) the data from the tape to a PC in the Transportation Engineering department (McLaughlin Hall) at UC Berkeley. Then, each 12-hour tape was stored as a binary file on the PC, requiring 45-50 megabytes of disk storage space.

C. UC Irvine Extraction Program
To analyze the data in these binary files, the first step was to extract the data and convert it into ASCII format, a standard format for PC computing. A program was developed by researchers at UC Irvine (including Stephen Ritchie) for this purpose. However, the program did not support several key functions that were needed by the project team. First, it was determined that volume and occupancy counts would be most useful if they were aggregated over five minute periods (as opposed to 30 seconds on the tapes). Secondly, it was desirable to have the data in the output files separated by tabs. These delimiters made it easier to import the data sets into spreadsheets.

The most important modification involved the extraction of data into individual detectors. The 2000 sets of detector data are divided into zones, with each zone representing a group of detectors. For example, a group of detectors along each lane of a freeway would compose a zone. It was determined (with the help of JHK & Associates) that the tape contained data for up to 15 detectors per zone. However, the original UC Irvine program was limited in the number of detectors it could extract from each zone. Since many zones contain mainline, collector/distributor, and/or ramp data, it was critical to modify the program to support extraction of up to 15 detectors per zone.

Programmers from the ITS Systems Unit and the project team made modifications to support these new requirements. (The modified source code for this program is included as Appendix 1)

The extraction program is relatively simple and straightforward to use. It requires two inputs, the extracted binary data file and an input file called ***query.dat.*** This file must be created by the user and specifies the zones that will be extracted from the tape. For this analysis, ***query.dat*** included zone numbers within the Santa Monica freeway section. The input file also designates the time periods to be analyzed. Time periods range from O-1440 (in minutes) for morning tapes and from 1441-2880 for the afternoon/evening tapes. Figure 1 depicts a sample ***query.dat:***

2	0	1440
1200	15	
1204	6	
1219	15	

Figure 1: Sample *query.dat* input file

The first number is a constant parameter that will always be 2. The 0 and 1440 represent the beginning and ending times for the analysis. This example would extract data for the entire morning period. 1200, 1204, and 12 19 are the zone numbers for which data will be extracted. The second parameter on each line (e.g., 15 and 6) indicates the number of lanes (i.e., detectors) that are examined from each zone.

One problem that was found was that there was often some extraneous data at the beginning of the tape. It was found that skipping one time period at the beginning of the tape effectively eliminated the problem, and no detector data was lost.

D. Output

The output of the extraction program is two output files. Each is presented in tabular form, and broken down by zone and detector. The file ***vol.dmp*** contains volume data (in number of cars per five minute period) and the file ***occ.dmp*** contains occupancy data (in percentage of occupancy by five minute period). Figure 2 presents a sample ***vol.dmp*** output file (***occ.dmp*** looks similar):

1200	1	95	101	89	104	112	99
1200	2	85	89	92	102	101	104
1204	1	80	79	80	84	89	77
1204	2	67	68	80	77	81	69
1204	3	48	52	58	44	55	60

Figure 2: Sample *vol.dmp* output file

The first number on each line (i.e., 1200 and 1204) indicates the zone number being studied. The second number signifies the detector number within the zone. For this example, two detectors were studied in zone 1200 and three detectors were examined in zone 1204. The remaining numbers show actual volume data aggregated into 5 minute periods. Each value represents 10 30-second periods. In this example, thirty minutes of volume data are presented.

The *vol.dmp* and *occ.dmp* files generated from roughly 70 zones with 15 detectors per zone were about 75 kilobytes (in tabular form). To work with the data sets more easily, the *.dmp* files were imported into a spreadsheet (Microsoft Excel and Lotus 123 were used; there are some file size limitations with Quattro Pro). The resulting spreadsheet files were approximately 300 kilobytes.

These spreadsheets were the tool that was used to perform data analysis. The results of the analysis of the volume and occupancy data is given in Section 4.

E. Issues

Several issues were encountered during the process of extracting the detector data. Many of these were necessarily resolved during the project; however, some of these issues need further investigation.

The first major task was to correlate the zone numbers in the data with actual locations on the freeway. Caltrans provided several maps and a list of zones with mileposts, nearest cross street and other data for each zone. Figure 3 outlines the numbering scheme used to label the detectors.

O-900	Detectors that include ramps and collector/distributor lanes.
900- 1500	Freeway mainline collectors.
1500-2000	Freeway mainline collectors where the controller is on the opposite side of the freeway from the detectors.

Figure 3: Numbering Scheme for Detectors

Using this documentation, the coding scheme that was used for the detector data tapes was determined, and the map in the next section is a summary of that work. However, it was found that several detectors in the data were not listed on the maps (though their locations were found within other documentation), and that there are some detectors listed on the map produce no data. Therefore, it may be worthwhile to update a map with current detector information.

Another issue involves the identification of detectors within each zone. It is clear that the first ***n*** detectors in each zone correspond to the mainline freeway lanes (where n is the number of lanes in that section of freeway). However, it is not obvious which of the other detectors (of the 15 in each zone) correspond to ramp detectors, collector/distributor lanes, or other data. In fact, conversations with Caltrans officials indicated that there may be up to 28 detectors associated with a particular zone. However, in the tapes received from Caltrans, there is a maximum of 15 detectors per zone; it is not clear where the 28 figure arose. The Atlanta office of JHK &

Associates has had experience in decoding the data, and they are studying the results from this study. For this study, only the mainline freeway lanes were examined. However, future work will need to examine the other data. This is especially important for synthetic O/D development, where ramp on/off counts are required.

Section 4: Results

This section outlines the results of the analysis of the Santa Monica Freeway detector data. A general assessment of the data integrity is made, and then several studies of specific data (e.g., volumes and occupancies) are presented.

A. Data Integrity

Using the data generated from the extract tapes, the detectors were appraised to determine a general level of integrity. Figures 4 and 5 present the results of this analysis. (Figure 4 is for eastbound detectors and Figure 5 is for westbound detectors). The first columns list the zone number, milepost marker, and nearest cross street. These correspond to the map in Figure 6. The number of mainline freeway lanes in that zone is also indicated. Note that the number of lanes varies between four and five for most of the freeway section.

The fifteen numbered columns correspond to the "lanes" within each zone. Strictly speaking, only the first four or five detectors are lanes (the mainline freeway lanes). These are delineated with the heavy line on the chart. The remaining detectors are on ramps, collector/distributor lanes, or non-existent.

The symbols on the chart give a general assessment of the functionality of the detectors. A √ indicates data that appears reasonable for mainline freeway data (volume of at least 100 cars for a number of 5 minute periods during daylight hours). Note that this designation is based on volume counts only; in some cases the occupancy data is of different integrity. L signifies data that is significantly lower than that for the mainline (volume figures consistently under 70), but may be reasonable for ramps and/or collector distributor lanes. Note that √ and L denote detectors that appear to be giving good data, but there is no guarantee of accuracy; they just have reasonable values. Also, an L in the mainline is probably poor data, but may be reasonable in the other detector section.

x indicates data that is obviously flawed. Usually, this consists of a value that is repeated throughout the time period. Another common problem was ridiculously high values for volume and/or occupancy (e.g., 10000 cars or 99% occupancy). 0 indicates detector data that was captured as all zeroes. A blank cell shows where there is no data at all. Note that there are three possible reasons for detector cells that are noted as having flawed data:

- the detector is present but is returning no data
- detectors are present at the freeway location (the specific zone) but not in that particular "lane"
- there are no detectors at the freeways location (zone)

Without more detailed data on the detector locations it is difficult to specify the exact problem with flawed detector data (Section 5 discusses steps to address this issue). For now, the results are presented with as much detail as is possible.

