Abstract

Every year, traffic congestion costs American motorists $166 billion in lost time, wasted fuel and increased greenhouse emissions. Expenses related to traffic accidents add another $242 billion to the negative impact of traffic. Traffic congestion is so pervasive that most motorists and transportation engineers consider it a necessary evil. In reality, recent advancements in traffic management technology prove to solve the problem of traffic congestion and substantially improve quality of life in communities. This paper illustrates how In|Sync, an adaptive traffic control system first released by Rhythm Engineering in 2008, uses artificial intelligence to optimize traffic signals at individual intersections and coordinate signals along arterial corridors to reduce traffic congestion. By reviewing the system’s main hardware and software components, its optimization methodologies and available add-on modules, this paper explains how In|Sync overlays existing traffic cabinets and controllers to enable traffic signals to intelligently and immediately adapt to real-time traffic demand. To illustrate the versatility and performance of In|Sync’s adaptive technology, three case studies of In|Sync deployments in different cities, each with a unique traffic control problem, are reviewed. These case studies reveal how In|Sync’s adaptive technology works in real-world scenarios to intelligently improve traffic flow, thus improving safety and travel time for motorists while also decreasing wasted fuel and harmful emissions. These case studies and other independent studies demonstrate that on average In|Sync reduces traffic stops by 60 percent, travel times by 24 percent, emissions by 23 percent and fuel consumption by at least 17 percent, resulting in significant and quantifiable economic savings for cities using the In|Sync system.
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Executive Summary

Every year, congestion and poor signal timing cost motorists and society-at-large billions of dollars in wasted fuel, lost time, traffic accidents and environmental damage. Between 70 and 90 percent of traffic signals in the U.S. use outdated technology, are poorly timed and cause unnecessary delays. Improving signal timing to better manage traffic congestion is integral to improving roadway safety. In 2018, there were 33,654 fatal accidents in the US\(^1\) with approximately 40% of the crashes occurring at intersections.\(^2\) More time spent idling at red lights or in stop-and-go traffic also means more emissions injected into the atmosphere. As a result, over half of all Americans live in communities with unhealthy levels of air pollution. Increased air pollution makes us sicker while also accelerating climate change. Thus, improving traffic signal timing can create significant safety, economic and social benefits.

Concerned with the number of fatalities resulting from traffic accidents, as well as the negative impacts of congestion on communities, Rhythm Engineering developed In|Sync, an adaptive traffic control system that uses artificial intelligence to optimize traffic signals in real-time. In|Sync measures traffic demand, then adapts in real-time by adjusting signal timing each second using global and local optimization logic to move traffic in the most efficient manner possible.
Today the In|Sync system is deployed by more traffic agencies than all other adaptive traffic control systems combined. The **In|Sync system has been selected for use on over 3000 intersections in 32 states.**

![Figure 1 – In|Sync deployments in the United States](image)

The essential components of the In|Sync system—integrated vehicle detection including cameras and/or radar technology, the In|Sync processor and the selected method of connecting to the controller through either detector cards or cabling—are 100 percent compatible with existing digital controllers, functioning as an overlay system that simply plugs into existing traffic cabinet hardware.
Typically installed on the mast arms of traffic signals, the IP digital cameras detect presence like traditional image detection cameras, but also measure occupancy, queue length and delay every second and communicate that information through an Ethernet connection to the In|Sync processor, which resides at the local traffic cabinet.

Based on information from the cameras showing the real-time traffic demands at the intersection, the In|Sync processor determines the priority of service for each approach. Because the In|Sync processor is a modern, digital state machine, thereby nonlinear and nonsequential, the system is able to serve traffic demand without being inhibited by predetermined cycles or green splits.

Connected to the traffic controller, the In|Sync processor at each second requests a green signal for the state that is most appropriate to serve by inputting the appropriate calls into the signal controller, which runs in free mode to allow for the acceptance of In|Sync’s detector calls.
In|Sync’s artificial intelligence consists of a local optimization algorithm for each intersection and global coordination between all the intersections on a corridor. The intelligent actuation and global coordination work in tandem to reduce stops and delay along the corridor.

