WHAT ARE YOUR SIGNALS COSTING YOU?

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Have you ever stopped at a traffic signal and waited, seemingly endlessly, and no other cars can be seen? Sitting at the red light, wondering why you are not moving when no one else is coming is frustrating and wastes time and energy. There are several possible reasons for this, but the most common is that the signal is not properly timed.

Many municipalities don't have the on-staff traffic signal expertise necessary to maintain proper signal timings, so the original signal timing remains year after year, without change, regardless of how traffic patterns may have varied. Or worse yet… More time is added to the more congested movements, without adjusting side street timing, in an attempt to improve traffic flow. Though this might seem to work as a short term fix, adjustments of this type will eventually cause longer wait times and vehicle queues as the signal timings are continually adjusted on each street in an attempt to "chase the congestion" and fix the problem. Increased delays, caused by improperly timed traffic signals costs a community both time and money. They decrease the quality of life within that community and in the most severe instances, drive residents, visitors, and businesses away from that community.

Many municipalities don't realize how a low cost solution such as retiming a traffic signal can reap huge benefits. They worry that no real improvement can be seen without a major investment, so nothing is done, however, if the overall user cost savings are calculated and if the improved air quality was considered, it would be obvious that even a small investment in improved traffic signal timing would save their community money and add to the overall quality of life.

To illustrate these quality of life improvements and show the significant effect signal timing optimization can have on issues such as user costs, vehicular queue lengths and air quality, consider this example project, representative of a situation commonly found throughout upstate New York.

EXAMPLE PROJECT

Shown in Figure 1 is a three-legged signalized intersection in an upstate New York municipality. Typical to much of New York State, this intersection once had significant side street traffic (eastbound) because of heavy industrial development to the west, but over the last 20 years much of that development has moved on, leaving a significantly different traffic pattern than when the signal was first installed. Currently, Main Street is a major commuter route that sees significantly more traffic than in the past, yet the Side Street sees traffic that barely warrants a traffic signal. The existing PM peak hour traffic volumes are illustrated in Figure 2 on the next page.

Figure 1

Field observations at the site reveal significant back-up "queuing" southbound, which sometimes blocks adjacent signalized intersection located just 500 feet north of this location. This severe queue length and associated delay is a direct result of the signal timings at this intersection, which was set to cycle through 25 seconds of green time for the

Side Street and 25 seconds of green time for Main Street every one minute. This signal is a "fixed time" signal, meaning it gives that 25 seconds of "green time" to each approach regardless of whether traffic is present or not.

Often, this condition will cause residents to demand high cost lane improvements such as intersection widening to increase capacity, but are those improvements truly needed? Or could simply retiming the signal be enough?

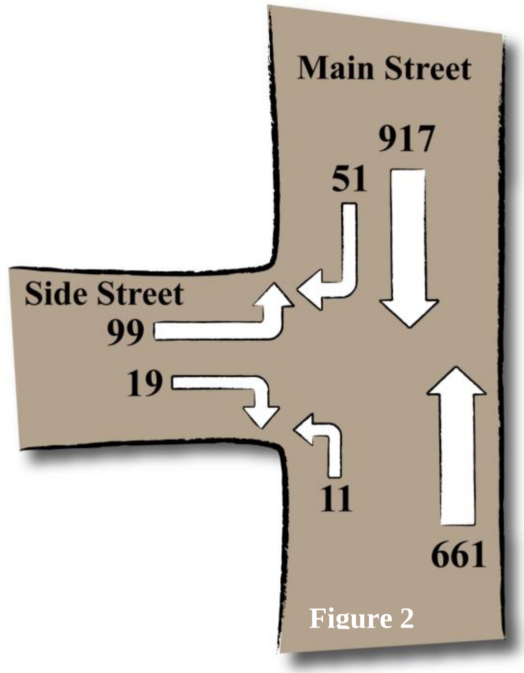

Figure 2

TRAFFIC SIGNAL ANALYSIS

To determine the benefit of retiming the traffic signal, a software program called SYNCHRO 7 is often used. SYNCHRO is a traffic analysis tool that allocates time to each movement base on volume to capacity ratios and the approach delays. This analysis helps balance timings that minimize overall delay and vehicular queues. The delays from SYNCHRO are reported in seconds of delay per vehicle and are categorized by a Level of Service (LOS) grade. These levels of service, which are defined in the "*Highway Capacity Manual"* published by the Transportation Research Board, range from "A" to "F", with LOS A being free flowing traffic and LOS F being highly congested conditions with significant delays. Typically, LOS C is desirable and LOS D is minimally acceptable during peak travel periods.

For this example, only the PM peak hour was reviewed since it is typically the most highly congested hour of the day and will yield a "worst case scenario" analysis. The PM peak hour traffic typically represents about 10% of the daily traffic.

