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Advanced Simulation Tools for Freeway Corridor Management

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

As part of the California PATH program, the Paramics microscopic traffic simulation model was applied to the I-580 freeway-arterial corridor. The main purposes of the project were two-fold:

- Develop the expertise and transfer the knowledge required in calibrating a large-scale freeway corridor with Paramics;
- Prepare a calibrated model for the I-580 corridor that could be used to address operational questions, evaluate potential improvement alternatives and provide input to the decision-making process.

In agreement with Caltrans District 4 and Headquarters, the study focused on the eastbound direction of I-580 (a 25 mile section) during the afternoon peak period of a typical weekday. The freeway network to be simulated included, in addition to the eastbound direction of 580, the westbound direction as well as a segment of I-680 and the portion of SR 84 connecting 580 and 680. The grid network also included a large number of surface streets and a total of more than 100 signalized intersections.

The network coding effort relied on traditional coding techniques (mostly aerial photos) because the GIS conversion program intended to be tested as part of this project was not available at the time. The original intent of the project was to include only a portion of the most critical surface street system adjacent to the I-580 freeway. As the project proceeded in the demand estimation effort, the need for extending the freeway corridor to encompass most of the surface street and the adjacent freeway was required. This resulted in much more time being spent in coding the freeway corridor than originally contemplated.

The traffic data available to carry out the demand estimation and calibration activities was of good quality as far as the I-580 eastbound direction was concerned. For the other freeways and the surface streets, however, the research team could not assembly data of the same quality. The quality of data available for portions of the freeway corridor excluding the I-580 eastbound data were not as comprehensive or as high quality as had been expected. This was one of the contributing factors in the difficulty in calibrating the model

The project provided a valuable and timely opportunity to apply the OD Estimator software, the latest module of the Paramics suite just released by Quadstone following some development work and testing supported by Caltrans. OD Estimator proved to be a very useful tool in the process of generating a reliable OD matrix for the Paramics model. Working with a pattern matrix extracted from the EMME2 planning model of Alameda County, the research team used the counts available to produce an optimized demand table for the first hour of the afternoon peak period. By going through this process, much knowledge was gained in identifying the required data input, preparing and adjusting the various input data files, improving the method and fine-tuning the parameters in order to optimize the quality of the demand file generated by OD Estimator. Since this research

project provided the first real freeway corridor application of the OD Estimator, considerable effort was required in getting familiar with the technique and learning how to interact the OD Estimator with other features of the Paramics model

Once the demand side of the simulation was available, further adjustments on the supply and control sides were needed to improve the results of the calibration. The final project deliverable is a detailed model of the area, with a demand file optimized for the 2-3 PM period. When compared to real-life traffic performances on the eastbound direction of I-580, the model shows some fidelity in replicating counts, but tend to overestimate the amount of congestion occurring during the first hour of the simulation period.

ACKNOWLEDGEMENTS

This research was funded by the California Department of Transportation (Caltrans) through the California Partners for Advanced Transit and Highways (PATH) Program.

Several units of Caltrans Headquarters in Sacramento participated in this project. Steve Hague (Traffic Operations), Andrew Lee and Haniel Chung (Division of Research and Innovation) and Leo Gallagher (Transportation Systems Information) and) provided much valuable time and input into the project.

Steve Hague was particularly involved in helping us collecting the necessary data, reviewing the work in progress, and serving as an interface with Quadstone. He provided continuous technical guidance to the project.

Caltrans District 4 (San Francisco Bay Area) was instrumental in collecting and sharing the data and information used in this study, as well as supporting and reviewing the work as it progressed. Alan Chow and Ray Ovaici were more particularly involved in the project.

Traffic engineers at the cities of Pleasanton and Livermore provided much needed data for the project, including signal timings and traffic data counts.

Initial construction of the new I-580 corridor network was based on previous Paramics modeling efforts carried out in the same area by Dowling and Associates (downtown Pleasanton) and by Caltrans District 10 (around the 580/205 split).

Changmo Kim, PhD student at UC Davis, provided some support to the research team in the phase of network coding.

Thanks to Dr. Henry Liu, Assistant Professor at Utah State University (and former PATH researcher) for reviewing the final draft of the report and providing timely and relevant comments.

Finally, Scott Aitken, Richard Braidwood and Ewan Speirs, at Quadstone in Scotland, provided continuous technical support and advices in applying Paramics Modeller and Paramics OD Estimator.

CHAPTER 1: INTRODUCTION

1.1 Project scope and objectives

This report presents the approach developed and the results obtained as part of a project conducted for Caltrans by the California PATH program. The project involved the application of the Paramics microscopic traffic simulation model to the I-580 freeway-arterial corridor.

The main purposes of the project were two-fold:

- Develop the expertise and transfer the knowledge required in calibrating a large-scale freeway corridor network in Paramics;

- Prepare a calibrated model for the I-580 corridor that could be used to address operational questions, evaluate potential improvement alternatives and provide input to the decision-making process.

The various tasks carried out to meet these objectives are documented in details in this report. The methodology that was followed, and the initial results that were obtained are reported for future reference. This pilot study is intended to serve as a foundation for further work, either on the same network or on similar types of applications to be undertaken on different sites.

1.2 Organization of the report

Chapter 2 of this report describes the process of assembling the data to be used in calibrating and validating the model against typical traffic conditions.

Chapters 3 through 5 describe the general approach taken and the methodologies developed to code the network and control data, estimate the demand information, and calibrate the model.

Chapters 6 and 7 present a number of further refinements that were carried out in the second phase of the project in order to improve the quality of the calibration.

Chapters 8 and 9 describe the latest status in terms of calibrating the model for the 2-3 PM period.

Chapter 10 highlights some important lessons learned throughout the process, while Chapter 11 provides some suggestions on how to continue the work and move forward on this type of applications. Chapter 12 presents a summary and general conclusions.

CHAPTER 2: DATA COLLECTION

2.1 Introduction

The purpose of this initial task was to:

- identify the study area boundaries;
- list the data required for performing the simulation work;
- assemble all existing data relevant to the I-580 modeling effort
- process these data in the format suitable for usage in Paramics and its supporting modules

It is important when using simulation models that comprehensive data sets be obtained that match data input requirements. It is also critical that a set of traffic performance data be acquired for the critical step of model calibration. A dataset for the eastbound section of I-580 set was made available by Caltrans at the beginning of this study that provided the research team with some of the data needed to develop and calibrate the model.

The required simulation input data generally falls into three categories: geometry, traffic performance and traffic control. Each of these categories will be successively reviewed in this chapter, in terms of requirements and data available for the I-580 application.

2.2 Identification of study boundaries

Preliminary discussions with Caltrans revealed that the primary interest was on modeling the Eastbound direction of I-580 during the afternoon peak period. It was agreed that the modeled section would extend from west of the I-680 interchange to east of the I-580/205 split. To take full advantage of the graphical capabilities of Paramics, and to give more realism to the simulation, it was determined that both directions of 580 would be coded into the model.

In addition to the mainline freeway and interchanges, it was found desirable to also code a number of parallel routes that could be used as alternatives to the freeway. Modeling route choices under various scenarios (including ramp metering schemes) had been identified as an objective of the study. Discussions with District 4 led to select the following routes as an initial set of potential alternative routes: Stanley Avenue, Bernal Avenue, Valley Boulevard, and State Route (SR) 84.

The original intent of the project was to include only a portion of the most critical surface street system adjacent to the I-580 freeway. However, as the project proceeded in the demand estimation effort, the need for extending the freeway corridor to encompass most of the surface street and the adjacent freeway was identified. This resulted in significantly more time being spent in coding the freeway corridor than originally contemplated. Other roads that were modeled in the network included all those streets that have an interchange on either the I-580 or I-680; this was to result in a grid network allowing for a number of alternative paths, closely matching real-life conditions.

A general map of the study area is presented on Figure 2.1.

The study period was to include the entire afternoon peak period, from 2 PM to 8 PM.

2.3 Network geometry information

The freeway study corridor consisted of a 40-kilometer (25 mile) segment of eastbound I-580 extending from just west of Interstate 680 to Interstate 205 in the east. The main emphasis of the simulation and calibration effort was to be on the eastbound direction of 580. This portion of I-580 EB included fifteen (15) off-ramps and seventeen (17) on-ramps.

To better replicate real world conditions, it was agreed that parallel arterial routes be modeled to serve as alternative routes for commuters. Although the eastbound I-580 was the primary concern of the study, by modeling parallel routing, there would be a better understanding of the OD travel patterns of commuters.

In order to assist in initial network coding activities, aerial photos and general maps of the Dublin/Pleasanton/Livermore area were obtained to determine lane configurations. Field trips to the study corridor were also made to validate network geometry information.

Further data that was supplied by Caltrans included vertical alignment profiles of the freeway study site, to be used in putting gradient information into the model.

Finally, at a later stage of the project, additional data sources were located, providing a way to further check and improve the network coding effort. These additional data sources included video logs taken on both directions of the main routes (I-580, I-680, and SR 84). Caltrans also provided high-resolution digital color photos showing the details of the geometry on the main highways and adjacent streets.

2.4 Traffic performance data

Once the study period is identified, the traffic performance information can be assembled. This data will be used to estimate the demand and to calibrate the model under base conditions.

Existing data already available either from automatic data collection systems or from past studies was used as much as possible. One of the primary reasons for choosing the I-580 corridor was that a lot of freeway performance data such as vehicle volumes and travel time data from tach runs were already available for this facility.

In September 2002, Caltrans District 4 collected data at the freeway study site (the eastbound direction of I-580) over three typical weekdays. During this extensive data collection campaign, a lot of the traffic performance data directly relevant to the Paramics simulation effort was gathered. In particular, counts and speed data was collected simultaneously on the eastbound direction of I-580. The data collection campaign was carried out by Caltrans District 4 and was successful in gathering all the data needed. Two days (Tuesday, September 17 and Thursday, September 19) were considered typical days to reflect traffic patterns on the freeway section and were selected for further analysis and potential usage in the simulation effort.

Count data

A set of 15-minute traffic counts for the afternoon peak period for each freeway entrance and freeway exit was produced using temporary counters installed by Caltrans District 4. In addition to all ramps, the data collected included the mainline freeway entrance and exit as well as one additional mid-section mainline location (at the Airway interchange).

The ramp data is presented on Figures 2.2 and 2.3 for the Tuesday 9/17 dataset and Thursday 9/19.

Speed data

Caltrans provided travel time tach runs coincident with the volume counts. These travel time tach runs consisted of continuous speed observations and total trip time over the entire freeway section, from Foothill to Grant Line, carried out on Tuesday, 9/17 and Thursday, 9/19 during the PM peak period. Eleven runs were made on Tuesday starting between 2:15 PM and 6:30 PM. Twelve runs were made on Thursday starting between 2:15 PM and 7:15 PM.

Speed contour maps were later constructed using the information gathered from these tach runs. Time slices were set at 15-minute intervals on the vertical axis of the time-space diagram. The horizontal axis represented the freeway segment broken down into subsections. The modeled freeway section of eastbound I-580 was divided into 31 subsections as shown on Figure 2.4.

Speeds for a given subsection at a given time were entered into the appropriate box in the time-space diagram. After all available tach run data was entered into the matrix, blank boxes were filled using the average of the previous and following time period’s speed.

The resulting 15-minute speed contour maps for the two days of tach run measurements are shown in Figures 2.5 and 2.6. Three levels of speed are identified by different colors on the figures: the green cells represent speeds greater than 50 mph; speeds from 35 to 50 mph appear in orange, and speeds lower than 35 mph in red.

The speed contour maps shown on Figures 2.5 and 2.6 give a clear indication of the high level of congestion experienced on the I-580 eastbound section during the afternoon peak period. Two bottlenecks appear to cause serious congestion problems: the first and most severe one is located at the northbound Tassajara on-ramp; congestion starts around 2:30 pm and can last until after 7:30 pm. The second bottleneck condition occurs at the Greenville on-ramp; it is less severe, starts later, and ends sooner. But in some instances, as happened on Thursday, 9/19/02, queues from the Greenville bottleneck can spill back to the Tassajara bottleneck.

Travel time data

Another way to use the tach run data is to compute and plot the total travel time required to traverse the entire freeway section, from the Foothill on-ramp to the Grant Line off-ramp. This type of information is useful in the validation phase of the model. Figure 2.7 presents the results of this analysis, for the two days of tach run measurements. Each point on the graph represent a specific tach run, indicating the total trip time required to reach the other end of the freeway as a function of the departure time.

Occupancy data

Further data that was supplied by Caltrans included occupancy split

Additional freeway counts

Caltrans also provided data called the Census Data Set, which is a compilation of hourly traffic counts at various freeway locations in the corridor, including ramps on the I-580 and I-680, and a number of mainline locations. These counts were collected on various days over several years. Very useful in the process of demand estimation, they complemented the set of target counts available on 580 eastbound, as described in details under section 4.5 of this report.

Surface street data

Municipal authorities in Pleasanton and Livermore also provided valuable information that was needed to model arterial routes. The City of Pleasanton, through its Synchro model, supplied traffic counts, signal timings, as well as information on the number of lanes on major routes for the afternoon peak. The data included all intersections for the PM peak hour (5 to 6) in 2001. The City of Livermore provided signal timings, daily total traffic counts on major arterials, also provided a Synchro file for one arterial corridor. For those areas in the arterial street network where information was not available, aerial photography was used to determine lane configurations, and conservative signal timings were assumed.

To ensure the quality of the data set, field trips were conducted to confirm the data that had been assembleed. This included additional test runs along the freeway study site to check geometric design features, checking the reasonableness of traffic count patterns and tach run data. A meeting was held with Caltrans District 4 engineers to review and comment on the assembled data set.

2.5 Traffic control information

The traffic engineering divisions of Pleasanton, Livermore and Dublin were contacted at the beginning of the project to see if they could provide some data regarding signal timings plans currently in operation.

The city of Pleasanton responded by providing a recent and complete dataset under the form of a Synchro file for the PM peak hour. All signalized intersections of Pleasanton were covered, and contained a wealth of useful data regarding signal plans, but also turning movements and lane configurations.

As an example, a screenshot of the Synchro file developed for the city of Pleasanton and used as part of the Paramics study is shown on Figure 2.8.

The city of Livermore also provided signal timings data under the form of signal timing sheets. The data was manually converted into the format suitable for use in Paramics. One arterial (Vasco) had data already available in Synchro, and the city engineers agreed to share those files.

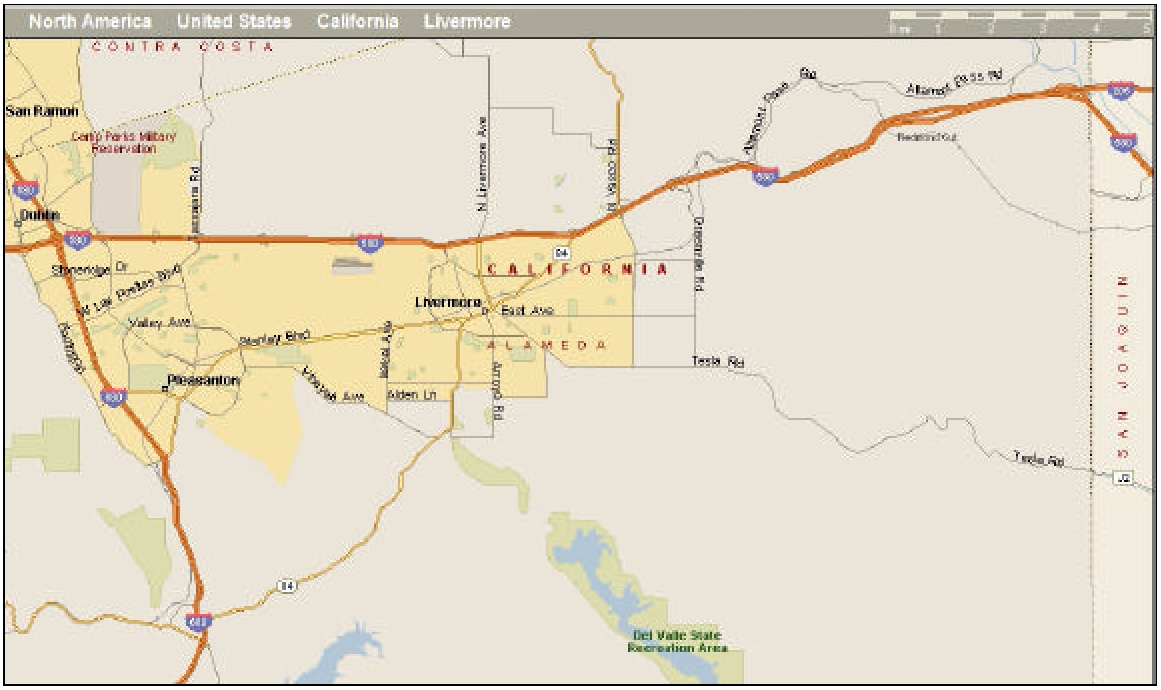
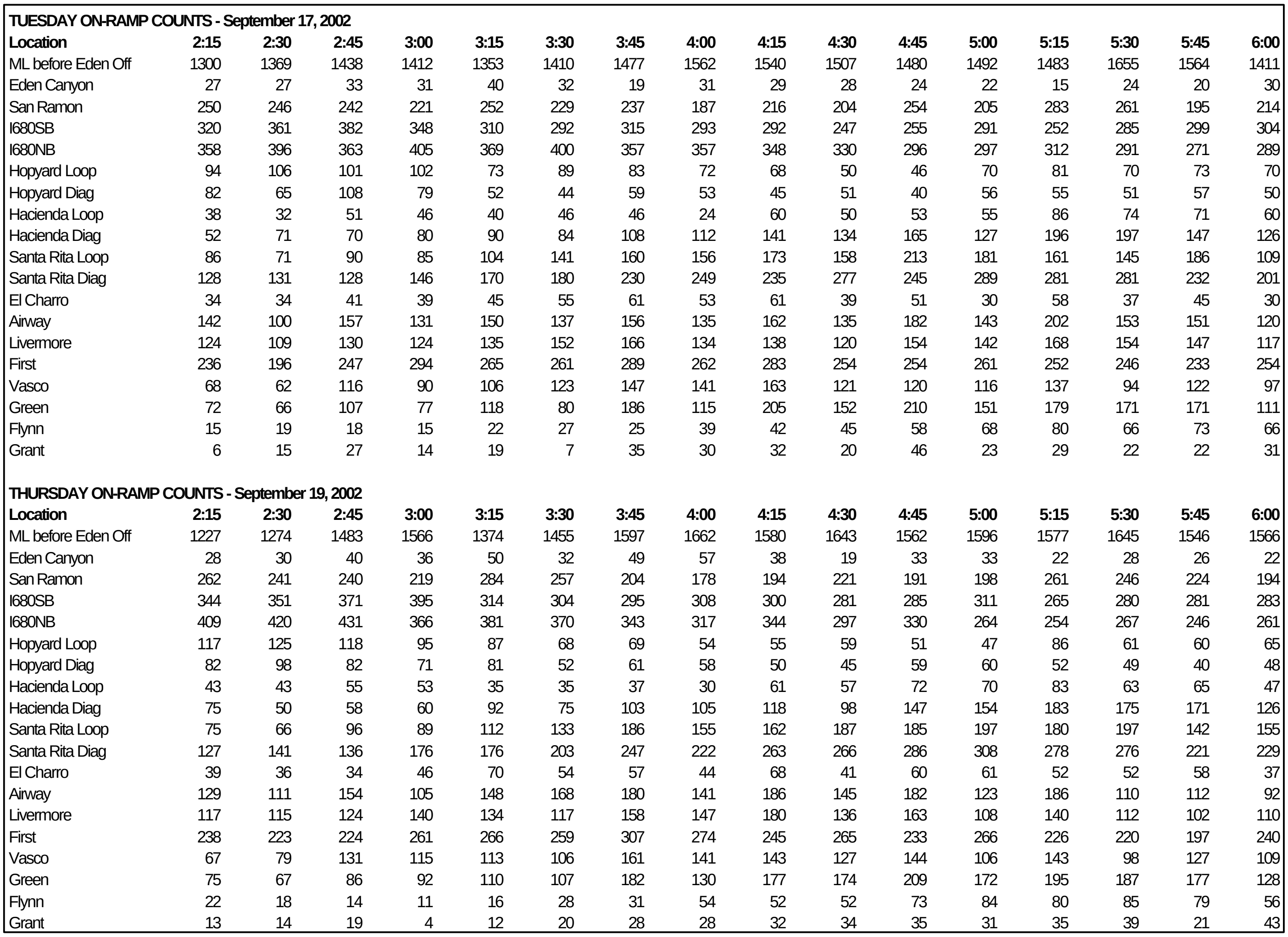


Figure 2.1: Map of the study area



TUESDAY ON-RAMP COUNTS - September 17, 2002

Location	**2:15**	**2:30**	**2:45**	**3:00**	**3:15**	**3:30**	**3:45**	**4:00**	**4:15**	**4:30**	**4:45**	**5:00**	**5:15**	**5:30**	**5:45**	**6:00**
ML before Eden Off	1300	1369	1438	1412	1353	1410	1477	1562	1540	1507	1480	1492	1483	1655	1564	1411
Eden Canyon	27	27	33	31	40	32	19	31	29	28	24	22	15	24	20	30
San Ramon	250	246	242	221	252	229	237	187	216	204	254	205	283	261	195	214
I680SB	320	361	382	348	310	292	315	293	292	247	255	291	252	285	299	304
I680NB	358	396	363	405	369	400	357	357	348	330	296	297	312	291	271	289
Hopyard Loop	94	106	101	102	73	89	83	72	68	50	46	70	81	70	73	70
Hopyard Diag	82	65	108	79	52	44	59	53	45	51	40	56	55	51	57	50
Hacienda Loop	38	32	51	46	40	46	46	24	60	50	53	55	86	74	71	60
Hacienda Diag	52	71	70	80	90	84	108	112	141	134	165	127	196	197	147	126
Santa Rita Loop	86	71	90	85	104	141	160	156	173	158	213	181	161	145	186	109
Santa Rita Diag	128	131	128	146	170	180	230	249	235	277	245	289	281	281	232	201
El Charro	34	34	41	39	45	55	61	53	61	39	51	30	58	37	45	30
Airway	142	100	157	131	150	137	156	135	162	135	182	143	202	153	151	120
Livermore	124	109	130	124	135	152	166	134	138	120	154	142	168	154	147	117
First	236	196	247	294	265	261	289	262	283	254	254	261	252	246	233	254
Vasco	68	62	116	90	106	123	147	141	163	121	120	116	137	94	122	97
Green	72	66	107	77	118	80	186	115	205	152	210	151	179	171	171	111
Flynn	15	19	18	15	22	27	25	39	42	45	58	68	80	66	73	66
Grant	6	15	27	14	19	7	35	30	32	20	46	23	29	22	22	31