Local refers to In|Sync’s activity at each individual intersection. At this level, In|Sync uses its local optimization algorithm to determine priority for each approach to immediately adapt to real-time vehicle demand. In|Sync then requests that the controller actuate the signal accordingly. Using the same algorithm, In|Sync decides in real-time how to serve minor movements – typically side streets and left turn lanes – so as to minimize delay at each approach.

Global refers to In|Sync’s synchronization of traffic signals at all the intersections on a given corridor. In|Sync coordinates signals to move traffic through the arterial at a desired rate, thus minimizing stops and congestion along the corridor. Keeping traffic flowing through a long series of intersections also frees up roadway capacity. The system schedules green tunnels in which arterial traffic experiences synchronized bands of green lights that progress groups, or platoons, of vehicles through the corridor. Once activating a green light, an intersection communicates with the other intersections along the corridor via an Ethernet connection to ensure the following intersections will also activate a green light as oncoming platoons approach. The adaptive characteristic of corridor progression is In|Sync’s ability to begin or end earlier the green time served to a platoon traveling in a tunnel.

In|Sync takes advantage of the gaps in time between passing platoons of vehicles traveling in the green tunnels. During these usable gaps, In|Sync’s local optimization algorithm moves traffic on the minor movements. This combination of intelligence allows for both prompt service on all approaches while guaranteeing progression on the main corridor.

Once Ethernet communication is established between intersections, In|Sync is configured and monitored through a user-friendly web interface using a standard browser such as Google Chrome, Mozilla Firefox or Internet Explorer. This allows the system to be monitored from any personal computer, smart phone, iPad or similar device with an Internet connection.
In|Sync can be enhanced and customized to local geographic and traffic conditions by integrating with any combination of our optional add-on modules—In|Sync:Fusion and the Pedestrian Module. In|Sync has built-in capabilities for smart cities and CV/AV environment. In|Sync integrates with In|Connect - a robust, future-proof connected vehicle and signal preemption system, based on Dedicated Short-Range Communication (DSRC) technology.

Independent studies conducted on various deployments throughout the U.S. indicate the real-world success and capability of In|Sync’s traffic optimization technology. Furthermore, these studies prove In|Sync can manage a wide range of corridor traffic issues.

In the current paper, we’ll discuss three case studies of In|Sync deployments, each of them depicting a single predominant traffic challenge of the corridor.

The city of Longmont, Colorado struggled with heavy congestion during the weekday peak morning and evening hours. In addition, several side street approaches had heavy demands throughout the day. CDOT and Longmont city staff established that they wanted to implement a better signal control system to continuously adjust to traffic conditions; to improve operations to reduce wasted costs in the form of travel time, delay, fuel consumption, and cost for staff; and to reduce the level of emissions produced by vehicles. Within days of its installation, In|Sync reduced peak-time traffic stops in Longmont by 41 percent and peak-time travel time by 22 percent. The significant reductions in wasted fuel, time and stops proved an equally significant economic benefit to the city of Longmont.

In Maricopa County, Arizona, In|Sync was deployed to mitigate congestion on Bell Road, the busiest arterial in the state. The corridor, being operated by four jurisdictional agencies, suffered from variable traffic patterns and high volumes. The project’s goals were to reduce recurring and non-recurring congestion on the corridor; to improve freeway and arterial operations; and to provide coordination across jurisdictions at key locations by adding adaptive capabilities to the existing signal system.
The independent study indicates that the In|Sync’s deployment resulted in a 51% reduction in driver delay during the weekdays which was translated into an increase in speed, fewer stops, and an overall reduction in travel time. In total, the study estimates that due to installing In|Sync on just thirteen signals along Bell Road, Maricopa experienced an economic benefit of $25.900 million per weekday in saved fuel, stops and time.