Three options were reviewed as part of the traffic analysis; each represents an action a municipality could take to address the congestion and queuing problem. Table I summarizes the conditions from each:

1. The first option is inaction, the "do-nothing" approach. For many municipalities with no signal operations personnel, this may be the only option they feel they have.
2. The second option is the "add time to the problem" method, where additional green time is added to the road with the congestion problem. This philosophy may work at times, but without reviewing current traffic conditions and adjusting the overall timings to a cycle that properly balances green time versus peak demand, needless time could still be wasted on approaches with few vehicles, causing a less than optimal situation. To simulate this method of improvement for the example project, the Main Street green time was increased by 30 seconds to a total of 55 seconds and the Side Street green time remained at its existing 25 seconds.
3. The final option reviewed was to optimize signal timings for the current traffic conditions. For this alternative, a municipality would need to collect current traffic count information and use traffic engineering techniques to determine

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the optimal timings for each approach based on volume to capacity needs. As part of this analysis, the minimum cycle length necessary to meet the traffic demand would be determined. This will help reduce queues, keeping them at a minimum. For the example project, the one minute cycle length that exists appeared to be sufficient if green times were properly allocated. Allowing 43 seconds for the Main Street green time and 7 seconds for the Side Street green time, instead of the 25 seconds each seen under existing conditions, yields the best results for this alternative shown in the summary table below.

TABLE 1 Summary and Comparison

Direction of Travel	PM Peak Hour								
	Option 1-"Do Nothing"			Option 2-"Add Time"			Option 3-"Optimize Timings"		
	Delay Sec/Veh	LOS	95th Percentile Queue	Delay Sec/Veh	LOS	95th Percentile Queue	Delay Sec/Veh	LOS	95th Percentile Queue
Southbound	178.7	F	705'	29.5	C	675'	10.9	B	340'
Northbound	20.1	C	175'	10.1	B	145'	3.6	A	60'
Eastbound	10.3	B	55'	25.2	C	100'	39.3	D	110'
Overall Intersection	**106.6**	**F**		**21.8**	**C**		**10.0**	**A**	
Number of Stops	**1,353 Vehicles/Hour**			**1,152 Vehicles/hour**			**864 vehicles/hour**		

	PM Peak Hour Annual Totals*		
Vehicle Hours of Delay (VHD)	13,546 VHD	2,782 VHD	1,274 VHD
Fuel Used	12,740 gallons	4,420 gallons	3,120 gallons
CO Emissions	1,963 pounds	700 pounds	467 pounds
NO Emissions	382 pounds	136 pounds	91 pounds
VOC Emissions	455 pounds	162 pounds	108 pounds
Total Pollutants	2,800 pounds	998 pounds	665 pounds

* Annual Totals are based solely on the weekday PM peak hour analysis, assuming 260 weekdays in a year. Overall Annual Totals, which would include 24 hours of 365 days has not been calculated, but can be assumed to be 10 to 20 times greater than the values shown.

As can be seen in Table 1, optimizing traffic signal timings can produce extremely significant results for a poorly timed traffic signal. In the example project, a condition typical to hundreds of locations throughout New York State, the analysis showed that optimized timings would reduce delay by 90% and would save more than 9,600 gallons of gas each year. It would also reduce harmful pollutants being releases into the air by more than 75%. In addition, the maximum queue lengths on the most critical movements are significantly reduced, which is something that simply adding green time to the congested approaches doesn’t fix. For the example project, the critical southbound queue was cut in half, which means it can now be accommodated without backing up through the adjacent traffic signal.

To further illustrate this, a traffic simulation model was developed for the existing and optimized conditions using a software known as Simtraffic. Simtraffic is a microanalysis simulation modeling program which models car movements and traffic control devices, while keeping statistics on each individual element on a second by second basis. Using this program, an animated model of each scenario was created to confirm how significantly queue lengths were affected by the optimized traffic signal timings. The resulting Simtraffic models mirrored the SYNCHRO analysis with regard to queues. Optimized signal timings reduced the queues such that they didn’t back up to the adjacent signal, even though the existing condition did. Figures 3 and 4 graphically depict this change in queue length for the same period of the day.