THURSDAY ON-RAMP COUNTS - September 19, 2002

Location	**2:15**	**2:30**	**2:45**	**3:00**	**3:15**	**3:30**	**3:45**	**4:00**	**4:15**	**4:30**	**4:45**	**5:00**	**5:15**	**5:30**	**5:45**	**6:00**
ML before Eden Off	1227	1274	1483	1566	1374	1455	1597	1662	1580	1643	1562	1596	1577	1645	1546	1566
Eden Canyon	28	30	40	36	50	32	49	57	38	19	33	33	22	28	26	22
San Ramon	262	241	240	219	284	257	204	178	194	221	191	198	261	246	224	194
I680SB	344	351	371	395	314	304	295	308	300	281	285	311	265	280	281	283
I680NB	409	420	431	366	381	370	343	317	344	297	330	264	254	267	246	261
Hopyard Loop	117	125	118	95	87	68	69	54	55	59	51	47	86	61	60	65
Hopyard Diag	82	98	82	71	81	52	61	58	50	45	59	60	52	49	40	48
Hacienda Loop	43	43	55	53	35	35	37	30	61	57	72	70	83	63	65	47
Hacienda Diag	75	50	58	60	92	75	103	105	118	98	147	154	183	175	171	126
Santa Rita Loop	75	66	96	89	112	133	186	155	162	187	185	197	180	197	142	155
Santa Rita Diag	127	141	136	176	176	203	247	222	263	266	286	308	278	276	221	229
El Charro	39	36	34	46	70	54	57	44	68	41	60	61	52	52	58	37
Airway	129	111	154	105	148	168	180	141	186	145	182	123	186	110	112	92
Livermore	117	115	124	140	134	117	158	147	180	136	163	108	140	112	102	110
First	238	223	224	261	266	259	307	274	245	265	233	266	226	220	197	240
Vasco	67	79	131	115	113	106	161	141	143	127	144	106	143	98	127	109
Green	75	67	86	92	110	107	182	130	177	174	209	172	195	187	177	128
Flynn	22	18	14	11	16	28	31	54	52	52	73	84	80	85	79	56
Grant	13	14	19	4	12	20	28	28	32	34	35	31	35	39	21	43

Figure 2.2: On-ramp counts for Tuesday (Top) and Thursday (Bottom)

TUESDAY OFF-RAMP COUNTS - September 17, 2002

Location	2:15	2:30	2:45	3:00	3:15	3:30	3:45	4:00	4:15	4:30	4:45	5:00	5:15	5:30	5:45	6:00
Eden Canyon	22	20	27	32	33	31	41	30	39	37	50	61	59	56	60	55
San Ramon	198	221	229	230	209	232	267	275	284	269	316	298	283	303	299	284
I680	294	345	356	368	402	375	333	375	373	362	380	396	397	457	446	493
Hopyard	93	101	112	100	112	94	125	121	110	122	144	145	150	133	132	142
Hacienda	220	178	183	205	182	217	238	325	354	340	355	390	363	367	263	208
Santa Rita	179	212	174	213	167	176	158	130	155	115	114	122	152	151	205	208
El Charro	47	43	37	37	27	35	29	24	24	20	22	29	20	21	13	13
Airway	232	202	206	187	181	177	150	178	170	195	180	206	225	237	233	235
Portola	181	148	161	158	149	182	153	166	135	139	169	176	175	181	180	172
Livermore	124	130	136	139	120	96	109	116	113	116	131	160	160	160	158	158
First	144	140	112	156	128	135	161	116	138	146	145	138	165	187	198	162
Vasco	339	344	339	352	333	366	382	379	360	347	344	340	311	329	305	359
Greenville	45	41	49	41	42	29	51	54	43	69	54	47	55	55	46	52
Flynn	17	18	12	10	14	15	26	5	17	10	10	11	17	8	5	15
Grant Line	15	30	25	24	32	38	38	71	59	55	74	60	77	75	79	92
I580	254	330	391	441	475	564	454	612	510	537	571	579	508	492	496	492
I205	891	1019	946	1040	1063	1068	938	1186	1062	1073	1289	1114	1075	1132	1182	1157

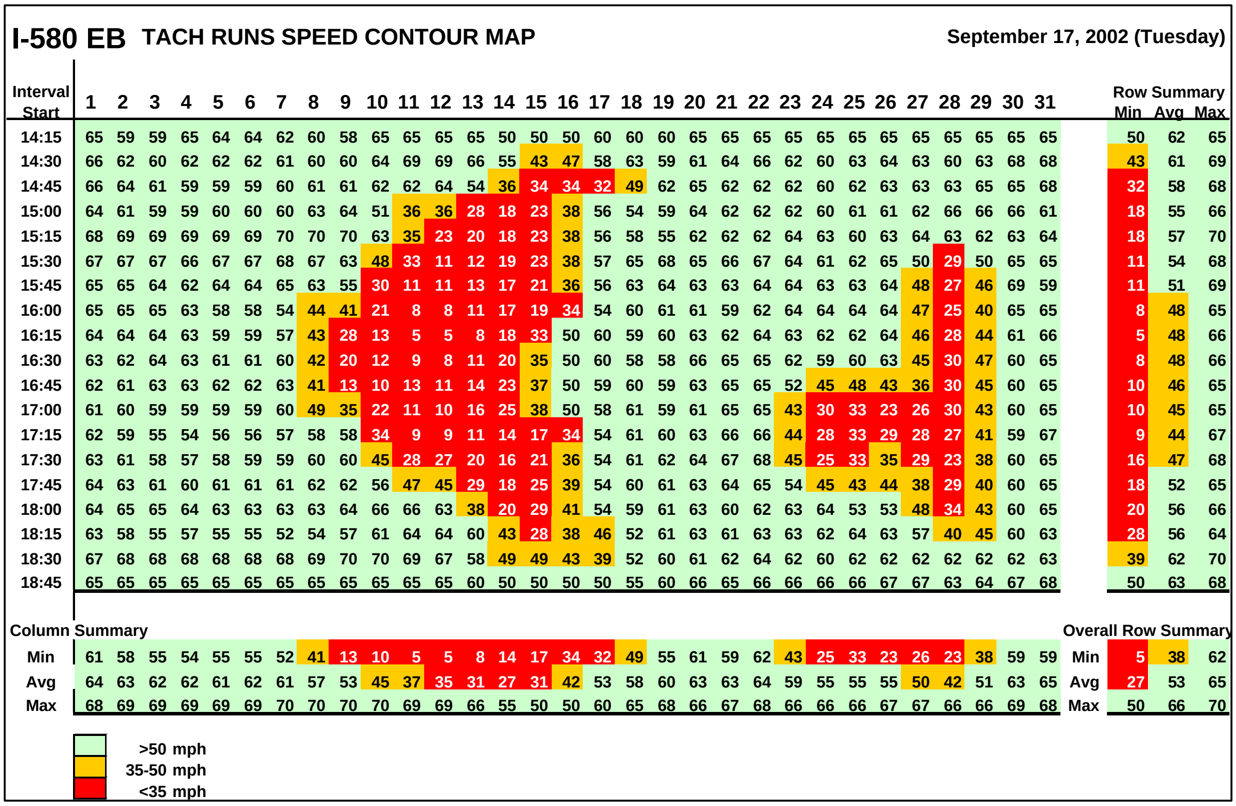
THURSDAY OFF-RAMP COUNTS - September 19, 2002

Location	2:15	2:30	2:45	3:00	3:15	3:30	3:45	4:00	4:15	4:30	4:45	5:00	5:15	5:30	5:45	6:00
Eden Canyon	19	20	25	29	34	26	43	106	59	79	65	64	61	74	56	45
San Ramon	206	207	246	263	239	227	298	296	299	307	276	345	310	318	311	317
I680	328	368	370	399	388	386	387	342	411	422	421	437	474	442	476	455
Hopyard	111	106	105	124	117	100	129	143	136	134	147	154	146	139	130	134
Hacienda	187	186	195	295	344	295	257	303	343	334	348	350	390	376	387	394
Santa Rita	222	223	195	151	138	128	135	127	128	111	108	92	133	106	128	143
El Charro	51	24	32	38	26	33	23	12	26	27	19	12	15	11	10	14
Airway	229	215	188	164	157	181	160	159	184	166	176	204	215	235	211	198
Portola	172	179	173	147	129	152	158	172	141	175	181	173	180	167	182	179
Livermore	123	140	145	135	132	112	134	117	134	144	155	149	180	159	177	191
First	148	154	152	160	116	140	150	140	141	159	144	154	127	108	144	104
Vasco	338	374	381	349	389	388	372	370	385	368	309	273	263	265	274	300
Greenville	50	53	43	38	34	26	44	37	47	61	52	59	57	50	74	62
Flynn	18	10	10	15	12	14	15	20	10	14	9	14	4	12	14	11
Grant Line	10	16	14	15	25	35	31	53	61	55	58	70	71	76	92	82
I580	254	330	391	441	515	535	595	570	588	566	588	564	559	555	544	553
I205	891	1019	946	1040	1076	1084	1041	1055	978	1144	1136	1125	1125	1156	1125	1145

Figure 2.3: Off-ramp counts for Tuesday (Top) and Thursday (Bottom)

Section ID			Section ID		
	U/S	D/S		U/S	D/S
1	Eden On	Foothill Off	**17**	El Charro Off	El Charro On
2	Foothill Off	Foothill On	**18**	El Charro On	Airway Off
3	Foothill On	I-680 Off	**19**	Airway Off	Airway On
4	I-680 Off	Hopyard Off	**20**	Airway On	Portola Off
5	Hopyard Off	Lane Drop	**21**	Portola Off	Livermore Off
6	Lane Drop	I-680 SB On	**22**	Livermore Off	Livermore On
7	I-680 SB On	I-680 NB On	**23**	Livermore On	First Off
8	I-680 NB On	Hopyard 1 On	**24**	First Off	First On
9	Hopyard 1 On	Hopyard 2 On	**25**	First On	Vasco Off
10	Hopyard 2 On	Hacienda Off	**26**	Vasco Off	Vasco On
11	Hacienda Off	Hacienda 1 On	**27**	Vasco On	Green Off
12	Hacienda 1 O	Hacienda 2 On	**28**	Green Off	Green On
13	Hacienda 2 O	Tassajara Off	**29**	Green On	Flynn Off
14	Tassajara Off	Tassajara 1 On	**30**	Flynn Off	Flynn On
15	Tassajara 1 O	Tassajara 2 On	**31**	Flynn On	Grant Off
16	Tassajara 2 O	El Charro Off			

Figure 2.4: Subsection structure



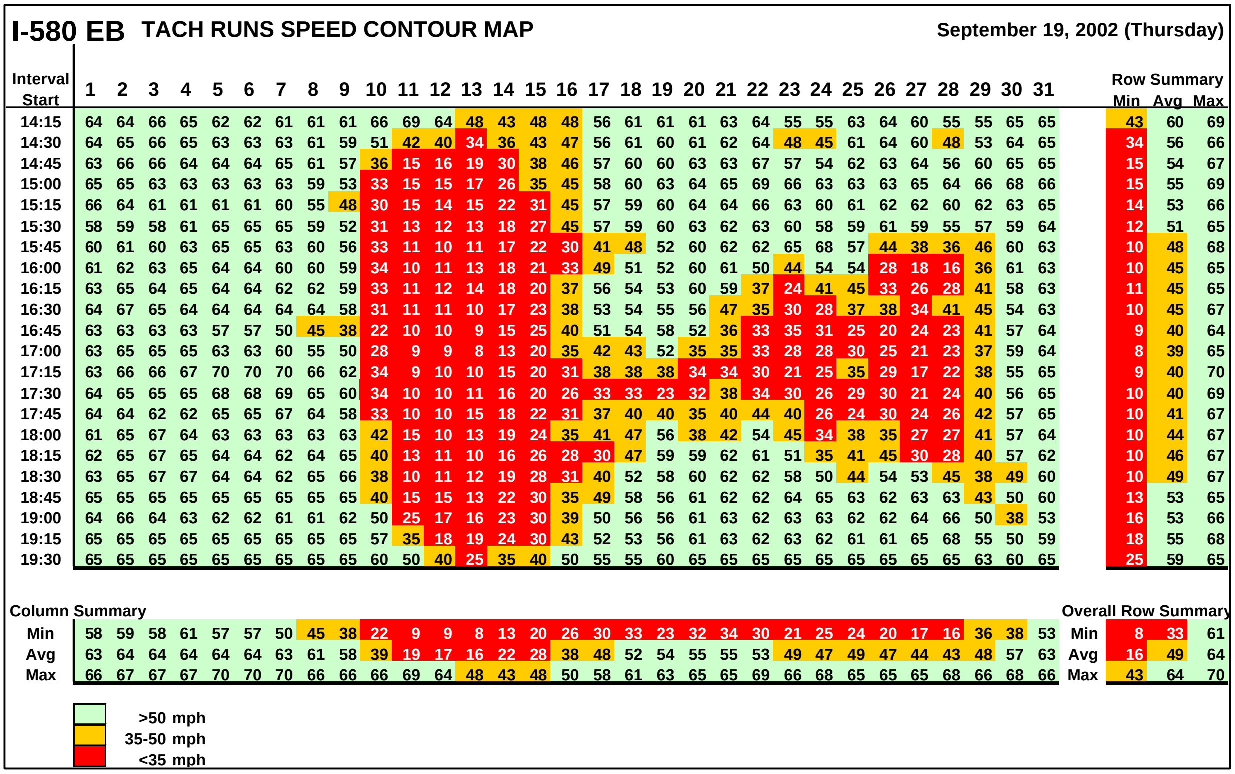
I-580 EB **TACH RUNS SPEED CONTOUR MAP** **September 17, 2002 (Tuesday)**

Interval Start	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Row Summary		
																																Min	Avg	Max
14:15	65	59	59	65	64	64	62	60	58	65	65	65	65	50	50	50	60	60	60	65	65	65	65	65	65	65	65	65	65	65	65	50	62	65
14:30	66	62	60	62	62	62	61	60	60	64	69	69	66	55	43	47	58	63	59	61	64	66	62	60	63	64	63	60	63	68	68	43	61	69
14:45	66	64	61	59	59	59	60	61	61	62	62	64	54	36	34	34	32	49	62	65	62	62	62	60	62	63	63	63	65	65	68	32	58	68
15:00	64	61	59	59	60	60	60	63	64	51	36	36	28	18	23	38	56	54	59	64	62	62	62	60	61	61	62	66	66	66	61	18	55	66
15:15	68	69	69	69	69	69	70	70	70	63	35	23	20	18	23	38	56	58	55	62	62	62	64	63	60	63	64	63	62	63	64	18	57	70
15:30	67	67	67	66	67	67	68	67	63	48	33	11	12	19	23	38	57	65	68	65	66	67	64	61	62	65	50	29	50	65	65	11	54	68
15:45	65	65	64	62	64	64	65	63	55	30	11	11	13	17	21	36	56	63	64	63	63	64	64	63	63	64	48	27	46	69	59	11	51	69
16:00	65	65	65	63	58	58	54	44	41	21	8	8	11	17	19	34	54	60	61	61	59	62	64	64	64	64	47	25	40	65	65	8	48	65
16:15	64	64	64	63	59	59	57	43	28	13	5	5	8	18	33	50	60	59	60	63	62	64	63	62	62	64	46	28	44	61	66	5	48	66
16:30	63	62	64	63	61	61	60	42	20	12	9	8	11	20	35	50	60	58	58	66	65	65	62	59	60	63	45	30	47	60	65	8	48	66
16:45	62	61	63	63	62	62	63	41	13	10	13	11	14	23	37	50	59	60	59	63	65	65	52	45	48	43	36	30	45	60	65	10	46	65
17:00	61	60	59	59	59	59	60	49	35	22	11	10	16	25	38	50	58	61	59	61	65	65	43	30	33	23	26	30	43	60	65	10	45	65
17:15	62	59	55	54	56	56	57	58	58	34	9	9	11	14	17	34	54	61	60	63	66	66	44	28	33	29	28	27	41	59	67	9	44	67
17:30	63	61	58	57	58	59	59	60	60	45	28	27	20	16	21	36	54	61	62	64	67	68	45	25	33	35	29	23	38	60	65	16	47	68
17:45	64	63	61	60	61	61	61	62	62	56	47	45	29	18	25	39	54	60	61	63	64	65	54	45	43	44	38	29	40	60	65	18	52	65
18:00	64	65	65	64	63	63	63	63	64	66	66	63	38	20	29	41	54	59	61	63	60	62	63	64	53	53	48	34	43	60	65	20	56	66
18:15	63	58	55	57	55	55	52	54	57	61	64	64	60	43	28	38	46	52	61	63	61	63	63	62	64	63	57	40	45	60	63	28	56	64
18:30	67	68	68	68	68	68	68	69	70	70	69	67	58	49	49	43	39	52	60	61	62	64	62	60	62	62	62	62	62	62	63	39	62	70
18:45	65	65	65	65	65	65	65	65	65	65	65	65	60	50	50	50	50	55	60	66	65	66	66	66	66	67	67	63	64	67	68	50	63	68

Column Summary																																Overall Row Summary			
Min	61	58	55	54	55	55	52	41	13	10	5	5	8	14	17	34	32	49	55	61	59	62	43	25	33	23	26	23	38	59	59	Min	5	38	62
Avg	64	63	62	62	61	62	61	57	53	45	37	35	31	27	31	42	53	58	60	63	63	64	59	55	55	55	50	42	51	63	65	Avg	27	53	65
Max	68	69	69	69	69	69	70	70	70	70	69	69	66	55	50	50	60	65	68	66	67	68	66	66	66	67	67	66	66	69	68	Max	50	66	70

🟩 >50 mph
🟨 35-50 mph
🟥 <35 mph

Figure 2.5: Tuesday, 9/17/02 Speed Contour Map



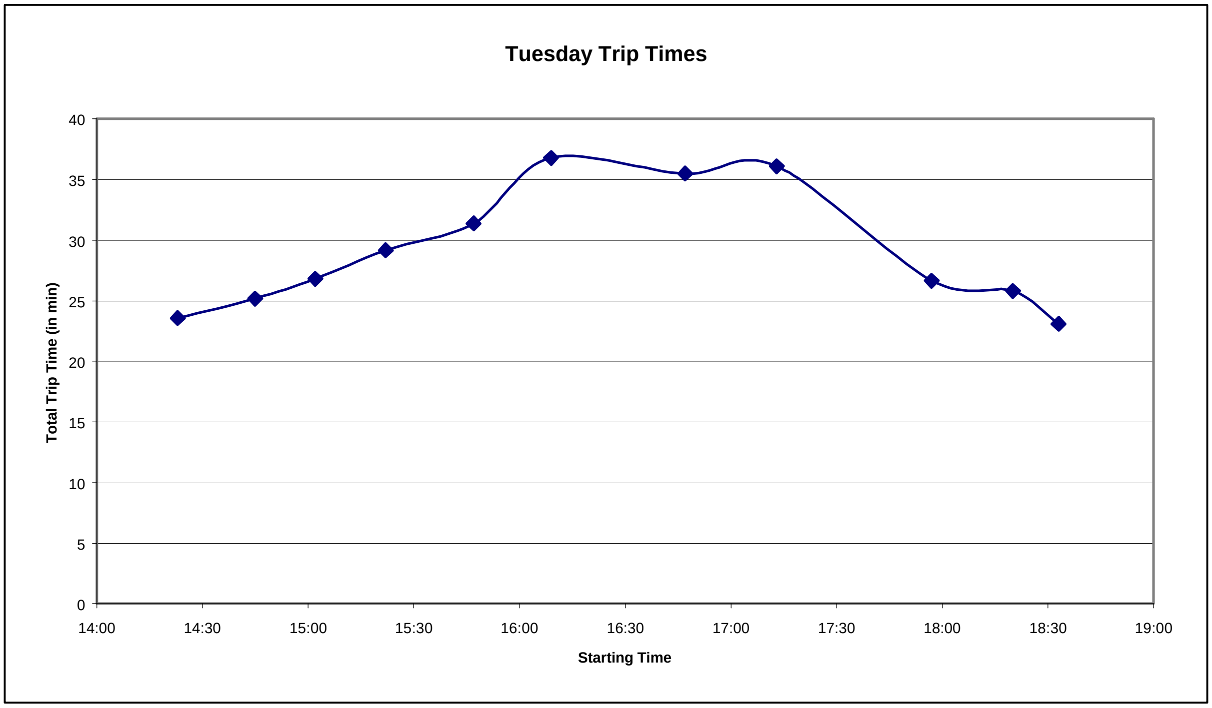
I-580 EB **TACH RUNS SPEED CONTOUR MAP** **September 19, 2002 (Thursday)**

Interval Start	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Row Summary Min	Avg	Max
14:15	64	64	66	65	62	62	61	61	61	66	69	64	48	43	48	48	56	61	61	61	63	64	55	55	63	64	60	55	55	65	65	43	60	69
14:30	64	65	66	65	63	63	63	61	59	51	42	40	34	36	43	47	56	61	60	61	62	64	48	45	61	64	60	48	53	64	65	34	56	66
14:45	63	66	66	64	64	64	65	61	57	36	15	16	19	30	38	46	57	60	60	63	63	67	57	54	62	63	64	56	60	65	65	15	54	67
15:00	65	65	63	63	63	63	63	59	53	33	15	15	17	26	35	45	58	60	63	64	65	69	66	63	63	63	65	64	66	68	66	15	55	69
15:15	66	64	61	61	61	61	60	55	48	30	15	14	15	22	31	45	57	59	60	64	64	66	63	60	61	62	62	60	62	63	65	14	53	66
15:30	58	59	58	61	65	65	65	59	52	31	13	12	13	18	27	45	57	59	60	63	62	63	60	58	59	61	59	55	57	59	64	12	51	65
15:45	60	61	60	63	65	65	63	60	56	33	11	10	11	17	22	30	41	48	52	60	62	62	65	68	57	44	38	36	46	60	63	10	48	68
16:00	61	62	63	65	64	64	60	60	59	34	10	11	13	18	21	33	49	51	52	60	61	50	44	54	54	28	18	16	36	61	63	10	45	65
16:15	63	65	64	65	64	64	62	62	59	33	11	12	14	18	20	37	56	54	53	60	59	37	24	41	45	33	26	28	41	58	63	11	45	65
16:30	64	67	65	64	64	64	64	64	58	31	11	11	10	17	23	38	53	54	55	56	47	35	30	28	37	38	34	41	45	54	63	10	45	67
16:45	63	63	63	63	57	57	50	45	38	22	10	10	9	15	25	40	51	54	58	52	36	33	35	31	25	20	24	23	41	57	64	9	40	64
17:00	63	65	65	65	63	63	60	55	50	28	9	9	8	13	20	35	42	43	52	35	35	33	28	28	30	25	21	23	37	59	64	8	39	65
17:15	63	66	66	67	70	70	70	66	62	34	9	10	10	15	20	31	38	38	38	34	34	30	21	25	35	29	17	22	38	55	65	9	40	70
17:30	64	65	65	65	68	68	69	65	60	34	10	10	11	16	20	26	33	33	23	32	38	34	30	26	29	30	21	24	40	56	65	10	40	69
17:45	64	64	62	62	65	65	67	64	58	33	10	10	15	18	22	31	37	40	40	35	40	44	40	26	24	30	24	26	42	57	65	10	41	67
18:00	61	65	67	64	63	63	63	63	63	42	15	10	13	19	24	35	41	47	56	38	42	54	45	34	38	35	27	27	41	57	64	10	44	67
18:15	62	65	67	65	64	64	62	64	65	40	13	11	10	16	26	28	30	47	59	59	62	61	51	35	41	45	30	28	40	57	62	10	46	67
18:30	63	65	67	67	64	64	62	65	66	38	10	11	12	19	28	31	40	52	58	60	62	62	58	50	44	54	53	45	38	49	60	10	49	67
18:45	65	65	65	65	65	65	65	65	65	40	15	15	13	22	30	35	49	58	56	61	62	62	64	65	63	62	63	63	43	50	60	13	53	65
19:00	64	66	64	63	62	62	61	61	62	50	25	17	16	23	30	39	50	56	56	61	63	62	63	63	62	62	64	66	50	38	53	16	53	66
19:15	65	65	65	65	65	65	65	65	65	57	35	18	19	24	30	43	52	53	56	61	63	62	63	62	61	61	65	68	55	50	59	18	55	68
19:30	65	65	65	65	65	65	65	65	65	60	50	40	25	35	40	50	55	55	60	65	65	65	65	65	65	65	65	65	63	60	65	25	59	65

