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CONSULTING ENGINEERS

MCMN0701/11

TECHNICAL MEMORANDUM

TO: Ashwin Patel, P.E., PennDOT Traffic Signals and Safety Manager

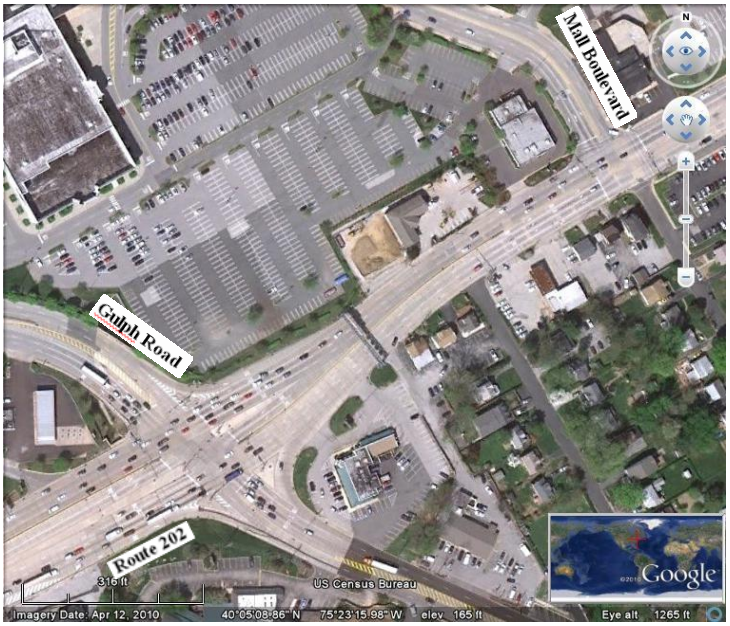
FROM: Brian R. Keaveney, P.E., PTOE, Transportation Division

DATE: December 14, 2010

RE: Traffic Signal System Comparison
Route 202 and Gulph Road/Mall Boulevard
Upper Merion Township, Montgomery County

Dear Mr. Patel:

As requested we have completed an operational comparison of two traffic signal control systems along Route 202 in Upper Merion Township. Data collection and field observations were conducted at the signalized intersections of Route 202 & Gulph Road, and Route 202 & Mall Boulevard (see map below) in order to determine the operational efficiency of the intersections during peak hours under the control of existing conventional time-of-day (closed loop) system program timings, and under the control of the InSync Traffic Adaptive System. It is important to note for the purposes of these analyses that the existing system peak hour timing programs were developed using traffic volume data from 2001, and were only recently implemented as part of Upper Merion Township and PennDOT's SR 0202 MS1 project. Diagrams of the existing signalized intersections, which depict the current lane configurations and phase operation, are attached in Appendix A.



Map: Route 202 & Gulph Road/Mall Boulevard

In order to assess the operation of the study intersections, traffic counts, speed/delay runs, and approach videos were collected during the AM, midday and PM weekday peak hours on the following dates:

- Wednesday, May 26, 2010 – InSync operation - speed/delay runs, video, manual counts
- Wednesday, June 2, 2010 – Closed Loop operation - video, manual counts
- Wednesday, June 9, 2010 – Closed Loop operation - speed/delay runs

Count data from the manual turning movement counts and Insync data files (the full count data is attached as Appendix B) from each of the three study days were reviewed and it was determined that traffic volumes were comparable for each day, with no significant variances that would impact the operational comparisons.

The results of the data collection efforts were analyzed and points of comparison were selected in order to compare the signal control systems. The two primary comparison points are the speed/delay runs that were conducted along Route 202 during the peak hours, and the residual queuing analyses completed through the review of video files collected during the peak hours. In addition, a comparison was completed between the count data collected by the InSync system and the manual turning movement counts conducted at the intersections to determine the accuracy of the InSync system counts.

Systems

Existing Closed Loop System:
The closed loop system analyzed as part of this study incorporates specific program times developed from previous traffic volumes and patterns, which were developed as part of a joint project between Upper Merion Township and PennDOT (known as SR 0202, MS1 project). Coordinated programs (Cycle/Split/Coordination Offsets) were developed for weekday morning peak, weekday afternoon peak, and off-peak time periods, and change for each peak period at specific times of the day. The signals within each coordinated corridor currently operate at a consistent cycle length during these coordinated programs in order to maintain progression along Route 202. Both study intersections include actuation for the side street approaches and Route 202 left turn phases, however no actuation is provided for the Route 202 through movements and any unused green time form the actuated phases is added to the Route 202 through movements in order to maintain the consistent cycle length and coordination points (offsets).

