University of California, Irvine
Institute of Transportation Engineers
Student Chapter

2000-2001 Annual Project:

SAND CANYON AVENUE

RETIMING STUDY

Project Participants:

Justin Leung
Yeuk-Cheung Ng
Brian Smolke
Larry Tay
Allison Tran
Quan Tran
Vincent Tran
Tai Vu
Alice Wong

TABLE OF CONTENTS

Introduction	**2**
Site Description	**3**
Figure 1: Sand Canyon and Adjacent Roadways	**4**
Existing Conditions	**5**
Project Procedure	**6**
Figure 2: Schematic of Lane Geometry and Traffic Counts	**7**
Results of Analysis	**8**
Analysis 1: City of Irvine	**8**
Analysis 2: Unrestricted	**9**
Figure 3: Proposed Intersection Splits for 100 sec Cycle Length	**10**
Table 1: Arterial Level of Service on Sand Canyon	**11**
Table 2: Existing Conditions	**12**
Table 3: 80 Second Cycle Length	**12**
Table 4: 100 Second Cycle Length	**12**
GPS Travel Times (Before Studies)	**13**
Table 5: GPS Data for North-Bound Runs	**14**
Table 6: GPS Data for South-Bound Runs	**14**
Meeting with City of Irvine	**15**
Table 7: 80 Second C.L.(After changed)	**15**
After Travel Study	**16**
Table 8 : After Travel Study Data for North-Bound Runs	**16**
Table 9 : After Travel Study Data for South-Bound Runs	**16**
Offset Table	**17**
Table 10 : Offset Table of Sand Canyon Avenue	**17**
Limitations of Results	**18**
Conclusion	**19**

INTRODUCTION

Each year at the University of California, Irvine, the student chapter of the Institute of Transportation Engineers (ITE) chapter performs a traffic engineering study as their annual project. In the January of 2001, the members decided that their interests would be best served by participating in a traffic signal re-coordination effort that involved the data collection, analysis and re-timing of a major arterial in the city of Irvine. After a brief correspondence with the City of Irvine traffic engineers, both parties agreed that a study of Sand Canyon Avenue between the I-5 and I-405 would be the most beneficial and feasible. The city of Irvine then assured us of their cooperation in this project.

The scope of this project involved collection of traffic volumes for the seven intersections within the study area, as well as obtaining geometric information and other significant parameters. Upon the completion of the data collection, the information was entered into Synchro v3.2 so that an analysis of the current settings could be performed, and an optimal signal timing suggested. The project proposal called for GPS runs to study travel times and stopped times along the arterial and within individual links for both the original signal settings as well as the suggested settings. Included in this report are comparisons of the Synchro results for both current and optimal signal timings. A travel-time and delay study for the original timings has been completed per GPS runs and is documented as well. The after-study for the GPS-runs is currently a work-in-progress. It is expected to be completed soon after the City of Irvine approves the final signal timings. A discussion of methods, procedures and other significant points are also contained within.

