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TECHNICAL MEMORANDUM

Date: July 12, 2002 **Project** #: 5025-3

To: Earl Salley
Lee County Department of Transportation

From: Jack Freeman, P.E., PTOE
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Project: Daniels Parkway Signal Retiming

Subject: Signal Timing Report

This technical memorandum summarizes the signal timing efforts conducted for Daniels Parkway (Zone 39) in Lee County, Florida. It includes the following elements:

- Scope of Project
- Methodology
- Analysis Notes
- Traffic Volumes
- Existing Timing Plans Analysis
- Implementation Notes
- Time of Day Schedule
- Traffic Responsive Plan Analysis
- Final Timing Plans

SCOPE OF PROJECT

The scope of this project was to develop coordinated signal timing plans for five intersections along Zone 39, Daniels Parkway, given with their intersection numbers:

- 3901: Fiddlesticks
- 3902: Danport

- 3903: I-75 SB Ramp
- 3904: I-75 NB Ramp
- 3905: Treeline

Parameters reviewed and modified as necessary include minimum green times, maximum green times, cycle lengths, splits, offsets, time-of-day functions, and traffic responsive plan functions. This study does not make any endorsement regarding vehicle or pedestrian clearance intervals at any of the study intersections.

METHODOLOGY

The following bullets highlight the key steps in the methodology incorporated for this project.

- Analyze existing timing in Synchro.
- Use Synchro to complete cycle search and determine whether changes to the cycle length are necessary.
- Identify field conditions that require adjustments (vehicle splits, detection settings).
- Modify existing timing plans (vehicle splits) based on volumes.
- Revisit offsets and coordination patterns based on a certain set of volumes for a plan.
    - Analyze each plan with different volumes.
    - Identify volume trends between scenarios (is one direction higher than another are turning volumes increasing, etc.)
- Add new cycle lengths (105, 135, 150) and remove 70.
- Make changes to Aries Database and submit to Lee County.
- Modify per Lee County comments and submit as final.
- Implement in field and fine-tune.

ANALYSIS NOTES

Daniels Parkway currently has six different cycles in the Econolite database (70, 85, 95, 115, 125, & 145). The 145-second cycle has zero offsets for all but the Fiddlesticks Parkway intersection. For that reason, it is difficult to determine whether that plan is in use at this time.

The 125-second cycle seems long at first glance, but after additional analysis is necessary because of the high speeds and distance between the intersections. The downside of that cycle length is that it results in significant queuing. One of the primary reasons that the 125-second cycle is necessary is for accommodation of pedestrian splits within the desired vehicle splits. At the 115-second cycle, the pedestrian timing required cannot be accommodated in many instances.

Analysis of the natural cycle length for each intersection during the p.m. peak hour shows that the intersection with the highest natural cycle length is the Fiddlesticks intersection. At 105 seconds, the intersection serves an increasing number of land uses in this vicinity.

The Danport intersection's natural cycle length (as calculated by Synchro) is 95 seconds. At a cycle length of 125 seconds during the p.m. peak hour the estimated v/c ratio is 0.63. Further, the limited throat distance on the south leg suggests that a lower cycle length would be beneficial from a queuing standpoint at that intersection. However, Danport plays a minor role in the progression of the system, and thus the longer cycle lengths required by the system override the optimal cycle length for this intersection.

The interchange intersections are simple because of the limited turning movements offered at the signal due to the ramps that provide yield movements to traffic entering or exiting the freeway. The northbound ramp is a simple 2-phase intersection, the southbound ramp a 3-phase intersection. These intersections reach their effective capacity during the midday and p.m. peak hour. The ramp approaches to the interchange are to be widened in the next year.

A considerable amount of analysis has been completed on the Treeline Avenue intersection. Under the current configuration, it remains a minor collector of traffic for the Business park in the southwest corner of the I-75/Daniels Parkway interchange. The optimal cycle length for that intersection is 95 seconds (as determined by Synchro and based on our p.m. peak traffic volumes).