Column Summary	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Overall Row Summary			
Min	58	59	58	61	57	57	50	45	38	22	9	9	8	13	20	26	30	33	23	32	34	30	21	25	24	20	17	16	36	38	53	Min	8	33	61
Avg	63	64	64	64	64	64	63	61	58	39	19	17	16	22	28	38	48	52	54	55	55	53	49	47	49	47	44	43	48	57	63	Avg	16	49	64
Max	66	67	67	67	70	70	70	66	66	66	69	64	48	43	48	50	58	61	63	65	65	69	66	68	65	65	65	68	66	68	66	Max	43	64	70

🟩 >50 mph
🟨 35-50 mph
🟥 <35 mph

Figure 2.6: Thursday, 9/19/02 Speed Contour Map



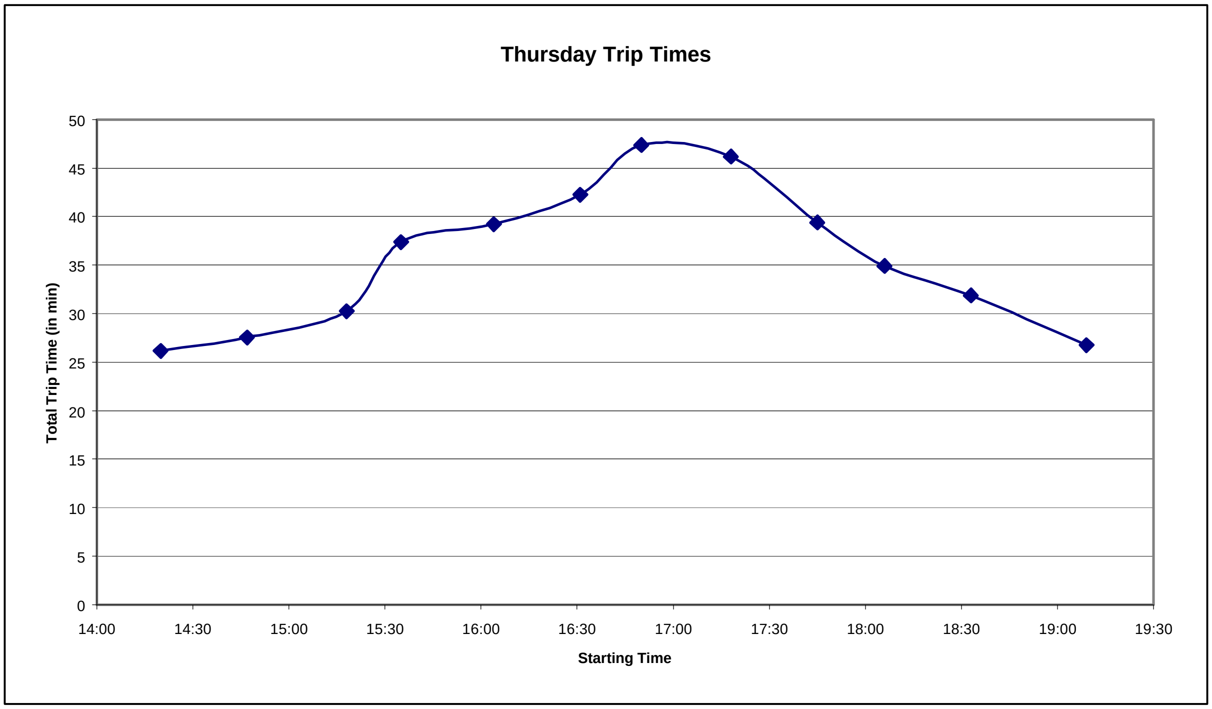
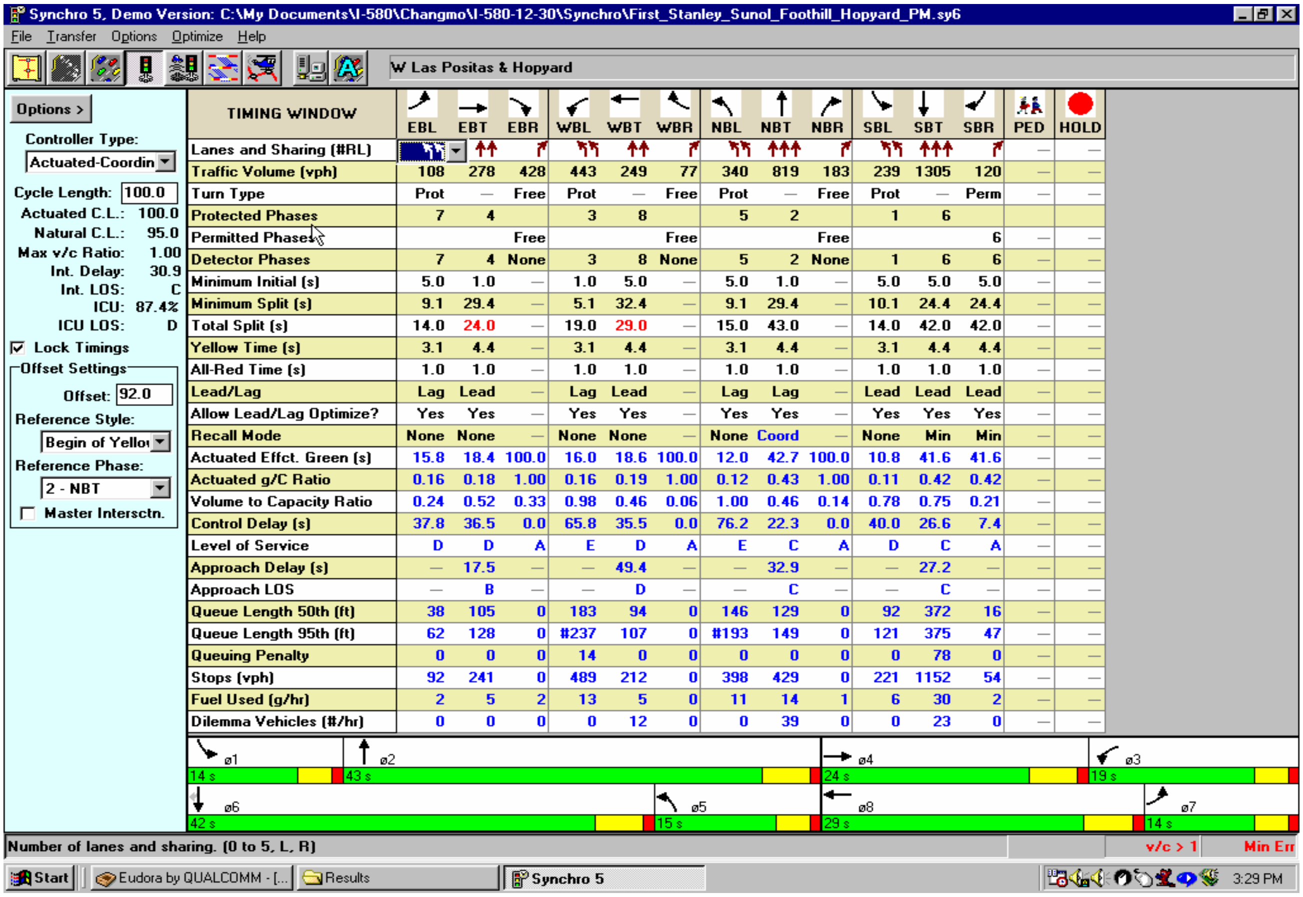


Figure 2.7: Freeway crossing travel times (I-580 eastbound end to end)



Controller Type: Actuated-Coordin
Cycle Length: 100.0
Actuated C.L.: 100.0
Natural C.L.: 95.0
Max v/c Ratio: 1.00
Int. Delay: 30.9
Int. LOS: C
ICU: 87.4%
ICU LOS: D
☑ Lock Timings
Offset Settings
Offset: 92.0
Reference Style: Begin of Yellow
Reference Phase: 2 - NBT
☐ Master Intersctn.

TIMING WINDOW	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR	PED	HOLD
Lanes and Sharing (#RL)													—	—
Traffic Volume (vph)	108	278	428	443	249	77	340	819	183	239	1305	120	—	—
Turn Type	Prot	—	Free	Prot	—	Free	Prot	—	Free	Prot	—	Perm	—	—
Protected Phases	7	4		3	8		5	2		1	6			
Permitted Phases			Free			Free			Free			6	—	—
Detector Phases	7	4	None	3	8	None	5	2	None	1	6	6	—	—
Minimum Initial (s)	5.0	1.0	—	1.0	5.0	—	5.0	1.0	—	5.0	5.0	5.0	—	—
Minimum Split (s)	9.1	29.4	—	5.1	32.4	—	9.1	29.4	—	10.1	24.4	24.4	—	—
Total Split (s)	14.0	24.0	—	19.0	29.0	—	15.0	43.0	—	14.0	42.0	42.0	—	—
Yellow Time (s)	3.1	4.4	—	3.1	4.4	—	3.1	4.4	—	3.1	4.4	4.4	—	—
All-Red Time (s)	1.0	1.0	—	1.0	1.0	—	1.0	1.0	—	1.0	1.0	1.0	—	—
Lead/Lag	Lag	Lead	—	Lag	Lead	—	Lag	Lag	—	Lead	Lead	Lead	—	—
Allow Lead/Lag Optimize?	Yes	Yes	—	Yes	Yes	—	Yes	Yes	—	Yes	Yes	Yes	—	—
Recall Mode	None	None	—	None	None	—	None	Coord	—	None	Min	Min	—	—
Actuated Effct. Green (s)	15.8	18.4	100.0	16.0	18.6	100.0	12.0	42.7	100.0	10.8	41.6	41.6	—	—
Actuated g/C Ratio	0.16	0.18	1.00	0.16	0.19	1.00	0.12	0.43	1.00	0.11	0.42	0.42	—	—
Volume to Capacity Ratio	0.24	0.52	0.33	0.98	0.46	0.06	1.00	0.46	0.14	0.78	0.75	0.21	—	—
Control Delay (s)	37.8	36.5	0.0	65.8	35.5	0.0	76.2	22.3	0.0	40.0	26.6	7.4	—	—
Level of Service	D	D	A	E	D	A	E	C	A	D	C	A	—	—
Approach Delay (s)	—	17.5	—	—	49.4	—	—	32.9	—	—	27.2	—	—	—
Approach LOS	—	B	—	—	D	—	—	C	—	—	C	—	—	—
Queue Length 50th (ft)	38	105	0	183	94	0	146	129	0	92	372	16	—	—
Queue Length 95th (ft)	62	128	0	#237	107	0	#193	149	0	121	375	47	—	—
Queuing Penalty	0	0	0	14	0	0	0	0	0	0	78	0	—	—
Stops (vph)	92	241	0	489	212	0	398	429	0	221	1152	54	—	—
Fuel Used (g/hr)	2	5	2	13	5	0	11	14	1	6	30	2	—	—
Dilemma Vehicles (#/hr)	0	0	0	0	12	0	0	39	0	0	23	0	—	—

Number of lanes and sharing. (0 to 5, L, R)

Figure 2.8: Example of Synchro signal timing data for an intersection in Pleasanton

CHAPTER 3: NETWORK CODING

3.1 General methodology

The original project proposal indicated that new tools and methodologies for network coding would be tested as part of the present research effort. More specifically, it was anticipated that a new program to convert GIS shape files into a Paramics network could be available and applied when the I-580 corridor network was being coded.

The development of the GIS conversion tool was to be funded by Caltrans as part of a separate contract to UC Santa Barbara. The software called S2P (Shape file To Paramics) was indeed developed as planned and a first version of the prototype became fully operative in June 2003. Reference 1 provides detailed information about the tool, and some evaluation work that was performed.

This tool would have been of great value in the process of building a network such as the 580 corridor. However, the time schedule of the two projects did not match, as the I-580 coding effort took place before the GIS conversion tool became available.

The research team working on the I-580 project had to rely instead on traditional network coding techniques, essentially using background aerial photos to manually code the Paramics I-580 network.

As agreed upon with Caltrans, the I-580 Paramics network was to include the I-580 freeway itself, and several parallel routes that commuters may use as alternatives. These routes included Stanley Avenue, Bernal Avenue, Valley Boulevard, and State Route (SR) 84. Other roads that were modeled in the network included all those streets that have an interchange on either the I-580 or I-680. A general map of the study area is presented on Figure 2.1.

Initial steps in the coding effort benefited from the existence of two sets of Paramics input files: the Pleasanton network developed by Dowling & Associates, and the 205 network developed by Caltrans District 10. Having access to these base networks laid out the foundations of the new network, which was build by expanding from these base networks.

The initial 580 network coding effort was performed with Version 4 of the Paramics software, which had been released shortly before the start of the project. Later in the project life cycle, an upgraded version (4.1) became available (Reference 2). However, upgrading the network to Version 4.1 did not require any changes in any model input files.

The Paramics software consists of a suite of modules: Modeller, Processor, Analyzer, Programmer, Monitor, and Estimator. As part of the 580 project, Modeller (Reference 2), Analyzer (Reference 3) and Estimator (Reference 4) were used.

Paramics Modeller provides the three fundamental operations of model build, traffic simulation (with 3-D visualization) and statistical output accessible through a graphical user interface. All the network coding activities are carried out within Modeller.

A snapshot of the entire network modeled in Paramics is shown on Figure 3.1. A specific interchange along I-580 (Hopyard) is shown on Figure 3.2.

3.2 Steps in network coding

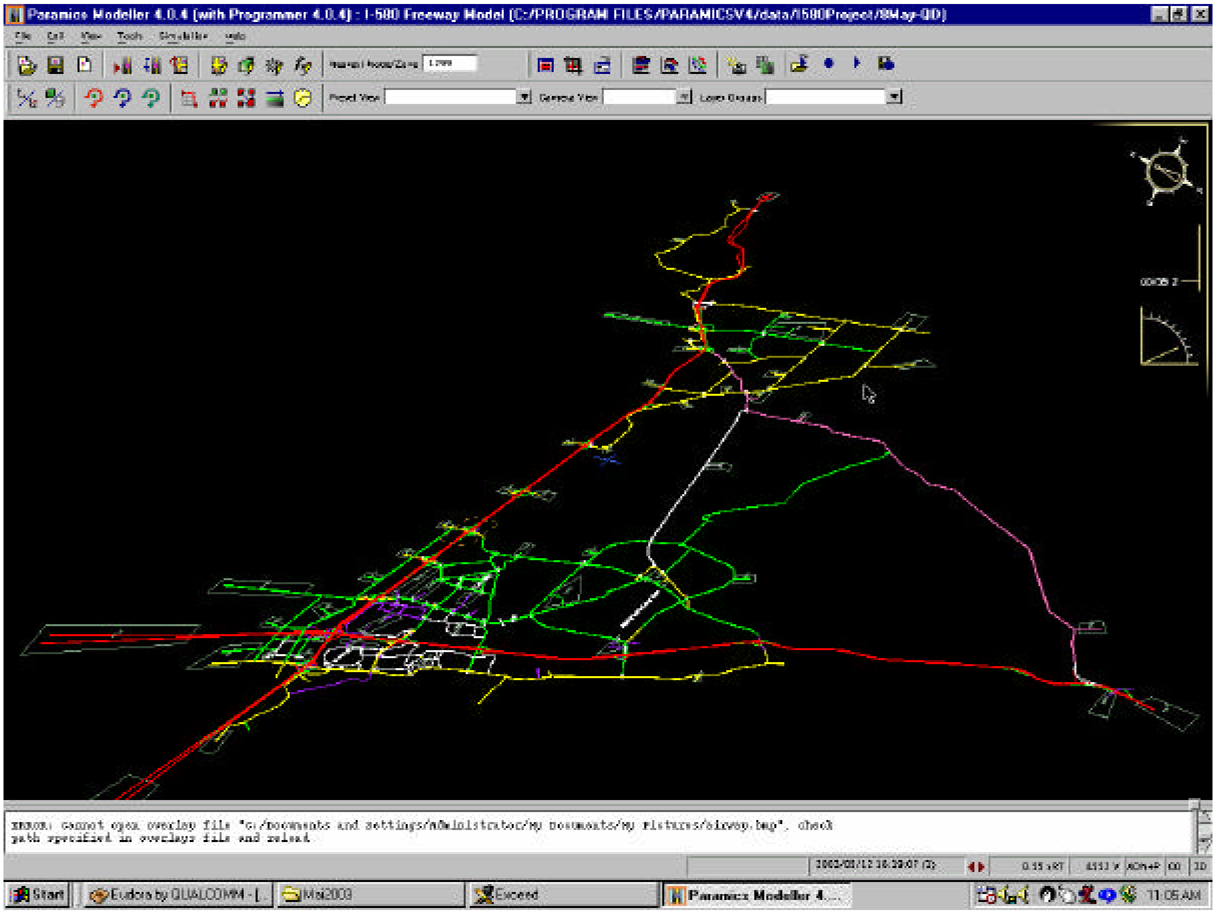
The network supply data was coded based on the information available as described in Chapter 2 of this report.

Network coding in Paramics typically involves the following steps:

- create nodes and links, adjust node positions, add curvatures if needed
- adjust positions of kerbs and stoplines (the "kerbs" represent the edges of the traveled way; the stoplines represent specific points vehicles have to pass through at a certain angle)
- specify link attributes (number of lanes, free flow speeds, grades…)
- add on-ramp specific parameters (acceleration lane length)

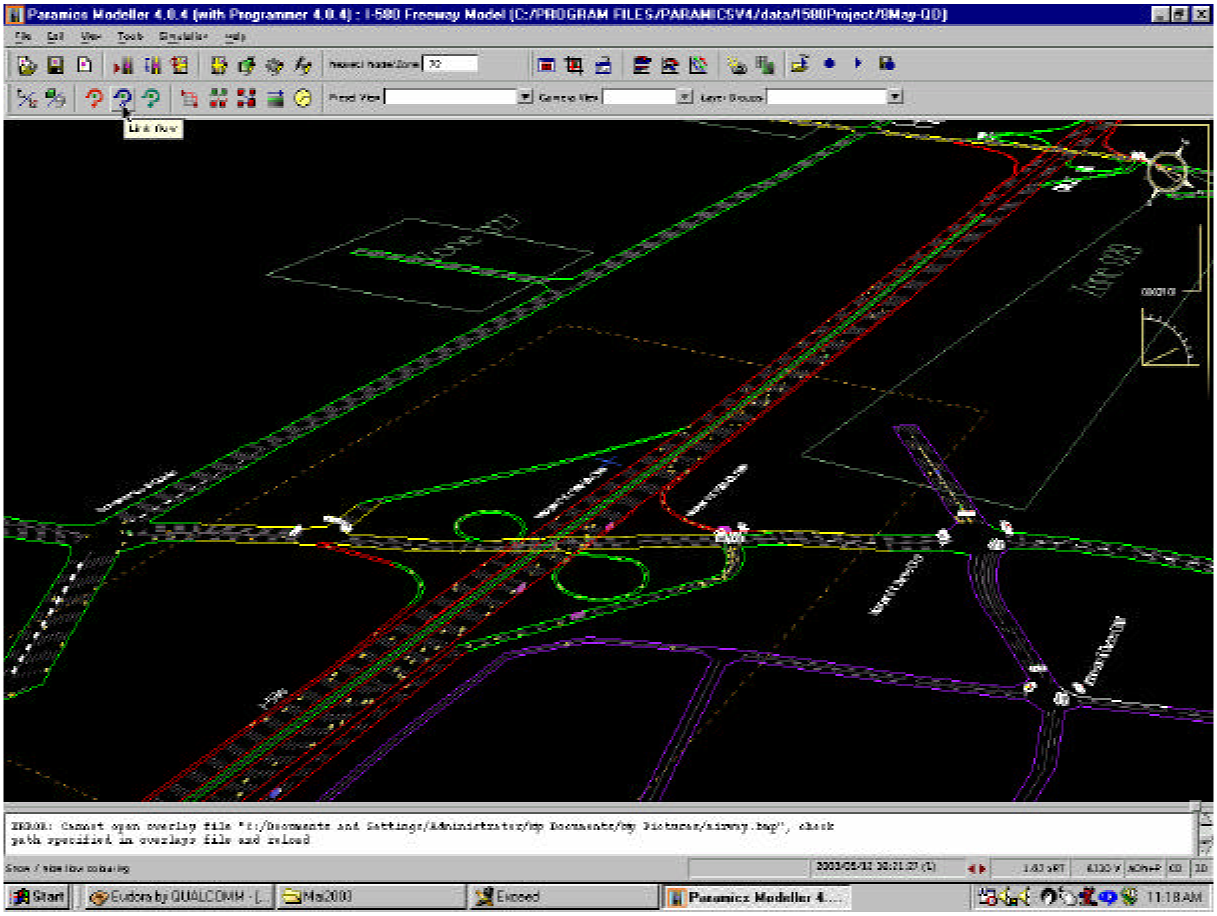
As part of the network coding, the zones (traffic origins and destinations) were also specified and the connections between the network and the zones were defined. The zones were initially chosen on the basis of the structure used in the EMME2 planning model developed for the Alameda County Congestion Management. The reason for considering this zone structure was that the EMME2 model was intended to be used in the OD estimation process, as described in details in Chapter 4 of this report.

It was decided to start with the EMME2 model structure in the Paramics simulation. All internal zones from EMME2 were kept in Paramics, and connected to the modeled network. At the periphery of the network, external zones were specified to represent all exchanges with either an origin or a destination outside the study area.



```
ERROR: cannot open overlay file "c:/documents and settings/administrator/my documents/my pictures/sievey.bmp". check
path specified in overlays file and reload
```

Figure 3.1: Screenshot of entire Paramics network 3D



ERROR: Cannot open overlay file "C:/Documents and Settings/Administrator/My Documents/My Pictures/airway.bmp", check path specified in overlays file and reload

Figure 3.2: Screenshot of Hopyard Interchange 3D

3.3 Control data

For all signalized intersections within the modeled network, signal timings data had to be entered in the model. Whenever data was available from the filed (see section 2.5), it was used as a model input.

