Adaptive Traffic Control Systems (ATCS) — Part 5: SynchroGreen
By Ron Whitelock

This is the final article in this series. To review: the original intent of these articles was to provide an overview of the new approach to adaptive controls being introduced into the marketplace.

In this article, we discuss Trafficware’s SynchroGreen. Anyone in the traffic industry will be familiar with the durable Synchro® traffic analysis package. Like TRANSYT, which became the foundation for SCOOT, it appears the Synchro may be headed in a similar direction with SynchroGreen. You be the judge!

Nevertheless, here is background on SynchroGreen as “told” by Trafficware.

[Note: Neither IMSA nor myself assume any responsibility for the accuracy of this material.]

Background

SynchroGreen is a real-time adaptive signal control technology (ASCT) from Trafficware, the makers of the industry standard for traffic optimization and simulation software, Synchro® and SimTraffic®. SynchroGreen collects traffic data at signalized intersections, analyzes the data for changing trends, and adjusts traffic signal timings in real-time based on current demand. SynchroGreen has three optimization engines designed to optimize the split, cycle, and offset. SynchroGreen considers all vehicle movements and pedestrians within the algorithm, and is designed to optimize the entire traffic network.

SynchroGreen is a software-based ASCT that does not require proprietary hardware. Trafficware has installed SynchroGreen on various traffic controller makes and models and does not require the agency to install any proprietary detection technology. Other significant SynchroGreen system features include:

- Interface and system parameters are based on conventions and standards in the United States. SynchroGreen appears familiar and intuitive to new users.
- Leverages NTCIP and NEMA standards to provide safe and efficient traffic signal operations.
- Algorithm accounts for pedestrians without needing to purchase additional modules.
- Modes of operation provide an “easy button” for favoring different phase movements within a system.
- System settings are calibrated in a simulation before system deployment, resulting in a fast and efficient deployment process.
- After the initial system configuration, no human intervention is needed for the system to efficiently time traffic signals.
- Generates real-time and historical MOEs and other performance management initiatives.

System Architecture

There are three major components to any SynchroGreen system: (1) the management system (server), (2) local controllers, and (3) vehicle detection. Within the SynchroGreen interface, the server and local controller are commonly referred to as Signal System Master (SSM) and Signal System Local (SSL), respectively. A typical SynchroGreen setup will have one SSM and several SSLs. There is no limit to the number of SSLs assigned to an SSM. The SSL is responsible for gathering and buffering detection data, as well as executing commands from the SSM. The SSM is responsible for processing all data and calculating updated timing plans. The interaction between SSL and SSM is repeated every few seconds to ensure signal timings are always up to date. SynchroGreen Central Server Software on the SSM installs as a Windows-based executable file on the agency’s computer (server), while the SynchroGreen Local Intersection Software replaces the controller’s prior software on each of the SSLs (see Figure 1).

Optimization Process

The primary objective of the SynchroGreen algorithm is to minimize total network delay, while provid-
SynchroGreen has three optimization engines designed to optimize the split (phase allocation), cycle (period), and offset (start time) in real-time based on current traffic conditions.

**Phase Allocation (Split)**

The Phase Allocation is calculated for each phase every period that SynchroGreen is operational. Phase allocation is the adaptive counterpart of the phase split, typically used under standard coordinated type of operation. The Phase Allocation calculation is based on the Green Utilization, or the duration of time that the phase is processing vehicles while at saturation flow. The Green Utilization is estimated using the stop bar detectors.

In addition to the Green Utilization, a Detector Calibration Factor is also used in the Phase Allocation calculation. The Detector Calibration Factor is used to calibrate detectors based on various sizes, positions, and prevailing vehicle speed over the detectors. The Detector Calibration Factor is the percentage of time that a phase should be utilized at saturation flow. The Detector Calibration Factor is user-defined. A smaller factor causes a larger Phase Allocation, while a larger factor causes a smaller Phase Allocation.