TRAFFIC VOLUMES

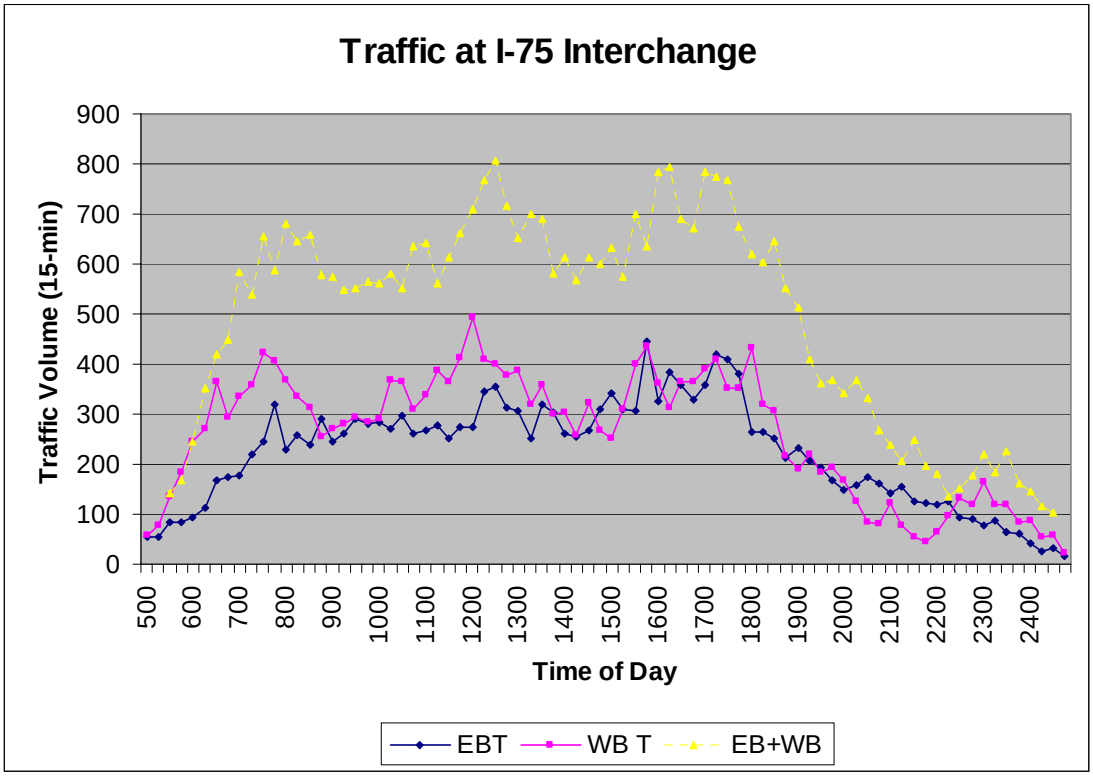
Traffic volumes for use in this retiming project have been obtained from the following sources:

- I-75 interchange study (completed by CH2M Hill)
- Shoppes at Fiddlesticks (Publix) TIA (completed by Vanasse & Daylor)
- Airport Master Plan Report (completed by Metro)
- Volumes received from Lee County (from February 13, 2002).

The traffic volumes along the arterial are fairly balanced during the p.m. peak conditions. Further analysis of the permanent count stations was completed to verify the directional nature of traffic throughout the day.

Figure 1 shows the 15-minute traffic volumes collected at the external links of the Daniels Parkway/I-75 interchange on February 13, 2002.

Figure 1 Traffic Volumes at I-75 Interchange

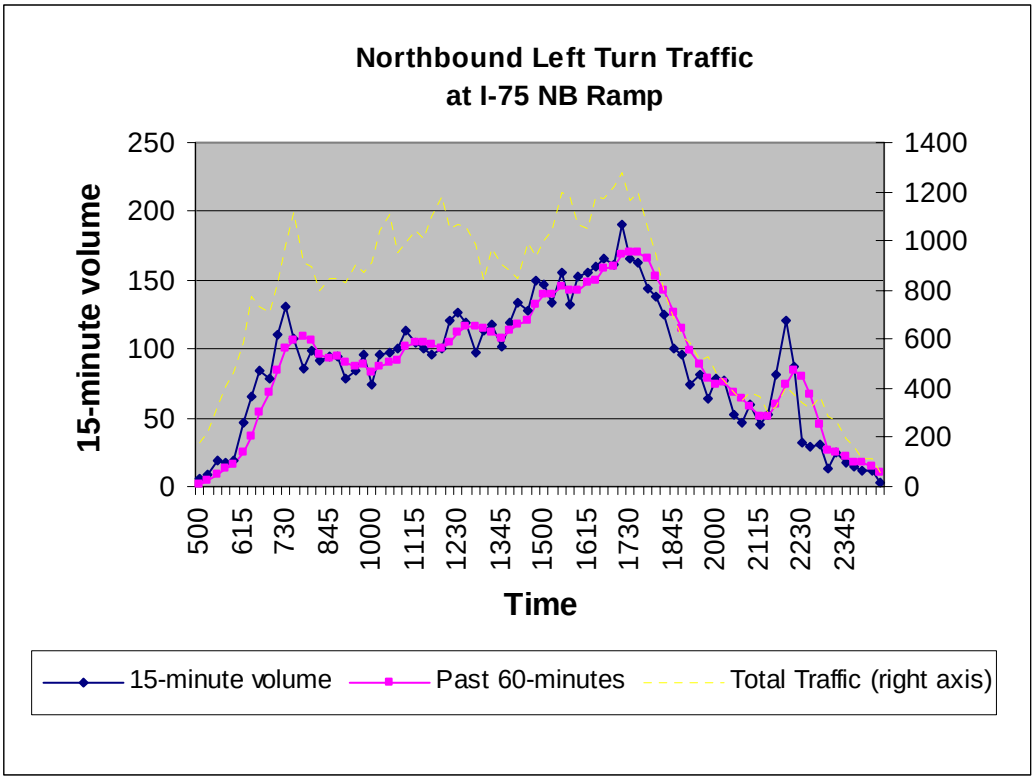


The westbound direction has recorded slightly higher volumes during the a.m. and midday peak periods and mostly during the periods of highest traffic midday and a.m. periods. The p.m. peak period is fairly balanced as shown.