In Miami-Dade County, Florida, In|Sync was deployed to meet the increasing travel demand on SW 8th Street, one of the most traveled transportation corridors in the county. The study corridor experiences an average daily traffic (ADT) of more than 50,000 vehicles. In|Sync reduced daily travel time by 7.3% percent and driver delay by 11.8% percent on SW 8th Street. Some of the most significant results were recorded on the cross streets where the benefit from the In|Sync installation was most noticeable with 17.3% reduction in delay. The safety analysis also showed that the adaptive system reduced crash frequency on both the main street and the cross streets, reaching 9.7% on SW 8th Street.

In|Sync has seen success in optimizing traffic signals in a wide breadth of deployments, each with unique traffic demands and concerns. The aforementioned case studies are evidence of the real-world success of the In|Sync adaptive traffic control system. In its deployments nationwide, In|Sync has decreased travel time by 24 percent, fuel consumption by 17 percent and stops by 60 percent. More importantly, In|Sync has cut the crash rates by 23 percent, which prevents injuries, saves lives and creates better communities.

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<th>Reduction in Stops</th>
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In|Sync Adaptive Traffic Signal Technology
Traffic Congestion: The Cost of Complacency

Roadways across the United States are plagued by congestion. According to an article in The New Yorker, approximately “one out of every six American workers commutes more than forty-five minutes, each way.”³ Additionally, 3.5 million American workers commute 90 minutes or more.⁴ With the number of motorists on the road and the number of miles traveled increasing every year, congestion has become a national problem in the United States.

Of course, many of these heavily saturated roads rely on traffic signals to manage traffic. Yet 70-90 percent of traffic signals in the U.S. use outdated technology or are poorly timed and cause unnecessary delay. Day after day, Americans fight their way through an increasingly larger sea of vehicles and an abundance of red lights. Poor throughput and traffic control not only cause frustration for motorists and traffic professionals, but significantly diminish our quality of life, our health, and the wellbeing of our communities.

Congestion and poor traffic control costs individual motorists and American society-at-large millions of dollars in lost time, wasted fuel, environmental damage, and traffic accidents. In 2017, congestion costs American motorists $166 billion in wasted time and fuel.⁵ On an individual level, time wasted at traffic signals costs each motorist $1080 per year.⁶ Taking into consideration all transportation-related expenses, families now spend more money on transportation each year than they do on groceries.⁷

The fuel wasted idling at red lights or in stop-and-go traffic also increases harmful emissions in the atmosphere, increasing air pollution and accelerating climate change. Over half of all Americans now live in areas with unhealthy levels of air pollution.⁸ Furthermore, studies have shown that regular exposure to air pollution increases the occurrence of asthma, cancer, lung and cardiovascular diseases and the related fatalities from these illnesses.⁹

Poor signal timing and congestion also compromise roadway safety. Every year, there are over 30,000 traffic fatalities with approximately 40% of crashes occurring at intersections.¹⁰ According to AAA, car accidents cost the US population $299.5 billion annually, or more than $1,522 for every man, woman and child in the US.¹¹
Traffic Congestion: The Cost of Complacency

$299.5 Billion
Annual cost of traffic accidents

$166 Billion
Annual cost of traffic congestion

Clearly traffic congestion carries significant economic and social costs: less time with loved ones, lower quality of life, stress, frustration, road rage, increased air pollution and respiratory illnesses, paychecks that go to fueling and insuring our vehicles more than putting food on the table and accident-related expense, injuries and fatalities, to name a few of the negative consequences.

Yet traffic congestion has become so pervasive that most motorists and transportation engineers consider it a necessary evil. Saturated roads are thought to be the inevitable by-product of too many vehicles and too little capacity. The stop-and-go traffic that fosters rear-end accidents is viewed as a normal part of one’s daily commute and the chances of getting home quickly and safely by catching a series of green lights in a row is so rare that it’s considered lucky.

Traditional Traffic Control Methods and Drawbacks

Still, congestion isn’t necessary and motorists should not have to accept it as such. Signal synchronization can reduce the negative impacts of congestion. So, if the solution is available, why is it not implemented? The answer is simple: cost. Government agencies – especially today – are constantly battling finite and often contracting budgets.