The Target Phase Allocation calculation is performed every period for every phase. Once the most recent Green Utilization is known, SynchroGreen divides the Green Utilization by the Detector Calibration Factor. Essentially, the Phase Allocation is derived by determining the amount of time a phase is running at saturation flow based on the Detector Calibration Factor. SynchroGreen will always use the Detector Calibration Factor as a target for the proportion of time a phase should be utilized at saturation flow. The Target Phase Allocation is not the final Phase Allocation that is sent to the controller. Before the final Phase Allocation is assigned, SynchroGreen must analyze the system globally, and must analyze every phase at every intersection.

**Period (Cycle)**

Once the Target Phase Allocation has been calculated for every phase at every intersection, SynchroGreen analyzes the system globally. First, SynchroGreen sums the Target Phase Allocations and constructs standard ring and barrier diagrams; this establishes the Target Period at each intersection. SynchroGreen then looks at the system globally and selects the intersection with the highest Target Period as the critical intersection. The Target Period duration at the critical intersection is assigned to every intersection and the actual phase allocation is assigned to each phase based on the proportion of the Target Phase Allocations (Figure 2).

**Start Time (Offset)**

Start Time is the adaptive counterpart of the offset under standard coordinated traffic signal opera-
tions. The Start Times recalculate due to changes in the period (cycle) duration as well as traffic flow changes. The Start Time has two components, the lag time and the travel path. The lag time is essentially the relative offset from one intersection to the next. While the initial lag time is user-defined, it also dynamically optimizes based on traffic flow characteristics. The advanced detectors allow lag time modification based on the presence of queuing and the measured platoon arrival distribution. If there is a standing queue at the beginning of green for a given phase, the advanced detectors may be occupied. In this situation, SynchroGreen can incrementally modify the lag time such that the phase releases queues sooner and are less likely to impede an oncoming platoon. SynchroGreen also establishes historical arrival distributions over time. If vehicles tend to arrive sooner or later than historical trends, the lag time can be incrementally modified to accommodate the platoons.

The last component of the start time is the travel path. The user must construct potential travel paths, which are essentially intersection relationships that describe how platoons move through the system. Travel paths ensure that when a platoon arrives at an intersection, the local intersection (SSL) has the most recent timing plans so that coordination and progression are maintained. The illustration above (Figure 3) shows two typical travel path combinations utilized by current SynchroGreen customers.

### Modes

SynchroGreen allows the user to customize the algorithm based on the goals and objectives of their project. By default, the SynchroGreen algorithm equitably distributes green time based on demand, while providing reasonable mainline bandwidth. However, the user can select different modes to promote mainline bandwidth or critical movements. SynchroGreen modes are as follows:

- **Balanced Mode** — Equitable distribution of green time with reasonable mainline bandwidth.
- **Progression Mode** — Mainline green time is favored over the side streets.
- **Critical Movement Mode** — Critical movements are identified at each intersection. These movements and the associated phase(s) are favored.

### Data Collection

SynchroGreen is compatible with non-proprietary vehicle detection technology (i.e., inductive loops, video, wireless sensors, radar, etc.). Vehicle detection provides the input data upon which decisions are made within the SynchroGreen algorithm; detection data is continuously recorded by the local intersection traffic controllers and communicated to the SynchroGreen Server. Vehicle detector placement and configuration are critical. SynchroGreen requires stop bar detection and advanced detection. Stop bar detectors must be placed on every lane, on every intersection approach; advanced detectors should only be placed on mainline through lanes, between 250 ft. and 500 ft. upstream of the stop bar. Where intersection spacing is less than 1,000 ft., advanced detectors are not required. All detectors must be placed on independent channels. The user can adjust a calibration factor in order to account for varying detector size, position, and sensitivity (Figure 4).