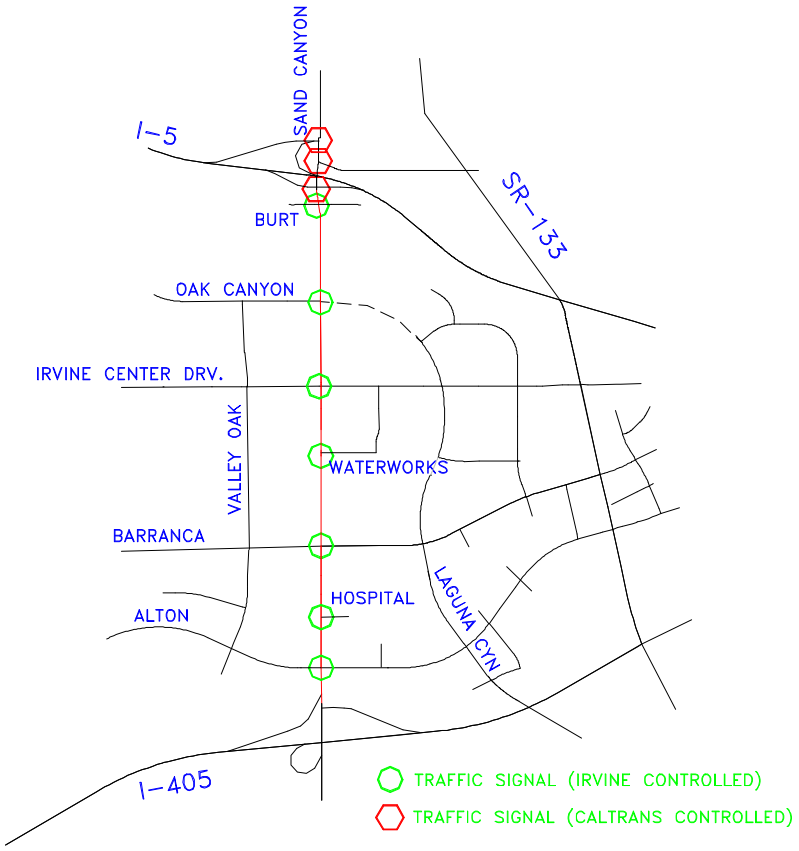
SITE DESCRIPTION

As previously mentioned, the study area is a stretch of Sand Canyon avenue in between the I-5 and I-405-freeways. In all, seven intersections were included in the study area. The southernmost intersection was Sand Canyon @ Alton, while the northern boundary was the intersection of Sand Canyon and Burt. Sand Canyon Ave is a north/south arterial, which lies west of SR 133 and east of Jeffrey Road. This road connects the El Toro Air Base to the newly proposed Planning-Area 17.

Major points of interest that generate travel demand along Sand canyon include the I-5, and Old Town Irvine in the north. In the south, Irvine Medical Center, several business parks, I-405, Oak Creek Community and Planning Area 17 are directly responsible for much of the traffic on Sand Canyon. In addition, there are several small shopping areas, a major post office, as well as the Irvine Ranch Water District that create demand on Sand Canyon Avenue. Figure (1) contains a map of the area in the vicinity of Sand Canyon Avenue.

Relatively speaking, Sand Canyon Avenue is not a heavily traveled arterial. Geographically, it is positioned between the highly developed and business oriented Irvine Spectrum and the more residential and commercial areas of Irvine, which lie to the west of Jeffrey Road. Currently, many areas that are accessible to Sand Canyon Road are under extensive development. Many shopping areas, office buildings and homes are being built in the surrounding area. This has lead to heavier use along the road, and increased travel times. There has been only moderate need for coordination along Sand Canyon. However, the City of Irvine, as well as the members of ITE felt that an adequate coordination plan that did not adversely impact levels of service on adjacent arterials would be of great use to the users of the road.