Northbound Left Turn Traffic at I-75 NB Ramp

Figure 2 shows the 15-minute traffic volumes collected at the Daniels Parkway/I-75 interchange on February 13, 2002.

Figure 2 Northbound Left Turn Traffic at I-75 NB Ramp

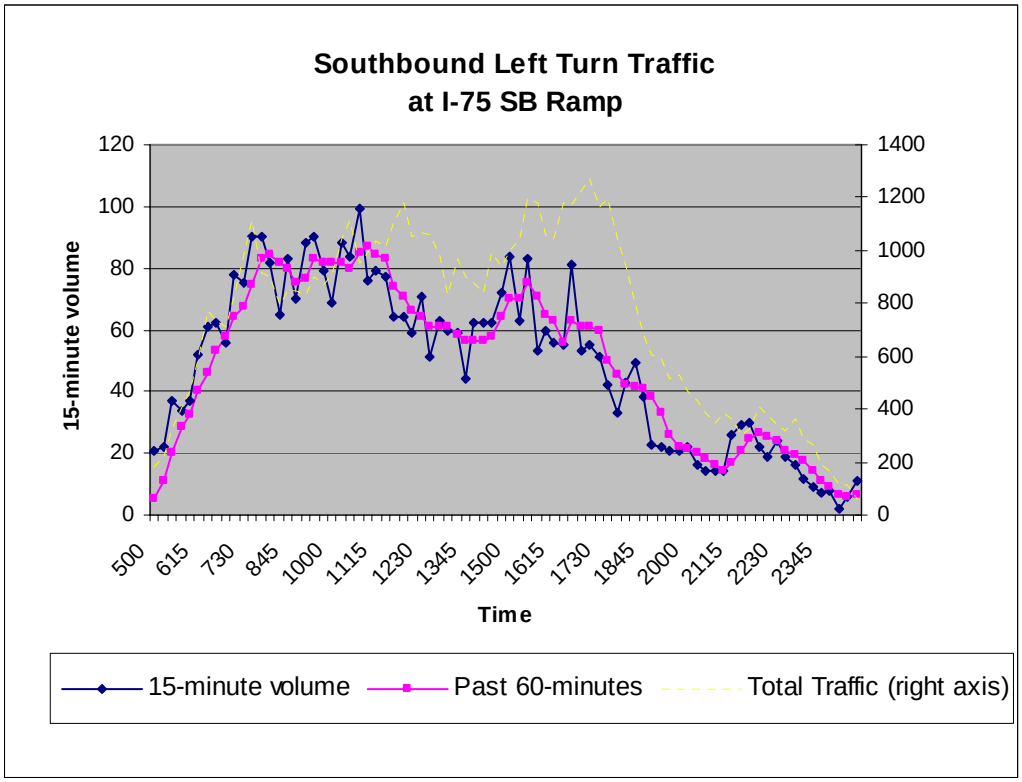


The traffic volume turning movement intensity at the interchange is noteworthy. The turning movement off the northbound ramp (left turn onto Daniels Parkway) reaches 191 vehicles during its peak 15-minute period (5:00p.m.-5:15 p.m.), thus intermittent queuing will occur because of the high peaking characteristics of the demand. The queuing is further complicated by the narrow off-ramp that traps right turning traffic in the queue (the eastbound traffic is provided a free flow right turn movement at the northbound ramp). The longer cycle length has an effect on this queue and can further the problem.

Southbound Left Turn Traffic at I-75 SB Ramp

Figure 3 shows the 15-minute traffic volumes collected at the Daniels Parkway/I-75 interchange on February 13, 2002.