Zone Detector Data

Santa Monica - Route 10 - Eastbound
From Centinela to **Soto**

Lane Number:

Zone #	Mile	Cross St.	lanes	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	C/D	Map
1525	3.93	Centinela	4																N	Y
1526	4.37	Pico	4																N	Y
1527	4.77	Bundy	5																N	Y
1530	6.15	Westwood	5																N	Y
254	6.50	Overland	4	√	√	√	√	L	L	x	x	x	x	0	x	x	x	x	N	Y
1631	6.73	Motor	5																N	Y
667	7.22	Manning	5	√	√	√	√	√	L	L	x	x	x	o	x	x	x	x	N	Y
1533	7.82	Robertson	5																N	Y
668	7.99	National	5	√	√	√	√	√	L	L	L	x	x	0	x	x	x	x	N	Y
1234	8.36	Cattaraugu	5																N	Y
266	8.73	La Cienega	4																Y	Y
562	9.01	Venice	4	x	x	x	x	x	x	0	0	0	0	x	x	x	x	x	Y	Y
1537	9.21	Fairfax	4	√	√	√	√	√	0	x	x	x	x	x	x	x	0	x	N	Y
669	9.51	Washington	5	√	x	√	x	√	L	L	0	L	L	0	x	x	x	x	N	Y
1538	9.80	Hauser	5	o	o	o	o	o	o	o	o	o	o	o	x	x	x	x	N	Y
825	10.23	La Brea 1	4	√	√	√	√	x	L	L	L	L	0	0	x	x	x	x	Y	Y
261	10.53	La Brea 2	4	√	√	√	√	L	L	L	L	0	0	0	x	x	x	x	Y	Y
947	10.70	Harcourt	4	x	x	x	x	x	x	x	x	x	x	0	x	x	x	x	N	Y
1503	11.06	West	5	√	√	√	√	0	0	x	x	x	x	x	x	x	0	x	N	Y
827	11.53	Crenshaw	5	√	√	√	√	√	L	L	0	L	L	0	x	x	x	x	Y	Y
1504	12.23	Arling. 1	5																Y	Y
812	12.45	Arling. 2	4																Y	Y
986	12.58	Gramercy	4																Y	Y
810	12.95	Western 2	5	0	0	√	√	L	L	L	x	L	L	L	x	x	x	x	Y	Y
824	13.44	Normam. 2	4	L	L	L	L	x	x	x	x	x	x	0	x	x	x	x	Y	Y
1506	13.53	Budlong	4	√	√	√	x	x	o	x	x	x	x	x	x	x	o	x	N	Y
807	13.95	Vermont 1	5	√	√	√	√	L	L	L	L	L	0	√	L	x	x	x	N	Y
1507	14.12	Hoover	5																N	Y
911	14.81	E of 110	4	0	0	√	√	0	0	0	0	0	0	0	0	0	0	x	N	N
640	15.33	Flower	4	0	0	0	0	0	0	L	x	x	x	0	x	x	x	x	N	N
645	15.78	Los Angeles	4	x	L	0	0	x	x	0	x	x	x	0	0	x	x	x	N	N
653	16.21	San Pedro	5	0	0	0	L	0	L	L	L	x	x	0	x	x	x	x	N	N
654	16.84	Central	5	0	0	0	x	x	x	x	x	x	x	0	x	x	x	x	N	N
655	17.09	Alameda	5																N	N
912	17.40	Olympic	5	0	L	L	0	0	0	0	0	0	0	0	0	0	0	x	N	N
913	17.78	W of 5	5	0	0	0	L	x	x	x	x	x	x	0	x	x	x	x	N	N
908	0.18	E of Macy		L	L	L	L	L	x	x	x	0	x	o	x	x	x	x		N
907	0.52	Echandia		L	L	L	L	L	0	√	x	0	x	0	0	x	x	x		N
946	18.53	State		L	L	L	L	√	√	0	√	√	L	0	0	x	x	x		N
945	18.75	S Louis		L	√	√	√	L	√	√	L	√	L	√	√	x	x	x		N
944	19.03	Soto		L	x	L	√	√	L	√	L	√	0	0	0	x	x	x		N

Figure 4 - Eastbound Detectors

Zone Detector Data

Santa Monica - Route 10 - Westbound
From Soto to Centinela

Lane Number:

Zone #	Mile	Cross St.	lane	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	CD	Map
1569	18.75	S. Louis		√	√	√	√	x	x	x	x	X	X	X	X	X	0	X		N
1567	18.53	State		√	√	√	x	x	x	x	x	X	X	X	X	X	0	X		N
980	18.5	Bus. State		x	L	L	x	x	0	0	L	X	X	X	X	X	0	X		N
1531	0.52	Echandia		√	√	√	x	x	x	x	x	X	X	X	X	X	0	X		N
1558	0.18	E. of Macy		√	√	√	x	x	x	x	x	X	X	X	X	X	0	X		N
1207	14.74	oak	3	0	0	0	x	x	x	x	x	X	X	X	X	X	0	X	Y	Y
813	14.12	Hoover	4																Y	Y
808	13.66	Vermont 1	5	0	0	0	0	0	√	L	L	L	x	√	L	x	0	x	Y	Y
1206	13.53	Budlong	4	√	√	√	√	x	x	x	x	x	x	x	x	x	x	x	Y	Y
952	13.21	Normandie 1	4	√	√	√	√	√	L	L	0	L	0	√	√	x	x	x	Y	Y
1505	12.95	Western 2	4	√	√	√	√	x	0	x	x	x	x	x	x	x	o	x	Y	Y
828	12.7	Western 1	4	L	L	L	0	0	x	x	x	x	x	x	x	x	x	x	Y	Y
1501	12.58	Gramercy	4	0	√	√	0	x	0	x	x	x	x	x	x	x	o	x	Y	Y
809	12.23	Arlington	5	√	√	√	x	√	L	L	L	L	0	0	x	x	x	x	N	Y
1502	11.53	Crenshaw	5	√	√	√	√	√	x	x	x	x	x	x	x	x	0	x	N	Y
1202	11.06	West	5	√	√	√	0	√	0	x	x	x	x	x	x	x	o	x	N	Y
1540	10.7	Harcourt	4	x	0	x	x	x	0	x	x	x	x	x	x	x	o	x	Y	Y
265	10.53	La Brea 2	4	√	√	√	√	L	L	L	L	L	√	0	x	x	x	x	Y	Y
826	10.24	La Brea 1	4																Y	Y
1238	9.8	Hauser	5																N	Y
811	9.21	Fairfax	4	√	√	√	√	L	L	0	L	0	L	0	0	x	x	x	N	Y
252	8.75	La Cienega	4																N	Y
1534	8.36	Cattarauga	5																N	Y
262	7.81	Robertson	4																N	Y
1532	7.22	Manning	4	√	√	√	√	x	x	x	x	X	X	X	X	X	0	X	N	Y
1231	6.73	Motor	4																N	Y
1230	6.15	Westwood	5																N	Y
1227	4.77	Bundy	5																N	Y
1226	4.37	Pico	4																N	Y
1225	3.93	Centinela	4																N	Y