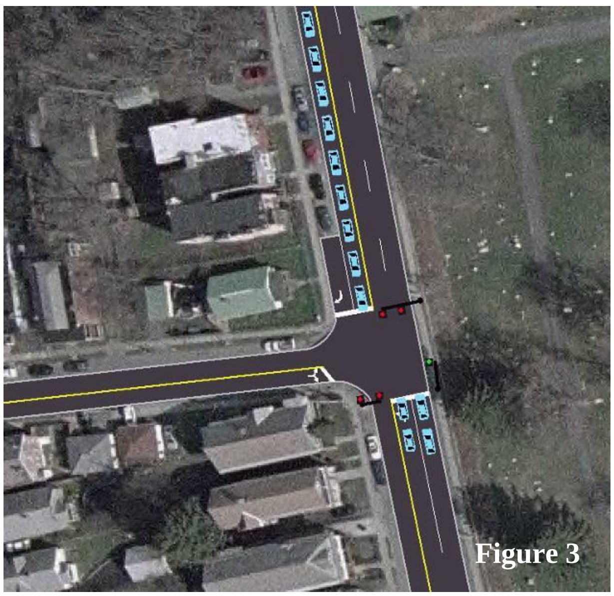

Figure 3

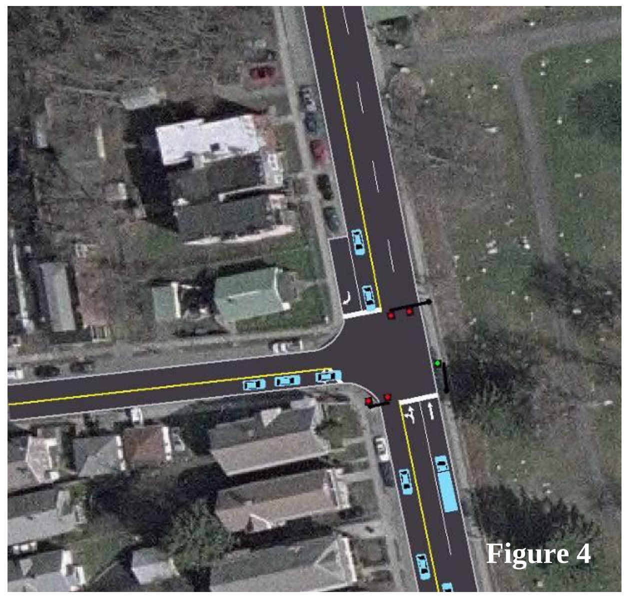

Figure 4

COST BENEFIT ANALYSIS

As the traffic analysis shows, optimized and properly implemented signal timings can significantly reduce queues and delays and improve air quality with no costly geometric changes or equipment upgrades, but without qualified traffic operations engineers on staff, how can a municipality justify the expense to retime a traffic signal? For most municipalities, doing nothing or just adding time when an approach starts backing up are virtually free to implement, while timing optimization may require retaining a qualified traffic consultant, the cost of which, depending on the scope of work, could range between $1,000 and $5,000 per traffic signal. The answer is clear if the time and fuel user costs are assessed. Table 2 depicts the expenses and cost savings of each of the three options for the PM peak hour.

TABLE 2 Cost Comparisons

	Annual PM Peak Hour		
	Option 1-"Do Nothing"	**Option 2-"Add Time"**	**Option 3-"Optimize Timings"**
Vehicle Hours of Delay (VHD)	13,546 VHD	2,782 VHD	1,274 VHD
Cost of Delay at Minimum Wage (7.15/hr)	$96,850 dollars	$19,890 dollars	$9,100 dollars
Annual Fuel Used	12,740 gallons	4,420 gallons	3,120 gallons
Cost of Fuel at Average Gas Price ($3.35/gal.)	$42,680 dollars	$14,800 dollars	$10,450 dollars
Cost of Implementation	$0	$0	$5,000 Max.
Total Cost*	$139,530 dollars	$34,690 dollars	$24,550 dollars
Cost Savings for PM Peak Hour	----	$104,840 dollars	$114,980 < Option 1
			$10,140 < Option 2

* Total Cost is based solely on the weekday PM peak hour, assuming 260 weekdays in a year. Overall Annual Totals, which would include all 24 hours of each of 365 days has not been calculated, but can be assumed to be 10 to 20 times greater than the values shown.

As Table 2 shows, even using very conservative numbers, assuming one person per vehicle earning only minimum wage and only considering only the 260 peak hours of the 8,760 hours in a year, it is clear that retaining a traffic operations specialist is the most prudent choice and will cost the community far less money in the long run. In the example project, the cost savings in just the PM Peak Hour of one year was more than $10,000 when compared to haphazardly adding time to different approaches.

CONCLUSION

There are many ways to deal with traffic problems at signalized intersections and the equipment found in many municipalities. Sometimes, improved signal equipment or geometric improvements may be necessary to improve capacity, but before these costly improvements are initiated, a good look at the root of the problem is required. In many cases, altering signal timing to match the current traffic conditions can significantly reduce delay at an extremely low cost to the municipality. It many cases, poorly timed traffic signals are costing communities huge amounts of money in the form of user costs (delay time and fuel costs incurred by each and every roadway user within a municipality) and a reduced quality of life in the form of increased air pollution. Look around at the signals in your community and ask yourself, "What are our signals costing us? The answer may surprise you.

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