To understand the context of the environment of In|Sync, a review of traditional signal synchronization is offered here. First, a summary of traditional signal control management methods is provided, and, second, a brief outline of the process required to time signals is described.
There are three ways to control traffic signals: actuated, pre-timed and semi-actuated. Actuated (or “fully actuated”) signals rely on sensors such as inductive loops or cameras to alert the traffic controller of the presence of at least one vehicle (or “demand for service”) in an approach. When the presence of vehicles waiting for a green light is detected, the controller will serve a green signal to the appropriate approach for a predetermined, fixed amount of time. While it is very responsive to demand, the shortcomings of this approach are that one vehicle is served as much green time as twenty vehicles which will likely either waste or underserve green time and there is no coordination between one signal and the next, so a motorist can literally stop at numerous contiguous signals.

Pre-timed signals do not rely on detecting the presence of traffic. The green time allotted to each approach is fixed, which can mean that a green signal is served to an empty approach or a lengthy approach queue is not cleared. This is the least desirable (and oldest) method of controlling signals.

The third method of controlling traffic signals is semi-actuated. The green light “rests” on the main (or busiest) street, and the green light cycles to the side streets and left turns when a sensor detects the presence of at least one vehicle. While this is the best method, it also has its drawbacks. Just like fully actuated signals, the sensors employed do not know how many vehicles are waiting, so too much or too little green time may be served. It is possible to coordinate a series of semi-actuated signals so they are synchronized and motorists can travel through multiple signals on green lights.

However, accomplishing synchronization is costly and temporary. The FHWA recommends corridors are re-timed every three years; in practice this is rarely the case. To understand the burden of timing signals, following is an outline of the signal timing process.

**Step 1.** Data collectors go to each intersection and they manually count the number of cars that go through each approach. Northbound left turn movement is an approach. Southbound through movement is another approach. Each approach may have multiple lanes. Counting is a two-person job. Normally, counts are collected during morning peak hours (7-9AM), noontime peak hour (11AM-1PM) and evening peak hours (4-6PM) on Tuesday, Wednesday and Friday. Mondays and Fridays are considered anomalies and data is not collected on those days. Thus, a two-person data collection team can collect data for 3 intersections at a maximum. 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 that 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, he/she can download from his/her office. 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 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 of over several days or weeks rectifying and tweaking the timing plans generated by the software model.

This four-step process is so tedious and resource consuming that between 70 and 90 percent of traffic signals in the United States are not synchronized. The National Transportation Operation Coalition grades the U.S. traffic signal operation a grade D.

Recent advancements in traffic management technology prove to solve the problem of traffic congestion and substantially improve quality of life in communities without the negative side effects of the traditional methods. Given congestion’s cost both in dollars and in lives, Americans must demand a higher standard of traffic management and safety.

Rhythm Engineering is a company founded on this imperative. The company’s mission is to be the global leader in delivering innovative traffic solutions that bring loved ones to their destination faster and more safely.
Concerned with the number of fatalities resulting from traffic accidents as well as congestion’s negative impact on communities, Rhythm Engineering developed In|Sync, an adaptive traffic control system that uses artificial intelligence to optimize traffic signals in real-time. In|Sync has been selected by dozens of state and local traffic agencies to intelligently optimize over 3000 intersections in the United States.

Independent studies reveal that In|Sync reduces stops by 60 percent, which in turn reduces fuel consumption by 17 percent and harmful emissions by 23 percent. Most importantly, this reduction in stops decreases the likelihood of traffic accidents, which saves lives and prevents injuries. The Lee’s Summit Police department reports a 17 percent crash reduction with the In|Sync system. The artificial intelligence employed by the In|Sync system saves lives, helps motorists get to their destinations safer and quicker and positively impacts communities.

"Rhythm Engineering’s mission is to bring loved ones to their destination safer and faster."
In|Sync: Solving Real-World Traffic Problems in Real-Time

When developing the In|Sync system, Rhythm Engineering used creative approaches and technologies that were new to the transportation engineering industry. The In|Sync research and development team drew upon advancements in artificial intelligence, electronics, sophisticated mapping systems and wireless communications instead of limiting themselves to the industry-accepted methodologies. For the first time in history, the revolution taking place in consumer electronics such as data digitalization, real-time information processing, customization, networking and web-based applications began to affect traffic engineering.