Figure 5 - Westbound Detectors

Smart Corridor: Santa Monica Freeway

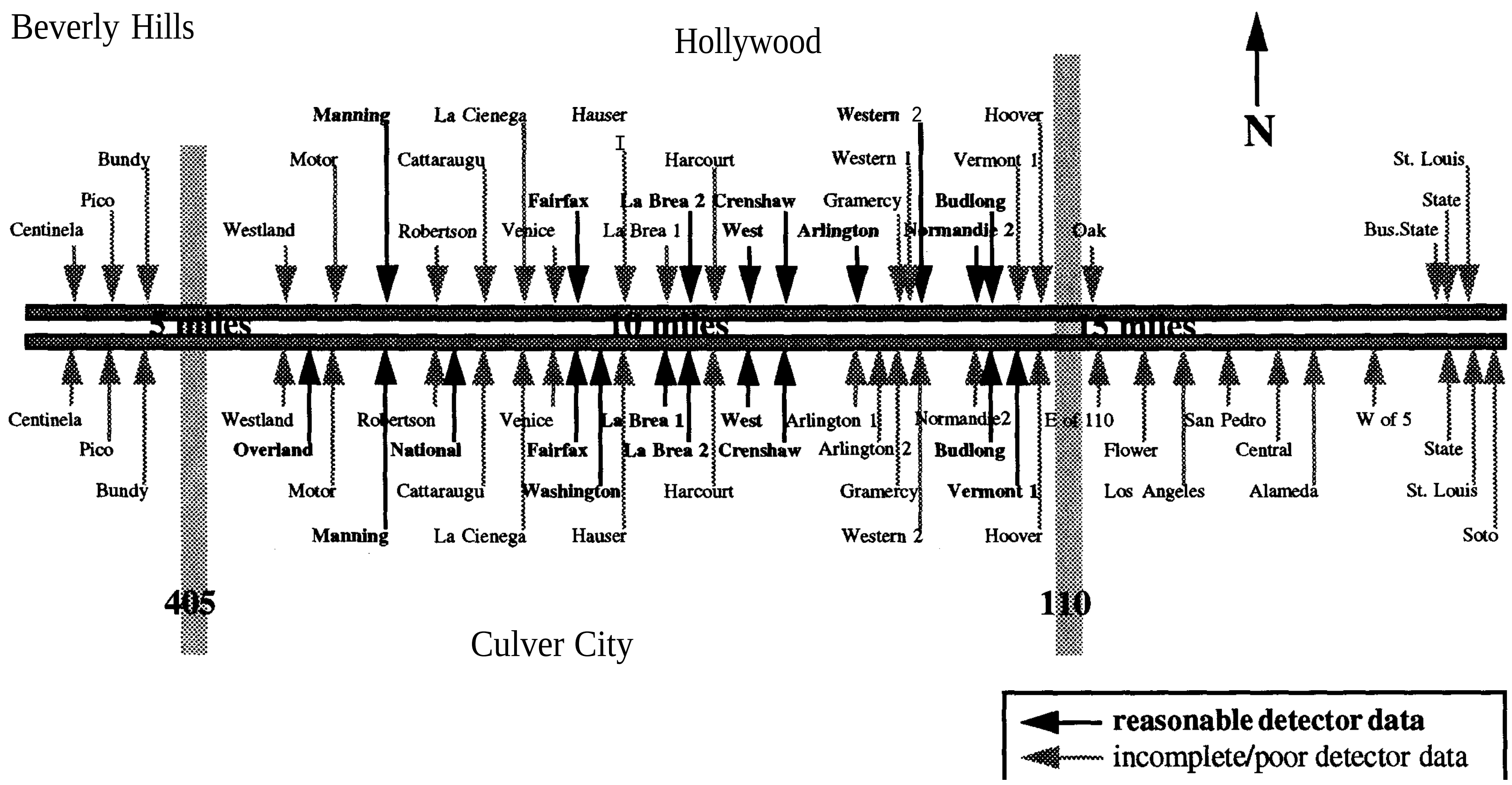


Figure 6: Map of Smart Corridor Freeway

The last two columns indicate whether collector/distributor lanes are in the area and if the zone was located on a map of the Santa Monica Freeway. Figure 7 summarizes the results from this classification of data:

Detector	√			L(ow)			x			0			(blank)			Total		
Location	E	W	T	E	W	T	E	W	T	E	W	T	E	W	T	E	W	T
Mainline	49	39	88	11	3	14	15	4	19	29	13	42	62	48	110	166	107	273
Other	19	19	38	60	23	83	165	165	330	70	29	99	135	107	242	449	343	792
Total	68	58	126	71	26	97	180	169	349	99	42	141	197	155	352	615	450	1065

Figure 7: Summary of Detector Results

Several points should be noted in terms of the general validity of the data:

- According to the results of the study, only about 32% of the mainline freeway detectors are returning data that might be accurately used for analysis. Again, it should be noted that even this data is not certain to be accurate; it is likely that even less of the detectors are returning true values. A cross-checking of this data with field measurements at certain locations would be desirable for validation. On the other hand, it is possible that some of the missing data may be because certain detectors do not even exist. If this is the case, the percentage of functioning detectors may be underestimated. A more detailed study may be needed, but it seems safe to say that a large proportion of the detectors are not returning good data.

- The usable data is spotty in many areas and two major trouble spots exist. First, the west end of the Santa Monica Freeway between La Cienega and Centinela has very few detectors working. Secondly, the section between the Harbor and Golden Gate freeways has no functional detectors whatsoever. This is a 5 mile gap in the data.

- No information could be found relating to detectors east of I-5. Without an accurate map of these detectors, it is not particularly helpful. Also, it is possible that the detector data may be invalid, because magnetic detectors were used in this area. The freeway structures include metal, which may be setting off the detectors.

B. Mainline Flow and Occupancy Data

Using the data from 6 A.M. to 12 noon on Tuesday Dec. 8, 1992, several studies of flow and occupancy were made. The first step was to develop aggregate spreadsheets. For each zone, detectors from the (assumed) mainline lanes were grouped together and data values were summed (for volumes) and averaged (for occupancies). To further clarify, the data was aggregated into 15 minute periods by simply summing (or averaging) over blocks of three 5 minute periods. Figure 8 presents the occupancy data by mainline freeway zone by time. Figure 9 provides similar data for the volume data. Note that data is provided for freeway sections between Centinela and approximately I-5 (zone numbers 1525-913 eastbound and 1207 to 1225 westbound). Also, the volume data is aggregated over the lanes in the freeway mainline section (given in the second column). The occupancy data is calculated using an average (non-weighted) over the lanes.

Eastbound Occupancy 6 A.M. to 12 Noon

		6:00	6:15	6:30	6:45	7:00	7:15	7:30	7:45	8:00	8:15	8:30	8:45	9:00	9:15	9:30	9:45	10:00	10:15	10:30	10:45	11:00	11:15	11:30	11:45
Zone	# Lanes	6:15	6:30	6:45	7:00	7:15	7:30	7:45	8:00	8:15	8:30	8:45	9:00	9:15	9:30	9:45	10:00	10:15	10:30	10:45	11:00	11:15	11:30	11:45	12:00
1525	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1526	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1527	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1530	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
254	4	5	6	18	10	14	15	13	13	13	13	13	12	12	12	13	11	11	12	12	12	12	12	13	12
1631	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
667	5	4	5	8	10	19	31	27	12	10	14	11	10	10	12	14	10	9	9	10	9	9	9	10	9
1533	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
668	5	5	6	8	11	29	32	35	22	17	18	24	15	12	13	19	11	10	12	12	10	12	12	13	11
1234	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
266	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
562	4	4	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1537	4	16	18	19	20	22	25	30	28	31	34	35	26	22	22	21	20	20	20	20	20	20	20	20	20
669	5	25	26	38	47	49	52	56	57	56	58	56	55	47	45	48	48	29	28	29	29	29	29	29	29
1538	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
825	4	8	19	7	9	11	24	21	19	32	43	21	31	18	29	16	11	10	9	9	10	26	18	10	10
261	4	7	10	31	33	39	42	43	38	39	38	41	41	33	32	27	24	12	12	12	13	13	13	14	14
947	4	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	9
1503	5	14	15	16	17	18	19	19	23	24	23	21	20	21	19	19	19	17	17	17	17	17	17	17	18
827	5	7	8	25	27	28	31	32	35	37	33	32	29	31	26	27	33	11	12	11	11	11	11	12	13
1504	5	5	7	21	20	23	24	27	29	27	26	24	20	16	17	18	20	11	9	9	9	9	11	9	10
812	4	16	16	16	16	16	16	16	16	17	17	17	17	17	17	17	17	17	16	17	17	16	17	17	16
986	4	23	24	25	25	26	27	30	30	29	29	29	30	26	25	25	25	25	25	25	25	25	25	25	25
1504	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
812	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
986	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
810	5	5	7	21	25	23	28	34	34	31	29	31	25	24	20	17	17	9	8	9	9	9	10	10	10
824	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1506	4	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
807	5	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
1507	5	22	22	23	22	22	22	23	22	22	22	22	22	22	23	22	22	22	22	22	22	22	22	23	22
911	4	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
640	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
645	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
653	5	12	12	12	13	12	12	13	12	12	12	12	12	13	13	13	13	13	13	13	13	13	13	13	13
654	5	12	13	14	14	14	14	14	15	15	14	14	14	13	13	13	13	13	13	12	13	13	13	13	13
655	5	2	3	4	4	4	5	5	6	6	8	5	5	3	3	3	2	2	2	2	2	2	2	3	2
912	5	2	3	3	4	5	5	5	5	5	5	4	4	5	4	4	5	5	5	4	5	5	5	5	6
913	5	4	5	7	7	8	9	9	10	9	9	8	8	7	6	7	6	7	6	6	6	6	6	6	6