Figure 3 Southbound Left Turn Traffic at I-75 SB Ramp

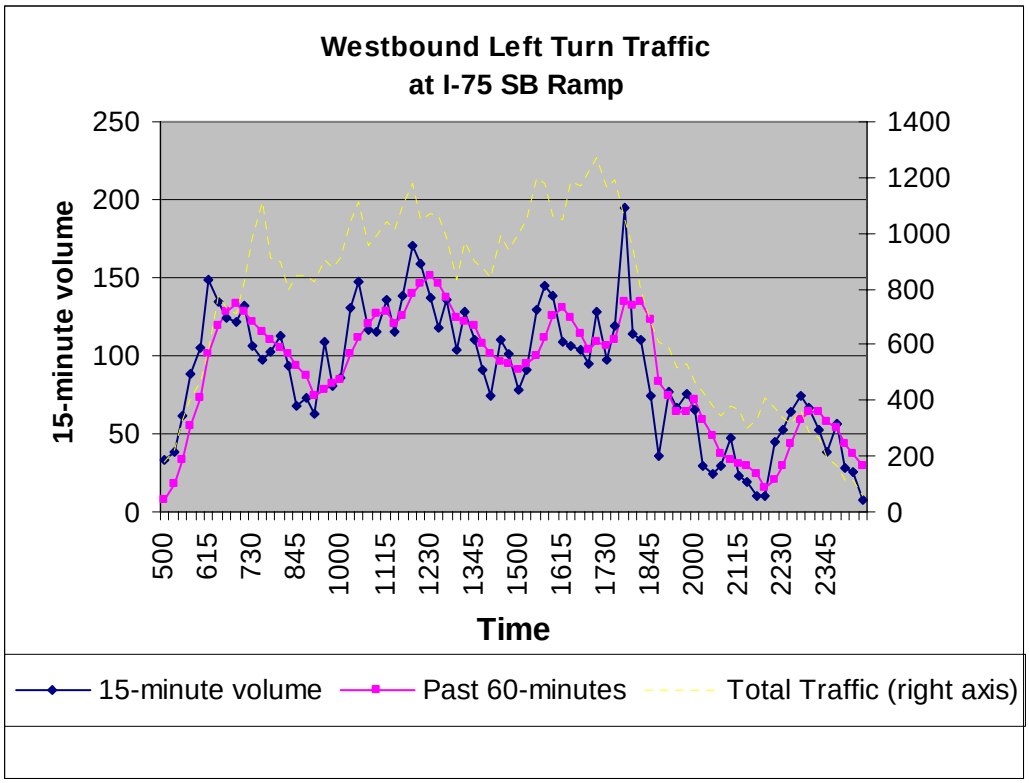


The turning movement from the southbound ramp (left turn onto Daniels Parkway) reaches its peak during off-peak periods, which provides different challenges than the northbound ramp.

Westbound Left Turn Traffic at I-75 SB Ramp

Figure 4 shows the 15-minute traffic volumes collected at the Daniels Parkway/I-75 interchange on February 13, 2002.

Figure 4 Southbound Left Turn Traffic at I-75 SB Ramp



The westbound left turn traffic volume at the southbound ramp is heavy throughout the day. Queuing occurs during the a.m., midday, and p.m. peak periods. The peak traffic periods shadow the peaks of the Westbound left turn traffic fairly closely, thus the splits recommended in the timing plans should accommodate the peak volumes fairly closely.

EXISTING TIMING PLAN ANALYSIS

The original scope of work suggests that timing plan development will include implementation for three signal timing plans (a.m., midday, and p.m. plans).

145-second cycle length

The 145-second cycle length did not have splits or offsets for four of the five intersections (Fiddlesticks has split and offset data in the database). It was determined that a timing plan should be developed for the 145-second cycle length. This cycle length was then replaced with 150 seconds per direction from Lee County to accommodate coordination with Zone 38 to the west during the weekday midday.

125-second cycle length

The bandwidth is adequate at the 50th percentile level. The Max Band is lower and should be further evaluated in the field to determine whether the side streets reach their split maximums and the Max Band is likely to occur during the p.m. peak hour. During our first visit to the arterial in January, our field notes describe operations that indicate that the non-arterial approaches do not reach their maximum frequently enough to warrant concern. Again, this should be field verified to determine whether existing bandwidth is adequate and whether the signal settings (gap timers, presence of pedestrian timing, etc) will allow us to presume frequent gap out and thus conditions more likely to be 50th percentile conditions.

Evaluating the arterial in Synchro and allowing the program to optimize the signal timing suggests that a 125-second cycle length may be high. (Synchro recommends a cycle length of 94 seconds when optimizing between 90 and 110 using the p.m. peak hour volumes and a one-second increment). In using Synchro however, we must keep in mind that the program is optimizing for delay and this may not necessarily represent the interests of the engineer. Similarily, the analysis of the a.m. peak hour traffic suggests a 100-second cycle length would provide optimal operations.

Due to high projected demands at Fiddlesticks, a 135-second cycle length has been used for the weekday p.m. peak hour. The 125-second cycle length has been reserved for use during Saturday and Sunday where traffic volumes were not available for analysis.

115-second cycle length

At the 115-second cycle length, it becomes more difficult to accommodate both pedestrian timing and vehicle timing into the cycle because of the large FDW time that is necessary to cross Daniels Parkway. This occurs at Fiddlesticks, Danport, and Treeline Avenue. The WALK time (10 seconds) could be reduced to mitigate this situation.

Analysis of the 115-second cycle length under midday traffic conditions indicated that the *westbound left turn is over capacity (v/c ratio or 1.04).* The northbound ramp (NB LT) is at 0.86 during the midday. The northbound ramp is at 0.99 under the p.m. peak traffic conditions. The 115-second cycle length, however, proved adequate for weekday a.m. peak period operations.

95-second cycle length

The 95-second cycle length is well timed. The differences between the 50th percentile time and the max times is smaller because the intersections are running closer to capacity. No changes are recommended for the 95-second plan. The 95-second cycle length has been reserved for off-peak operations.

85-second cycle length

The 85-second cycle length has not been reviewed because it is an off-peak plan. There is some question as to whether this plan is necessary in deference to a plan between 125 and 145 seconds.

70-second cycle length

The 70-second cycle length has not been reviewed because it is an off-peak plan. There is some question as to whether this plan is necessary in deference to a plan between 125 and 145 seconds. This cycle length has been deleted to accommodate the 135 second cycle length.

IMPLEMENTATION NOTES

Implementation of the above plans was conducted Wednesday, April 24; Friday, April 26; and Saturday, April 27, 2002.