The attributes of signalized intersections, as specified in Paramics, include the following:

- cycle length, number of phases
- phase length
- assigned link priorities (barred/major/medium/minor) for each phase;
- lane allocation

All signals within the network were simulated as fixed-time signals.

3.4 Network checking and revisions

A thorough review of the network coding status took place at a later stage of the project, after an initial unsuccessful attempt at calibration was reported. The network checking took advantage of newly available sources of data (detailed digital photos and video logs). Subsequent revisions in the network geometry coding are presented in detail in Chapter 6 of this report. They included a general revision of the link category hierarchy, improvements in the details of link attributes (number of lanes, curvatures, gradient, speed limit, visibility, nextlanes) and some adjustments on intersection configuration (lane allocations, priorities, signal timings).

CHAPTER 4: OD MATRIX ESTIMATION

4.1 Introduction

Once the network geometry coding is completed, the most critical simulation input to generate is the demand data. Micro-simulation models such as Paramics traditionally use an Origin-Destination (OD) table to specify the amount of traffic traveling between origin and destination zones within a given time slice. Each cell of the OD table represents the rate of vehicles to be generated at a given origin and heading to a particular destination within a given time slice.

Generating an OD matrix that properly matches real-life travel conditions has always been a challenge in all transportation modeling and traffic simulation activities. Researchers have been tackling this problem for a long time, and some methodologies and tools are now available to practitioners.

The I-580 corridor simulation project provided the opportunity to test a software that was recently developed by Quadstone, called OD Estimator, specifically designed to generate and optimize OD tables as part of the Paramics suite of programs. This project was the first to use the OD Estimator in a real-life freeway corridor application.

For the purposes of the I-580 project, the simulation period covering the entire PM peak period (2-8 PM) was divided into six hourly time slices. OD Estimator was to be used to generate and optimize the six corresponding OD tables. The work reported in this report focuses on the OD development and calibration for the first time slice of analysis (2-3 PM).

This chapter presents a general introduction to the OD Estimator tool and the main steps involved in generating an optimized OD matrix. Further details more specific to the particular application of OD estimator to the I-580 project are reported in Chapter 7.

4.2 OD Estimator overview

Paramics OD Estimator (References 4,5) is an OD matrix estimation package that is integrated with the other components of the Paramics software suite. Estimator provides the user with a tool that calculates OD matrices for networks of all scales. Not only can users develop OD matrices from scratch using Estimator, but the tool can also serve as an interface between large regional demand models and the Paramics microscopic simulation model.

Since matrix development can be a time consuming process, Estimator helps reduce this time by carrying out OD estimation on a run time basis. A flexible data interface associated with Estimator allows the user to provide as much, or as little, information needed to aid the OD estimation.

Paramics generates and optimizes an OD matrix based on a set of input files including:

- A pattern OD (or seed matrix) which serves as a starting reference in the optimization process;

- A set of target traffic counts, including link flows, cordon flows and turning movements.

Figure 4.1 illustrates the general process of establishing the best OD matrix using OD Estimator. Once the best OD matrix is generated by Estimator, it is used as the demand input to run Paramics Modeller and further calibrate the network. OD Estimation can therefore be considered as one of the key elements in the calibration process.

Paramics Estimator estimates an OD matrix based on a level of confidence, or weight, associated with each input parameter. The user can accept the input parameter as is, or move it away from the initial value towards one that is measured in the simulation. By adopting a target value away from the original indicates that the original value may not have been accurate, and is equivalent to lowering the weight for that target. Keeping the original target value indicates there is confidence in the parameter, thereby a high weight factor can be assigned to that target.

Paramics Estimator employs continuous simulation to arrive at the generated OD matrix. Continuous simulation means that static snapshots of the demand cycle are continuously generated. By continuously varying the OD matrix, Paramics Estimator iterates towards the most likely solution that corresponds to a particular level of static demand.

The OD estimation process requires quality input data along with a good understanding of all the interactions between the network configuration, the demand, and the routing patterns. It involves an iterative cycle between the user and the OD Estimator software, each providing information in an attempt to converge towards a suitable solution.

The process of developing the input data required by OD Estimator is illustrated in the remainder of this chapter using the I-580 application as a case study.

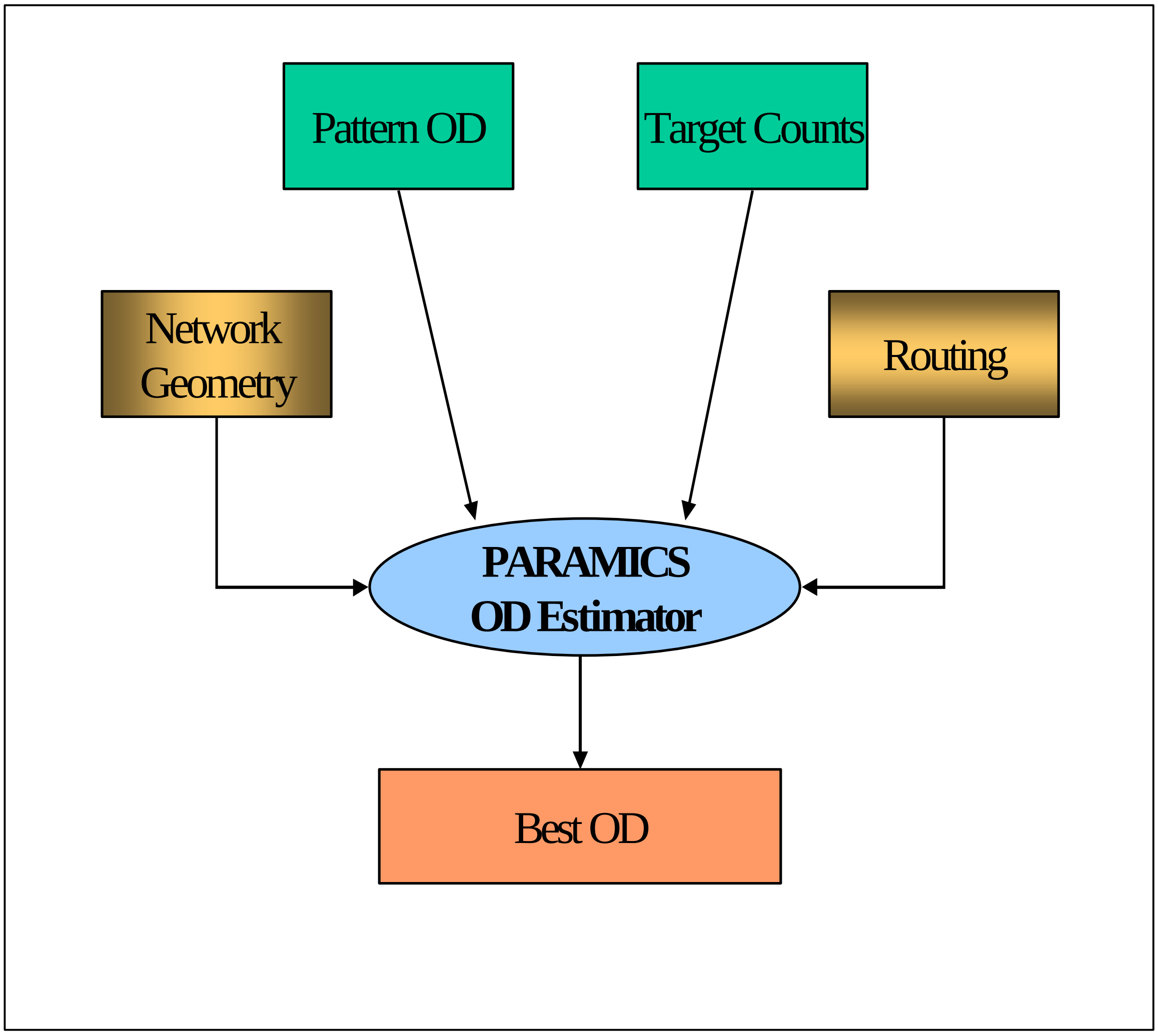


Figure 4.1: OD estimation process flowchart

4.3 Generating the pattern OD matrix from EMME2 model

The basic concept behind specifying a pattern matrix is to define the travel patterns between OD pairs. In practice, for large network applications, this pattern matrix is developed using a four-step transportation planning model.

In order to generate a pattern matrix for the I-580 Paramics network, data was extracted from an EMME/2 (Reference 6) planning model developed by the Alameda County Congestion Management Agency (ACCMA). This model is built upon nodes, which represent points of origin and destination in the region; and links, which represent major thoroughfares and connect the different nodes. As the ACCMA model is comprised of nodes and links that represent the entire San Francisco Bay Area, an extraction of a sub-area was required in order to derive travel demand strictly for the Dublin/Pleasanton/Livermore area that is modeled in the Paramics study.

To cut out a sub-area, all nodes and links within the area covered by the Paramics network were flagged in the EMME/2 model. In order to define the boundaries of the sub-area, specific links were identified as gateway links and were given a special identifier in the EMME/2 model. This identifier would then treat the gateway like a node with inputs and outputs for the sub-area. It is important to note that the matrix that is derived from the ACCMA model is for single-occupancy, 2 and 3 occupancy vehicles. The ACCMA model is also comprised of many matrices that identify transportation and socio-economic attributes for each node, and therefore it was essential to choose matrices that reflected the data that was needed for the Paramics network, namely PM-peak vehicle trips. Matrices were available for each of single, 2 and 3 occupancy vehicles for the peak hour interval. In order to have one O-D matrix, the three vehicle classes were aggregated into one.

The final OD matrix that was extracted from the ACCMA model was comprised of 79 zones, 20 of which were gateways into the sub-area. Since there were initially more links in the EMME/2 model compared to the Paramics network, there would be some zones that would not be connected in Paramics. These isolated zones were aggregated with other zones into super zones. A final matrix was then created with 53 zones. Zone boundaries were then created in the Paramics network based on the location of the zones in the EMME/2 model.

4.4 Network geometry and zone structure modifications

As introduced in section 2.2, the original plan in developing the Paramics network was to code a series of arterial routes to offer vehicles alternative ways to reach their destinations. Stanley, Bernal, Valley, and SR 84 were the key arterial routes that would connect Dublin/Pleasanton with Livermore.

The pattern origin-destination matrix was developed as a subset of the Alameda County Congestion Management Agency EMME/2 model. However, the geometry of the Paramics network had fewer links than in EMME/2, and some zones had to be aggregated. With the resulting 53-zone structure, it became obvious that connector links in the Paramics network were not able to accommodate the level of traffic. Some zones were then disaggregated, and a 72-zone pattern OD matrix was developed with the hope that demand would be spread out rather than be aggregated into a fewer number of zones.

After running the model with the existing geometry and new zone structure, it became clear that the problem was that not enough parallel routes were being modeled in the network. It was seen that congestion on the arterial networks would spill over onto the freeway, and thus, operation on the I-580 was hampered. It was decided that more links be modeled in the network, especially in the Livermore area where congestion was most pronounced.

Additional routes that were modeled in the network at this stage included: Isabel Avenue, Murrieta Blvd, Railroad Avenue, P St., L St., 4th St., and College Ave. Adding these streets upgraded the Paramics network in the Livermore area to the same level as seen in the Dublin and Pleasanton area, meaning that more route choices that were previously unavailable in the Livermore area were now being provided.

Now with more route choices, it was observed that the zones in the Livermore area were too large and had to be disaggregated. Since vehicles take the shortest route to their destination zone, it was often seen that certain connector links would receive all the demand while other connectors would receive no flow. The strategy is to then establish a zone for each entry into a neighborhood. There were also some zones in the Dublin and Pleasanton areas that were too large and thus they were disaggregated as well. As a result, a 127-zone matrix was developed. With more zones, the estimation process leads to faster convergence and easier control of the estimation process in the interactive manipulation.

4.5 Assembling target counts

Starting with the pattern OD matrix, Estimator uses user-specified target counts to optimize the OD matrix, as shown in Figure 4.1. These counts are intended to help improve the accuracy of the OD synthesis by providing target counts to match in the model.

Target flows in OD Estimator can be specified as Cordon flows, Mid-link flows or Turn flows. The data is specified in vehicles per hour.

- Cordon flows represent the flow of traffic entering or exiting a zone, specified by the zone identifier.

- Mid-link flows represent the flow of traffic along a link, specified by the link identifier.

- Turning flows represent the flow of traffic making a turn, specified by the link identifiers for the entry and exit links to an intersection.

In the I-580 project, target counts were specified in terms of link flows and turning flows.

The traffic data originally used to develop the target counts in the I-580 corridor application came from four different sources:

1. For the eastbound direction of I-580, as described in Chapter 2 of this report, a set of 15-minute counts was available for all ramps and at three mainline locations. Data for one particular day, Tuesday, September 17, 2002 was used. The 15-min counts were aggregated into hourly counts for the five hours of simulation study.

2. For the westbound direction of 580 and for both directions of 680, the target counts were derived from the census data that provided hourly counts at various locations on the mainline and ramps. The data was processed to retain only weekday data and to produce an average hourly value over all the counts available at a given location.

3. In Pleasanton, the Synchro file provided by the city included turning movements for the PM peak hour (5 to 6) on a given day. Nine intersections were selected to extract turning movements. Table 4.1 provides a list of these nine intersections.

Foothill and Dublin Canyon
Stoneridge and Hopyard
Hacienda and Owens
Stoneridge and Las Positas
Santa Rita and Valley
Foothill and Las Positas
Bernal and Valley
Stanley and Sunol
Vasco and Patterson Pass

Table 4.1: List of intersections selected for turning flow data

It was necessary to convert the Peak hour flow rates from Synchro into hourly rates for the entire peak period. A profile was derived based on the census dataset of hourly counts previously mentioned. The reference factor being 1.0 for the 5-6 PM hour, the other multiplying factors resulted to be the values shown in Table 4.2.

2-3 PM: 0.854
3-4 PM: 0.960
4-5 PM: 0.988
5-6 PM: 1.00
6-7PM : 0.878

Table 4.2: Profile used to convert Synchro PM peak flows

4. In the Livermore area, the city authority provided a map with average daily traffic volumes on a number of key arterials. Once again, the census data set was used to determine a profile and convert those ADT values into hourly counts. The resulting profile is shown on Table 4.3. One further assumption was that the same traffic level was assumed for both directions.

2- 3 PM: 6.13 % of 24-hr flow
3- 4 PM: 6.88 % of 24-hr flow
4- 5 PM: 7.09 % of 24-hr flow
5- 6 PM: 7.17 % of 24-hr flow
6- 7 PM: 6.29 % of 24-hr flow

Table 4.3: Profile used to convert ADT flows

At the end of the data processing, hourly linkflows and turnflows were available for each of the six hours within the peak period.

4.6 Specifying confidence weights

There is always some degree of uncertainty associated with the input data required for the OD estimation process. OD Estimator offers the option of specifying confidence weights associated with the different types of input data. These confidence weights correspond to the level of variability a value can have during the estimation process. Confidence levels can apply to the pattern OD matrix as well as to the target counts.

A confidence rate of 0 would mean the value could range from zero to infinity, while a confidence weight of 1 would mean there is no variability.

In the I-580 study, the confidence level of the pattern OD matrix was originally set to 30%.

With regard to the target counts, different rates were applied depending on the data sources. The values originally selected were as follows:

- for the eastbound direction of I-580, a high confidence level of 90% was used;
- for the westbound direction of 580 and for both directions of 680 (census data), a medium confidence level of 50% was assigned;
- for the Pleasanton turning movements, the level of confidence was set to 50%;
- in the Livermore area where only ADT were available, the confidence level was low and set to 20% in the model.

These confidence weights were intended to reflect the perceived reliability of the data available. The values presented here are first-cut figures, which have later been revisited as part of the demand optimization and calibration efforts (see Chapter 7 for more details on subsequent investigations dealing with confidence weights).

4.7 Checking for data accuracy

When the full dataset required to run OD Estimator was assembled and properly formatted, some further data checking was necessary. It is critical that during the initial stages of model development, thorough checks are made to traffic count data to insure validity and minimize error.

Problems are likely to arise when using different data sources with counts collected on different days and using different surveying techniques. The I-580 project provides an example of such a situation; one potential problem, for instance, has to do with turning movements and mid-block link counts being extracted from different datasets. Checks for compatibility are necessary.

Manual checking was first carried out, resulting in the elimination of a number of redundant flows. When flow data was redundant, the flow data with the lower confidence rate was eliminated.

Figure 4.2 illustrates another situation where data checking was required and conducted.

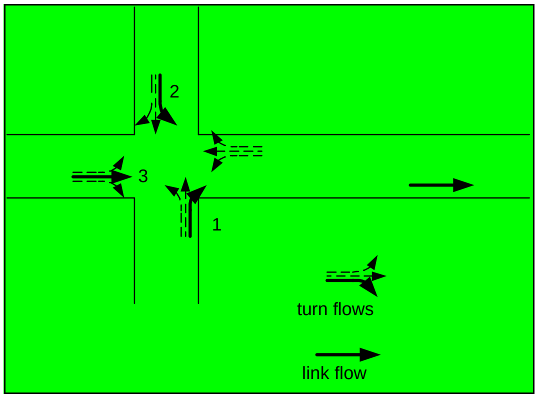


Figure 4.2: Data checking example

In the case illustrated on Figure 4.2, the sum of the turn flows at 1,2 and 3 should be equal to the mid-block link flow. If the discrepancy is fairly large, the flows with less confidence level should be excluded in the estimation process. The latest release of OD Estimator, Version 4.1 (Reference 4) provides a tool to automatically check the data for this type of incompatibility, and warn the user when it occurs. This tool was used in the estimation process carried out with the I-580 dataset.

4.8 Adding intermediate mainline counts on I-580 eastbound

Another adjustment to the initial input dataset was made following recommendations received from the Paramics model developers at Quadstone. Because the study was to focus on the 580 EB freeway analysis, it was suggested that additional target counts be placed on the mainline freeway section.

The initial dataset of 15-minute counts had only three counter stations on the mainline freeway section of 580 eastbound: at the mainline origin, mainline destination, and at the Airway interchange in-between.

In order to generate additional mainline target counts to help improve the demand estimation process, it was decided to use a FREQ model of the same freeway section, using the same dataset including all 15-minute ramp counts, and the mainline origin and destination counts available for I-580 eastbound on 09/17/02. FREQ is a macroscopic freeway operation simulation tool that can predict flows on each subsection of the mainline freeway for the given time period, based on ramp input and output traffic flows. The FREQ-predicted flows were then used as an additional resource for providing target counts in the OD Estimator link flow input file.

It should be noted, however, that developing a FRQ model of the freeway section under investigation is not a pre-requisite to applying OD Estimator. Other ways to collect or compute additional target counts maybe available.

CHAPTER 5: METHODOLOGY FOR CALIBRATION

5.1 Introduction

The I-580 corridor project provided an opportunity to develop, test and apply a general procedure for model calibration and validation of large-scale freeway-arterial networks.

The methodology that was developed and applied was largely based on previous experience gathered by the research team through various Paramics applications (Reference 7,8,9) as well as on the recommendations contained in the "Guidelines for Applying Traffic Micro-Simulation Modeling Software" (Reference 10).

Calibration refers to the process of identifying and fine-tuning the model inputs in order to ensure that model correctly replicates the movement of traffic to match existing observed conditions. Validation is the next step, comparing model outputs with real-life conditions.

5.2 General approach to calibration

The main purpose of the model calibration phase is to ensure that the

When the comparison between simulation and observed operation is not acceptable (either from a visual or from a numerical point of view), it may be necessary to go back to the model input data and make some checks and modifications; these checks and modifications may affect all or part of the different model input components:

- general simulation configuration;
- network geometry;
- control information (signals);
- demand data;
- driver behavior and routing patterns;

5.3 Calibration criteria

Because of the large number of input parameters that can affect the simulation results, calibration can be a labor-intensive task. It is important to adopt a logical methodology in order to ensure that satisfactory results can be obtained in a timely and efficient manner. In particular, it is critical to establish clear thresholds values when judging the quality of the calibration output, so that the process can be stopped when satisfactory results are reached.

Such criteria were proposed in Reference 11 based upon guidelines developed in the United Kingdom. Figure 5.1, which was extracted from References 10 and 11, presents the suggested calibration criteria specifically designed to be used in freeway applications of Paramics.

Criteria & Measures	Acceptability Targets
HOURLY FLOWS, MODEL VS. OBSERVED	
Individual Link Flows	
Within 15%, for 700 vph < Flow <2700 vph	> 85% of cases
Within 100 vph, for Flow < 700 vph	> 85% of cases
Within 400 vph, for Flow > 2700 vph	> 85% of cases
Total Link Flows	
Within 5%	All Accepting Links
GEH Statistic – Individual Link Flows	
GEH < 5	> 85% of cases
GEH Statistic – Total Link Flows	
GEH < 4	All Accepting Links
TRAVEL TIMES, MODEL VS. OBSERVED	
Journey Times Network	
Within 15% (or one minute, if higher)	> 85% of cases
VISUAL AUDITS	
Individual Link Speeds	
Visually acceptable Speed-Flow relationship	To analyst’s satisfaction
Bottlenecks	
Visually acceptable Queuing	To analyst’s satisfaction

Figure 5.1: Freeway model calibration criteria (Ref. 10-11)

The GEH statistic, often used in the UK, is a modified Chi-squared statistic that incorporates both relative and absolute differences.

The GEH statistic is computed as follows:

$$GEH = \sqrt{\frac{(V - C)^2}{(V + C)/2}}$$

where V is the model estimated directional hourly volume at a location, and C is a directional hourly count at this location.

An indication of the 'goodness of fit' is given in Table 5.1 below:

GEH < 5.0	Flows can be considered a 'good fit'
5 < GEH < 10	Flows may require further investigation
10 > GEH	Flows cannot be considered a 'good fit'

Table 5.1: Indication of fit goodness as a function of GEH value

5.4 Check link connection areas

Network geometry is probably the most obvious first stage in any Paramics calibration effort. Many aspects of the network geometry coding are worth checking for potential problems. Only the most critical steps involved in the early calibration effort are reviewed in this chapter. Chapters 6 through 8 will provide further insights on what additional adjustments were made in the process of calibrating the I-580 Paramics network.

Once the network supply side is coded in, it is critical to carefully check the transition areas, connecting successive links in the Paramics network. These connection zones are prone to generate disturbances in the regular flowing of the vehicles.

The roadway geometry had to be checked very carefully to ensure fluidity in traffic patterns. The best way to achieve fluidity is to check the network with a very low demand profile. Vehicles are sent traveling through the network, and their behavior is checked visually using the graphical user interface provided by Paramics. The "dashboard" view is particularly useful in identifying those areas where vehicles are shown to slow down or stop for no apparent reasons. It is usually a sign of poor alignment of the stoplines.