Figure 8: Detector Occupancy

Westbound Occupancy 6 A.M. to 12 Noon

Zone	# Lanes	6:00 6:15	6:15 6:30	6:30 6:45	6:45 7:00	7:00 7:15	7:15 7:30	7:30 7:45	7:45 8:00	8:00 8:15	8:15 8:30	8:30 8:45	8:45 9:00	9:00 9:15	9:15 9:30	9:30 9:45	9:45 10:00	10:00 10:15	10:15 10:30	10:30 10:45	10:45 11:00	11:00 11:15	11:15 11:30	11:30 11:45	11:45 12:00
1207	3	37	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38	38
813	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
808	5	1	2	14	14	13	15	11	12	8	10	10	9	9	9	8	9	2	2	17	16	2	2	2	2
1206	4	34	37	38	37	37	44	53	54	55	55	52	52	53	53	54	53	43	41	37	41	37	37	39	37
952	4	10	12	28	28	25	42	48	42	42	47	50	47	49	43	41	39	20	18	14	17	16	15	18	13
1505	4	34	37	38	38	38	48	48	50	53	51	50	50	49	49	50	50	42	40	38	39	39	39	39	39
828	4	15	16	16	17	17	16	16	16	15	16	15	15	15	15	16	16	15	16	16	16	16	16	16	16
1501	4	56	58	59	59	60	64	66	66	67	64	64	64	64	64	64	64	60	59	58	58	58	58	57	58
809	5	8	10	25	41	38	50	60	57	58	59	63	62	56	54	53	52	33	31	28	28	27	26	27	24
1502	5	17	18	21	28	31	41	45	45	44	38	41	31	18	17	17	17	21	20	19	19	19	19	18	19
1202	5	36	37	40	42	47	48	50	51	50	48	47	47	40	36	36	36	39	39	38	38	38	37	37	38
1540	4	41	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	43	14
265	4	7	10	28	36	42	48	51	47	41	37	30	29	19	11	8	7	10	11	11	9	9	9	8	9
826	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1238	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
811	4	6	8	25	40	47	48	49	53	47	54	44	44	36	18	9	9	11	11	10	9	9	9	10	10
252	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1534	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
262	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1532	4	47	40	41	49	48	46	47	42	41	40	40	40	41	40	36	36	37	38	38	37	37	38	38	38
1231	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1230	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1227	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1226	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1225	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 8: Detector Occupancy

Eastbound Flows: 6 A.M. to 12 Noon

Zone #	Lanes	6:00 6:15	6:15 6:30	6:30 6:45	6:45 7:00	7:00 7:15	7:15 7:30	7:30 7:45	7:45 8:00	8:00 8:15	8:15 8:30	8:30 8:45	8:45 9:00	9:00 9:15	9:15 9:30	9:30 9:45	9:45 10:00	10:00 10:15	10:15 10:30	10:30 10:45	10:45 11:00	11:00 11:15	11:15 11:30	11:30 11:45	11:45 12:00
1525	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1526	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1527	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1530	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
254	4	817	1128	1426	1672	1892	2055	1861	1749	1691	1750	1728	1710	1680	1781	1809	1713	1709	1757	1749	1698	1718	1682	1773	1711
1631	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
667	5	725	986	1308	1532	1773	1926	1748	1650	1614	1677	1617	1589	1584	1648	1695	1584	1557	1594	1642	1503	1626	1551	1666	1576
1533	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
668	5	690	933	1286	1482	1757	1853	1699	1585	1499	1603	1555	1509	1481	1524	1621	1493	1434	1470	1526	1450	1461	1458	1574	1523
1234	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
266	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
562	4	774	38388	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1537	4	816	1060	1449	1773	1914	1929	1719	1656	1370	1532	1487	1713	1600	1511	1781	1579	1534	1567	1635	1594	1582	1572	1694	1702
669	5	463	621	897	1095	1163	1206	1067	1008	894	940	962	1022	1029	930	1075	962	902	913	954	927	924	936	993	999
1538	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
825	4	1019	1357	1709	2045	2238	2147	2046	1780	1790	1819	1866	1925	1840	1838	2098	1868	1795	1801	1913	1909	1816	1887	1985	1927
261	4	973	1319	1734	2037	2197	2146	2065	1794	1756	1809	1906	1927	1876	1847	2092	1877	1786	1809	1865	1882	1820	1849	1934	1932
947	4	1229	1230	1230	1230	1230	1230	1230	1230	1230	1230	1230	1230	1230	1230	1230	1230	1230	1230	1230	1230	1230	1230	1230	410
1503	5	852	1149	1518	1741	1822	1816	1717	1500	1409	1539	1599	1650	1588	1551	1736	1486	1506	1534	1562	1594	1534	1579	1630	1638
827	5	915	1260	1622	1946	2013	2090	2022	1802	1714	1834	1889	1930	1867	1811	1901	1691	1666	1665	1657	1694	1683	1665	1742	1771
1504	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
812	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
986	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
810	5	478	644	836	994	1054	1062	954	860	833	918	884	913	886	882	854	809	809	772	732	761	759	784	760	815
824	4	358	339	418	370	459	413	435	449	463	458	465	450	464	415	463	460	476	413	447	453	378	475	489	469
1506	4	761	1046	1343	1545	1602	1590	1367	1339	1284	1360	1355	1407	1346	1325	1288	1207	1294	1217	1206	1224	1229	1243	1244	1308
807	5	882	1192	1550	1758	1840	1782	1556	1509	1493	1512	1549	1579	1482	1516	1559	1460	1554	1436	1478	1463	1458	1480	1557	1639
1507	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
911	4	400	534	625	665	733	753	691	641	641	602	639	579	590	558	524	641	560	538	616	630	653	660	644	715
640	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
645	5	17	18	23	23	13	22	23	12	16	24	22	22	22	16	21	19	18	27	38	13	21	25	26	28
653	4	105	164	155	158	154	154	157	142	145	127	126	118	129	121	88	128	122	139	135	118	135	141	153	150
654	4	658	660	660	660	660	660	660	660	660	660	660	660	660	660	660	660	660	660	660	660	660	660	660	660
655	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
912	5	66	84	94	125	136	114	146	114	125	142	141	118	114	125	92	126	109	119	126	107	113	110	111	123
913	5	530	531	563	563	569	562	578	562	565	559	567	567	582	579	596	582	590	594	614	605	619	594	623	601

Figure 9: Detector Flow Data

Westbound Flows: 6 AM to 12 Noon

Zone	# Lanes	6:00 6:15	6:15 6:30	6:30 6:45	6:45 7:00	7:00 7:15	7:15 7:30	7:30 7:45	7:45 8:00	8:00 8:15	8:15 8:30	8:30 8:45	8:45 9:00	9:00 9:15	9:15 9:30	9:30 9:45	9:45 10:00	10:00 10:15	10:15 10:30	10:30 10:45	10:45 11:00	11:00 11:15	11:15 11:30	11:30 11:45	11:45 12:00
1207	3	8	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
813	4	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
808	5	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1206	4	539	1742	1961	2024	1808	1621	1265	997	984	899	1138	1188	1192	1216	1210	1173	1234	1834	1883	1850	1910	1901	1919	1835
952	4	543	1704	1935	2006	1783	1532	1186	1025	916	872	1143	1208	1201	1177	1197	1160	1281	1821	1894	1793	1905	1873	1882	1828
1505	4	601	1822	2082	2223	2024	1787	1320	1227	1025	974	1362	1353	1358	1370	1374	1296	1479	1960	2068	1960	2069	2041	2058	1965
828	4	82	201	233	252	254	292	214	230	183	229	219	188	220	210	201	253	233	232	254	350	285	271	285	302
1501	4	358	964	1061	1138	1023	860	645	557	499	487	696	672	698	695	690	659	780	983	1031	1001	1036	1026	1024	968
809	5	555	1731	2006	2292	1750	1700	1268	1064	974	986	1250	1243	1193	1134	1230	1164	1398	1683	1748	1590	1764	1711	1679	1609
1502	5	524	1658	1846	2082	1882	1378	1224	1161	883	1081	1245	1276	1360	1370	1367	1310	1627	1986	1982	1816	1934	1819	1816	1774
1202	5	441	1382	1565	1756	1558	1214	1160	1110	870	1085	1153	1170	1305	1186	1163	1098	1352	1686	1666	1538	1652	1492	1530	1485
1540	4	389	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140	1140
265	4	576	1760	1991	2145	1873	1532	1326	1272	1050	1368	1379	1477	1529	1643	1544	1474	1770	2156	2074	2070	2121	1961	2005	1943
826	4	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1238	5	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
811	4	474	1513	1716	2007	1596	1481	1350	1307	1195	1618	1513	1629	1720	1710	1484	1451	1569	1904	1878	1825	1872	1713	1805	1732
252	4	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1534	5	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
262	4	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1532	4	350	1417	1606	1696	1663	1825	1927	1768	2123	2144	2123	2143	2232	2151	1998	1820	1805	2061	2031	2036	1948	1978	1958	1957
1231	4	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1230	5	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1227	5	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1226	4	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1225	4	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure 9: Detector Flow Data