The following changes were made in the field:

- 3901 (Fiddlesticks)
    - Plan 311: Adjusted OS +7%.
    - Added 433 plan for a.m. peak to match intent of plan 311, adjusted offset –6% to compensate for change in phase 1, phase 2 split.
    - Plan 511: Adjusted OS +7% and splits.
    - Plan 611: Adjusted OS +5%.
- 3902 (Danport)
    - Added 433 plan for a.m. peak to match intent of plan 311.
- 3903 (I-75 SB Ramp)
    - Added 433 plan for a.m. peak to match intent of plan 311.
    - Plan 511: Adjusted OS –10%.
- 3904 (I-75 NB Ramp)
    - Adjusted Phase 4 Vehicle Extension from 4.0 to 6.0 per Lee County direction
    - Plan 211: Adjusted OS –10%.
    - Added 433 plan for a.m. peak to match intent of plan 311.
    - Plan 611: Adjusted OS –10%.
- 3905 (Treeline)
    - Plan 411: Adjusted OS +10%.
    - Added 433 plan for a.m. peak to match intent of plan 311.
    - Plan 511: Adjusted OS +9%.
    - Plan 611: Adjusted OS +10%.

TIME OF DAY SCHEDULE

Table 1 presents the final time-of-day schedule selected and refined during implementation.

TABLE 1 TIME OF DAY (TOD) SCHEDULE

Day of Week	Time Starting	Plan	Enable TRP?
Weekday	0:00	Free	
(Program 1)	5:00	Free	
	6:00	311	
	7:15	433	
	8:30	322	
	10:00	422	
	11:00	611	
	13:30	422	
	15:00	511	
	16:00	511	
	18:30	211	X
	21:00	211	X
	0:00	Free	
Saturday	0:00	Free	
(Program 2)	5:30	Free	
	6:30	211	X
	9:00	411	
	10:30	411	
	13:00	411	
	18:30	211	X
	21:00	211	X
	23:00	Free	
Sunday	0:00	Free	
(Program 3)	5:30	Free	
	6:30	211	X
	9:00	411	
	10:30	411	
	13:00	411	
	18:30	211	X
	21:00	211	X
	23:00	Free	

TRAFFIC RESPONSIVE PLAN (TRP) ANALYSIS

Per observations in the field during implementation of time-of-day plans and discussion with Lee County, it was agreed that the time-of-day plans are performing well during the majority of the day due to the more regular pattern of traffic in the study area. However, Lee County expressed a desire to enable traffic responsive operation during off-peak periods outside the central part of the day, in particular to accommodate fluctuations in traffic to and from the airport. Therefore, this analysis focuses development of TRP operation during time periods in the above TOD schedule where Plan 211 is in effect. This occurs during weekday evenings and before and after the weekend peak periods.

Existing traffic responsive operations were analyzed for data collected on Friday, April 26, and Saturday, April 27, respectively. The detector data collected by the system is aggregated into five-minute bins; however, the traffic responsive system is currently set to sample every three minutes. As a result, the replication of the existing traffic responsive system operation is approximate. Figure 5 and Figure 6 present an analysis of existing TRP operation on the aforementioned Friday and Saturday, respectively. *Appendix A provides the controller log of existing traffic responsive plan selection.*