InSync Traffic Adaptive System:
The InSync system utilizes full actuation for each phase at both study intersections, including the Route 202 through movements. The InSync system is able to measure the volume of vehicles waiting on each approach (within the specified detection area), and the cumulative delay of the traffic on each approach. This information is utilized to prioritize which approach (or phase) should receive the green signal, and the length of the green signal provided to that approach. The system does not operate on a set cycle length or phase pattern. Instead, the software can prolong or truncate any phase, or modify the order in which the phases occur based on the prioritized demand. Additionally, neighboring signals can communicate through the system in order to identify approaching platoons of vehicles. "Green tunnels", or bands of green time, are reserved at each intersection along the corridor in order to platoon traffic through each intersection. The software at each local intersection plans around these green tunnels, and utilizes short and long-term historical data collected by the system, in addition to the detector data to determine the order and duration of each signal phase.

Speed and Delay

In order to assess the ability of each signal system to accommodate through traffic along Route 202, speed and delay runs were completed utilizing *PC-Travel* software. Runs were completed during the AM, midday and PM weekday peak hours for both the northbound and southbound directions. For the northbound direction, a run length of approximately 1,300 feet was utilized with a start point in the vicinity of King of Prussia Road and an end point just north of Mall Boulevard. For the southbound runs, a run length of approximately 1,800 feet was utilized, with the start point at Long Road, and the end point just south of Gulph Road near Kirk Avenue.

A total of 115 runs were completed as part of this study, with 6 to 12 runs completed for each direction in each time period. The "floating car" method was utilized in the speed/delay runs in order to mimic the speed of the majority of drivers on Route 202. With the floating car method, the driver attempted to maintain position in the traffic stream, passing only as many cars as pass the test vehicle. Additionally, a random arrival was utilized at the start of each run, as not to arrive at the same point each time in the corridor cycle.

The following tables summarize the key comparison points taken from the *PC-Travel* study reports (the full reports are attached as Appendix C). Tables 1 and 2 summarize the comparison of the total travel time, number of stops, total delay, and average speed for each direction during each peak period between the two traffic control systems.

Table 1

PC-Travel Results Comparison - Northbound Route 202

NORTHBOUND										
Measure of Effectiveness (Average per Run)	AM			Midday			PM			Avg %Δ
	Existing System	InSync	%Δ	Existing System	InSync	%Δ	Existing System	InSync	%Δ	
Travel Time (sec)	86	76.8	**-11%**	115.9	70.3	**-39%**	111.9	62.7	**-44%**	**-31%**
# of Stops	0.9	0.6	**-33%**	1	1.1	**10%**	1.3	1	**-23%**	**-15%**
Total Delay (sec)	66.4	57.1	**-14%**	96.1	50.7	**-47%**	92.3	43.3	**-53%**	**-38%**
Avg Speed (mph)	9.9	11.1	**12%**	7.4	12.1	**64%**	7.6	13.6	**79%**	**52%**

Table 2
PC-Travel Results Comparison – Southbound Route 202

SOUTHBOUND										
Measure of Effectiveness	AM			Midday			PM			Avg %Δ
	Existing System	InSync	%Δ	Existing System	InSync	%Δ	Existing System	InSync	%Δ	
Travel Time (sec)	92.7	68.2	**-26%**	104.8	94.8	**-10%**	122.9	93.9	**-24%**	**-20%**
# of Stops	1.1	0.8	**-27%**	1.5	1.3	**-13%**	1.7	1.1	**-35%**	**-25%**
Total Delay (sec)	64.2	39.9	**-38%**	76.5	66.4	**-13%**	94.7	66.1	**-30%**	**-27%**
Avg Speed (mph)	13.4	18.2	**36%**	11.8	13.1	**11%**	10.1	13.2	**31%**	**26%**

As shown in the summary tables, the implementation of the InSync system resulted in reductions in travel time, number of stops, and total delay when compared to operation under the existing closed loop system using timing and coordination programs based upon 2001 traffic data. Likewise, the average speed through the study area was higher during all study time periods under the InSync system. The most notable improvements were seen for the northbound direction during the evening peak hour, where the travel time was reduced by 44%, the total delay was reduced by 53%, and the average speed was 79% higher under the control of the InSync system.

Queuing

Utilizing recorded peak hour video, the queuing for each signal phase was reviewed to determine how often the queue on each approach was not able to clear during a single cycle. The video data for the highest volume hour (evening peak) was reviewed for May 26th (InSync system), and June 2nd (existing closed loop system). For both systems, while the queues generally cleared for all phases at the intersection of Route 202 and Mall Boulevard, several movements suffered from residual queuing at the intersection of Route 202 and Gulph Road.

Under the control of the existing closed loop system, the northbound left turn movement (from Route 202, onto Gulph Road) was not able to clear its queue 87% of the time during the afternoon peak hour. This means that for the majority of the phase cycles, vehicles that were waiting towards the back of the queue were required to wait through multiple cycles in order to progress through the intersection. Likewise, the southbound left turn movement was not able to clear its queue 67% of the time. Conversely, each of these movements was able to completely clear their respective queues during each signal phase under control of the InSync system.