Using these tables, it is possible to get a general assessment of the congestion on the morning of December 8. Traffic becomes very heavy on the freeway around 6:30 A.M. and remains congested (occupancies greater than 20 percent) until about 9:30 A.M. The late morning has relatively high flow values but lower occupancies (15 to 20 percent). However, with data only available for about one third of the detectors, it is impossible to perform a complete analysis. Therefore, it was decided to study a small subset of the detectors in order to present a sample of the studies that would be possible with a complete set of accurate detector data.

Two zones with reasonable data were selected for more detailed analysis: Crenshaw (zone numbers 827 eastbound and 1502 westbound) and La Brea 2 (261 eastbound and 265 westbound). These zones are located exactly one mile apart in the approximate center of the Smart Corridor freeway section. Figure 10 shows flow (traffic volume) for these detectors over the time period. Note that La Brea is a four-lane section while Crenshaw has five, but the volume data are presented as hourly flows per lane. The graphs show good correlation between the flows on the two detectors. Also, there may have been an incident upstream of the westbound detectors during the morning rush hour; the flows fall off substantially during this period.

Figure 11 shows the average occupancy per lane for each of the zones during the same period. Again, there is generally a good correlation between the data, as would be expected for two zones located in close proximity to each other. The eastbound and westbound traffic appears to sharply decrease in density by around 10 A.M. The westbound traffic decreases earlier; around 8:45 A.M.

Figure 12 provides a scatter plot of flow vs. occupancy for these detectors, (Density is linearly related to occupancy as a function of the detectable vehicle length and detector zone length.) The flow/occupancy graph in Figure 12 also appears to reasonably represent the relationship between flow and occupancy that might be expected on a freeway section, although the flow data appears to be somewhat high for occupancies around 30%.

These graphs are a sample of the analysis that can be accomplished for any of the zones in the data set (subject to the integrity of the data). Other traffic flow relationships naturally follow from the flow and occupancy data, and it would be a straightforward process to study these.

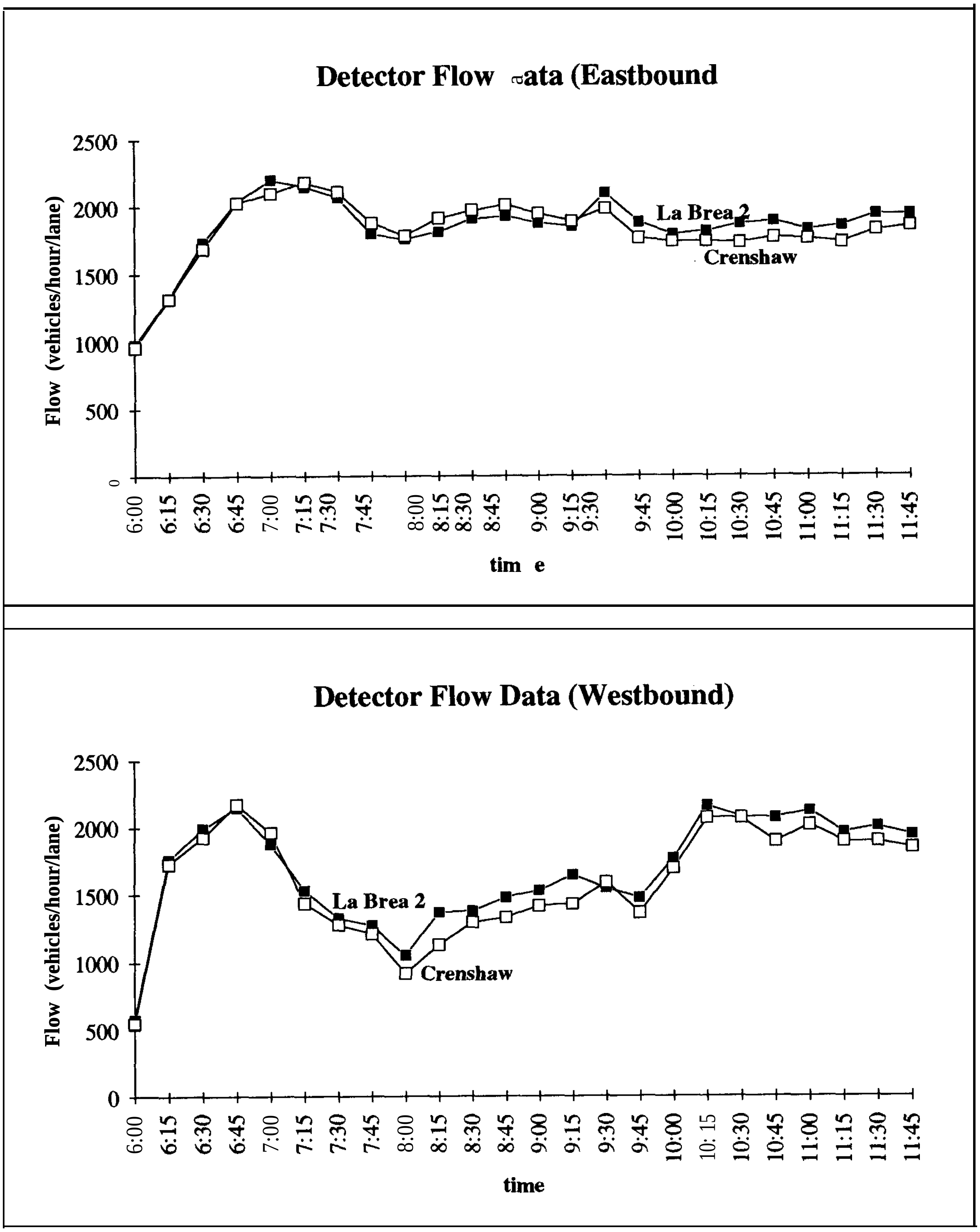
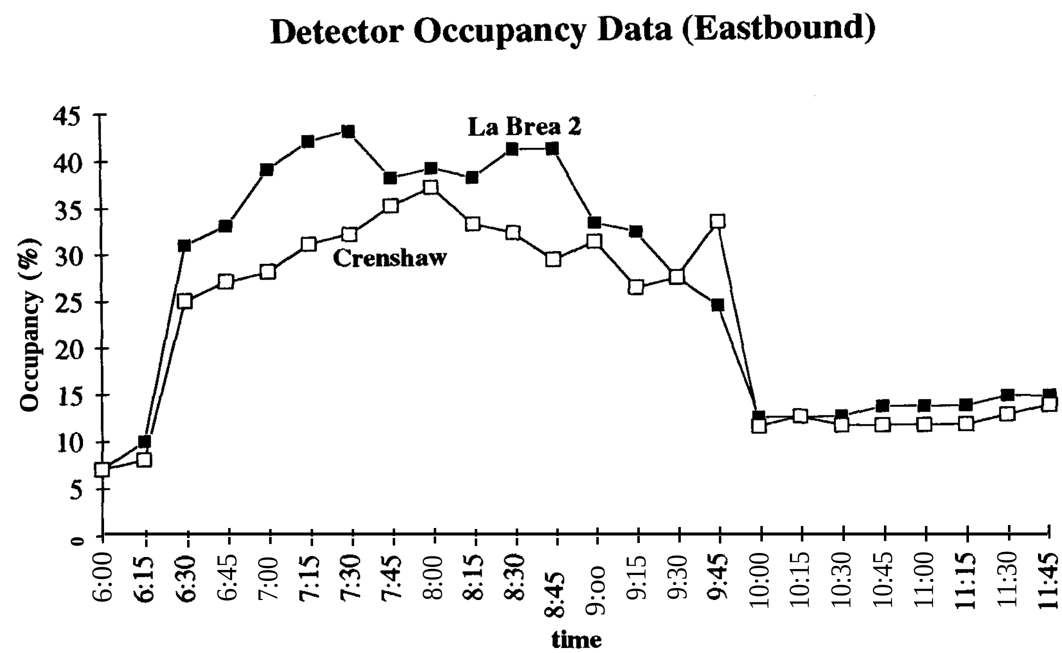