Nearly all traffic control systems today use digital hardware but remain constrained by analog thinking, such as fixed offsets, common cycle lengths and standardized allotment of green time, or splits. The In|Sync processor is instead a modern state machine, meaning it can dynamically choose which phases to serve and instantly adjust and coordinate service and green time. In|Sync is superior to predetermined signal timing plans which, at best, estimate traffic demand based on a small historical sampling and generalize those results across years of traffic signalization.

In|Sync relies on detection cameras or radar technology and artificial intelligence to move traffic in the most efficient manner possible. In effect, In|Sync makes decisions as a traffic engineer would: accepting inputs of actual traffic demand, determining phase priority based on occupancy and delay and anticipating and coordinating traffic along the entire corridor.

Installation and configuration of In|Sync

As an overlay system, In|Sync’s hardware components plug into existing traffic cabinet hardware. The system is Ethernet- and web-based, compatible with all cabinets and controllers and does not require removal or upgrades of any hardware or software.
Installation of the In|Sync system consists of installing cameras for each approach and a processor, equipment panel and method to transmit detection calls (such as cabling or detector cards) in each signal cabinet. Once cables are pulled from the camera location to the traffic cabinet, installation of the cameras and in-cabinet hardware typically requires about four hours per intersection. After the hardware is installed, the initial configuration of the system is performed by Rhythm in-house engineers. The time from an agency or contractor ordering the system to full operation is less than 90 days.

Customization is part of the initial configuration and an option that remains available to the local traffic engineers. Local engineers can determine permissible phase pairs and sequences, minimum green time, maximum delay thresholds and more. This allows the system to combine artificial intelligence with local engineers’ knowledge of motorist expectations, surrounding streets’ traffic needs, specific geometries, regulations and other considerations to efficiently manage traffic.
In|Sync’s Hardware and Software Components

The three main components of the In|Sync system are digital IP cameras for each approach, an In|Sync processor for each intersection and a method to transmit detection calls (such as specific cabling, SDLC interface or plug-in detector cards). Ancillary equipment includes cables, an Ethernet switch and an equipment panel, housing the power supply unit, a grounding block, surge protection, and a DIN relay.

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**In|Traffic**
Adaptive configuration settings for the corridor

**Vehicle Detection**
In|Sync video cameras or your preferred detectors, such as loops or radar

**Non-Standard Detection**
Adaptive configuration settings for the corridor

**In|Sync Processor**
Core of the adaptive system’s capabilities

**Equipment Panel**
Power and communications hub

**Connection Methods**
Choose one of the following:
- Detector Card
- Spade Cable
- C1 Y-Cable
- ABC Y-Cable
- SDLC Interface Module

**Optional Components**
- Monitor + Keyboard
- Ethernet Repeater
- DIN Relay

**Traffic Controller**
In|Sync is compatible with all major makes and models of modern traffic controllers
The digital IP cameras monitor the traffic at each of an intersection’s approaches. Installed in weatherproof or thermal warming enclosures usually on the mast arms of traffic signals, the cameras measure occupancy, queue length and delay for configured detection zones at each of an intersection’s approaches. Approaches generally have between fifteen and fifty detection zones depending on the depth of the field of view and number of lanes. Because there is no analog-to-digital conversion, the cameras instantly provide high-quality images. Furthermore, In|Sync’s cameras use pixel amplifying CMOS sensors, which guarantee faster light and noise processing for better quality and contrast of the image. Additional stabilization features of the cameras also enable moving images to be presented without distortion. The accuracy of the In|Sync cameras in detecting demand is at the leading edge of the video detection systems on the market.