Stoplines in Paramics play a crucial role in governing vehicle behaviors at the transition between two links. Stoplines (shown as arrows on the Paramics graphical interface) are associated with each lane at the beginning or end of each link. The position and angle of the stopline will determine how the vehicles will negotiate the connection between the end of a given link and the beginning of the next link. If the stoplines are not well positioned and oriented, the mis-alignment will result in unexpected vehicle behaviors leading to slow downs, stops, or the creation of an artificial bottleneck at this location. Therefore, the checking of stopline alignment carried out on an empty network is a critical first step in checking the network geometry.

Default stopline positions and angles are generated automatically by Paramics, based on the node and link configuration, and the relevant kerb points (kerbs are the edges of the road). In most cases, the default stoplines are appropriate and provide a smooth transition between links. However, several situations were found to be a potential source of poor default stopline alignment: when one of the links is curved, when the links are too short, or in the diverge areas. These cases require particular attention and in some cases, manual readjustment of the stoplines is necessary.

Stopline alignment is usually sufficient to guarantee a smooth transition between links. However, when the number of lanes changes at the end of a link, or in any diverge or weaving section, it is often desirable to use the “nextlane” function of Paramics. By using nextlanes, it is possible to force the flow exiting from a traffic lane in one segment into a specific lane in the downstream segment. Nextlanes were implemented when necessary in the 580 network.

5.5 Signposting

Signposts, also called hazards in Paramics, are associated with lane additions, lane drops, and on- and off-ramps. Signposting provides drivers with information in advance of the hazard so that they have time to react and change lanes. Two numbers specify the signposting: the first represents the signpost location, and the second represents the distance along the link that vehicles can react to the hazard in selecting an appropriate lane to switch to.

Based on previous calibration efforts (Reference 7), the freeway signposting distance was increased from the default value. Signposting was found to be particularly important when dealing with diverge areas. Signposting was placed in the I-580 network for all freeway interchanges. By placing signposts, it reduces the likelihood of erratic late lane changes at diverge locations.

5.6 Overall simulation configuration parameters

Two general configuration parameters play a significant role in the Paramics simulation process: the number of simulation time steps per second and the speed memory (the number of time steps for which a vehicle remembers its speed

Based on previous experience (Reference 8), it was established that there would be 5 time steps per second, meaning that calculations in the simulation are conducted every 0.2 seconds. The simulation time steps determine when calculations are carried out during every second of simulation. Because a number of calculations such as vehicle speed and acceleration have some randomization associated with them, the simulation results will differ if different time steps are used. It was determined that high density flows often require more time steps per second (than the default value of 2) to operate in a freer manner

The speed memory has to be adjusted in conjunction with the time step change. Changing the size of the speed memory (the number of time steps for which a vehicle remembers its speed, with default value of 3) allows the modeling of the same reaction time with smaller time steps. The speed memory value of 8 was adopted for the I-580 simulation study.

5.7 General driving behavior parameters

Paramics controls the movement of individual vehicles in the network using three basic models: vehicle following, gap acceptance and lane changing. These models are strongly influenced by two user specified parameters: the mean target headway and the mean reaction time.

Extensive study on the sensitivity of these two parameters can be found elsewhere (Reference 7). Based on these background investigations, it is generally agreed that the default values proposed by Paramics and calibrated under UK traffic conditions (one second for each parameter) do not necessarily represent typical US freeway traffic performance. Several calibration studies carried out in California have recommended that these values be decreased, suggesting that drivers on US freeways may tend to accept smaller gaps and have lower reaction times than drivers on UK freeways.

On the I-680 simulation study (Reference 8), optimal calibration results were produced with 0.98 seconds as the mean target headway and 0.6 seconds as the mean reaction time. The same values were used in the 580 study.

CHAPTER 6: FURTHER REVISIONS ON NETWORK GEOMETRY AND ROUTING PATTERNS

6.1 Introduction

The process of calibrating the I-580 corridor model required checks and revisions to be made to the network initially coded. These adjustments were deemed necessary to improve the performances of the network in terms of being able to replicate existing traffic conditions. A number of additional data sources that were not available at the earliest stages of the project life cycle were used as part of the later revision process described in this chapter.

The revisions and checks were conducted in three main components of the simulation inputs: network geometry, routing patterns and demand data. The demand data generation will be extensively covered in Chapter 7 of this report. The present chapter deals with network geometry and routing.

6.2 Network hierarchy

When the 580 network was first coded a "category" file specific to the 580 application was developed. The category file is a component of the geometry files in Paramics; it specifies the operating speed of roads as well as their relative importance to the roadway network. Each link in the model is assigned to a category based on the speed as well as the number of lanes.

A cost factor is associated with each link category. The default cost factor for all routes is 1.0. The link cost is calculated as the time taken to travel along the link at free-flow speed, multiplied by the cost factor. The factored costs are then used in the routing calculations.

When the initial runs were performed to test the network as part of the calibration effort, it was noticeable that the utilization of the freeway network was not optimal, and certainly lower than what would be expected. Too many vehicles were traveling on the surface streets when they would normally use the freeway. Assignment options available within Paramics can be used to modify such routing behaviors. However, it was recommended by the model developers at Quadstone to first adjust the network hierarchy by using category cost factors.

In order to have better utilization of the freeway network, a lower cost factor of 0.8 was employed for freeway links and higher costs were placed on particular links of some arterial routes. This method would mean that short distance trips would utilize the arterial system and longer trips would try to use the freeway as much as possible. Hence, arterial congestion that is seen in the Paramics network but not seen in field conditions would be mitigated.

The Paramics category file for the I-580 network is comprised of over 100 categories. The reason why there is such a large number of categories is because a category was not only developed for an arterial with a certain operating speed, but categories were also developed for each variation in the number of lanes. This meant that a category was assigned for 2-lane links, 3-lane links, etc.

As stated above, certain links in the network would receive higher cost factors. Based on the correspondence with Quadstone, it was decided that a hierarchy of categories be developed in order to prioritize the routes that drivers would take.

A four-stage structure was thus developed and categories were assigned to specific category:

- Major primary   Cost Factor 0.8
- Major secondary   Cost Factor 1.0
- Minor primary   Cost Factor 0.8
- Minor secondary   Cost Factor 1.0

All freeway sections and ramps are coded as major/primary links, with a cost factor of 0.8. They are colored in red.

Major arterials, namely SR84, Stanley, and N. Livermore are coded as major/secondary links with a cost factor of 1.0. Free-flow speeds were coded as either 55 mph (in yellow) or 40 mph (in orange).

Altamont Pass Road is coded as minor, with a speed of 50 mph and a cost factor of 0.8. It appears in white.

Other arterials are coded as minor links with a cost factor of 0.8 and a speed of 35 mph. They appear in green.

Connector links through urban areas are coded as minor, with a cost factor of 1.0 and a speed of 25 mph. They appear in purple.

6.3 Node elevations

The Eastern section of I-580 modeled in this study is hilly, with the presence of the Altamont Pass. The topography of the roadway, combined with a high level of truck percentage, is known to significantly affect the traffic performances of the freeway. Paramics has a truck-climbing model embedded into Modeller, which attempts to replicate some of the effects observed in the field. In order to take advantage of this feature, it is necessary to enter a correct profile, as well as a realistic truck percentage in the vehicle fleet.

To specify the gradients in the 580 network, the approach used was to specify node elevations as one of the attributes in the node file. The default value for the elevation coordinate is 0. Based on grade information provided by District 4, node elevations were computed and entered in the Paramics node input file. This was done for all nodes on 580 east of the Greenville interchange. In order, to have realistic 3-D representations of the interchanges, node elevations were also required on all other routes connected to the freeway.

6.4 Freeway geometry refinements

When additional and more detailed geometrical data sources became available, it was decided to undertake further checks and adjustments on the network geometry.

The series of modifications were based on:

- A set of digital color photos (for 580, 680 and 84) provided by Caltrans Headquarters showing the details of freeway interchanges, and some adjacent intersections

- A set of digital video logs (for 580, 680 and 84) provided by District 4 showing movie clips as a dashboard view when traveling on both directions of the freeways.

The general process used was to go over the digital photos one by one. When some differences between the field and the model were identified, the necessary adjustments were made in the model. In order to confirm or clarify the geometry for the mainline freeways, video logs were sometimes used in addition to the digital photos.

Route 84 required a lot of additional work. In the urban northern section, many minor intersections (signalized or not) had to be added. The major intersections almost all required modifications in the number of lanes and lane configuration. The coding of the southern part of 84 was improved by adding curvatures: this was done by directly loading the digital photos as overlays in Paramics. Different speed limits on various sections of Route 84 were used in the model based on what was observed on posted signs when viewing the videos.

It was also decided to extend the southern portion of I-680 coded in the model, all the way to just north of the Andrade interchange. This was done based on a specific overlay file for this area.

The four major freeway zones at the periphery of the freeway system (zones 1,2,10, 11) have zone connectors coded in (shown in green in the Paramics graphical interface).

In most freeway interchanges, it was found desirable to add visibility and nextlane functions.

The “Visibility” distance applies to links where vehicles must give way to traffic crossing at the end of the link. The visibility defines the distance from the stopline point at which a vehicle can see whether there is a gap for the vehicle in the crossing traffic.

The “Nextlane” function is a way to guide the lane choice behavior at the transition between two links, by directly specifying possible movements and banning all others. Most of the diverging and merging areas, in addition to cases where a lane is added or dropped, are potential candidates to add nextlanes. Doing so usually greatly improves the realism of the vehicles’ behavior in these areas.

As a general rule of thumb, any modifications made in the network geometry was carefully checked by sending vehicles through the area, and making sure that the vehicle behaviors were in line with what was expected.

6.5 On-ramp parameters

The correct representation of freeway on-ramp merging is a critical aspect when simulating a freeway section for traffic operation analysis. The geometrical configuration of the nodes and links in the merge area has to be carefully constructed in Paramics, to make sure that the user can take advantage of the merging behavior model embedded into Modeller. For example, the ramp awareness parameter requires that a sufficient distance be available between the last downstream mainline node (before the merge) and the last node on the ramp. In some cases, the initial Paramics network had to be revised to ensure that this requirement be met.

Other parameters that needed to be checked and updated when necessary included the ramp headway factor (set to 0.33) and the minimum ramp time (set to 1 second). The headway factor is a way to adjust on a link-by-link basis the target headway for all vehicles. The mean target headway that applies to the entire network will thus be modified specifically for the relevant link.

The minimum ramp time specifies the time, in seconds, which vehicles spend on the ramp before considering merging into the mainline traffic. Reducing the value from the initial value (which is 2 seconds) allows vehicles to merge at a much faster rate, closer to what is typically observed on California freeways.

6.6 Intersection configuration

The latest set of digital photos covered some signalized intersections in addition to freeway interchanges. Those intersections in the immediate vicinity of I-580 and I-680 were part of the dataset available. For Route 84, digital movie clips taken while traveling along the route (in both directions) provided details on the intersection configuration, in addition to what was available through the digital color maps.

Based on these additional data sources, it was decided to revisit the geometry of all intersections for which new data was available, and check for possible incompatibilities between the model as coded and the field. In some cases, modifications were found necessary and the corresponding adjustments were made in the Paramics input files. Those adjustments typically involved adding (or dropping) lanes, revising lane turning allocations, and adding nextlanes.

6.7 Routing

When dealing with a freeway corridor network with several parallel routes, drivers' behavior in terms of route choice is an essential part of the calibration phase.

Several important decisions have to be made at the early stages of calibration, including defining and implementing a structured network hierarchy, selecting an appropriate the assignment strategy, and specifying the ratio of familiar versus unfamiliar drivers to be applied.

Broad assignment techniques available in Paramics fall into three main categories: all-or-nothing assignment, stochastic assignment, and dynamic feedback assignment.

All-or-nothing assignment assumes that all drivers traveling between two zones choose the same route (ie. the lowest cost route) and that link costs do not depend on flow levels.

Stochastic assignment methods try to account for variability in travel costs or drivers perception of those costs. These methods assume that the perceived cost of travel on each network link varies randomly, within predefined limits.

Dynamic feedback assignment assumes that drivers who are familiar with the road network will reroute if information on the present state of traffic conditions is fed back to them. This is achieved by taking real time information from the Paramics model and using this data to update the routing calculations.

In the I-580 application, calibration started with an All-or-Nothing assignment, by disabling the perturbation factor. This was intended to make the routing pattern deterministic, and provide better control and understanding of the path decisions made.

Another way of controlling the routing patterns was to change the percentage of familiar and unfamiliar drivers in the demand files. The major/minor designation previously described as part of the network hierarchy plays an important role in route assignment. Unfamiliar drivers will use "major" roads in preference to "minor" roads. The link costs perceived by unfamiliar drivers on minor roads are twice the cost of an equivalent major road.

Assigning arterials the proper major/minor designation is critical. It was intended that the freeway receives the highest priority in route choice. Key arterials routes such as Bernal, Hacienda, Livermore, Portola, were given a "major link" designation in the network hierarchy, while those arterials deemed less important would be assigned a minor. Zone connector links and local roads, especially modeled in the Pleasanton area, are given secondary status with a high cost factor to lower the attractiveness of these routes.

A 50%-50% split of familiar and unfamiliar drivers respectively was initially assigned to the network at the early stage of calibration. These values have later been revisited, as explained in Chapter 7.

The sensitivity of the time and distance coefficients was not investigated. The initial set of parameters (0.65 for time; 0.35 for distance) was retained until further checking.

6.8 Analysis of 680/84 split

As part of the routing checks, special attention was given to gather information and properly replicate vehicles' path choices at the 680/84 interchange. Vehicles traveling north on 680 from the southern end of the modeled region, and going all the way the eastern end (580/205 split and further east) are facing a major decision when they reach the 84 interchange: either staying on the freeway (north on 680 then east on 580), or alternatively, take route 84 and cut through Livermore to merge back into the 580 freeway.

It was decided to conduct a specific analysis on this strategic route choice, by first assembling data on field conditions, and then determine if (and how) the model could replicate actual measurements.

District 4 provided the research team with a set of Census data containing hourly counts at specific locations (mainline and ramps) at the 680/84 interchange. The data was processed, so that hourly traffic splits between the two routes could be gathered on a particular day, assumed to represent typical traffic conditions.

As can be seen in table 6.1, based on data collected on April 14, 1999, the percentage of traffic getting off at 84 ranges from 21 to 30%. During the first time period of your study (2-3 PM), it is 23%.

Traffic Volumes Counts

Dist	Cnty	Rte	PM	Leg	Dir	Description	Date	Day	24 hour Period Hourly Counts					
									14-15	15-16	16-17	17-18	18-19	19-20
4	ALA	680	11.761	F	N	NB OFF TO NB RTE 84	4/16/99	THU	1234	1996	1866	2050	1369	966
4	ALA	680	11.761	F	N	NB OFF TO NB RTE 84	4/15/99	WED	1187	1694	1738	1733	1628	1002
4	ALA	680	11.761	F	N	NB OFF TO NB RTE 84	4/14/99	TUE	1188	1763	2134	2111	1549	872
4	ALA	680	11.761	F	N	NB OFF TO NB RTE 84	4/13/99	MON	1169	1801	1927	1909	1510	798
4	ALA	680	11.761	F	N	NB OFF TO NB RTE 84	4/10/99	FRI	1513	1985	1932	2106	1846	1001
4	ALA	680	11.761	F	N	NB OFF TO NB RTE 84	4/9/99	THU	1234	1996	1866	2050	1369	966
4	ALA	680	11.761	F	N	NB OFF TO NB RTE 84	4/8/99	WED	1172	1620	1904	2148	1389	874
4	ALA	680	11.845	A	N	JCT. RTE. 84 EAST	7/29/99	WED	3932	4945	4759	5169	4626	4061
4	ALA	680	11.845	A	N	JCT. RTE. 84 EAST	7/28/99	TUE	4071	4653	5064	4818	4613	4086
4	ALA	680	11.845	A	N	JCT. RTE. 84 EAST	7/27/99	MON	3935	4646	4795	4821	4522	3487
4	ALA	680	11.845	A	N	JCT. RTE. 84 EAST	7/26/99	SUN	3885	3910	3833	3848	3502	3295
4	ALA	680	11.845	A	N	JCT. RTE. 84 EAST	7/25/99	SAT	4134	4114	4067	4089	3786	3291
4	ALA	680	11.845	A	N	JCT. RTE. 84 EAST	7/24/99	FRI	4718	5064	4935	5043	5190	4540
4	ALA	680	11.845	A	N	JCT. RTE. 84 EAST	7/23/99	THU	4282	4878	4878	5172	4783	4181
4	ALA	680	11.845	A	N	JCT. RTE. 84 EAST	7/22/99	WED	3932	4945	4759	5169	4626	4061
4	ALA	680	11.845	A	N	JCT. RTE. 84 EAST	7/21/99	TUE	3863	4558	4895	4771	4833	3908
4	ALA	680	11.845	A	N	JCT. RTE. 84 EAST	4/15/99	WED	3819	4875	5287	4995	4686	3302
4	ALA	680	11.845	A	N	JCT. RTE. 84 EAST	4/14/99	TUE	3985	4920	5009	4928	4594	3312
4	ALA	680	11.845	A	N	JCT. RTE. 84 EAST	4/13/99	MON	3727	4740	4740	4785	4362	3220
4	ALA	680	11.845	A	N	JCT. RTE. 84 EAST	4/12/99	SUN	3231	3251	3317	3094	2677	2406
						Percent SPLIT	Off to NB 84		23%	26%	30%	30%	25%	21%
							Continuing on 680NB		77%	74%	70%	70%	75%	79%

Table 6.1: I-680 / Route 84 traffic split field data

In order to reach a similar pattern in the model, two main components are available to the user: modifying the geometry data (link attributes) of the different routes; specifying the split of familiar vs. unfamiliar drivers. Both techniques have to be used in parallel to achieve optimal results.

What was initially observed was a pattern of all vehicles using Route 84 (which is shorter). In order to adjust this, a number of options were investigated, including:

- changing the link category for the southern part of SR84 from major to minor;
- decreasing the speed of southern SR84 from 55 mph to 50 mph (or lower)
- increasing the cost factor of southern SR84 from 1.0 to 1.3 (or higher)
- increasing the time coefficient in the cost function, from 0.65 to 0.8 (or higher).

All these options result in changing the routing of unfamiliar drivers from 84 to 680-580. Finally, it was decided to change the speed of southern SR84 from 55 mph to 50 mph to reach the desired routing pattern for unfamiliar drivers. By further adjusting the mix of familiar vs. unfamiliar drivers in the vehicle file, it is possible to obtain a traffic split between the two routes that is mirroring the one obtained with field data.

CHAPTER 7: GENERATING OPTIMAL O/D MATRIX FOR THE 2-3 PM PERIOD

7.1 Introduction

The process of generating the best possible OD matrix was based on applying the Paramics OD Estimation software (Reference 4). Far from being a black box, Paramics OD Estimator requires lots of input from the user at all stages of the estimation process. The input data need to be as detailed and reliable as possible; then, when the estimation process is performed, the user is required to specify and adjust a number of parameters to ensure that the optimization converges towards a suitable solution.

This chapter will successively present:

- the process of generating, checking and adjusting the necessary input data;
- the various options that were investigated to improve the results, and those finally used to produce optimal results;
- an initial assessment of the quality of the results finally obtained at the end of the demand estimation process for Hour One of the study period..

7.2 Updating OD Estimator data inputs

In Section 4.2 of this report, an overview of the input data required to run OD Estimator was provided. Following sections (4.4 through 4.8) presented the process of developing the initial set of input data to run OD Estimator on the I-580 corridor network.

The revisions to the network geometry and routing options that were subsequently made (as described in Chapter 6) led to a need to update and revise the OD Estimator inputs in parallel.

The process of revising and updating the OD Estimator input dataset is described in this section. The revisions can be classified in three categories:

- update the zone structure;
- update the pattern OD and confidence level;
- update target counts and associated confidence levels.

Revisions to the zone structure

Based on an audit performed by Quadstone, it was found desirable to further disaggregate the zone system, in an attempt to have only one connector link for each zone. Having numerous links loading out of one zone doesn't give the right level of control and understanding of the routing, due to the random nature of vehicles loading onto a network.

Even if the zoning system that existed in the original EMME2 planning model (which serves as a foundation for the pattern matrix) will significantly differ from what is now used in Paramics, it was considered important to further disaggregate the zone system.

Based on this comment, the zone structure was revisited in details, and a number of large zones in the previous structure were disaggregated. Ten large zones were divided into smaller sub-zones (between two and eight sub-zones depending on the local configuration). As a result, the original ten zones produced fifty-six zones in the new structure.

The pattern OD based on the EMME/2 model (see section 4.3) had to be updated accordingly. This was done in a spreadsheet, by assuming that the traffic in and out of each new sub-zone was equally distributed, the total traffic remaining similar to what it was originally with the unique larger zone.

At the end of this process, the zone system consisted of 177 zones. A pattern OD, with 177 origins and 177 destinations, was available.

Further updates to the pattern O/D

- Split pattern in two matrices

It was originally suggested that the pattern OD matrix be divided into two matrices:

- a matrix specific to the freeway traffic with only four zones directly connected the freeway mainline boundaries (eastern and western boundaries on I-580, southern and eastern boundaries on I-680)
- another matrix for all other OD pairs.

The purpose of this initial subdivision was two-fold: first, it allowed for different truck percentages to be applied to the freeway-only traffic; secondly, it would likely provide better control on the routing patterns of freeway-only traffic by adjusting the rate of familiar vs. unfamiliar drivers.

The freeway-only matrix was constructed manually based on actual counts on I-580 and I-680 (in particular counts measured at the mainline boundaries and on the connector links at the 680/580 interchange). The original pattern OD derived from the EMME2 model was used to complete the freeway-only matrix, and to produce the second matrix.

Different vehicle fleet composition was applied to the two matrices: initially the truck percentage was set to 12.5% on the freeway-only matrix, and 2% on the other matrix.

Different levels of driver familiarity were applied to the two matrices, the initial values being 15% familiar on the general matrix, and 0% familiar on the freeway-only matrix. Using all unfamiliar drivers on the freeway-only matrix was found to be a way to ensure that this traffic would stay on the freeway, because it is sensitive to the network hierarchy (minor/major link distinction) and to the category cost factor.

- Introduce truck zone area and third matrix

At the Flynn Road interchange of I-580, there is a truck stop area for both directions of the freeway. No zones were initially coded to model this location.

Two zones were added in the revised network, at the Flynn (zone 135) and Grant (zone 134) interchanges. The pattern OD had to be updated accordingly, using the 15-minute counts available at these on and off-ramps. Because zone 135 is essentially a truck stop area, it was found desirable to create a specific matrix for that zone (matrix 3 in the demands file), with a 95% truck percentage.

- Assemble more accurate truck percentages

With some support from Caltrans Headquarters (Traffic Operations), it was possible to gather data on truck traffic from weigh-in motions located on 580 and 680.

The data available was from two locations (for both directions of the freeway):

- on I-680 at the Alameda/Contra Costa county line, i.e. about 12 miles south of the 680/84 interchange;

- on I-580 at the junction with Route 132, i.e. about 4 miles southeast of the 580/205 split

The data was collected on various days in October 2002. Data collected on Tuesdays during that month was extracted, because the rest of the counts used in this study were also collected on a Tuesday (in September 2002). On I-680, two tuesdays (10/8-15) were available. On I-580, four tuesdays were available. The dataset allowed for extraction of hourly truck percentages by direction between 2 PM and 8PM.