Figure 10: Flow Data vs. Time



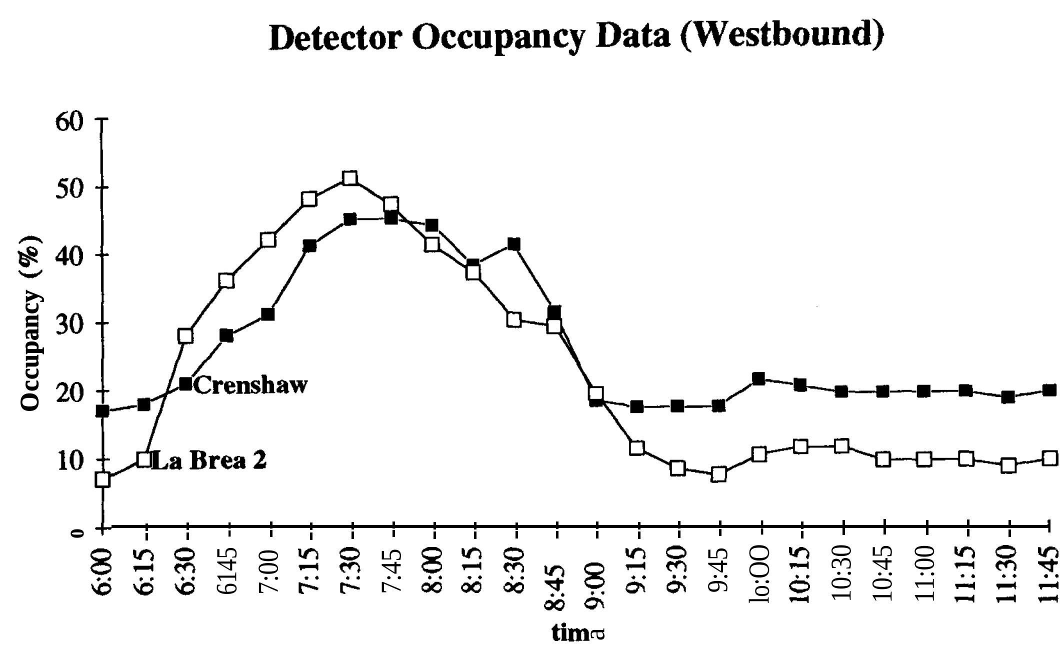


Figure 11: Occupancy Data vs. Time

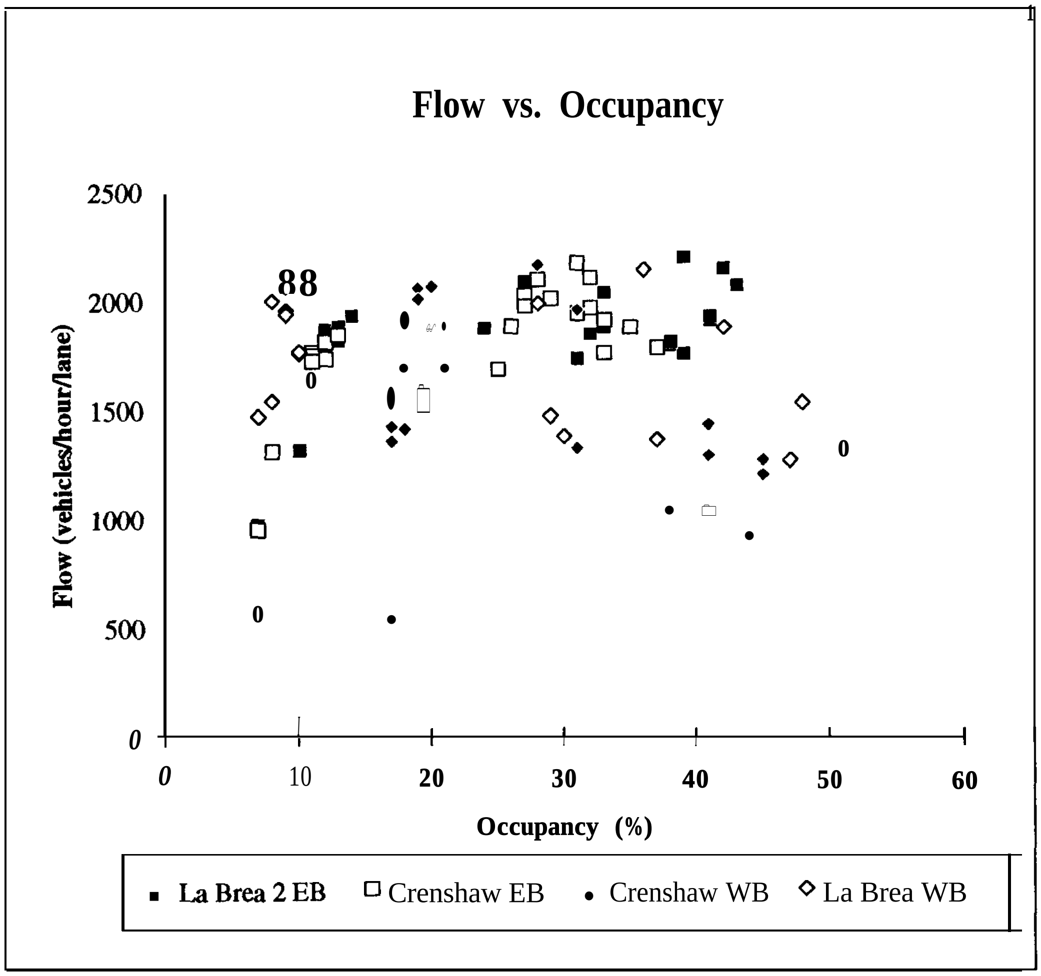


Figure 12: Flow vs. Density (both Crenshaw and La Brea 2 detectors)

Section 5: Further Investigations

The conclusions in this report are based on observations and analysis of a relatively limited data set. This section suggests some additional studies that might be undertaken with additional resources.

A. Additional Days and Times

Data was gathered for four days in early December 1992. While these periods were selected to minimize other factors (e.g., Christmas and weekend traffic), it is certainly premature to base analysis on one week of data. At a minimum, data could be collected during one other week during the year (probably in the summer). Also, given the relatively high frequency of incidents on the Santa Monica Freeway sections, it would be beneficial to have a larger sample size for study. With more data, it would be possible to study congestion under the effects of traffic blockages and incident-free traffic.

Also, only the data from Tuesday was considered for this study. As a baseline, the data from Monday (both morning and afternoon) was analyzed. This was done to set the procedures for handling the data. However, the data from Monday was not closely studied because there were heavy rains in the Los Angeles area on Monday, December 7. Since the weather was clear on Tuesday, it was decided that it was the best day for study. However, to be complete, other studies could be made on the remaining data (Wednesday and Thursday).

Efforts were concentrated around the morning rush hour because expected traffic volumes and occupancies were known. To check the integrity of the detector data, it was helpful to have baseline figures to compare with the detector data. For more detailed studies, analysis of the afternoon rush hour and off-peak times would give more complete results.