Figure 3 – By measuring the quantity of occupancy and the waiting time of each vehicle in the presence zone, In|Sync serves green time commensurate with actual demand thus not wasting green time by over-serving an approach or reducing service levels by underserving an approach.
Every second, the cameras communicate the queue length and delay in each approach to the In|Sync processor via a local Ethernet connection. Unlike even the latest solid-state traffic controllers, the In|Sync processor is a nonlinear and non-sequential state machine, allowing the system to service demand without being inhibited by fixed rules. The processor resides in the traffic cabinet at each intersection and communicates to the signal controller through provided cabling, SDLC interface module or an In|Sync detector card. The In|Sync processor dynamically calls up states, or phase pairs, by evaluating queue length and delay information from the system’s cameras. The signal controller runs in free mode to allow for the acceptance of In|Sync’s calls, which the controller understands as concurrent phase pair detector calls. The processor places two concurrent, passive calls into the controller such that the controller responds to the single pair of calls. (The existing conflict monitor continues to operate as usual.)

Because the processors reside at the intersection and In|Sync does not depend on a central server to make decisions, the traffic controller can respond to local traffic issues immediately and efficiently. Additionally, the traffic cabinets at each of the corridor’s intersections are linked by Ethernet connection, allowing the network to communicate with each intersection and optimize traffic signals at multiple lights along the corridor. In|Sync’s bandwidth requirements are low enough so that the system is able to operate on wireless Ethernet and Ethernet-over-copper. Once Ethernet communication is established to the local intersections’ processors, In|Sync can be configured, monitored and managed using a standard web browser such as Google Chrome, Mozilla Firefox or Internet Explorer. Thus, the system can be monitored from any personal computer, laptop, smart phone, iPad, or similar device with an Internet connection. There is no need for software to be installed on a computer’s hardware for monitoring and there is no dependency on a central system for regular operation.

Each processor and camera has a unique IP address, allowing them to be remotely accessed for monitoring, troubleshooting and updating. The IP addresses can also be configured remotely.

All this complex network of In|Sync devices and features is orchestrated by In|Traffic – a configuration and device management tool. In|Traffic, a Windows-based configuration software, is available to give more control to the local traffic engineers. In|Traffic offers time-space diagram views, editing of progression protocols, geographic mapping of intersections, intersection groupings, dynamic phasing sequencing, and viewing and editing of other configuration settings.
In|Sync works at both the local and global level to mitigate traffic congestion on arterial roadways. In effect, In|Sync operates as “intelligently fully-actuated” intersections along with the best possible progression coordination along the entire corridor. By using green time in the most efficient manner, LOS (Level of Service) for all approaches can be increased.

In many ways, In|Sync’s optimization algorithm can be thought of as green time efficiency maximization, as it serves green time in a manner to move the most vehicles through an intersection inside a measurement of time. To move as many vehicles as possible, it is critical to not waste finite, nominal time on empty approaches, the yellow and amber signal times between phases or the time needed for vehicles to accelerate after stopping.

**Figure 4** – The In|Traffic software companion to In|Sync enables local traffic managers, such as engineers and technicians, to visualize the configuration of the In|Sync system and adjust it if needed.
Local Optimization

At each individual intersection, In|Sync optimizes signals by determining priority for each approach in immediate reaction to real-time vehicular and non-vehicular traffic demand and requesting that the controller serve concurrent phase pairs and sequences accordingly. The algorithm emulates the decisions a traffic engineer would make if she/he was standing at each intersection with full control of the signals. The In|Sync processor assigns priority to approaches based on the queue volume and the delay for each vehicle in the approach by counting time delay every 5 seconds, making it more intelligent than traditional fully actuated intersections. Unconstrained by cycles, In|Sync avoids transition and actuates a green light for those approaches with the highest priority while suppressing calls of a lesser priority. After the highest priority calls are satisfied, the algorithm then determines the next highest priorities and distributes green time accordingly.

In|Sync also decides in real-time how to serve side streets and left turn lanes so as to minimize delay for each as well as allow progression on the main arterial. The highest priority is the global optimization’s green tunnels (discussed later). After serving the main corridor progression, In|Sync’s local optimizer determines how to most efficiently distribute green time. Based on queue length and delay, In|Sync serves the approach with the greatest need. It then reassesses demand in real-time to service the approach that then has the greatest need.