On I-580, the truck percentage ranges from 16 to 23% in the Westbound direction, and from 10 to 25% in the Eastbound direction.

On I-680, it ranges from 4 to 10% both in the Northbound and Southbound direction.

The highest truck percentage is consistently observed in the 2-3 PM time slice, which é precisely the one relevant to the current demand estimation effort.

Once the data was processed, the question was how to apply these results in the model. Different truck percentages can be specified for different matrices in the demand file, by varying the fleet composition in the vehicle file. The problem was that none of the truck data available from the field was actually collected within the study boundaries.

With regard to the I-680 data, there is no source of truck traffic generation or attraction between the count location and the study boundary. Therefore, using the measured truck percentage directly seems to be a reasonable assumption.

The I-580 count location raised more concerns, as the field data was collected beyond the 580/205 split. How safe is it to assume that truck percentages on I-580 are similar before and after the 205 split? Additional information coming from Caltrans District 10 provided additional input to address this question. Based on 2001 truck volume data for SR 205 (east of 580 interchange) the peak hour truck percentage is around 15%. Another indication was that as a general rule, the peak hour truck percentage is approximately 70 to 80% of the Average Daily Traffic truck percentage. When compared to the Weigh-in-motion data from 580, these results appear to be similar, indicating that the pattern of truck traffic seems to be fairly close on 205 and 580 (past the split). Based on these findings, it can be reasonably assumed that the truck percentage figures are also similar on 580 before and after the split.

In conclusion, it was found possible to use the truck percentage data available, even though the measurements were done exactly within the boundaries of our study area.

- Introduce fourth O/D table

The introduction of additional truck percentage data led to a revision of the structure of the pattern OD. In the previous vehicle file, truck percentages were set to 12.5% for matrix 1 (freeway-only), 2% from matrix 2 (general) and 95% for matrix 3 (truck stop area).

The latest truck data that was just introduced in the previous paragraph indicated that the truck percentage on I-680 (for the 2-3 PM period) is 9.5% in the northbound direction and 9.7% in the southbound direction. On 580, the truck ratio is 23.1% traveling westbound, and 25.5% eastbound.

Based on these values, the freeway-only matrix was gain subdivided into two tables, one primarily dealing with I-580 traffic (using a truck percentage of 25%), and the other primarily dealing with I-680 traffic (using a truck percentage of 10%).

- Update confidence levels in four pattern OD tables

The role of the confidence weights has already been described in section 4.6 of this document. As indicated before, the confidence weight originally specified for the pattern OD matrix was 30%. Subsequent exchanges with Quadstone suggested that best results could potentially be obtained with a higher confidence weights, and as a consequence, a value of 70% was used in the updated series of OD Estimator runs reported in this Chapter.

It is important to notice, however, that the 70% confidence value applies only to one of the four tables now forming the pattern OD: the “general” OD matrix that relies exclusively on data coming from the planning model. The other three matrices (freeway-only and truck zone) were made up manually using actual counts from the field, and therefore, it was thought appropriate to lock these OD pair values in the OD estimation process. In other words, a confidence level of 100% was used for all cells in these three tables, in an effort to force the model to stay as close as possible to the specified values.

Target counts and associated confidence levels

Putting together the linkflow and turnflow files, which contain all target count information needed by Estimator, relied on the data sources and techniques previously described in Chapter 4 of this report.

Initial data sources for the mainline, ramp, and surface street counts were introduced in section 4.5. Additional mainline freeway counts were derived from a run of FREQ with the same input data, as explained in section 4.8. The initial set of confidence weights was presented in section 4.6.

A number of revisions and additions were necessary, however, after the network geometry was updated, new counts became available, and more discussions were held with Quadstone and Caltans.

Obviously, the original linkflow and turnflow files had to be check in light of the revisions made in the network geometry, which in some cases resulted in changes in node location or number, or even nodes being deleted. Each target count was individually checked to ensure that the specified location (link number) was appropriate in the revised network.

The set of census data (hourly counts) to be used as target counts on the freeways to complement the 15-minute counts, was expanded to cover the area around the 680/84 interchange. Because if the desire to analyze in details the split of traffic between 84 and 680 (see section 6.8), additional hourly counts were provided by District 4 at different locations including both directions of mainline highways and ramps. These counts were used as additional counters in the updated linkflow file.

Based on a general recommendation from Quadstone, it was decided to increase the confidence weights used on most of these counts.

The table below shows a summary of the number of counters available in different categories, and the associated confidence weights.

Type	Location	Source	Number	Confidence Weight
Link flows	I-580 EB (Ramps + three on Mainline)	D4, 15 min counts (from 9/17/02)	34	90%
Link flows	I-580 EB (Mainline only)	FREQ output	32	80%
Link flows	I-680, I-580 WB and SR 84	Census hour counts	72	70%
Link flows	Livermore	ADT map	64	20%
Subtotal			202	
Turn flows	Pleasanton (8 intersections) Livermore (1 intersection)	Synchro files	81	50%
Subtotal			81	
TOTAL			**283**	

Table 7.1: Summary of target counts and confidence weights

7.3 Running OD Estimator

Most of the estimation options used as part of the 580 application followed either the default settings or the recommended settings listed in the OD Estimator User Guide (Reference 4) or in a series of walkthrough examples provided by Quadstone (Reference 5).

Once these settings were specified, they would usually remain fixed. Only two of the main option settings were typically modified as the optimization process was going on: the minimum demand value, and the flow intensity..

Estimation method

OD estimator provides three methods: periodic normalization, incremental and combined. Usually, the first one, periodic normalization is recommended and was applied here. The release mechanism applied in this study is "Regular".

Calculation period / Simulation period

Usually, OD Estimator will recommend the calculation period when a new network is opened in Estimator, the recommended value being based on the duration of the longest trip when the network is running in an un-congested state. The trade-off is between the running time for each iteration, and the ability to cover the longest trips including potential congestion effects.

In the case of the I-580 application, a calculation period of 40 minutes was found to be appropriate. The simulation period was therefore set to 40 minutes as well.

Minimum/maximum demand values

Minimum and maximum trip demand values can be specified, they apply to all tables in the demand file. These values define absolute bounds for the variation of the demand between each OD pair.

The minimum value plays a critical role by allowing for manual adjustment of the OD pairs with very low expected demand. And this is particularly important for the zones that have relatively small trip productions. If the minimum flow is set too high, there will be unnecessary excessive demand starting from that zone which will adversely affect the estimation process.

The process followed was to gradually decrease the minimum demand value, starting at 5, then 3, then 2. At each step, a number of iterations (between 5 and 10) were performed.

Locking to zero technique

The minimum trip value is associated with the "locking to zero" technique. If an OD cell in the matrix is stationary for several iterations at the value of minimum trip number, it is reasonable to check the network to see whether the trip is possible or not. If it is not possible, these cells can be locked to zero.

This technique was used after the minimum demand value was progressively reduced to 2. After a few more iterations, all cells below 2 were finally locked to zero.

Flow intensity

Starting with a low flow intensity helps to reduce gridlocks in applications were congestion conditions may occur. The general recommendation made by the model developers is to start with a low flow intensity, and then gradually increase it.

In the I-580 corridor application, a value of 15% was used. It was found that the results would not improve with a higher flow intensity, suggesting that gridlock effects would occur if the flow intensity was higher than 15%. Further discussion on this topic is provided in Section 11.1 under “Further improve demand estimation”.

Revert to Best

This option allows to fine-tune a Best matrix, by specifying the percentage of trip values from the Best matrix to be kept in the next iteration. This is not intended to be used at the early stages of the process, as it may cause the optimization to get stuck in a local optimum rather than converging towards a global optimum.

The use of this function, however, was not found to improve the quality of the results, and therefore, it was decided not to use it.

7.4 Estimation results

GEH statistics

While the optimization process is running, at the end of each iteration, an assessment of the new OD matrix quality is automatically provided in the form of an overall GEH index. The GEH is a statistical test comparing the target flows and the predicted flows based on the latest OD table. A GEH of 5 or below is considered acceptable (see section 5.3 for more details on the GEH test)

The GEH value directly computed by OD Estimator is based on a comparison of all target counts specified by the user, and all the corresponding counts as estimated by the demand estimation software.

Two observations are important to be made at this point. First, with regard to the counts generated by OD Estimator, it has to be recognized that these counts are only an approximation of the actual simulation results (which will later be produced by Paramics Modeller). Because OD Estimator uses only a fraction of the demand (in this case 15%), it can not be expected to capture all the effects that would be represented in Modeller.

Secondly, the GEH value computed by Estimator, and used to assess the quality of the O/D matrix, takes into account all counts provided, and give equal weight to all these counts. In the 580 project, it was recognized that the critical objective was to calibrate the 580 eastbound section, and therefore, particular attention was to be given to those counters directly relevant to 580 eastbound. This was done by breaking down the overall GEH into subset comparison, only dealing with part of the counters and not all of them at once.

Initial results with 282 counters

When OD Estimator was first tried with the revised network (see Chapter 6) and the additional input files described in section 7.2, the initial results were disappointing. The best overall GEH that could be obtained was 8.62, quite far from the objective of 5. This result was based on the GEH comparing all 283 counters.

Best results with 66 counters

After additional input was received from Quadstone, a new attempt was made with the idea of focusing on the counters directly relevant to I-580 eastbound. Instead of using the entire set of target counts (the 283 values), only the first two types of counts shown in Table 7.1 were kept. The 34 target counts measured in the field were assigned the highest confidence weight (92%) while the 36 target counts derived from the FREQ study were assigned a confidence level of 88%.

Using this limited set of target counts, in addition to the various settings described in section 7.3, turned out to produce the best results ever obtained during the I-580 demand estimation effort: an average GEH (over the 66 counters) of 2.73. This vale was well below 5, considered to be threshold value under which results are acceptable.

Details of Estimator report

The Estimator Report is an output file generated by OD Estimator and is a summary of the results obtained in the OD estimation process. The Estimator Report is comprised of three parts: demand matrices, turn and link flow summaries, turn and link flow. Each report is accompanied by a header that indicates the iteration number for which the report is generated.

In the first part of the report, three demand matrices are listed. The “active demands” matrix is the current matrix utilized to generate GEH statistics for the given iteration. The next matrix, called “next demands”, indicates the OD matrix that would be used in the next iteration, if simulation were to continue. It is important to know what OD matrix is used, since each iteration uses a different matrix due to the dynamic nature of the estimation process. Subsequent iterations may not necessarily mean that a better OD is utilized, thus the Estimator Report keeps track of the best OD matrix used in the simulation. This best OD is listed as “Best demands”.

The key to obtaining a good OD matrix is to provide Estimator with reliable target counts, whether they are turn flows or link flows. In this case, only a subset of the target counts available (those directly pertaining to 580 eastbound) were used to produce optimal results.The Estimator Report indicates how closely modeled counts matched those supplied by the user as well as the GEH value for each count and the confidence level of each.

The last part of the Estimator report is an overall summary of the GEH values obtained for the turn flows (if any) and the link flows. This section indicates what percentage of counters fall into a specific range of GEH values.

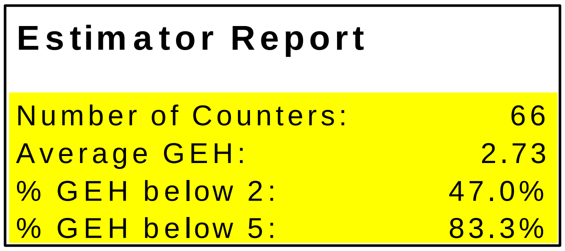
For the optimized run that resulted in an overall average GEH of 2.73, the detailed results of the Estimator reports are presented in Tables 7.2, 7.3 and 7.4

			Field Counts	Estimator Counts	GEH Value
MAINLINE COUNTERS					
174:435	ML1		5519	5583	0.86
749:767	ML2		6403	6133	3.41
955:956	ML3		5312	5197	1.58
ON RAMP COUNTERS					
327:1353	Foothill	OnRamp1	959	692	9.30
585:1354	680SB	OnRamp2	1411	1524	2.96
596:1355	680NB	OnRamp3	1522	1484	0.97
453:454	HopyardSB	OnRamp4	403	355	2.49
1279:306	HopyardNB	OnRamp5	334	377	2.26
689:690	HaciendaSB	OnRamp6	167	204	2.73
698:699	HaciendaNB	OnRamp7	273	325	3.01
742:743	SantaRitaSB	OnRamp8	332	317	0.82
1379:739	SantaRitaNB	OnRamp9	533	410	5.65
754:764	ElCharro	OnRamp10	148	51	9.79
780:781	Airway	OnRamp11	530	471	2.66
819:1356	Livermore	OnRamp12	487	511	1.07
844:845	First	OnRamp13	973	955	0.56
879:880	Vasco	OnRamp14	336	444	5.48
913:918	Greenville	OnRamp15	322	211	6.83
926:931	Flynn	OnRamp16	67	73	0.69
970:976	Grant	OnRamp17	62	102	4.37
OFF RAMP COUNTERS					
1337:434	Foothill	OffRamp1	878	847	1.07
213:201	680	OffRamp2	1363	1804	11.09
592:593	Hopyard	OffRamp3	406	375	1.54
686:702	Hacienda	OffRamp4	786	518	10.51
1335:716	SantaRita	OffRamp5	778	926	5.07
759:760	ElCharro	OffRamp6	164	164	0.01
777:778	Airway	OffRamp7	827	831	0.13
801:1400	Portola	OffRamp8	648	656	0.30
798:823	Livermore	OffRamp9	529	408	5.57
836:837	First	OffRamp10	552	631	3.26
872:873	Vasco	OffRamp11	1374	1457	2.21
916:1606	Greenville	OffRamp12	176	257	5.52
904:930	Flynn	OffRamp13	57	71	1.70
943:969	Grant	OffRamp14	94	140	4.23
			Number of counters:		34
			Average GEH:		3.52
			% GEH below 2:		38.2%
			% GEH below 5:		70.6%

Table 7.2: Best OD Estimator Report (Field Counts)

MAINLINE SUBSECTION	FREQ Counts	Estimator Counts	GEH Value
580EB ML1	5643	5583	0.79
580EB ML2	4719	4746	0.40
580EB ML3	5699	5812	1.50
580EB ML4	4264	4012	3.92
580EB ML5	3834	3638	3.22
580EB ML6	3834		
580EB ML7	5276	5169	1.48
580EB ML8	6827	6647	2.20
580EB ML9	7237	7003	2.77
580EB ML10	7575	7339	2.73
580EB ML11	6745	6788	0.53
580EB ML12	6913	6975	0.74
580EB ML13	7190	7216	0.31
580EB ML14	6372	6333	0.50
580EB ML15	6713	6661	0.63
580EB ML16	7258	7115	1.68
580EB ML17	7087	6934	1.82
580EB ML18	7237	7003	2.77
580EB ML19	6363	6133	2.91
580EB ML20	6903	6694	2.54
580EB ML21	6218	6035	2.33
580EB ML22	5661	5582	1.05
580EB ML23	6158	6175	0.23
580EB ML24	5579	5606	0.37
580EB ML25	6571	6559	0.15
580EB ML26	5127	5074	0.73
580EB ML27	5469	5482	0.18
580EB ML28	5284	5169	1.59
580EB ML29	5612	5365	3.34
580EB ML30	5553	5285	3.63
580EB ML31	5619	5352	3.61
580EB ML32	5525	5182	4.68
580EB ML33	5588	5197	5.31
	Numbe of counters:		32
	Average GEH:		1.89
	% GEH below 2:		56.3%
	% GEH below 5:		96.9%

Table 7.3: Best OD Estimator Report (FREQ Counts)



Estimator Report	
Number of Counters:	66
Average GEH:	2.73
% GEH below 2:	47.0%
% GEH below 5:	83.3%

Table 7.4: Best OD Overall Results in Estimator

Table 7.2 shows the OD Estimator Report for the counters where field data was available. Table 7.3 shows the comparison with the counts predicted by the FREQ model. Finally, Table 7.4 shows an overall summary taking into account all the counters used. With reference to the criteria defined in section 5.3, it appears that the objective of reaching an overall GEH below 5 is reached. The other relevant criteria, obtaining a GEH below 5 for 85% of the counters is almost reached as well (with 83.3% overall).

However, it is important to point out that the counts used in these comparisons are the ones produced by Estimator, which are only an approximation of how the model performs. The real meaningful comparison in terms of whether or not the model is calibrated has to be done with the counts produced when running Paramics Modeler, which is the process described in the next two chapters of the report.

The conclusion of the demand estimation process is that, by accepting to focus on the 580 eastbound only, it was possible to derive an optimized OD matrix for the fist time slice that would meet our criteria in terms of matching target counts available. It should be made clear, however, that only target counts along the I-580 eastbound freeway are used and the assessment of the calibration is made based only on the predicted performance along I-580 eastbound freeway. In this case, no attempt is made to consider other parts of the freeway corridor either in the form of target counts nor predicted traffic performance.

CHAPTER 8: CALIBRATION OF THE 2-3 PM PERIOD IN PARAMICS MODELLER

8.1 Introduction

The previous chapter described in details the steps involved in producing an optimized OD table (in fact four OD tables forming the overall demand), so the demand side of the simulation is available, and will remain unchanged during the subsequent steps of the calibration effort.

Once the best OD matrix is produced through the estimation process described in Chapter 7, it can then be used as the demand data to run Paramics Modeller. Following the general calibration method described in Chapter 5 of this report, Paramics Modeller is used to visually check the realism of the model, and also to compute a series of output files that are used to compare model results with field data.

The present chapter deals with the steps taken to analyze the results and calibrate the I-580 corridor network in Paramics Modeller. The demand data remaining fixed, other simulation components that can potentially be adjusted in the calibration phase include the network geometry, the vehicle routing options and the general configuration parameters. The vehicle routing option remained unchanged: the all-or-noting assignment was the only strategy that was implemented.

The next chapter of the report will deal with the validation stage, where the model outputs are compared with real-life traffic performances.

8.2 Gather simulation outputs

In order to assess the quality of the calibration effort, comparisons were to be made between model predictions and field data, with a focus on the I-580 eastbound direction. Based on the field data available, that was described in details in chapter 2 of this report, comparison were to be conducted in three areas: counts on ramps and freeway mainline locations, freeway speeds and travel times. The study period focused on the first hour of the peak period, 2 to 3 PM.

In order to gather the relevant simulation statistics, the most direct approach is to use the Analyzer module (Reference 3) of the Paramics suite. In Analyzer, a report was requested every 15 minutes for data pertaining to link speeds and counts. The Analyzer-produced data can be used directly when the comparison is made on a link buy link basis. For instance, ramp counts fall into this category: once the relevant Paramics link has been identified, the corresponding link data produced by Analyzer is directly used for comparing simulated counts with field data.

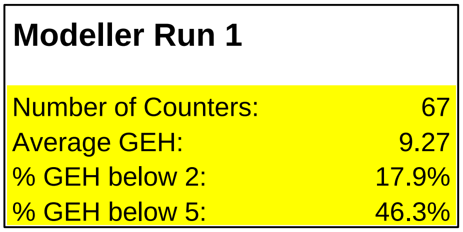
Mainline data analysis, however, is different in the sense that the performances are typically considered not on a link-by-link basis but on a subsection basis. A freeway subsection is defined as an homogeneous stretch of freeway, usually starting or ending with either a lane addition/drop, or a ramp merge/diverge. For example, the subsection structure used in the 580 eastbound analysis was presented in Figure 2.3 of this report. Because Paramics Modeller and Analyzer do not deal with subsections but only individual links, it is necessary to use an external process to derive subsection data from link data. Typically, a subsection is made of a number of individual links in the Paramics structure. The idea is to aggregate the link data relevant to each subsection, thus producing performance data that can be compared with the freeway mainline subsection data. Recognizing the need for such a tool, Caltrans has sponsored the development of a utility program, called Report Analyzer (Reference 12). This tool is a Microsoft Access database that reads the link speed and link flow results of Paramics Analyzer to generate additional reports by subsection and by time slice. Report Analyzer was used to generate all relevant subsection-based statistics in the I-580 project.

8.3 Adjust general configuration parameters

Paramics Modeller was first run with the revised network geometry (as described in Chapter 6), the best OD matrix (derived from OD Estimator as explained in Chapter 7), the general configuration parameters introduced in section 5.6 and the driver behavior parameters presented in section 5.7.

Analyzer and Report Analyzer were used to compute count statistics predicted by the model, either on a link or a subsection basis. These results were used to statistical comparisons between the modeled results and the field (or FREQ-generated) counts. The comparisons followed the technique presented in Chapter 7: first, all available field counts (34 locations) were compared to the model predictions; then Paramics counts were compared against the FREQ counts (for the 33 subsections of the freeway); finally, an overall GEH comparing the results at all 67 locations was produced.

Table 8.1 shows the result of this comparison, for the initial run (called Run 1).



Modeller Run 1

Number of Counters:	67
Average GEH:	9.27
% GEH below 2:	17.9%
% GEH below 5:	46.3%

Table 8.1: Overall count comparison for Run 1

When comparing these results with those previously obtained in Estimator (shown on Table 7.4), one can be surprised by the differences between Estimator and Modeller, and disappointed by the overall performance reached in Modeller.

With regard to the first observation, it is important to recognize that Estimator and Modeller are bound to produce different results, as the underlying processes are quite different. Estimator only uses a fraction of the demand (in our case, 15%) to derive an estimation of the counts to be used essentially in comparing the quality of different OD matrices. Modeller, on the other hand, performs a much more detail simulation involving all individual vehicles and therefore, is more likely to capture the complexity of real-life situations, in particular when they involve congestion conditions.

If there is no doubt that the results should be different, the magnitude of the different was quite surprising, and raised some concerns. After discussions with Caltrans and Quadstone, and further investigations by the research team, it was determined that two factors may have been contributing to this situation: the use of different general configuration parameters in Estimator and Modeller, and some congestion effects that were significantly more severe in Modeller compared to Estimator.

The OD Estimator process was carried out with a time step of 2, meaning that the traffic state in the simulation was refreshed every 0.5 second. This was done in an effort to increase the speed of each iteration in OD Estimator. In Modeller, however, the time step parameter that was initially selected was 5. This difference was thought to be a potential source of discrepancy between Estimator and Modeller results.

A new run of Modeller (called Run 2) was conducted, using all the same inputs and settings, except for the timestep parameter which was set to 2 instead of 5, replicating the value previously applied in Estimator. The results of Run 2 are presented on Table 8.2.

Modeller Run 2	
Number of Counters:	67
Average GEH:	8.34
% GEH below 2:	22.4%
% GEH below 5:	50.7%

Table 8.2: Overall count comparison for Run 2

Comparing these new results with those obtained in Estimator (Table 7.4) and in Modeller Run 1 (Table 8.1), it can be seen that Run 2 led to only marginal improvements over Run1, and certainly did not lead to results as promising as those predicted by Estimator.

Further adjustments beyond the timestep parameter were necessary to improve the performances as measured in Modeller.