B. Additional Detector Data

Obviously, the study is limited because only about one third of the detectors are operational. For a complete analysis of the freeway section, a much higher percentage (at least 80%) would be required. It is recognized that it would require significant effort for Caltrans to repair and calibrate all of the freeway detectors. However, some automated method of traffic data collection is very helpful for useful studies of the freeway.

Another limitation of the study is the lack of detailed maps to reference some of the detector stations. For further research, it would be desirable to obtain accurate and detailed maps of the detectors from Caltrans.

Perhaps more importantly, the issue of the ramp and collector/distributor detectors has still not been resolved as of this report. For the purposes of simulation, the flows on the ramps are more important than detector data from the mainline freeway sections. Therefore, the logical next step for this study would be to concentrate efforts on determining, analyzing, and calibrating ramp flow and occupancy data.

It may be appropriate to have a meeting of involved parties as a next step for the analysis of the freeway sections. This meeting might include members of the UC Berkeley project team and representatives from Caltrans. Discussions could include limitations of the data (as found in this study), additional data on location and operation of detectors (from Caltrans), and plans for future study. With a relatively complete data set from the ramps, the simulation effort for the Smart Corridor would be enhanced.

C. Study Recommendations

From the results of the study, several recommendations can be made that may further the research effort. They are presented below as possible discussion points during future meetings:

- Consider efforts directed toward increasing the number of detectors that give reliable information

- Collect and analyze detector data from freeway ramps on the Santa Monica Freeway

- Collect and analyze detector data from additional days and times; this effort was limited by project scope.

- Locate and/or develop a detailed and accurate map that includes current detector information for all detectors included in the study.