Figure 5 Analysis of Existing TRP Operation, Friday, April 26, 2002

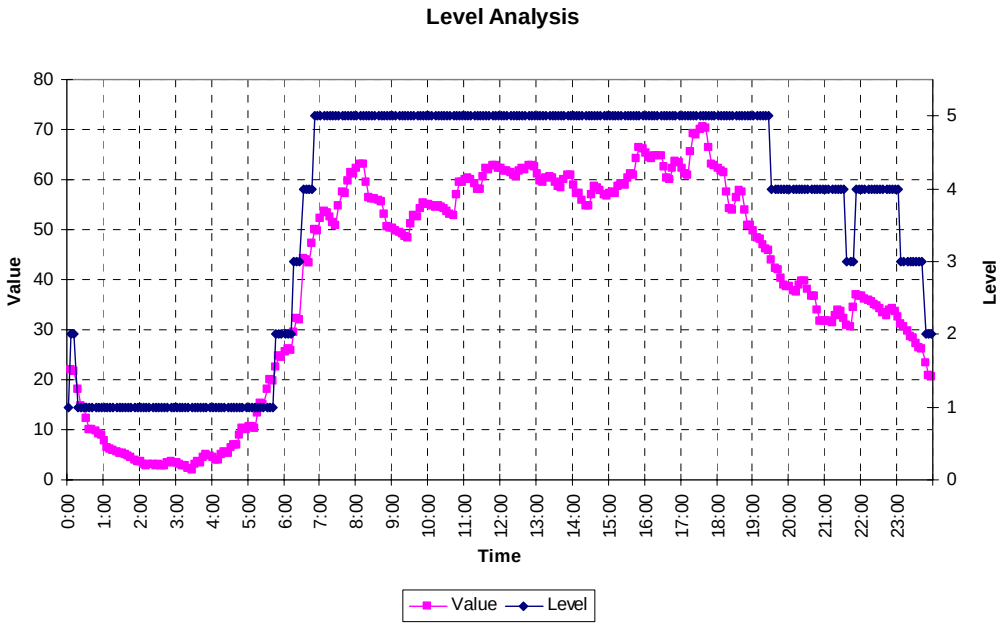
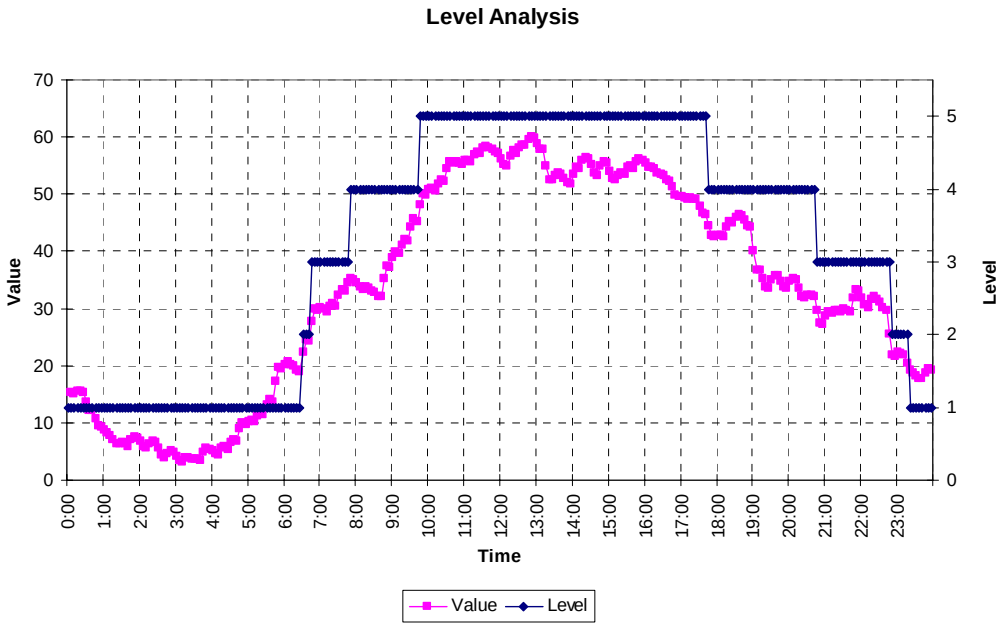


Figure 6 Analysis of Existing TRP Operation, Saturday, April 27, 2002



Analysis of the existing operation reveals the following observations:

- The current TRP settings drive the master into selecting Level 5 throughout most of the weekday and much of the weekend. It is best for the TRP level selection to settle on Level 3 or Level 4 for most of the day, reserving Level 5 for the highest peak periods.
- The current TRP settings cause the master to bounce back and forth between levels, sometimes as frequently as one sample interval (3 minutes). This creates considerable inefficiency as each of the local controllers transitions from one pattern to the next. The combination of small sample interval and long cycle lengths can result in skewed data from one interval to the next, as some intervals contain more platoons than others.
- Some system detectors assigned to detector groups do not produce any data and thus skew the results; others are assigned twice or three times.

To address these issues, the following general changes are proposed:

- The levels have been adjusted upwards to center the peak periods around Level 4 and the off-peak periods around Level 2. This is appropriate because all of the cycle lengths have been adjusted upwards to accommodate the high cycle lengths needed during the peak periods.
- The thresholds between moving up levels and moving down levels have been separated further to minimize the amount of bouncing between plans.
- The assignment of system detectors to detector groups was simplified, and extraneous and unused data was eliminated.

Table 2, Table 3, and Table 4 present a summary of the major changes to thresholds, plan assignments, and cycle lengths, respectively.

TABLE 2 EXISTING AND PROPOSED TRP THRESHOLDS

Threshold	Existing Algorithm Level	Proposed Algorithm Level
2>1	20	20
1>2	22	22
3>2	24	31
2>3	27	35
4>3	31	47
3>4	35	51
5>4	45	59
4>5	58	64

TABLE 3 EXISTING AND PROPOSED TRP PLAN ASSIGNMENTS

Level	Existing Plan	Proposed Plan
1	111	111
2	211	211
3	311	411
4	411	511
5	511	611

TABLE 4 EXISTING AND PROPOSED TRP CYCLE LENGTHS

Cycle	Existing Cycle Length	Used in TRP?	Proposed Cycle Length	Used in TRP?
1	70	X	85	X
2	85	X	95	X
3	95	X	115	
4	115	X	125	X
5	125	X	135	X
6	145		150	X

Due to the proposed use of TRP during offpeak periods, the existing use of volume as the indicator for setting levels is appropriate. Note that the sample interval of 3 minutes was considered for adjusting upwards to 5 minutes to assist in the smoothing of transitions between levels. However, for consistency with Lee County's desire to have TRP operation sufficiently reactive to traffic from the airport, the sample interval was retained at its existing value.

Figure 7 and Figure 8 present analysis of the proposed TRP operation, tested against the same volume data discussed previously for Friday and Saturday, respectively. Note that only those portions during the offpeak periods will actually be in effect.