In addition to actuating phases, In|Sync also adjusts green time according to queue volume and intersection geometry. If there is a low number of vehicles demanding service, less green time is allocated. By not serving green time to empty approaches and instead distributing time to those approaches with demand for service, all approaches benefit. By the same token, In|Sync can extend green time duration by going into phase recall, when there are still vehicles passing through the intersection on the active phase. This helps avoid spillback and red runners which ultimately results in enhanced safety for both drivers and pedestrians.

Global Coordination

Likewise, In|Sync coordinates signals along a corridor to move traffic through the arterial at a desired rate, thus minimizing stops and congestion along the corridor. The system schedules green tunnels in which arterial traffic experiences synchronized bands of green lights that progress platoons of vehicles through the corridor.
In|Sync Adaptive Traffic Signal Technology

In|Sync’s Hardware and Software Components

Upon activating a green light to commence a green tunnel, an intersection communicates with the other intersections along the corridor via an Ethernet connection to ensure the downstream intersections will also turn green as the traffic progression approaches. Because the vehicles arrive at green signals, green time is not wasted on standing and accelerating vehicles. Instead, a precise offset is used to move vehicles through the intersection at their traveling speed. More vehicles can travel through an intersection per second of green time, because green time is not spent on drivers reacting to the signal change and the low rate of travel associated with acceleration. This continual traffic movement eliminates dilemma zone risks and creates additional benefits, such as reducing fuel usage, emissions and circumstances conducive to traffic accidents.

Figure 5 – In|Sync schedules green tunnels to guarantee progression along the corridor. Each green tunnel’s duration can expand or contract based on real-time demand. As platoons of vehicles travel through the corridor, they arrive at each intersection to a green signal, thus not wasting time and fuel on stopping and accelerating.
InSync initiates green tunnels throughout the day; their frequency and duration are determined by traffic demand. As traffic needs change, InSync varies the bandwidth and frequency of green tunnels to best support traffic conditions. InSync can adapt to real-time traffic demands by beginning or ending a tunnel earlier or later at each intersection.

In the time between tunnels, InSync uses its local optimization algorithm to serve minor movements before the next platoon of vehicles moves through the intersection.

It is this ability to prioritize traffic movements at the local level, while also coordinating signals at the global level, which allows InSync to adapt to traffic demands in real-time and create a meaningful difference in stops and travel time for motorists. InSync is unique among all adaptive traffic control systems in that it is intelligently actuated, globally coordinated and completely compatible with existing equipment.

**System Operation and Maintenance**

Once installed, InSync can be controlling traffic within a week’s time. Typically, Rhythm Engineering and local traffic professionals spend 2-3 weeks tweaking the system, after which InSync immediately optimizes traffic. There are no timing plans to create and upload. Once installed and operational, the maintenance required to sustain InSync’s functionality is minimal, averaging around one hour of maintenance per month per intersection. Maintenance issues are typically minor and include adjusting camera angle, zoom and focus, as well as the occasional detection or fog zone adjustment. Maintenance is similar to that of video detection systems.

After configuration, operating the system is a passive activity. There is little or no ongoing configuration or alteration unless there is a significant and permanent change in traffic patterns or volume. Rhythm Engineering has seen evidence of corridors and motorist behaviors evolving with the introduction of better progression – prevailing speeds and volume tend to increase as motorists become aware of and accustomed to the improved progression and level of service. This may cause the need for a small investment of time to modify the configuration.
In|Sync has a failure mitigation plan that allows it to control traffic even when the system experiences some form of reduction in capability. When cameras are disabled by severe weather, such as fog or a lightning strike, In|Sync switches to fog mode or emergency mode (while the Controller is in Free mode) and accesses its historical optimization data collected from the previous four weeks of operation. Using this data, In|Sync determines the optimal way to move traffic through the corridor based on past demand. In addition, the system sends out email and SMS alerts to notify traffic professionals when the system has been compromised or damaged. Local staff can review the situation by looking at camera views and other settings in the In|Traffic management console remotely, through a standard web browser, rather than having to make an emergency trip to the troubled traffic signal or the traffic management center. In a worst-case-scenario, manual calls to controllers can be placed through the web interface.