8.4 Fine-tune network geometry and control settings

As mentioned previously in the methodology section, the calibration of Paramics relies in part in taking advantage of the graphical user interface to observe vehicles' behavior and detect some problems that can adversely affect the quality of the simulation performances. That is precisely what happened when watching in details the screen animation while Paramics Modeller was running (under the Run 2 scenario).

It became apparent that some unexpected congestion conditions would occur on the surface street network, and the resulting queues would eventually spillback onto the freeway. These situations were observed to occur primarily in downtown Livermore where several intersections would reach a saturated stage, resulting in congestion eventually backing up all the way to the Livermore Avenue off-ramp and the I-580 mainline. To a lesser extend, the Vasco loop off-ramp was also showing congestion conditions spilling back on the mainline.

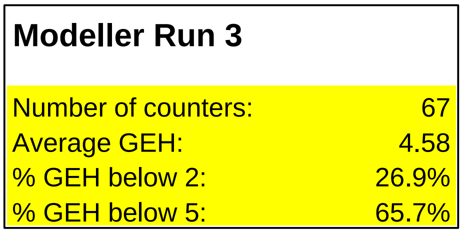
Because these congestion situations do not exist in real-life during the 2-3 PM period, it was decided to remedy to the problem by manually increasing the capacity of those links that created bottlenecks that would eventually back up to I-580 eastbound.

The capacity increases in the model were made by:

- increasing the green times for specific movements at several intersections throughout downtown Livermore;
- changing lane allocations to favor specific movements;
- adding nextlanes;
- revising the priority rule at the end of the Vasco off-ramp.

All these changes were made in an effort to avoid the situation where any I-580 eastbound off-ramps would be blocked during the 2-3 PM period. This objective was met after all the modifications were implemented, as could be visually checked while running Modeller.

The next step was to run Modeleller with the revised settings (Run 3), and compute the statistics as done previously. The new results are shown in Table 8.3. Clearly, the latest changes in the network and control settings have had significant and positive impact on the results. The overall GEH comparing all modeled and target counts for I-580 eastbound is down to 4.58. The threshold value of 5, which had been announced as the threshold value, has been reached.



Modeller Run 3	
Number of counters:	67
Average GEH:	4.58
% GEH below 2:	26.9%
% GEH below 5:	65.7%

Table 8.3: Overall count comparison for Run 3

In addition to the overall count comparison, the validation of the model involved much more analysis, which are presented in the next chapter of the report.

CHAPTER 9: VALIDATING MODEL OUTPUT STATISTICS FOR 2-3 PM PERIOD

9.1 Introduction

One of the input parameters have been adjusted as part of the calibration phase, the model validation can start: validation is the process of comparing the model predicted performances against field measurements.

In the 580 corridor application reported here, comparisons were made between model outputs and measured flows, speeds and travel times for the first hour of the study period (2-3 PM). The different comparisons are successively presented and discussed in this chapter.

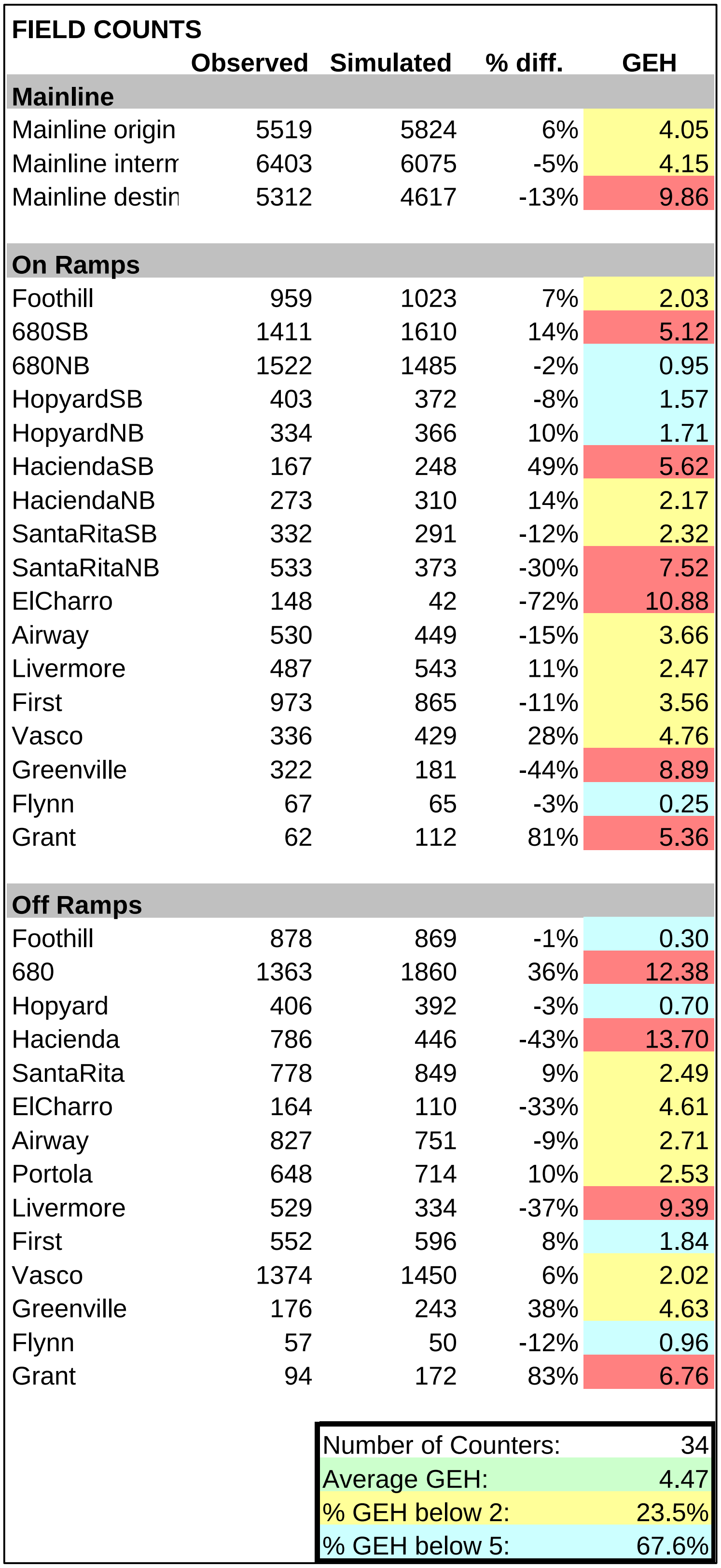
9.2 Traffic count comparison

A comparison was made between the results obtained with Paramics Modeller and the real life traffic counts collected at specific locations along the mainline freeway and at all on- and off-ramps. The Modeller results presented here are those obtained with the settings of Run 3 (see section 8.4 of this report for more details), which appeared to produce the best match between modeled and target counts.

Table 9.2 shows the counts predicted by the model over the one-hour period, in comparison with the counts collected in the field, respectively at the three mainline locations where counts were available, and at all on-ramp and off-ramp locations along the eastbound direction of I-580. The table presents the numerical results, and a comparison of the two series of counts, first the percentage difference, and then the GEH value. The average GEH over field counts was 4.47.

Table 9.3 shows a similar type of comparison, this time between the Paramics Modeller results, and the ones obtained with the FREQ macroscopic model. In this comparison performed over the 33 subsections of the mainline freeway, the overall GEH was 4.69.

Table 8.3 in the previous chapter already presented the overall results, obtained when combining field counts and FREQ counts, and comparing with the Paramics Modeller output from Run 3. The global GEH over the 67 count location was 4.58. This result is positive in the sense that the overall global GEH is below 5, but the goal of reaching a GEH below 5 on 85% of the locations is not met.

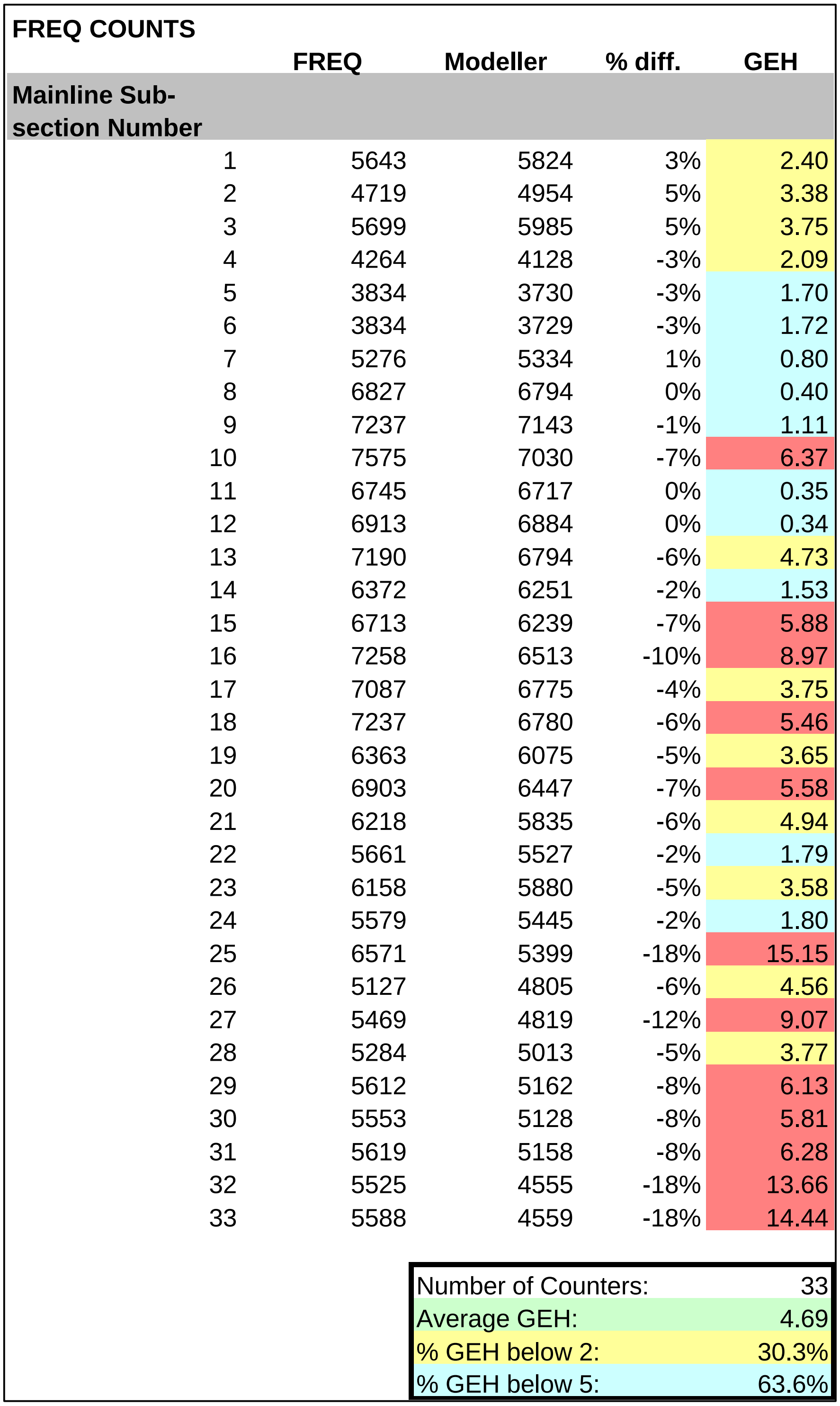


FIELD COUNTS

	Observed	Simulated	% diff.	GEH
Mainline				
Mainline origin	5519	5824	6%	4.05
Mainline interm	6403	6075	-5%	4.15
Mainline destin	5312	4617	-13%	9.86
On Ramps				
Foothill	959	1023	7%	2.03
680SB	1411	1610	14%	5.12
680NB	1522	1485	-2%	0.95
HopyardSB	403	372	-8%	1.57
HopyardNB	334	366	10%	1.71
HaciendaSB	167	248	49%	5.62
HaciendaNB	273	310	14%	2.17
SantaRitaSB	332	291	-12%	2.32
SantaRitaNB	533	373	-30%	7.52
ElCharro	148	42	-72%	10.88
Airway	530	449	-15%	3.66
Livermore	487	543	11%	2.47
First	973	865	-11%	3.56
Vasco	336	429	28%	4.76
Greenville	322	181	-44%	8.89
Flynn	67	65	-3%	0.25
Grant	62	112	81%	5.36
Off Ramps				
Foothill	878	869	-1%	0.30
680	1363	1860	36%	12.38
Hopyard	406	392	-3%	0.70
Hacienda	786	446	-43%	13.70
SantaRita	778	849	9%	2.49
ElCharro	164	110	-33%	4.61
Airway	827	751	-9%	2.71
Portola	648	714	10%	2.53
Livermore	529	334	-37%	9.39
First	552	596	8%	1.84
Vasco	1374	1450	6%	2.02
Greenville	176	243	38%	4.63
Flynn	57	50	-12%	0.96
Grant	94	172	83%	6.76

Number of Counters:	34
Average GEH:	4.47
% GEH below 2:	23.5%
% GEH below 5:	67.6%

Table 9.1: Comparison with Field Counts



FREQ COUNTS

Mainline Sub-section Number	FREQ	Modeller	% diff.	GEH
1	5643	5824	3%	2.40
2	4719	4954	5%	3.38
3	5699	5985	5%	3.75
4	4264	4128	-3%	2.09
5	3834	3730	-3%	1.70
6	3834	3729	-3%	1.72
7	5276	5334	1%	0.80
8	6827	6794	0%	0.40
9	7237	7143	-1%	1.11
10	7575	7030	-7%	6.37
11	6745	6717	0%	0.35
12	6913	6884	0%	0.34
13	7190	6794	-6%	4.73
14	6372	6251	-2%	1.53
15	6713	6239	-7%	5.88
16	7258	6513	-10%	8.97
17	7087	6775	-4%	3.75
18	7237	6780	-6%	5.46
19	6363	6075	-5%	3.65
20	6903	6447	-7%	5.58
21	6218	5835	-6%	4.94
22	5661	5527	-2%	1.79
23	6158	5880	-5%	3.58
24	5579	5445	-2%	1.80
25	6571	5399	-18%	15.15
26	5127	4805	-6%	4.56
27	5469	4819	-12%	9.07
28	5284	5013	-5%	3.77
29	5612	5162	-8%	6.13
30	5553	5128	-8%	5.81
31	5619	5158	-8%	6.28
32	5525	4555	-18%	13.66
33	5588	4559	-18%	14.44

Number of Counters:	33
Average GEH:	4.69
% GEH below 2:	30.3%
% GEH below 5:	63.6%

Table 9.2: Comparison with FREQ Counts

9.3 Speed contour maps

Speed contour maps based on tach run data and Paramics Modeller results (for Run 3) are shown on Figure 9.1. The bottom part of the figure is a remainder of the subsection structure used to construct the time/space diagrams.

Each cell of the speed contour maps represents the average speed over a 15-minute time slice for a given subsection of the freeway.

The contours are drawn with three speed levels: below 35 mph, between 35 and 50 mph, and over 50 mph.

It appears that the model predicts more congestion than what was observed in the field between 2 and 3 PM. Paramics seems to identify the bottleneck location (at subsection 16) observed in field data, but tend to overestimate the amount of congestion occurring early on in the PM peak period.

9.4 Travel time comparison

While comparison of traffic volumes and speeds is a good measure of traffic performance, these indicators are location specific. For a commuter, travel time is a more attractive measure of operational performance as elapsed journey time is more apparent to the driver than the number of cars that utilize a ramp.

For this network, the travel time to cross the eastbound I-580 from the western end of the network to the eastern end was measured in the field during the tach run measurement campaign. The trip time measurements collected from the tach runs are from the Eden Canyon on-ramp (west of Foothill) to the Grant Line exit, a distance of 24.25 miles.

Trip times in Paramics were collected for a specific O/D pair (from zone 1-western freeway boundary to zone 10-eastern freeway boundary). The distance to cover is slightly longer: 25.6 miles.

Results are shown graphically on Figure 9.2. It appears that average trip times in Paramics are somewhat higher than those taken from field measurements. This finding was expected, due to the combination of two factors: first, the Paramics travel times are measured on a longer trip; secondly, Paramics tend to overestimate the amount of congestion in the 2-3 PM period, as appeared in the speed contour map analysis.

9.5 Conclusion

When compared to real-life traffic performances on the eastbound direction of I-580, the model shows some fidelity in replicating counts, but tend to overestimate the amount of congestion occurring during the first hour of the simulation period. As a result, the travel times predicted by the model on the I-580 eastbound tend than those observed in the field.

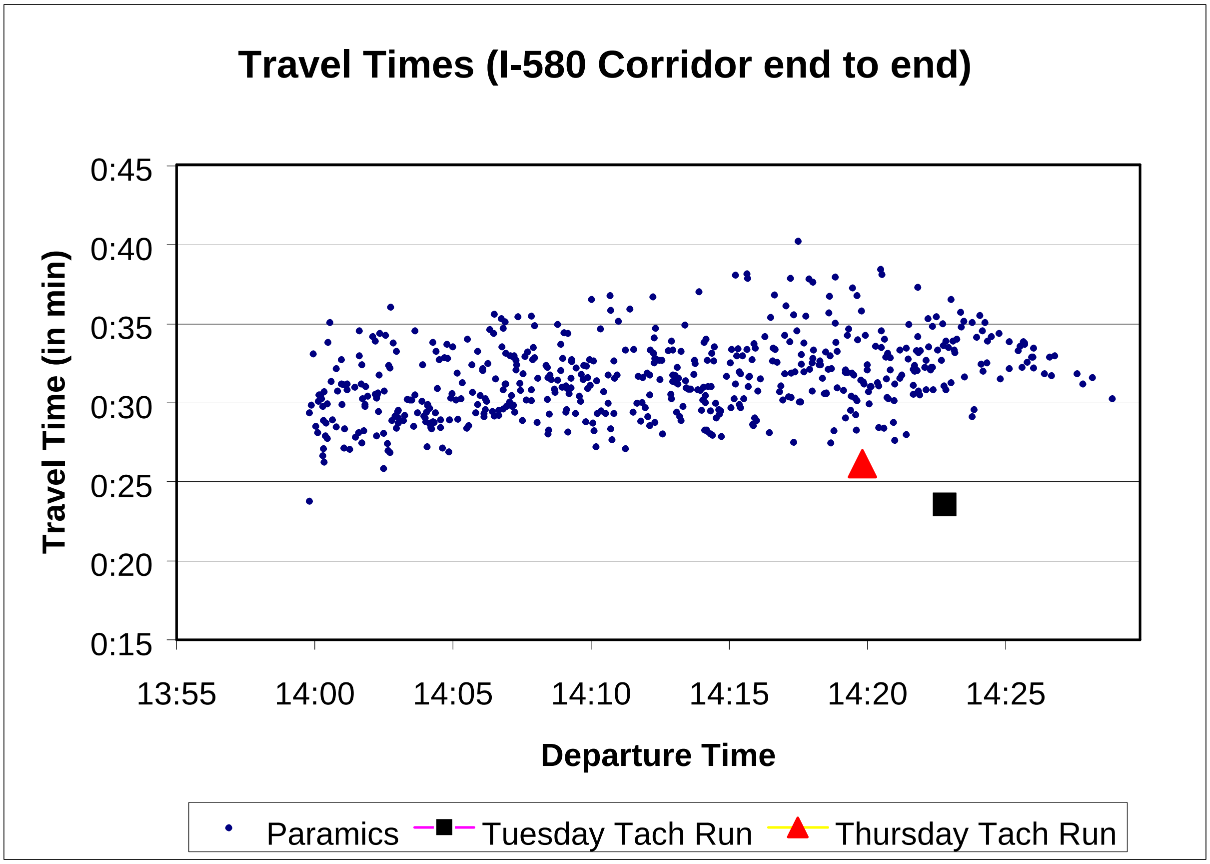


Figure 9.2: Travel Time Comparison

I-580 EB **Tach Runs Speed Contour Map** **September 17, 2002 (Tuesday)**

Interval Start	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Column Summar		
																																Min	Avg	Max
14:15	65	59	59	65	64	64	62	60	58	65	65	65	65	50	50	50	60	60	60	65	65	65	65	65	65	65	65	65	65	65	65	50	62	65
14:30	66	62	60	62	62	62	61	60	60	64	69	69	66	55	43	47	58	63	59	61	64	66	62	60	63	64	63	60	63	68	68	43	61	69
14:45	66	64	61	59	59	59	60	61	61	62	62	64	54	36	34	34	32	49	62	65	62	62	62	60	62	63	63	63	65	65	68	32	58	68

I-580 EB **PARAMICS Modeller Run 3 Speed Contour Map**

Interval Start	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Column Summar		
																																Min	Avg	Max
14:15	57	77	41	66	65	47	44	87	49	53	45	17	17	44	40	30	65	62	74	58	68	63	59	66	47	63	62	71	59	75	58	17	56	87
14:30	57	77	44	66	66	50	44	87	47	24	19	9.2	14	39	36	31	65	63	75	57	69	63	59	66	48	64	62	70	60	74	53	9	53	87
14:45	58	78	41	67	69	54	43	64	24	13	19	10	17	39	37	30	65	62	75	56	68	63	60	67	47	63	62	71	61	76	51	10	52	78

Section ID	U/S	D/S
1	Eden On	Foothill Off
2	Foothill Off	Foothill On
3	Foothill On	I-680 Off
4	I-680 Off	Hopyard Off
5	Hopyard Off	Lane Drop
6	Lane Drop	I-680 SB On
7	I-680 SB On	I-680 NB On
8	I-680 NB On	Hopyard 1 On
9	Hopyard 1 On	Hopyard 2 On
10	Hopyard 2 On	Hacienda Off
11	Hacienda Off	Hacienda 1 On
12	Hacien. 1 On	Hacienda 2 On
13	Hacien. 2 On	Tassajara Off
14	Tassajara Off	Tassajara 1 On
15	Tassa. 1 On	Tassajara 2 On
16	Tassa. 2 On	El Charro Off

Section ID	U/S	D/S
17	El Charro Off	El Charro On
18	El Charro On	Airway Off
19	Airway Off	Airway On
20	Airway On	Portola Off
21	Portola Off	Livermore Off
22	Livermore Off	Livermore On
23	Livermore On	First Off
24	First Off	First On
25	First On	Vasco Off
26	Vasco Off	Vasco On
27	Vasco On	Green Off
28	Green Off	Green On
29	Green On	Flynn Off
30	Flynn Off	Flynn On
31	Flynn On	Grant Off

Figure 9.1: Speed Contour Map Comparison

CHAPTER 10: SUMMARY OF LESSONS LEARNED

Within the course of calibrating the Paramics model of the I-580 freeway corridor for the 2-3 PM period, the research team gained a lot of expertise. The purpose of this chapter is to highlight the main lessons learned throughout the process, in order to ensure that similar applications to be conducted in the future can fully benefit from the I-580 experience.

10.1 Calibration is a highly integrated and iterative process

The chart on Figure 10.1 shows the four main components involved in any Paramics calibration effort. This chart does not intend to represent the entire calibration process, and all the steps involved (see Reference 13 for a more complete calibration flowchart).