### Reporting

SynchroGreen has over 60 built-in reports that allow users to generate presentation-quality documents related to system I/O, alarms, events, parameters, and performance. SynchroGreen has numerous reports that provide measure of effectiveness (MOEs) by intersection and approach, such as v/c ratio or level of service (LOS) (Figures 5 and 6).

### Fallback Operation

By default, during a communications malfunction that impacts the entire system, SynchroGreen will operate using historical data up until the specified fallback time, which is set by the user. After the fallback timer expires, SynchroGreen will revert to standard time-of-day coordination. When only a few intersections within the system are impacted during a communications failure, the user has several options. The user may pre-program SynchroGreen to simply allow these
intersections to use historical data, or the user may program the system to eliminate impacted intersections from the optimization group or instruct the entire system to revert to time-of-day coordination.

When detectors fail, SynchroGreen will automatically eliminate erroneous detectors from system calculations and will rely on alternate detectors assigned to the same phase/approach. Alternatively, the user may pre-program SynchroGreen to perform a specified action when detectors fail. For instance, the user may configure SynchroGreen to eliminate intersections where erroneous detectors occur from the optimization group or instruct the entire system to revert to time-of-day coordination when a specified number of detectors fail.

System Configuration

System design and deployment is performed by Trafficware or an authorized SynchroGreen distributor, and can typically be completed in 90 days or less. The actual system software installation and turn-on can typically be completed in one day and causes minimal, if any, disruption to the public. After system turn-on, Trafficware or an authorized representative will make adjustments on site or remotely for a period of two to three weeks.

SynchroGreen monitoring and configuration is performed by the system operator using the SynchroGreen Client Application. The SynchroGreen Client Application can be installed on PCs, laptops or tablets and allows the user to easily access all system functionality, settings, and databases. Trafficware will provide the agency with an unlimited number of Client Applications. The Client Application can be configured for different clients based on their designated clearances and permissions to control and monitor the adaptive signal network. Furthermore, client profiles can be customized based on the user’s preferences and can display different views, status screens, and reports. The SynchroGreen Client

Figure 4.

Figure 5.

Figure 6.
Application is important in a mission-critical environment, as it allows the agency to quickly monitor and control the system and ensure it is performing at optimal levels (Figure 7).

**Handling Pedestrians, Transit, Emergency Vehicles**

SynchroGreen handles pedestrian movements similar to time-of-day coordination and considers pedestrians within the default algorithm, without requiring additional modules. SynchroGreen will account for pedestrians and maintain synchronization, and will even account for pedestrian recalls and advanced functionality, such as “green delay” or “pedestrian delay” functions.

SynchroGreen handles transit signal priority (TSP) and preemption (rail, emergency, bus) the same way as it is handled during time-of-day coordination. When a TSP service request is received, local traffic controllers can modify SynchroGreen adaptive signal timings and can provide early or extended green. SynchroGreen will maintain synchronization and adaptive coordination during TSP operations. During preemption, SynchroGreen allows the subject intersection to service preempted phases and operate any track, dwell, and exit phases. During preemption, non-preempted intersections will remain under adaptive operations. After preemption, the subject intersection will resynchronize with SynchroGreen intersections within the group.

**Cost Estimates**

Typical SynchroGreen costs are usually between $10K–$17K per intersection. The cost to deploy a SynchroGreen project varies based upon the agency’s existing detection and traffic control infrastructure.

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**Contact Person for additional Information**

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**Summary**

If you have been following these articles, you have seen that a number of vendors are supplying various types of new adaptive traffic systems. One of the difficulties for the users is determining which works best in his situation.

The traditional ATCS, SCOOT, SCATS, RHODES, and others, have been studied in great length over the years — lots of material on operations, maintenance, and performance is available. I would call upon FHWA and the academic community to conduct similar analysis of these new systems and publish the results. Such information would provide the end-user with independent data to assist in the decision-making process regarding an ATCS and its suitability for their agency.

Something to think about!