Figure 7 Analysis of Proposed TRP Operation, Friday, April 26, 2002

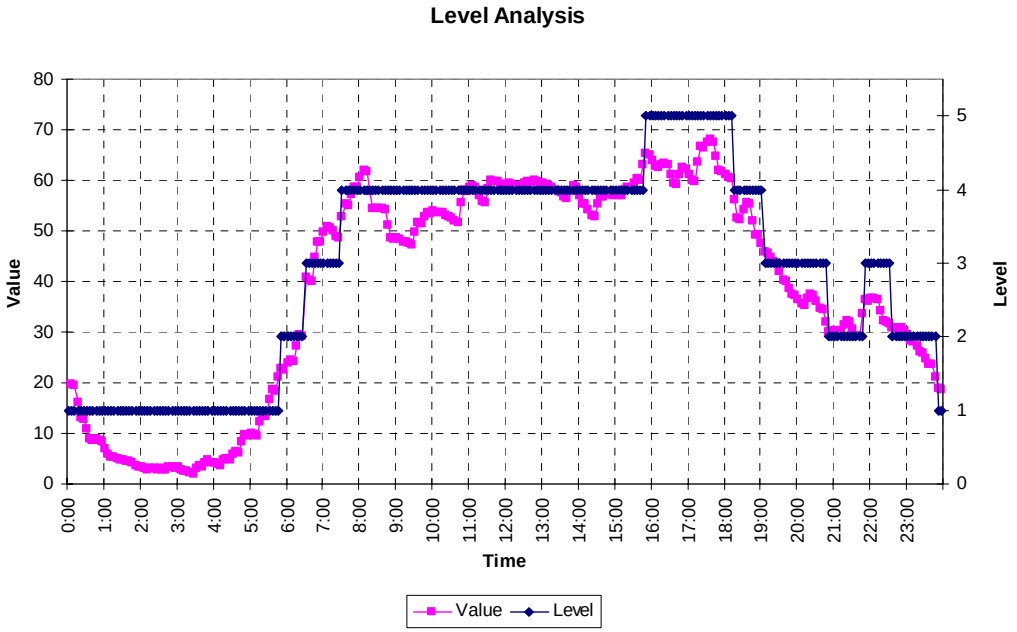
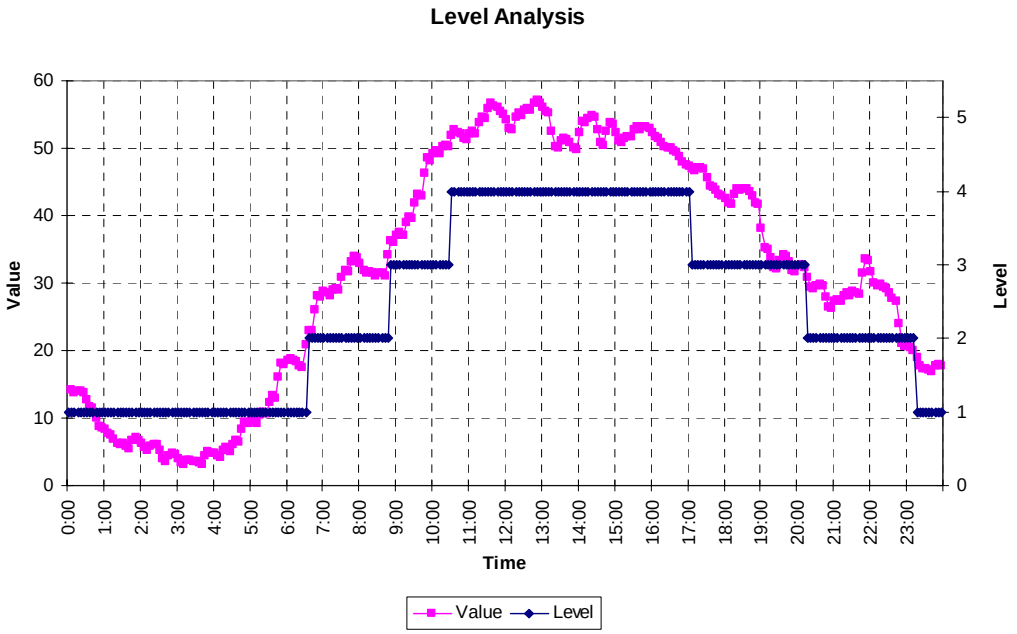


Figure 8 Analysis of Proposed TRP Operation, Saturday, April 27, 2002



FINAL TIMING PLANS

Table 5 presents the estimates from Synchro of measures of effectiveness for each of the five timing plans developed for this project. *Appendix B includes time-space diagrams and intersection output for each plan.*

TABLE 5 ESTIMATED FINAL MEASURES OF EFFECTIVENESS

Plan 311 (AM Peak) – 115 s cycle

Daniels Pkwy.