Figure 1: Sand Canyon and Adjacent Roadways



EXISTING CONDITIONS

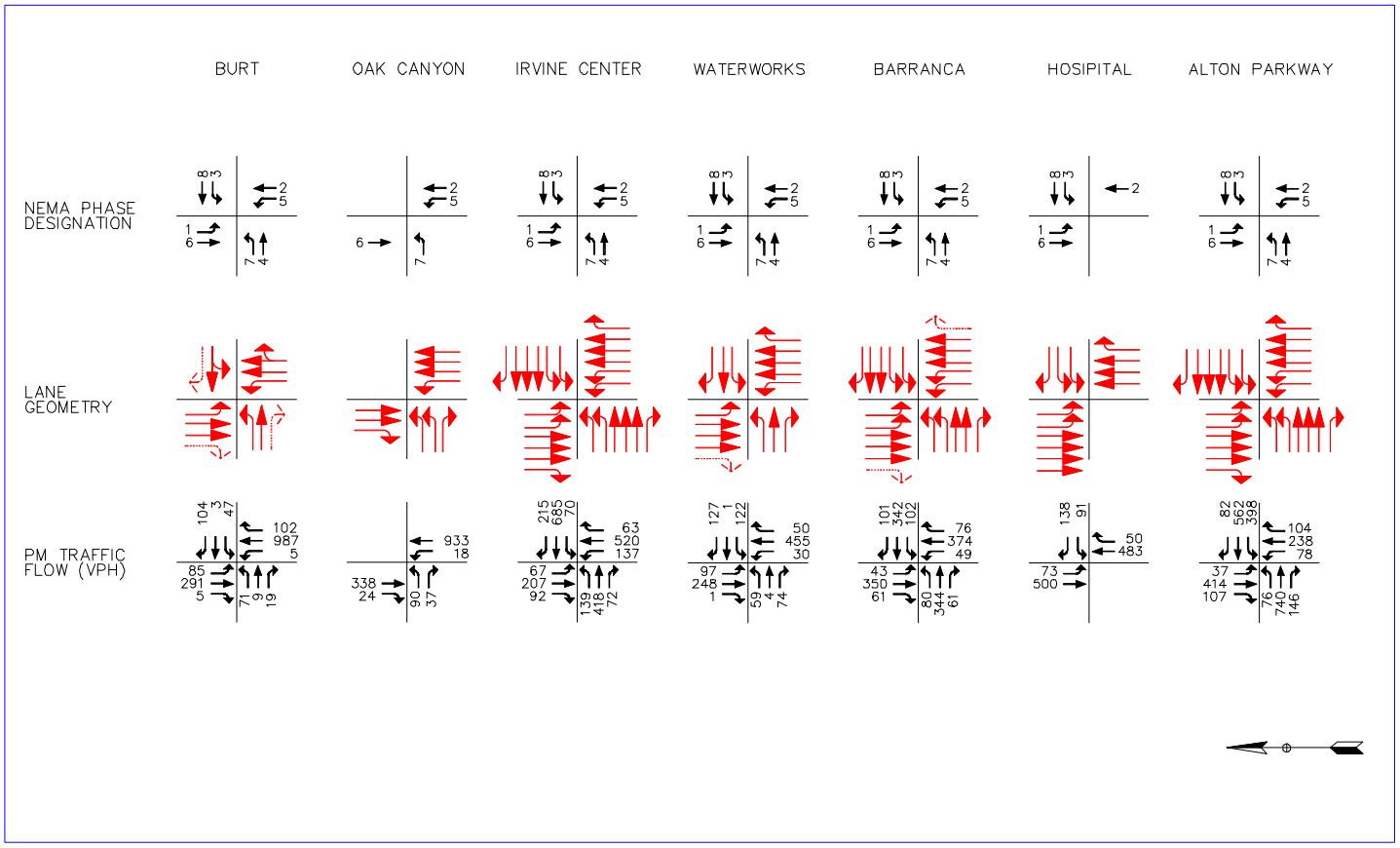
Currently, the portion of Sand Canyon Road that lies within the study area is under actuated-uncoordinated signal timing. There are however, two exceptions. Alton and Barranca Parkways are both heavily traveled arterials that run east and west. These two arterials have existing coordination plans that will serve as additional constraints for our re-timing. The portion of Sand Canyon Avenue within the study area has two to four lanes each direction and a speed limit of 50 to 55 miles per hour. Sand Canyon at Alton, Barranca, Irvine Center, and Waterworks are all eight-phase signals with protected left turns from all approaches. When most of the existing data was collected, both the intersections at Oak Canyon and Hospital were T-intersections with four signal phases. After analysis was done, new development changed Oak Canyon from a T-intersection to a four-way. Another traffic count was accomplished to account for this, but the travel time data was taken during the previous condition. Sand Canyon at Burt is unique since the left turns that originate from Burt are allowed only on a “permissive” basis.

PROJECT PROCEDURE

In late January and Early February, traffic volume counts were obtained from the field with the assistance of a few Jamar Counters. Counts were made for the PM peak from 4:50-5:50. Roadway geometrics were obtained through the use of As-Built plans and then verified in the field. Figure (2) shows a schematic of these properties. Upon the collection of all pertinent data, and the verification of its accuracy by Professor Will Recker, the data was entered into Synchro for analysis and optimization. Synchro would be used to measure existing levels of service, as well as predict existing travel times and stopped delay. An optimization study was then performed allowing lead-lag optimization but prohibiting half and double-cycle lengths. Using Synchro's reporting abilities, certain measures of effectiveness were then compared between the existing and optimal conditions. The GPS runs were made so that travel times and stopped delay were then measured and compared to the predicted values provided by Synchro.

