**Adaptive Traffic Signal Operation with**

**Real-time Satellite Communications**

For many years, traffic engineers have relied upon the time-based coordination (TBC) of traffic signals as the primary means of creating efficient vehicle progression through a corridor with multiple signalized intersections. In a TBC system, all signals within the corridor have a uniform cycle length, and each intersection has a pre-programmed time band within the cycle when a green indication is displayed on the main street. In optimum operation, each signalized intersection displays green on the main street just when a vehicle queue is projected to reach the intersection, then the process is repeated at each adjacent intersection, both upstream and downstream. The time band for the green display is preset to allow an arbitrary queue length to pass through the intersection. Cycle lengths are typically longer during periods of heavy traffic flow and shorter during periods of light traffic flow. TBC works well on corridors with predictable traffic patterns; however, its primary weakness is an inability to adjust to accommodate unanticipated traffic flows, such as those that may occur during weather emergencies, detours, special events, etc. In order to operate most efficiently, TBC systems must also be updated periodically to account for changes in traffic volumes and directional splits.

A new technology called Adaptive Traffic Signalization (ATS) has recently emerged as a means to improve vehicle progression and reduce delays over TBC systems. Intersections with ATS have no pre-timed cycle lengths; instead, the signal timing at each intersection in the corridor is adjusted instantly in response to approaching vehicle queues. Vehicles are detected by traditional technologies, such as induction loops and/or video cameras, which are placed at multiple locations in advance of each signal within the corridor. When a signal controller is alerted of an approaching queue by the detection devices, its signal phasing and timing is adjusted so the queue receives a green indication when it arrives at the intersection. The controller holds the green indication until the entire queue has passed through the intersection, then the next downstream controller is alerted of the same queue, where the process is repeated. Vehicles on side streets receive green indications at times when there are no approaching queues on the main corridor. Numerous studies have shown that ATS is more effective at improving traffic progression over TBC, particularly in situations where daily traffic patterns have large variations in density, time, and direction.

The proliferation of wireless electronic devices, such as cell phones, tablets, personal computers, and in-vehicle navigation systems, provide another means for vehicles to be detected along highway corridors. All ‘smart phones’ have the capability for their locations to be tracked through Global Positioning Systems (GPS). Each wireless device has a unique, yet anonymous, identification code in its signal that allows it to be individually monitored by satellites and cell towers. GPS involves the use of orbiting satellites and/or cell towers to ‘triangulate’ signals from the wireless devices into an accurate location on the ground. These anonymous signals are transmitted constantly between the wireless devices, satellites, and cell towers to provide real-time positions for each device, even as the device is moving.

Columbus’ Smart City concept merges the technologies of Adaptive Traffic Signalization and Global Positioning Systems by creating a transportation network where traffic signal operations are optimized from information provided by wireless electronic devices. Traditional vehicle detection technologies, such as induction loops and video cameras, will be replaced by the real-time location information provided by cell phones and in-vehicle navigation systems. The vehicle-to-infrastructure (V2I) signals between wireless devices, cell towers, and satellites that determine the ground location of each device will also be transmitted to the local Traffic Command Center (TCC). Data processors at the TCC instantly convert the thousands of incoming wireless signals into vehicle movements on local roads. The TCC then transmits the vehicle movement information to each traffic signal via fiber-optic cable so the adaptive signalization software at each intersection can determine when the signals should change and how long their green indications should be held before changing again. Prioritized vehicles, such as those used for emergency response, transit, and freight, will each have a unique wireless identification code to identify their priority. The unique code allows the adaptive signalization software to recognize their location on the roadway and therefore adjust the signal indications and timing so these vehicles can proceed to their destinations more quickly. Pedestrians with smart phones can also actuate pedestrian signal phases as they approach an intersection on foot.

The implementation of a City-wide adaptive traffic signal system using real-time satellite communications provides many advantages over a standard time-based coordination system:

1. Safety is improved at signalized intersections due to the increased efficiency of their operation. Full vehicle queues will be allowed to pass through the intersections without vehicles near the end having to stop suddenly and re-start. This will reduce the frequency of rear-end collisions from sudden stops and right-angle collisions from red-light running.
2. Less fuel is consumed due to fewer vehicles having to wait and idle at red signals. Lowered fuel consumption also reduces carbon dioxide emissions, which consequently has a positive impact upon climate change.
3. Mobility is enhanced through the reduction of intersection delays. Drivers and passengers will be able to reach their destinations more quickly, which provides more available time for other personal activities.