Direction	EB	WB	All
Total Signal Delay (hr)	30	28	57
Stops	3206	3455	6661
Average Speed (mph)	27	29	28
Total Travel Time (hr)	65	64	129
Distance Traveled (mi)	1768	1841	3608
Fuel Consumed (gal)	130	135	265
Fuel Economy (mpg)	13.6	13.6	13.6
Unserved Vehicles (#)	0	0	0
Vehicles in dilemma zone (#)	288	262	550
Queuing Penalty (veh)	18	9	27
Performance Index	39.0	37.5	76.5

Network Totals

Number of Intersections	12
Total Signal Delay (hr)	122
Stops	8686
Average Speed (mph)	20
Total Travel Time (hr)	213
Distance Traveled (mi)	4205
Fuel Consumed (gal)	349
Fuel Economy (mpg)	12.0
Unserved Vehicles (#)	0
Vehicles in dilemma zone (#)	554
Queuing Penalty (veh)	328
Performance Index	154.9

Plan 411 (Sat. Peak, PM data) – 125 s cycle

Daniels Pkwy.

Direction	EB	WB	All
Total Signal Delay (hr)	33	41	74
Stops	3977	4338	8315
Average Speed (mph)	28	25	27
Total Travel Time (hr)	75	82	157
Distance Traveled (mi)	2095	2083	4178
Fuel Consumed (gal)	156	166	322
Fuel Economy (mpg)	13.5	12.5	13.0
Unserved Vehicles (#)	0	0	0
Vehicles in dilemma zone (#)	271	351	622
Queuing Penalty (veh)	104	758	862
Performance Index	47.4	73.6	121.0

Network Totals

Number of Intersections	12
Total Signal Delay (hr)	122
Stops	10702
Average Speed (mph)	21
Total Travel Time (hr)	225
Distance Traveled (mi)	4811
Fuel Consumed (gal)	397
Fuel Economy (mpg)	12.1
Unserved Vehicles (#)	21
Vehicles in dilemma zone (#)	630
Queuing Penalty (veh)	1394
Performance Index	190.5

Plan 433 (AM Peak) – 125 s cycle

Daniels Pkwy.

Direction	EB	WB	All
Total Signal Delay (hr)	26	30	55
Stops	2749	3312	6061
Average Speed (mph)	30	29	29
Total Travel Time (hr)	63	70	133
Distance Traveled (mi)	1857	2018	3875
Fuel Consumed (gal)	123	140	263
Fuel Economy (mpg)	15.1	14.4	14.7
Unserved Vehicles (#)	0	0	0
Vehicles in dilemma zone (#)	193	255	448
Queuing Penalty (veh)	17	100	117
Performance Index	33.8	41.8	75.6

Network Totals

Number of Intersections	12
Total Signal Delay (hr)	95
Stops	7989
Average Speed (mph)	23
Total Travel Time (hr)	190
Distance Traveled (mi)	4433
Fuel Consumed (gal)	327
Fuel Economy (mpg)	13.6
Unserved Vehicles (#)	0
Vehicles in dilemma zone (#)	451
Queuing Penalty (veh)	441
Performance Index	129.4

Plan 511 (PM Peak) – 135 s cycle

Daniels Pkwy.

Direction	EB	WB	All
Total Signal Delay (hr)	31	38	69
Stops	4009	3937	7946
Average Speed (mph)	29	26	27
Total Travel Time (hr)	73	80	153
Distance Traveled (mi)	2095	2083	4178
Fuel Consumed (gal)	155	158	313
Fuel Economy (mpg)	13.6	13.2	13.4
Unserved Vehicles (#)	0	0	0
Vehicles in dilemma zone (#)	185	257	442
Queuing Penalty (veh)	117	746	863
Performance Index	45.5	69.9	115.4

Network Totals

Number of Intersections	12
Total Signal Delay (hr)	134
Stops	10707
Average Speed (mph)	20
Total Travel Time (hr)	237
Distance Traveled (mi)	4811
Fuel Consumed (gal)	402
Fuel Economy (mpg)	12.0
Unserved Vehicles (#)	139
Vehicles in dilemma zone (#)	449
Queuing Penalty (veh)	1473
Performance Index	204.3

Plan 611 (MD Peak) – 150 s cycle

Daniels Pkwy.

Direction	EB	WB	All
Total Signal Delay (hr)	28	45	73
Stops	3375	4161	7536
Average Speed (mph)	29	25	27
Total Travel Time (hr)	67	90	158
Distance Traveled (mi)	1950	2261	4211
Fuel Consumed (gal)	138	173	310
Fuel Economy (mpg)	14.1	13.1	13.6
Unserved Vehicles (#)	0	0	0
Vehicles in dilemma zone (#)	169	350	519
Queuing Penalty (veh)	166	1057	1223
Performance Index	42.3	86.0	128.2

Network Totals

Number of Intersections	12
Total Signal Delay (hr)	121
Stops	9553
Average Speed (mph)	21
Total Travel Time (hr)	224
Distance Traveled (mi)	4791
Fuel Consumed (gal)	382
Fuel Economy (mpg)	12.6
Unserved Vehicles (#)	0
Vehicles in dilemma zone (#)	522
Queuing Penalty (veh)	1618
Performance Index	192.7

Appendix A:

Existing Controller TRP Plan Selection

Appendix B:

Final Signal Timing Plans

- Plan 311 (AM Peak shoulders)
- Plan 411 (Saturday Peak, PM data)
- Plan 433 (AM Peak)
- Plan 511 (PM Peak)
- Plan 611 (MD Peak)