After all optimizations were made, a feasible timing plan was recommended and submitted to the City of Irvine Traffic Research and Control Center. At that time, the lead traffic engineer requested that a cycle length of 80 seconds be given a higher priority despite our recommendation. This required using Synchro to optimize offsets and splits, and perform a cycle length evaluation to make sure that an 80 second cycle length would not result in unacceptable levels of service for any movement of the intersections within our network. After further analysis and fine-tuning, the traffic engineers office was ready to move forward with implementation.

Figure 2: Schematic of Lane Geometry and Traffic Counts



RESULTS OF ANALYSIS

The existing signal conditions along Sand Canyon Avenue operate on an actuated-uncoordinated timing with variable cycle lengths and a speed limit of 50 to 55 mph. The cross streets include Alton, Hospital, Barranca, Waterworks, Irvine Center Drive, Oak Canyon, and Burt. Two sets of analyses were done for the PM peak traffic hours. One analysis was based on the restrictions given by the City of Irvine and the other assumed no restrictions. As shorter cycle lengths are normally preferred by motorists, the City of Irvine believes that an 80 second cycle length will accommodate citizens' satisfaction. The 80 second cycle length also could be integrated with the existing coordination plans on Barranca and Alton. On the contrary, the other study was performed by ITE by optimizing the signal timings and the background cycle length to obtain the optimal arterial Level of Service (LOS). Existing conditions with no coordination were input into Synchro for the project. Some of the details for this condition are displayed in Table 2, including travel times and the LOS.

Analysis 1: The City of Irvine

According to the restrictions by the City of Irvine, the cycle length for Sand Canyon Avenue was reduced to 80 seconds and the speed to 45 mph. Alton Parkway and Barranca Parkway are main collector streets that are already coordinated and thus have fixed offsets, whereas the other cross streets are free. After implementing the data in Synchro, the arterial LOS on Sand Canyon Avenue improved dramatically. A northbound green band of 6 seconds was created, though there was no band for the southbound direction. For the 80 seconds cycle length the average number of stops along Sand Canyon Avenue is 2102 veh/hr in the

northbound direction and 1178 veh/hr in the southbound direction. Table 3 shows details about this cycle length. Refer to Table 1 for a LOS comparison.

Analysis 2: Unrestricted

When Synchro optimized the original signal timing without constraints, the best cycle length was 100 seconds. No offsets were fixed on any main collector streets. Again the arterial LOS increased, but not quite to the level of an 80 second cycle length. A northbound green band of 20 seconds was created, though there still was no southbound band. Although the cycle length increased, the number of stops in vehicles per hour decreased compared to the 80 seconds cycle length. The average number of stops is 1867 veh/hr for northbound Sand Canyon and 1245 veh/hr for southbound Sand Canyon. While this is an increase in performance over the 80 second cycle length, the City of Irvine decided that obstructing the coordination of the more critical cross streets would not be worth the benefits. Table 4 shows details of this cycle length. Figure 1 shows the intersection splits of each intersection for the 100 second cycle length. Refer to Table 1 for a LOS comparison between all three conditions, the uncoordinated conditions and both cycle lengths.