For the eastbound approach of Gulph Road, the queue was not able to clear 70% of the time under the existing closed loop system. With the InSync system, the eastbound Gulph Road queue was not able to clear only 30% of the time.

As such, it is apparent that the queuing for each signal phase is handled more efficiently under the control of the InSync system, resulting in decreased delay, and a reduced volume of vehicles waiting multiple cycles to travel through the intersection.

Count Comparison

In order to determine the accuracy of count data collected by the InSync system, a comparison was completed of traffic volume information collected by manual turning movement counts, and the InSync system. Along with the count data included in Appendix B are tables that compare the volumes by signal phase, and provide a percent difference between the data.

The volumes collected by the InSync system generally varied from the manual counts by less than 20%, with several exceptions. Most of the exceptions appear to be related to camera placement and zone designation. Higher volumes counted by the InSync system are generally caused by vehicles stopping too close to the video count zone, or by vehicles overlapping lanes (Route 202 southbound left turn at Mall Blvd). When vehicles stop near the video count zones, there is a tendency for the system to count the vehicle multiple times. In some cases, a single vehicle was counted as many as ten times. This appears to be caused by slight oscillations of the camera (possibly due to wind) that cause the video count zone to move slightly and be cleared/tripped multiple times by the stationary vehicle.

Lower volumes counted by the InSync system are generally caused by a combination of closely spaced vehicles, and a poor camera angle (Route 202 through movement at Gulph Road) causing vehicles that are indiscernible from the vehicle in front of them to not be counted, specifically if the leading vehicle is a truck.

Due to the variances noted in the InSync count data collection, systems that will be utilized for data collection should be calibrated utilizing manual counts.

Observations

Occurrences were noted during the data collection, and through the review of the video files pertaining to the operation of the InSync system that should be considered for future installations.

It was observed on multiple occasions that some phases could be served multiple times prior to serving another phase, even though the other phase has vehicles waiting. For instance, at Route 202 & Mall Boulevard, the northbound left turn phase was served twice while vehicles were waiting on Mall Boulevard. This appeared to give motorists the impression that the Mall Boulevard phase was being skipped or was somehow malfunctioning. On one occasion, it was noted that after the northbound left turn phase was called up a second time, a vehicle waiting on Mall Boulevard entered the intersection illegally to make a left turn.

Another issue that was noted in the field and reviewed through the video files concerned the southbound left turn phase for Route 202 at Mall Boulevard. It was noted in the field that this phase was being served at times when there was no traffic in the left turn lane. A review of the video files confirmed that vehicles in the adjacent through lane were, at times, actuating the left turn lane detection area. Further, the system was not always able to clear the call once the adjacent vehicle had passed, and the left turn phase was called again later in the phase sequence. This issue should be correctable through camera adjustments; however, a delayed call feature should be placed on lower volume phases where this issue occurs.

Conclusion

As summarized in this letter, a comparison was completed of the operational efficiency of Route 202 & Gulph Road, and Route 202 & Mall Boulevard under the control of standard closed loop system program timings (developed using 2001 traffic data), and under the control of the InSync Traffic Adaptive System. The results of the comparison indicate that the InSync system was able to provide lower travel times and less delay along Route 202, while clearing queues for the side street approaches and left turn movements more efficiently than the closed loop system.

Total delay along Route 202 decreased 38% in the northbound direction and 27% in the southbound direction as a result of the InSync system. Additionally, the northbound and southbound Route 202 left turn queues at Gulph Road were not able to clear 87% and 67% of the time, respectively, under the closed loop system. Alternatively, these queues were able to clear after each phase under the InSync system. Further, for the eastbound approach of Gulph Road, the queue was not able to clear 70% of the time under the closed loop system, while with the Insync System, this was reduced to 30% of the time.

A review of count data collected by the InSync system indicates that video detection camera angle and detection zone locations are critical to the accurate collection of count data. While the system generally collected accurate data, several movements had significant differences from manual counts, and volumes obtained from the system should only be utilized if the system has been calibrated with manual count data.

Due to the decreased delay and improved queue clearing, it appears as though the InSync system is a viable alternative to standard closed loop systems on congested corridors. Further study may be required, however, to determine the impacts of video camera malfunctions on the operation of the InSync system.

If you have any questions or would like to meet to further discuss this evaluation, please do not hesitate to contact me.

cc: Dave Adams, P.E., PENNDOT Montgomery County Signals Manager
Charles DeVitis, Traffic Signal Division, Upper Merion Township
Earl Armitage, P.E., Pennoni Associates Inc.
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