Appendix: Data Extraction Program

Listed below is the source code for the data extraction program used for the freeway detector data tapes. The program was initially developed by UC Irvine by a team including Steven Ritchie, Neil Prosser, and Kelvin Cheu and was extensively modified by Randall Cayford of ITS. All modified statements are bracketed by comment lines in the code in the following format: /*************************/.

```
/* This query file reads Caltrans binary data tape with */
/* each cycle (=30sec) occupying 2 tracks */
/* modified from Neil Prosser's original program by Kelvin Cheu */
/* 10-25-91 */
/* Institute of Transportation Studies, University of California, Irvine */
/* all rights reserved */


/* modifications made */
/* (1) in get-cycle0 */
/* (2) in main0 */
/* (3) in read_query() */
/* all modified statements enclose by ----- lines • /

#include <stdio.h>
#include <io.h>
#include <fcntl.h>
#include <alloc.h>
#include <stdlib.h>


#define MAX_ZONE_NO 200
#define MAX-LANES 15
#define MAX-CYCLES 2000
#define MAX-READ 48

FILE *flog, *fvol, *focc ;
int  cycindex;
long SKIP;           /* offset to skip over garbage at front of tape */

getbytes (fd, pos, buf, n)
/*************************/
int fd, n ;
long pos ;
char *buf ;
{
   long fpos;
   int  numread;

   fpos = lseek (fd, pos + SKIP, 0);
   numread = read(fd, buf, n) ;
   return(numread);
}


unsigned short getword(fd, pos)
/******************************/
int fd ;
long pos ;
        {
        unsigned char i[2];
        getbytes (fd, pos, (char *)i, 2) ;
        return (i[0]*256 + i[1]) ;
        }

cyc_to_time (cyc, time)
```

```
/*********************/
int cyc ;
char *time ;
        {
        int i ;
        if ((cyc < 0) II (cyc > 2879))

                time[0] = '*' ;
                time[1] = '*' ;
                time[2] = '*' ;
                time[3] = '\0' ;
                return ;
                } ;

        i = cyc / 1200 ;
        time[0] = i + '0' ;
        cyc = cyc - i*1200 ;

        i = cyc / 120 ;
        time[1] = i + '0' ;
        cyc = cyc - i*120 ;

        time[2] = ':' ;
        i = cyc / 20 ;
        time[3] = i + '0' ;
        cyc = cyc - i*20 ;

        i = cyc / 2 ;
        time[4] = i + '0' ;
        cyc = cyc - i*2 ;

        time[5] = ':' ;
        if (cyc == 1)
                time[6] = '3' ;
        else
                time[6] = '0' ;
        time[7] = '0' ;
        time[8] = '\0' ;
        }

read-header (fin, cyc)
/*********************/
int fin ;
unsigned short *cyc ;
        {
        unsigned int word-value ;
        int year, month, day, dayofweek, trackno ;
        char time-str [10] ;

        *cyc = getword (fin, 0L) ;
        cyc_to_time (*cyc, time-str) ;

        word-value = getword (fin, 2L) ;
        year = word-value / 512 ;
        word-value -= year * 512 ;
        month = word-value / 32 ;
        day = word-value - month * 32 ;

        word-value = getword (fin, 4L) ;
        dayofweek = word-value / 256 ;
        trackno = word-value - dayofweek * 256 ;

        fprintf (flog, "\n\n TAPE HEADER INFORMATION') ;
        fprintf (flog, "\n ************************") .,
        fprintf (flog, "\n\n\n Date (MM/DD/YY)     : %2d/%2d/%2d",
                        month, day, year) ;
        fprintf (flog, "\n First cycle number : %u", *cyc) ;
        fprintf (flog, "\n Time                : %s", time-str) ;
        fprintf (flog, "\n Day of week         : %1d", dayofweek) ;
        fprintf (flog, "\n Number of tracks    : %1d", trackno) ;
        }

read_query (fin, pr_type, bcyc, ecyc, zone, nlanes)
/*************************************************/
```

```
FILE *fin ;
int *pr_type ;
unsigned short *bcyc, *ecyc ;
int zone [], nlanes [];
        {
        char time-str [10] ;
        int i = 0, j, k ;

        fscanf (fin, " %d", pr_type) ;

        fscanf (fin, . %d %d", Sj, &k) ;
        *bcyc = j ;
        *ecyc = k ;

        fprintf (flog, ● \n\n QUERY FIELDS') ;
        fprintf (flog, "\n *************") ;

        cyc-to-time (*bcyc, time-str) ;

        fprintf (flog, "\n\n First cycle : %u %s", *bcyc, time-str) ;

        cyc-to-time (*ecyc, time-str) ;
        fprintf (flog, "\n Last cycle : %u %s", *ecyc, time-str) ;

        fprintf (flog, "\n Print type : %d", ● pr-type) ;

/*------------------------------------------------------------------*/
/*      if ((*bcyc < 0 ) || (*bcyc > 28791 II (*ecyc < 0 ) ||
                (*ecyc > 2879) II (*bcyc > *ecyc))
                error (" error in cycle specification') ; */
        if ((*bcyc < 0 ) II (*bcyc > 28791 II (*ecyc < 0 ) ||
                (*ecyc > 2880) II (*bcyc > *ecyc))
                error (" error in cycle specification') ;
/*------------------------------------------------------------------*/

        fprintf (flog, "\n Zones (with lane no.) : ") ;
        while (fscanf (fin, "%d %d", &zone[i], &nlanes[i]) == 2)
                {
                if ((zone[i] < 0) II (zone[i] > 2000))
                        error (" invalid zone number') ;
                fprintf (flog, "\n      %6d (%1d)", zone[i], nlanes[i]) ;
                        if (nlanes[i] > MAX-LANES)
                    nlanes[i] = MAX-LANES;
                i++ ;
                }

        fprintf (flog, "\n\n\n") ;
        return (i) ;
        }


get-cycle (fin, offset, zone, nlanes, lanes,volume, occupancy)
/********************************************************/
int fin ;
long offset ;
int zone , nlanes;
int lanes ;     /* 0 = print lane config to log file */
int *volume:
int *occupancy;

{
   long off ;
   int j, track, length ;
   unsigned char list[MAX_READ] ;


        if (lanes == 0) {
           fprintf (flog, "\n\n\n LANE CONFIGURATIONS') ;
           fprintf (flog,      "\n ********************") ;
        }

                off = offset + 4 + zone * 2 ;
                if (getbytes (fin, off, (char *) list, 2) != 2) {
                   puts ('error in reading zone offset') ;
                                return(l);
```

```
                    }

                track = list[0] / 32 ;

/*-------------------------------------------------------------------------*/
/*              off = list[0] * 256 t list[1] ;*/
                        off = (list[0]-list[0]/32*32) * 256 t list[1];
/*-------------------------------------------------------------------------*/

                if (off == 0) {
/*
                   fprintf (flog, "\nNo data for zone = %d ", zone) ;
*/
                   return(0) ;
                }

/*-------------------------------------------------------------------------*/
                        off = offset + (long) 16384*track + off*2 - 2;
/*-------------------------------------------------------------------------*/

                if (getbytes (fin, off, (char *) list, 6) != 6) {
                   printf (" error in reading first 4 bytes of data') ;
                           return(2);
                        }

                if ((list[0] * 256 + list[1]) != zone)
                   error (" wrong zone number in data') ;

                length = list[2]*256 + list[3] ;
                if ((length < 0) || (length > 40))
                   error (" length of data invalid") ;

/*
                if (list[4] < 224)
                   error (" strange configuration"] ;
*/

                if (lanes == 0)
                   fprintf (flog, "\n Zone %6d Config : %5d", zone, list[4]) ;
                        if (length*2 >= MAX-READ) {
                           error ('Length too great for array');

                if (getbytes (fin, off, (char *)list, length*2) != length*2)
                   error (" can't read cycle data") ;

                if (zone <= 1000)
                   off = 16 ;
                else
                   off = 10 ;

                for (j = 0 ; j < nlanes ; j++) {
                                /* store in cycle array */
                                *(volume+sizeof(int)*(j*MAX_LANES+cycindex)) = list[off] / 4 ;
                                *(occupancy+sizeof(int)*(j*MAX_LANES+cycindex)) = ((list[off] % 4)
* 256 t list[off+1]) / 9 ;
                    off += 2 ;
                }
   return(0) ;
}
/* end of get cycle */

/* print out routine */

void dumpdata(volout,occout,zone,nlanes,bcyc,ecyc,volume,occupancy)
FILE *volout, *occout;
int   zone, nlanes;
unsigned short  bcyc, ecyc;
int *volume;
int *occupancy;

{
int i, j, k;
int  sum, volsum, occsum:
int  ocount, vcount;
```

```
        for (j=0; j < nlanes; j++){
              sum = 0;
              vcount = 0;
              volsum = 0;
              ocount = 0;
              occsum = 0;
              fprintf(volout,"%d\t%d", zone, j+1);
              fprintf(occout,"%d\t%d", zone, j+1);
              for (k=0; k <= ecyc - bcyc; k++){
                    sum++;
                    if (*(volume+sizeof(int)*(j*MAX_LANES+k)) != -1) {
                         vcount++;
                         volsum += *(volume+sizeof(int)*(j*MAX_LANES+k));
                    }
                    if (*(volume+sizeof(int)*(j*MAX_LANES+k)) != -1) {
                         ocount++;
                         occsum += *(occupancy+sizeof(int)*(j*MAX_LANES+k));
                    }
                    if (sum == 10 && vcount != 0 && ocount != 0){
                      fprintf(volout, "\t%d", (int) ((float) volsum /vcount * sum + 0.5));
                         fprintf(occout, "\t%d", (int) ((float) occsum/ocount + 0.5));
                         sum = 0;
                         vcount = 0;
                         volsum = 0;
                         ocount = 0;
                         occsum = 0;

              }
              if (sum != 0 && vcount != 0 && ocount != 0){
                    fprintf(volout, "\t%d", (int) ((float) volsum /vcount * sum + 0.5));
                    fprintf(occout, "\t%d", (int) ((float) occsum/ocount + 0.5));
              }
              fprintf(volout,"\n");
              fprintf(occout,"\n");
        }
}

error (mess)
/**********/
char *mess ;
        {
        fprintf (flog, "\n\n ERROR -----\n %s", mess) ;
        printf ("\n\n ERROR -----\n %s\n", mess) ;
        fclose (flog) ;
        fclose(fvol);
           fclose(focc);
           exit (2) ;



main 0
/*****/
        {
        FILE *fquery ;
        int fin, fvo12, focc2 ;
        int retcode;
        int volume[MAX_LANES][MAX_CYCLES];
        int occupancy[MAX_LANES] [MAX-CYCLES];

        unsigned short begcyc, endcyc;

        unsigned short bcyc, ecyc, cyc ,startcyc;
        int zone [MAX-ZONE-NO], nlanes [MAX_ZONE_NO], no-zones ;
        int  vol [MAX_ZONE_NO*MAX_LANES], occ [MAX_ZONE_NO*MAX_LANES] ;

        int i, j, pr_type ;
        int jj, kk;
        long k;
        unsigned char list[48];
        long offset = 0 ;
        char  timestr1[10],timestr2[10],timestr3[10] ;
        char filename [24] ;

        /* open query and data and log files */
```

```
    printf ("\nEnter binary data file name :- ") ;
    gets (filename) ;

    printf("\nEnter # of blocks to skip at beginning of file:- ");
    gets (list);
       SKIP = (long) atoi(list) * 16384;

    if ((fquery = fopen ("query.dat", "r")) == NULL)
            error ('Can't open query.dat") ;

    if ((fin = open (filename, O_RDONLY | O-BINARY)) == -1)
            error ('Can't open %s", filename) ;

    printf ("\nReading from file %s\n", filename) ;

    if ((flog = fopen ("query.log", "w")) == NULL)
            error ('Can't open query.log") ;

    /* read header information and write to log file */
    read-header (fin, &cyc) ;
    startcyc = cyc;

    /* read query data and write to log file */
    no-zones = read-query (fquery, &pr_type, &bcyc, &ecyc, zone, nlanes) ;
    begcyc = bcyc;
    endcyc = ecyc;

    /* open output files */

    if ((focc = fopen ("occ.dmp", "w")) == NULL)
            error ('Can't open occ.dmp") ;

    if ((fvol = fopen ("vol.dmp", "w")) == NULL)
            error ('Can't open vol.dmp") ;

for (k=0; k < no-zones; k++) {
    cyc = startcyc;
    bcyc = begcyc;
    ecyc = endcyc;
    offset = 0;

       /* initialize */
    for (jj=0; jj < MAX-LANES; jj++)
        for (kk=0; kk < MAX-CYCLES; kk++) {
        volume[jj][kk] = -1:
        occupancy[jj][kk] = -1;
    }

    /* seek first track */

    if (cyc > bcyc)
            fprintf (flog, "\n\n WARNING - beg. cycle not found') ;

    fprintf (flog, "\nProcessing following cycles :-") ;
    printf ("\nProcessing following cycles for zone %d :\n\n",zone[k]) ;

    for (i = 0 ;  ((i < 3000) && (cyc < bcyc)); i++)
            {
            offset += (long) 16384*2 ;
            cyc = getword (fin, offset) ;
            cyc = cyc % 4096 ;
            fprintf (flog, "\n   %ld", (long) cyc) ;
            printf ("\r%ld     ", (long) cyc) ;
            }

    if (cyc != bcyc)
            puts ("  Could not find first cycle') ;

    for (i = 0 ;  ((i < 3000) && (cyc < ecyc)) ; i++)
            {

                    cycindex = cyc - bcyc;
                    retcode = get-cycle (fin, offset, zone[k], nlanes[k], 1,
                                 volume,  occupancy) ;
                    if (retcode == 1 || retcode == 2) {
```

```
                              cyc = ecyc + 1;
                              continue;

/*
               fprintf (flog, "\n   %ld ****", (long) cyc) ;
*/
                           printf ("\r%ld ****", (long) cyc) ;

/*-----------------------------------------------------------------------*/
                           offset += (long) 16384*2 ;
/*-----------------------------------------------------------------------*/
               cyc = getword (fin, offset) ;

          } /* end of loop through cycles */

          dumpdata(fvol,focc,zone[k],nlanes[k],bcyc,ecyc,volume,occupancy);
   } /* end of loop through zones */

       printf ("\n\nSuccessful Completion\n\n") ;
       fprintf (flog,  "\n\n %d cycles extracted', i);
       fprintf (flog, "\n\n\n  ****** SUCCESSFUL COMPLETION ******") ;
       fclose(fvol);
       fclose(focc);
       fclose(flog);
       }
```