Figure 3

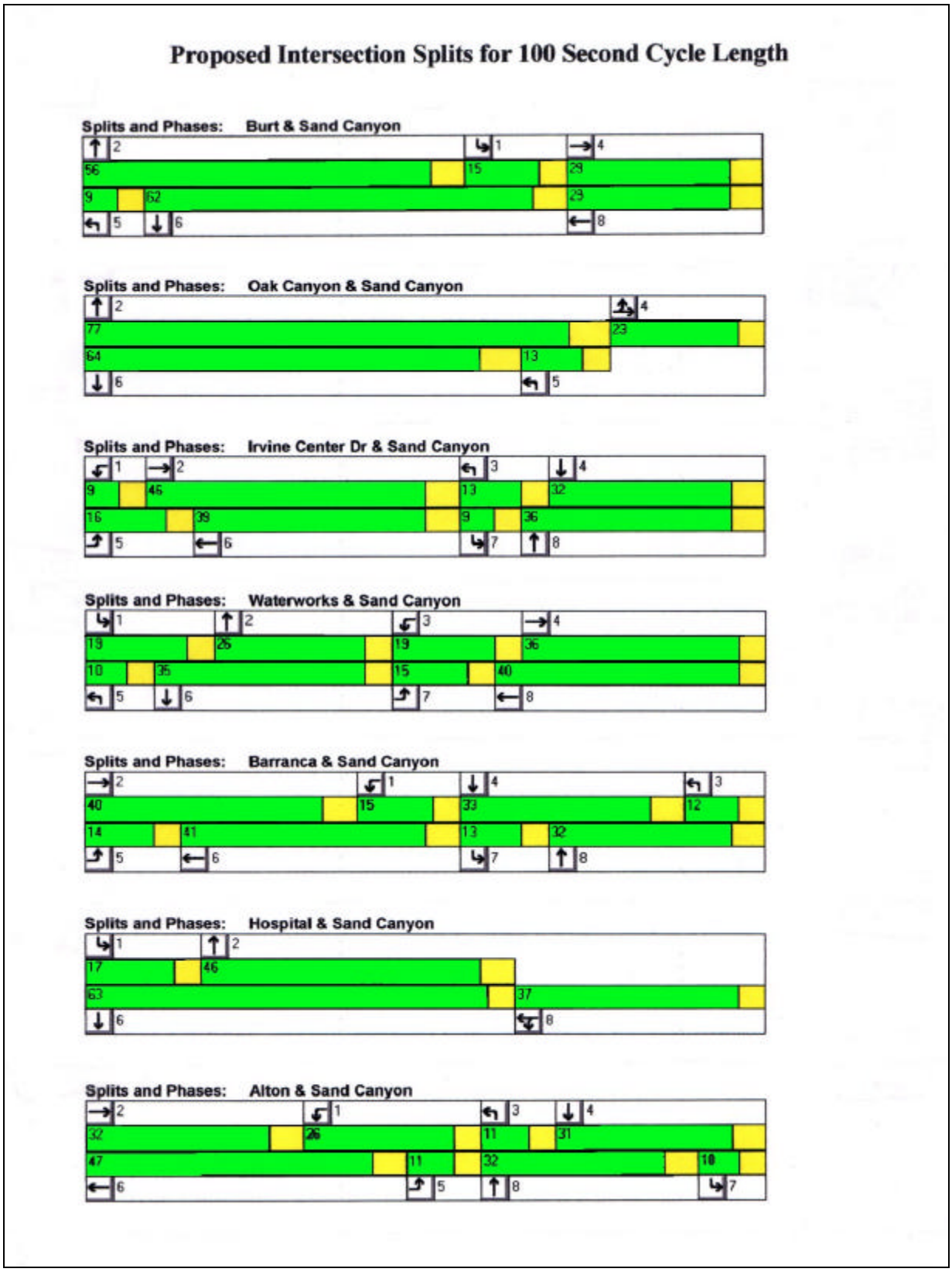

Proposed Intersection Splits for 100 Second Cycle Length
Splits and Phases: Burt & Sand Canyon
Splits and Phases: Oak Canyon & Sand Canyon
Splits and Phases: Irvine Center Dr & Sand Canyon
Splits and Phases: Waterworks & Sand Canyon
Splits and Phases: Barranca & Sand Canyon
Splits and Phases: Hospital & Sand Canyon
Splits and Phases: Alton & Sand Canyon

TABLE 1: Arterial Level of Service on Sand Canyon Avenue

NORTHBOUND	80 sec*	Uncoordinated**	100 sec***
Alton	E	F	F
Hospital	A	B	A
Barranca	C	E	D
Waterworks	A	C	A
Irvine Center Drive	B	F	D
Oak Canyon	A	A	A
Burt	B	B	A
Total	B	D	B

SOUTHBOUND	80 sec*	Uncoordinated**	100 sec***
Burt	C	B	C
Oak Canyon	B	A	A
Irvine Center Drive	D	F	F
Waterworks	A	B	A
Barranca	C	E	C
Hospital	A	A	A
Alton	C	F	E
Total	B	D	C

