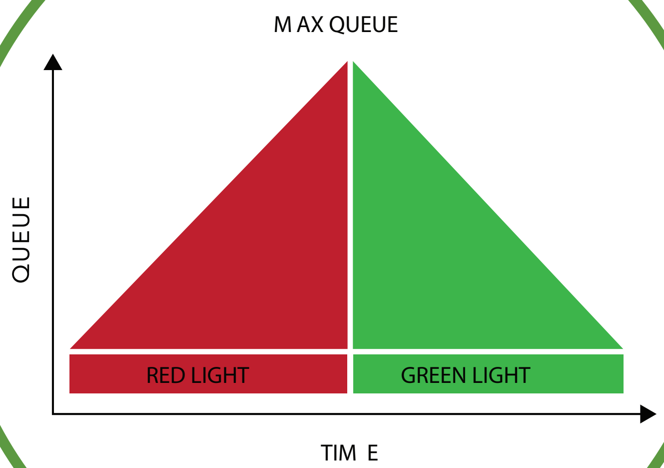
The Issues with Signal Communication: An Engineer's Perspective

Now that you understand all essentials necessary for a working traffic signal, let's review some technical challenges faced by traffic engineers while they attempt to synchronize traffic lights. Here we will explore, through an engineer's eyes, why traffic engineers are unable to keep traffic signals synchronized.

One fundamental difficulty in optimizing traffic signals lies in the limitations of the equations at the heart of traffic engineering. Most traffic signals are synchronized using one of the three available software models: Synchro®, PASSER ™, and Transyt-7F™. All three of these software models use some modified form of F. V. Webster's equation to calculate vehicle delay. They use flawed assumptions in the model and then add corrections for them. One such assumption is that all traffic arrives uniformly and leaves uniformly at an intersection. We know that this is not true; with vehicles ranging in size from zippy sports cars to behemoth SUVs and drivers ranging from the lead-footed teenager to the cautious carpooler, uniform traffic movements are virtually impossible. In reality, vehicle arrival and departures at an intersection are stochastic (random).

The following figure explains the foundational delay equation:



In the above figure, the Y-axis represents the queue length and the X axis represents time. As you can see, the queue length increases uniformly when the signal is red and decreases uniformly when the signal is green. In this case, at the end of the green light the queue drops to zero. The delay model assumes uniform arrival and departure of vehicles at the intersection and states that the first term of delay is calculated by determining the area of the triangle. The equations then add a second term as a correction for the flawed assumption of uniform vehicle arrival and departures. All traffic signal synchronization models use some variation of this equation to determine delay. Due to these inaccurate assumptions in delay modeling, it becomes very difficult for engineers to effectively optimize traffic signals.

Synchronized Engineering: The Traditional Method of Optimization

For the traffic engineer, the process of synchronizing traffic signals in an arterial extends beyond simply plugging through equations and programming signal controllers. Engineers create timing plans for each intersection in a four-step process that involves extensive data collection, careful analysis, software programming, and a period of observation and adjustment at a given intersection to ensure the effectiveness of their work.

Step 1. Data collectors go to each intersection and manually count the number of cars that go through each approach. For example, the northbound left turn movement is an approach and the southbound through movement is another approach. Each approach may have multiple lanes, making data collection a two-person job; as you can imagine, in larger intersections, that's a lot of cars! Normally, counts are collected during morning peak hours (7-9 am,) noontime peak hours (11 am – 1 pm) and evening peak hours (4 - 6 pm) on Tuesday, Wednesday and Thursday. Mondays and Fridays are considered anomalies and data is not collected on those days. A two-person data collection team can collect data for a maximum of 3 intersections per week. Imagine the challenges faced by cities with 300-plus signals. Having data collectors on staff is a luxury for most cities. Data collection is expensive. Consequently, most cities don't collect data and don't keep their signal timing updated.

Step 2. The engineer creates a software model of the arterial he is trying to synchronize and inputs the collected data. This is often a time-consuming process. Once all the data are input, the engineer runs the software model that spits out a timing plan for each time period.

Step 3. This timing plan is manually translated to a format the traffic signal controller understands and is downloaded to the controller. If the engineer has the luxury of having some form of communication to the traffic signal, she can download the new plans from her office to the intersection. The less fortunate have to go out in the field to each controller and manually download the timing plans. One mistake in the plan translation can cause gridlock in the arterial.

Step 4. The engineer observes the arterial and makes changes to the timing plan based on field observation. This is a time consuming and labor intensive activity as well. Due to the flawed

nature of the Webster equation, software models do not create an optimum traffic signal timing plan that can be easily deployed. The engineer has to spend countless hours over several days or weeks rectifying and tweaking the timing plans generated by the software model.

We hope you've begun to understand some of the technical reasons behind the difficulty of optimizing traffic signals. The foundational equation behind most of the software models is flawed, and furthermore, the process of synchronizing the signals based upon those flawed equations is itself a time consuming and expensive endeavor.