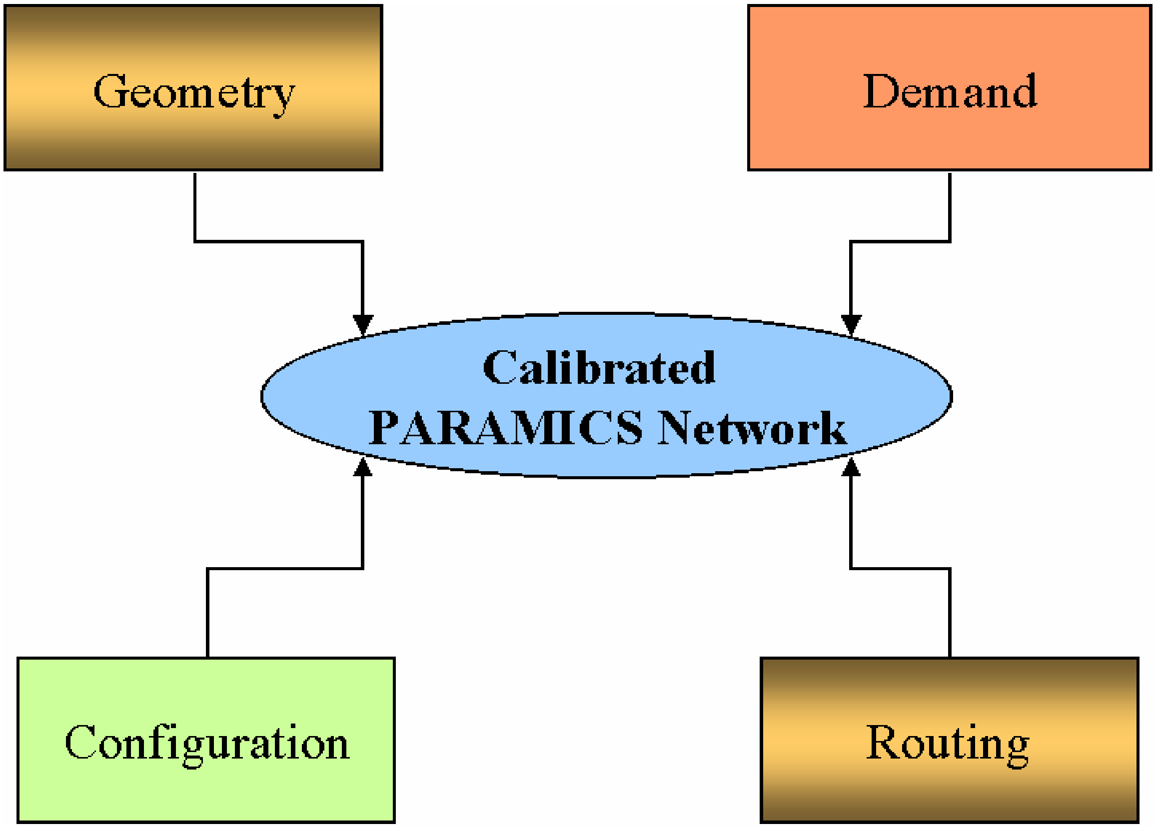


Figure 10.1: Four main components of calibration

The flowchart on Figure 10.1 clearly shows that the process is highly integrated in the sense that the model calibration requires the development and fine-tuning of many different components:

- Network geometry (and control) data;
- Demand;
- General configuration and driver behavior parameters;
- Routing options.

If any one of these components fails to be properly adjusted, then the model can not expect to be properly calibrated.

The added complexity of the process comes from the fact that these four major components are not independent. Any modifications made to one component are likely to affect one or more other components. For instance, it is clear that the process of generating an optimized OD matrix (the demand side of the simulation) relies on the three other components as an input. This was clearly illustrated, first in Figure 4.1 of this report, and then on the description of the OD estimation process provided in Chapter 7.

As a consequence, it is very important to keep in mind that the process needs to be iterative, and make sure that any modifications made to one of the four major input components are fed back to the others.

10.2 Network structure and coding details

Density of surface streets

An important lesson that was drawn from the I-580 project was to ensure a high level of consistency and balance between the different input components of the simulation. This observation is obviously related to the previous comment made about the integration of the whole process.

A critical issue that was faced by the research team was that of consistency between the supply and the demand sides of the simulation. The approach taken to model the demand side, based on the use of OD Estimator and a pattern OD matrix based on a general planning model of the area, resulted in a demand file that was close to replicate the entire traffic traveling from, to, or across the simulated area. On the other hand, the supply side originally intended to be coded into the Paramics model, only consisted of the freeways, state routes, and major parallel arterials. It certainly was not close to include all local road and streets available within the study boundaries. It became apparent that this disconnection between a full demand and a partial supply was generating a lot of unexpected congestion, starting with a number of origin zones in the Paramics model that could not release most of their traffic because they were getting blocked early on in the simulation. Similarly, the high traffic levels to be accommodated by fewer streets than actually exist in the field led to many signalized intersection to become saturated in the model.

The subsequent effort to add more arterials and increase the capacity of the surface street system contributed to improve the situation. However, the issue remains present, as the supply side coded in the model does not represent the actual total capacity of the surface street network. A lot of the unexpected congestion observed on the surface streets, for instance in the downtown Livermore can certainly be explained by this fact.

Geometry coding details

If the quantity of roads and streets to be coded in the model needs to be carefully thought of at the beginning of the project, it is also important to determine the level of quality in network coding that is actually required. Paramics offers a powerful visual interface that allows to see in great details the roadway geometry and the vehicles' movements through the network. It may appear that the optimum level of coding is always desirable everywhere. However, the extensive amount of data gathering and the labor resources required to achieve the best possible quality of network coding, should also be considered when determining the requirements for a specific project. Depending on the project objectives, the size of the study area, the data and resources available, it may be that optimum quality in network coding is not absolutely required everywhere. Some reasonable assumptions can be made, some simplifications can be acceptable in an effort to save time and concentrate on other aspects of the study.

This remark obviously applies particularly to large corridor network coding efforts, where on the one hand, it is important to code a high proportion of the roadway capacity available, but on the other hand, the finest level of coding quality may not be required everywhere. As an example, a way to simplify the coding task is to use straight links only, and no curvatures. Another way is to minimize the number of nodes in the model, by using longer links.

Network hierarchy

Modeling grid networks is significantly more complex than freeway sections because it involves route choices. Paramics offers some degree of flexibility in terms of routing strategies that can be applied. However, even before considering varying the assignment technique or the parameters in the generalized cost function, it is important to introduce a clear network hierarchy while coding the network geometry. The network hierarchy concept is based on the distinction between major and minor routes, and the application of different category cost factors to different routes. By establishing a clear hierarchy early on, the user can have more control on the route choices. For instance, the definition of an appropriate network hierarchy helps obtaining a more realistic behavior in terms of path selection involving multiple options: using mostly the freeway infrastructure, or choosing to divert to major arterials or even residential streets.

Zone structure

The zone structure is another very important aspect of the network coding. Decisions have to be made early on with regard to the zone density, their localization and shape, and the number and attributes of the connector links. Typical problems that may occur include the use of fewer and larger zones, requiring multiple connector links. This situation will usually lead to unrealistically high levels of congestion and lots of unreleased vehicles from the origin zones. Furthermore, having numerous links loading out of one zone doesn't give the right level of control and understanding of the routing, due to the random nature of vehicles loading onto the network.

When using OD Estimator to help generate the demand side of the Paramics model, the user typically uses an OD matrix developed from a four-step planning model. This was the case in the I-580 study where the EMME2 Alameda County model was used to derive the pattern OD. It is then logical to try to adapt a similar zone system in the Paramics model under construction. It should be pointed out, however, that this approach is not appropriate in cases where the planning model used very large zones. The initial structure based on the EMME2 model consisted of 79 zones; after many zones were further disaggregated to avoid over-saturated conditions and limit the number of connector links for each zone, the Paramics model finally used in the OD estimation process had 177 zones.

10.3 Quality of traffic data

The need for quality traffic data on the freeway eastbound direction of I-580 was recognized at the early stages of the project. In fact, a high quality dataset, including 15-minute counts at all ramps and simultaneous tach runs (for speed and travel time information), was available even before the network coding task started. This was obviously a strong asset for the research team in embarking on this new calibration effort.

There are other types of traffic data, however, that are of critical importance to a modeling study such as the one reported here. The truck percentage on the freeway section under investigation has a strong impact on the traffic performances. The presence of the Altamont Pass, with high grades associated, only reinforces the importance of capturing the effects of truck traffic. This first requires that the network geometry reflect the actual gradients, by coding appropriate node elevations. Secondly, reliable truck percentage data from the field is required: ideally, the data should be collected at various locations within the study area, simultaneously with the rest of the counts, and with the same data aggregation periods. Thirdly, the “vehicle” file in the Paramics inputs has to specify the right percentage of truck traffic (based on field measurements). For obvious reasons, one should not assume that the same truck percentage applies to all OD pairs in the demand matrix. To factor this in, it is necessary to break down the overall OD matrix into a number of sub-matrices that are more homogeneous in terms of truck matrix. This process was followed on the I-580 project, where the initial OD pattern finally produced four OD matrices, each one using a different truck percentage.

When dealing with an integrated freeway-arterial corridor, one should not underestimate the amount of data required on the surface street side. Even if the main focus of the project is on investigating freeway operations (as was the case in this study), there is obviously a lot of interactions between the freeway and arterial systems, and the model can greatly benefit from capturing these effects. This in turn, requires that a sufficient amount of resources be devoted towards coding the surface street system as accurately as possible, collecting all data available, and ensuring that the data is of highest possible quality.

The I-580 project clearly illustrates the issue associated with poor data quality on the surface street side. In many cases, the data was inexistent, too old, or not appropriate (for instance ADT flows in Livermore). Even when some data was available, it had not been collected at the same time than freeway data. Proper signal timings at intersections were not always available, and actuated signal operations was not modeled at all even though it is known to be used in the field.

This lack of data quality obviously contributed to a lack of realism in the simulation, not only on the surface street side, but also on the freeways due to the high level of interactions between freeways and surface streets.

10.4 Adjusting the pattern OD in demand estimation

This lesson relates to the fact that the pattern OD matrix to be used as an input to OD Estimator cannot be just taken directly out of a planning model. As described through the I-580 application, it is important to consider making a number of adjustments to the initial seed OD.

Revising the zone structure

As previously mentioned, large zones with a high level of traffic demand are prone to generate problems, and are easier to handle when disaggregated into smaller zones. This can easily be done in a spreadsheet, assuming that the traffic in and out of each new sub-zone is equally distributed.

Breaking down the overall table into smaller, more homogeneous OD matrices:

The resulting OD tables being more homogeneous in terms of traffic composition, it makes more sense to apply specific parameters (such as the truck percentage or the mix of familiar vs. unfamiliar drivers) that are really relevant to each sub-matrix. Another advantage is that this technique allows applying specific demand values to particular OD pairs, and locking these values throughout the demand estimation process. This can be desirable when a demand value is manually computed based on field counts, as opposed to being extracted from the planning model seed OD.

10.5 Target counts for demand estimation

In addition to all the observations related to the pattern OD, the other component of the OD estimation process, the target counts, require a lot of attention as well.

Target counts need to be looked at both quantitatively and qualitatively. On the one hand, it is desirable to have as many target counts as possible, covering a large proportion of the links forming the network, and being able to assess in details how the model performs in those areas that are of critical importance. On the other hand, having too many counts does not help if the counts are not reliable, or if they are incompatible.

Ideally, counts should all be collected at the same time, using the same high-quality data acquisition and processing methods. In practice, when dealing with large networks encompassing multiple operators and road types, this requirement can hardly (if ever) be met. Data checking is highly recommended to make sure that obvious inconsistencies between target counts collected from different sources are detected and dealt with. Dealing with these inconsistencies may require to manually adjust the target counts or to disregard some counts.

Another way to deal with data quality is to adjust the confidence weights associated with different set of counts when running OD Estimator. The experience gathered from the I-580 project, necessarily limited to very specific conditions, seems to indicate that it is better to use only the counts that are highly reliable, and increase the confidence level on those counts to really high values (close to or greater than 0.9).

The other interesting recommendation that came from Quadstone in this respect was that a good level of calibration on the eastbound direction of I-580 was more likely to be reached when using the maximum number of target counts directly relevant to that directional freeway. In this case, it was done by running the FREQ macroscopic model with the same dataset, and use mainline counts predicted by FREQ as an additional source of target counts for the link flow file. A high level of confidence for the FREQ-generated target count (0.88) was found to perform best.

10.6 Routing

Calibrating a large integrated freeway-arterial corridor requires a good understanding and an accurate representation of the route choices. This is a real challenge for model developers and users, as the underlying processes behind route choices are extremely difficult to capture and to replicate in simulation. This being said, Paramics offers some tools and features that can be used to at least partially replicate real-life behaviors in terms of route choices.

These options include:

- defining a network hierarchy;
- specifying familiarity levels;
- adjusting the generalized cost function (a user-specified combination of time, distance, and tolls);
- selecting an appropriate assignment technique (among the three available: All-or-Nothing, Stochastic, Dynamic);
- fine-tuning the parameters specific to that assignment technique.(for instance the perturbation factor in the stochastic assignment technique).

During the course of the I-580 project, the network hierarchy and familiarity levels were certainly used to control the routing patterns. That alone can go a long way towards reaching a reasonable degree of confidence in the route choice process. However, optimal calibration performances would be more likely to be obtained after a thorough investigation of the different assignment techniques and a detailed sensitivity analysis of all parameters related to each assignment technique. This could not be performed within the time available for this phase of the project, and appears to be an important task to accomplish in the future if the project is to continue.

CHAPTER 11: MOVING FORWARD

This chapter presents some ideas about how to move forward at the end of the current stage of the project. It is divided into two sections. First, a number of possible actions are presented in direct continuation of the work reported here on the I-580 project. Secondly, some more general ideas about how to develop successful microsimulation applications on large corridor networks are suggested.

11.1 Next steps on the I-580 study

First hour (2–3 PM)

The general conclusion of the calibration effort reported here is that more work is needed to obtain a satisfying level of performance in terms of replicating real life traffic conditions during the first hour of the afternoon peak period. Before going any further, it seems desirable to devote more effort into improving the results for the first hour.

Final tasks will be to establish criteria for accepting model results and to carefully review predicted performance by model experts and traffic experts to see that the model meets the established criteria

This effort would involve the following steps:

- Improve the quality of traffic data:

A critical aspect of the calibration task is to be able to apply a comprehensive and high quality set of traffic data. In the work carried out so far, there were obvious discrepancies between the level of data quality available on the freeways and surface streets. On the freeway side, the data was much more reliable for I-580 eastbound that any other freeway segments.

The traffic counts should be of high quality, collected simultaneously, and cover the entire region that is modeled. This means using more data on surface streets (mid-block and turning movements) and more data on other freeways (I-580 westbound, I-680). The conditions under which the data was collected (i.e. presence of upstream/downstream constraints) should be one of the criteria for judging quality of the data.

- Further improve network geometry coding

Further improvements in the network coding would be desirable. This observation is particularly relevant for the surface street system, which did not get the same level of attention than the freeway system in the first part of the project. Additional surface street should be coded, in an effort to better simulate the existing network available to the drivers. The geometry of all intersections should be carefully checked to make sure that the model really replicate actual field configurations.

- Further improve signal timings (fixed-time, actuated)

For the model to be realistic, it is important that the correct signal timings be represented in the model. This requires that actual fixed-time timings be available, for all intersections using this mode of operation. When the signalized intersections use actuated signal control in the filed, the simulation model should represent that type of operation, as opposed to using fixed timings. A Paramics API to model actuated signal control, developed by PATH researchers at UC Irvine, could be used.

- Further Improve demand estimation

The fact that optimal results so far were obtained with a very low flow intensity (15%) is a source of concern. It is usually recommended to progressively increase the flow intensity (to values around 90%) in order to increase the performance of the OD estimation process. With the current status of the input files, OD Estimator was not able to generate better results with flow intensities over 15%, probably due to gridlock effects that would develop. Improving the overall quality of the inputs (network, zone structure, target counts, pattern OD) should result in being able to apply higher flow intensities without degrading the performances. Using a higher flow intensity value should allow the OD Estimator to be more accurate in terms of replicating traffic congestion conditions, and therefore account for the discrepancies between target counts and actual demand values.

Another aspect of refining the OD demand estimation process is to apply the “Revert-to-Best” option, which is intended to gradually optimize the best OD matrix at the later stages of process. Further details can be found in Reference 10.

- Further Investigate Routing options

The effect of using different routing options and fine-tuning the relevant parameters should be further explored as a way to obtain better results in the demand estimation and calibration stages.

Further adjustments may be needed with regard to familiar vs. unfamiliar drivers. However, these adjustments should be handled carefully given that: 1) unfamiliar drivers will use “major” roads in preference to “minor” roads, 2) only familiar drivers will response to the real-time traffic condition when the dynamic feedback assignment is used. This is particular important if the traveler information strategies are later incorporated as part of the study.

- Improve Calibration in Modeller

Finally, once all the components of the simulation inputs have been updated independently, it is usually required to make further adjustments after running the simulation in Modeller, and computing results using either Analyzer or Report Analyzer.

These adjustments may include fine-tuning general configuration parameters, network or routing parameters.

Capacity calibration is likely to be required: capacity calibration means that, for the major freeway, the traffic counts of the simulation model should match the traffic counts from field observation at the immediate downstream of the freeway bottleneck.

Next time slices (3 PM to 8 PM)

It would initially intended to calibrate the model for the entire afternoon peak period. The work reported so far only covered the first hour (2-3 PM). A similar approach would be necessary for each of the subsequent one-hour time slices. The demand estimation process would have to be repeated for each hour, using specific target counts relevant to that particular period. At this stage, each time period would be treated independently.

Once all demand tables have been generated and optimized, the model can be run in Modeller for the entire peak period, loading each matrix successively as the simulation progresses. Evidently, the interactions between time slices and the high level of congestion expected during the peak period, add a significant level of complexity to the exercise.

The simulation of the next time periods are likely to be more demanding because of the heavy congestion in later time periods and the ultimate need to end congestion at the appropriate time.

Investigate alternative scenarios

The ultimate goal of the project, as seen by practitioners concerned with operation analysis, is not just to replicate existing conditions. Instead, the model should be used to develop, investigate and evaluate alternative improvement strategies.

On the I-580 corridor modeled as part of this project, various alternative scenarios are under consideration by Caltrans and local agencies. They include implementing ramp metering syatems, adding HOV lanes, or combining these two strategies. Once calibrated, the model could be used as an evaluation tool to assess the potential benefits of the various scenarios.

The different tasks involved in such a study would be:

- Design of experiment (Ramp metering? HOV lane? Combination?)
- Assemble and adjust tools required (Paramics APIs?)
- Collect the data
- Optimize the parameter settings in the APIs
- Run scenarios
- Evaluate system performances.

These investigations may reveal the need for additional data and model enhancements to adequately replicate the proposed strategies.

11.2 Using experience for future studies

The lessons learned and the expertise gained while conducting this initial calibration effort on the I-580 corridor should be of great value for future projects involving the application of Paramics on large freeway corridors. Clearly, the task of calibrating the model should not be underestimated when contemplating future projects.

The key lessons drawn from the I-580 project and presented in Chapter 10 should serve as a reference to identify the scope of the project and the data requirements, and make the best possible use of tools such as OD Estimator, Modeller and Analyzer.

Without pretending to be a complete user guide, this report should contribute to provide useful background material to future users facing the task of calibrating a large corridor with Paramics.

It is clear that more knowledge and experience would be required to produce a more extensive methodological manual on calibration of large networks. Caltrans should consider encouraging the development of more research work devoted to gather expertise and produce guidelines on best practice. This is a critical requirement to ensure that the Paramics program can be successfully and efficiently applied.

Continuing the development of supporting tools, whether they eventually become a module of the Paramics suite (such as OD Estimator), remain a specific API, or a separate utility program (such as Report Analyzer), should also be encouraged. It is important, however, that the developers constantly refer to end-users' needs, and produce tools that are really useful and easy to use.

Obviously, if the program of Paramics usage within Caltrans is to be continued, more staff training will be needed. In particular, advanced users should be targeted to make sure they benefit from the latest knowledge and tools available. Training sessions for advanced users, specifically devoted towards the specific needs and techniques for large corridor applications, should be organized.

Finally, user exchange sessions can generate a lot of interesting interactions between the staff and others involved in similar types of application. The Caltrans state-wide Paramics users' group provide the ideal forum for this type of activities.

CHAPTER 12: CONCLUSIONS

As part of the California PATH program, the Paramics microscopic traffic simulation model was applied to the I-580 freeway-arterial corridor. The main purposes of the project were two-fold:

- Develop the expertise and transfer the knowledge required in calibrating a large-scale freeway corridor with Paramics;

- Prepare a calibrated model for the I-580 corridor that could be used to address operational questions, evaluate potential improvement alternatives and provide input to the decision-making process.

In agreement with Caltrans District 4 and Headquarters, the study focused on the eastbound direction of I-580 (a 25 mile section) during the afternoon peak period of a typical weekday. The freeway network to be simulated included, in addition to the eastbound direction of 580, the westbound direction as well as a segment of I-680 and the portion of SR 84 connecting 580 and 680. The grid network also included a large number of surface streets and a total of more than 100 signalized intersections.

The network coding effort relied on traditional coding techniques (mostly aerial photos) because the GIS conversion program intended to be tested as part of this project was not available at the time.

The traffic data available to carry out the demand estimation and calibration activities was of good quality as far as the I-580 eastbound direction was concerned. For the other freeways and the surface streets, however, the research team could not gather data of the same quality. This problem certainly affected the results of the demand estimation process, and therefore, the general outcome of the calibration effort.

The project provided a valuable and timely opportunity to apply the OD Estimator software, the latest module of the Paramics suite just released by Quadstone following some development work and testing supported by Caltrans. OD Estimator proved to be a very useful tool in the process of generating a reliable OD matrix for the Paramics model. Working with a pattern matrix extracted from the EMME2 planning model of Alameda County, the research team used the counts available to produce an optimized demand table for the first hour of the afternoon peak period. By going through this process, much knowledge was gained in identifying the required data input, preparing and adjusting the various input data files, improving the method and fine-tuning the parameters in order to optimize the quality of the demand file generated by OD Estimator.

Once the demand side of the simulation was available, further adjustments on the supply and control sides were needed to improve the results of the calibration. The final project deliverable is a detailed model of the area, with a demand file optimized for the 2-3 PM period. When compared to real-life traffic performances on the eastbound direction of I-

580, the model shows some fidelity in replicating counts, but tend to overestimate the amount of congestion occurring during the first hour of the simulation period.

This initial calibration effort on the I-580 corridor provided useful lessons for future similar studies, with regard to scoping the work, identifying and collecting the required data, and making the best use of OD Estimator to generate the demand data.

The report finishes with a list of potential future work, first directly dealing with the I-580 network, and then more generally looking at any new large corridor Paramics modeling effort to be undertaken.

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