* = City of Irvine cycle length
** = Original conditions
*** = ITE cycle length

Table 2: Existing Conditions							
Arterial Levels of Service for NB Sand Canyon				**Arterial Levels of Service for SB Sand Canyon**			
Cross Street	Signal Delay	Travel Time	Arterial LOS	Cross Street	Signal Delay	Travel Time	Arterial LOS
Alton	15	57	F	Burt	5	10	B
Hospital	8	18	B	Oak Canyon	5	25	A
Barranca	38	52	E	Irvine Center Dr	55	67	F
Waterworks	17	33	C	Waterworks	11	25	B
Irvine Center Dr	56	70	F	Barranca	38	54	E
Oak Canyon	3	15	A	Hospital	3	17	A
Burt	14	34	B	Alton	51	61	F
Total	181	279	D	Total	168	259	D

Table 3: 80 Second C.L.							
Arterial Levels of Service for NB Sand Canyon				**Arterial Levels of Service for SB Sand Canyon**			
Cross Street	Signal Delay	Travel Time	Arterial LOS	Cross Street	Signal Delay	Travel Time	Arterial LOS
Alton	24	33	E	Burt	5	11	C
Hospital	6	16	A	Oak Canyon	6	35	B
Barranca	16	30	C	Irvine Center Dr	20	32	D
Waterworks	8	24	A	Waterworks	2	16	A
Irvine Center Dr	12	26	B	Barranca	22	38	C
Oak Canyon	5	17	A	Hospital	1	15	A
Burt	7	37	B	Alton	16	26	C
Total	78	183	B	Total	72	173	B

Table 4: 100 Second C.L.							
Arterial Levels of Service for NB Sand Canyon				**Arterial Levels of Service for SB Sand Canyon**			
Cross Street	Signal Delay	Travel Time	Arterial LOS	Cross Street	Signal Delay	Travel Time	Arterial LOS
Alton	37	43	F	Burt	5	11	C
Hospital	2	12	A	Oak Canyon	4	26	A
Barranca	25	39	D	Irvine Center Dr	49	61	F
Waterworks	5	21	A	Waterworks	8	22	A
Irvine Center Dr	26	40	D	Barranca	18	34	C
Oak Canyon	1	13	A	Hospital	0	14	A
Burt	5	27	A	Alton	31	41	E
Total	101	195	B	Total	115	209	C

GPS TRAVEL TIME STUDIES

The University of California, Irvine has been testing the use of Global Positioning System devices for several months. The research department permitted the ITE student chapter to use one of these devices for floating car travel time studies on Sand Canyon Avenue for the project. A floating car study involves driving a vehicle back and forth across the length of the roadway being studied, while the GPS unit in the car recorded positional data at 2 second intervals. This data was compared to the known coordinates of intersections to determine the times the vehicle passed each of them. Using this data, several sets of the total travel time of the roadway were found in both directions. These travel times were then averaged. The data obtained during the uncoordinated conditions is displayed in Tables 5 and 6. This data was collected over two separate days. When comparing these travel times with the values obtained from the non-optimized Synchro file, the numbers were quite close. This implies a fair accuracy of the program.

GPS runs for an after study were planned for this project to determine the actual benefits of coordination on the arterial. However, implementation by the City of the final timing plans along the Sand Canyon corridor was not scheduled to occur after the completion of this project.

Table 5: GPS Data for North Bound Runs:

Date	Direction	Start time	Stop time	Travel time
2/22/01	NB	5:00:24	5:02:58	0:02:34
2/22/01	NB	5:07:06	5:14:18	0:07:12
2/22/01	NB	5:20:22	5:22:44	0:02:22
2/22/01	NB	5:28:04	5:32:30	0:04:26
2/22/01	NB	5:37:38	5:40:46	0:03:08
2/22/01	NB	5:45:40	5:48:08	0:02:28
2/22/01	NB	5:53:42	5:56:54	0:03:12
			avg:	0:03:37
2/27/01	NB	4:50:50	4:54:28	0:03:38
2/27/01	NB	5:03:16	5:08:22	0:05:06
2/27/01	NB	5:16:06	5:18:36	0:02:30
			avg:	0:03:45
			Total avg:	0:03:41

Table 6: GPS Data for South Bound Runs:

Date	Direction	Start time	Stop time	Travel time
2/22/01	SB	5:03:44	5:07:04	0:03:20
2/22/01	SB	5:15:04	5:19:22	0:04:18
2/22/01	SB	5:23:00	5:26:56	0:03:56
2/22/01	SB	5:33:26	5:36:34	0:03:08
2/22/01	SB	5:41:00	5:45:34	0:04:34
2/22/01	SB	5:48:34	5:52:36	0:04:02
			avg:	0:03:53
2/27/01	SB	4:57:00	5:01:40	0:04:40
2/27/01	SB	5:10:16	5:13:42	0:03:26
2/27/01	SB	5:20:50	5:25:28	0:04:38
			avg:	0:04:15
			Total avg:	0:04:04

Actual average NB travel time: 3:41 = 217 sec
Synchro calculated NB travel time: 217 sec

Actual average SB travel time: 4:04 = 244 sec
Synchro calculated SB travel time: 233 sec

MEETING WITH CITY OF IRVINE

In a final meeting with the City of Irvine, two City timing plan policies were invoked:

1. Minimum pedestrian times were invoked for several streets.

2. Yellow and all-red times has been changed, as follows:

    a) all-red times set to 2 seconds

    b) yellow times set for:

        1) Major Street through, 5 seconds.

        2) Major Street Left Turn, 4 seconds.

        3) Minor Street through, 4 seconds.

        4) Minor Street Left Turn, 3 seconds.

Also, several streets data conflict has been fixed. The new results are tabulated below.

Table 7: 80 Second C.L.(After changed)

Arterial Levels of Service for NB Sand Canyon				Arterial Levels of Service for SB Sand Canyon			
Cross Street	Signal Delay	Travel Time	Arterial LOS	Cross Street	Signal Delay	Travel Time	Arterial LOS
Alton	24	35	D	Burt	6	13	C
Hospital	5	18	A	Oak Canyon	15	40	B
Barranca	12	30	B	Irvine Center Dr	30	44	D
Waterworks	8	27	A	Waterworks	4	21	A
Irvine Center Dr	15	32	B	Barranca	10	29	A
Oak Canyon	6	20	A	Hospital	3	21	A
Burt	8	33	A	Alton	18	31	C
Total	78	195	B	Total	86	199	B

As the results show, Arterial LOS has been improved.

AFTER TRAVEL STUDY

As the time limit and some unexpected happens, the signal time of City of Irvine cannot be changed. So, GPS travel study cannot be done after the Synchro data has been changed. Data below is the similar after field study, which is using the Synchro's data as the given value. Please note that all data below is not the real world travel data.

Table 8: After Travel Study Data for North Bound Runs:

Date	Direction	Start time	Stop time	Travel time
6/05/01	NB	5:00:00	5:03:15	0:03:15
6/05/01	NB	5:08:00	5:11:15	0:03:15
6/05/01	NB	5:16:00	5:19:15	0:03:15
6/05/01	NB	5:24:00	5:27:15	0:03:15
6/05/01	NB	5:32:00	5:35:15	0:03:15
6/05/01	NB	5:40:00	5:43:15	0:03:15
6/05/01	NB	5:48:00	5:51:15	0:03:15
6/05/01	NB	5:56:00	5:59:15	0:03:15
			Avg:	0:03:15

Table 9: After Travel Study Data for South Bound Runs:

Date	Direction	Start time	Stop time	Travel time
6/05/01	SB	5:04:00	5:07:19	0:03:19
6/05/01	SB	5:12:00	5:15:19	0:03:19
6/05/01	SB	5:20:00	5:23:19	0:03:19
6/05/01	SB	5:28:00	5:31:19	0:03:19
6/05/01	SB	5:36:00	5:39:15	0:03:19
6/05/01	SB	5:44:00	5:47:19	0:03:19
6/05/01	SB	5:52:00	5:55:19	0:03:19
			Avg:	0:03:19

After study average NB travel time: 3:15 = 195 sec
Synchro calculated NB travel time: 195 sec

After study average SB travel time: 3:19 = 199 sec
Synchro calculated SB travel time: 199 sec

OFFSET TABLE

The Offset table compares the offset time computed by Synchro with standard offsets used by the City. This format was provided by City of Irvine.

Table 10: Offset Table of Sand Canyon Avenue

Coordinated Arterial: **SAND CANYON AVENUE WEST** Revised Date: 5/29/2001
Arterial Directions: N / S _X_ E/W __ Date: 05/28/2001
Model Name: SYNCHRO_X_ Phase Sequence:
Group #: 80 Peak Period: AM__ MD__ PM_X_ OFPK__
Cycle Length : **80 Sec**
Double Cycle :

Date of Modifications: **45mph**

							Synchro Data					**Data after correct**				
Node	ICU	Art	Crossing	Travel Time			2 way Prog off-s 80					2 way Prog off-s 80				
#	#	Th-Ph	Street	ft	Sec	%	Offset	S_v	Seq	N ^	Offset	Offset	S_v	Seq	N ^	Offset
4	81	2N,6	Burt				42	|(-13	15	11-I	55	42	|(-13	15	11-I	55
			^	1631	25	31	-23				36	32				31
5	82	2N,6	Oak Cyn				19	(-14	1	14-)	19	**74**	**(-14**	**1**	**14-)**	**24**
			^	1407	21	27	32				-32	23				27
6	232	4S,8	ICD				51	I-19	12	15-I	51	97	I-19	12	15-I	97
			^	1117	17	31	49				-25	23				21
7	83	2N,6	Water works				0	I-24	2	13-)|	76	**20**	**I-24**	**2**	**13-)|**	**76**
			^	1567	24	30	-14				-10	26				30
8	74	4S,8	Barranca				86	11-I	16	13-I	86	46	11-I	16	13-I	46
			^	1170	18	22	16				-34	27				22
9	84	2N,6	Hospital				2	I(-18	5	31-I	20	**73**	**I(-18**	**5**	**31-I**	**24**
			^	846	13	16	36				-28	18				23
10	113	4N,8	Alton				38	I(-10	8	10-I	48	91	I(-10	8	10-I	1

In the travel time column, feet gives the distance between adjacent street intersections, sec gives the associated travel time calculate by the formula,

Distance (ft) / Speed (45mph) = Time (sec)

The "%" column refers to delay time between the two streets (given by City of Irvine).

The first data set is the data from Synchro program. The "Sv" and "N^" is the maximum split time given by Synchro. Offset columns next to them are the offset of the North

or South Bound of the Street. The numbers between the offsets is the delay time from one street travel to other street. So the number should be near or equal to the number given by the "%" column. The data above clearly show that the delay times given by Synchro program are significantly different than the policy values given by the City of Irvine. As a result, the offset times generated by Synchro must be changed to fit the City of Irvine requirement. The right hand side column represents these values after this correction.

LIMITATIONS

It is important to note that a primary purpose of this study is to improve progression along Sand Canyon, and along with it, the arterial level of service. Therefore our GPS runs and travel time comparisons focused only on the through movements along Sand Canyon. Any potentially adverse effect the re-timing may impose on the surrounding network of streets have not been addressed in as much detail. Ideally, coordination would improve performance for the overwhelming majority of the network. However, slight compromises of certain performance characteristics of a few turning movements were considered acceptable.

CONCLUSION

According to the preliminary Synchro analysis, the arterial level of service along Sand Canyon Avenue could be improved considerably. Travel times were collected along the arterial on two separate days with the use of a GPS receiver. The theoretical travel times as calculated by Synchro were quite close to the actual ones. As correspondence with the City of Irvine continued, the goals of both the student chapter and the city employees started diverging. Unfortunately, due to the many changes that the city continued to impose on the club's project along with time constraints, it was ultimately abandoned before the re-timing could be implemented. The UCI student chapter of ITE still would like to thank the City of Irvine for its assistance, as well as the help from the student chapter faculty advisor Dr. Michael McNally.

NOTE

This report is archived at the UCI ITE web site at http://www.its.uci.edu/~ite/