In|Sync’s alert system and ability to make efficient, real-time traffic decisions negates the need to monitor traffic flow at specific intersections. With little need to monitor or perform maintenance on the In|Sync system, traffic professionals can dedicate their time and energy to other important projects.

The In|Traffic software companion to In|Sync empowers traffic engineers to create and force plans for special circumstances, such as event traffic (i.e. tens of thousands of vehicles exiting a sporting event) or even evacuation situations. These plans can be scheduled in advance or enacted within a few hours of notice.
In|Sync’s Hardware and Software Components

**Figure 7** – Local traffic engineers can schedule special plans to handle traffic anomalies.

**Key Functionality**

**Railroad Preemption**

To accommodate railroad crossings, In|Sync reverts to detection mode when a train approaches, allowing the signal controller to take over traffic control and maintain all programmed safety protocols. After the train passes, In|Sync continues running in detection mode while adaptive mode runs in the background. When detection and adaptive modes align, In|Sync switches back into adaptive mode and continues moving traffic according to its global and local optimization. Detection mode describes In|Sync’s activity as purely a detection device feeding calls into the controller and allowing the controller to determine phasing.

**Emergency Vehicle Preemption (EVP)**

In|Sync is configured to make way for any higher-priority calls that go directly into a controller, such as those for emergency vehicles. When a vehicle with preemption approaches an intersection, In|Sync switches from adaptive mode to detection mode to allow emergency vehicles to move through the intersection without interference.
After said vehicles have passed through the intersection, In|Sync runs in detection mode (see above) and allows the controller to cycle naturally until it aligns with adaptive mode. It then resumes adaptive traffic control seamlessly.

Add-On Modules

**In|Sync:Fusion**

In some instances, traffic professionals may wish to combine In|Sync’s video detection with other traffic detection methods to bring vehicle data collection and traffic movement to an unprecedented level of accuracy. In|Sync:Fusion allows the In|Sync system to work in tandem with existing inductive loop detection, radar, microwave and other detection methods to enhance data collection and make traffic management even more efficient. In|Sync:Fusion integrates the accuracy of physics-based detection of presence from devices such as inductive loops, radar or magnetometers. These devices are used in addition to In|Sync’s cameras that are still relied on to calculate occupancy. This “fused” approach virtually eliminates the possibility for false calls and overcomes limitations common to video detection systems, creating an adaptive traffic control system that is nearly 100% free of detection errors.

**Pedestrian Module**

In|Sync can optimize service to pedestrian traffic in conjunction with vehicular traffic. This is accomplished by integrating the Pedestrian Module, which is a hardware and software upgrade. In|Sync is then configured to incorporate pedestrian releases into its global coordination and local optimization plans. By coordinating pedestrian movements with vehicle traffic, the impact of pedestrian calls on vehicular service levels is minimized. For instance, one pedestrian would not disrupt the progression of dozens of vehicles traveling in a green tunnel. Instead, In|Sync would recognize the pedestrian call and wait until it can coordinate the pedestrian movement along with vehicular traffic.
In|Sync’s Hardware and Software Components

Figure 8 – In|Sync optimizes the movements of pedestrians along with traffic so pedestrian service does not interrupt the progression of what may be dozens of vehicles traveling in a platoon which will pass the intersection in just a few seconds.

In|Sync: Hawkeye

In|Sync: Hawkeye uses 3D-UHD Radar Technology for highly accurate vehicle detection. Its Automated Signal Performance Measures (ASPM) are a comprehensive solution for collecting and visualizing high-resolution data. This data helps traffic professionals manage traffic signals efficiently and proactively. The application is cost-effective and permits continuous monitoring of intersections using the highly accurate 3D-UHD radar technology without the need to add additional detectors.

The Hawkeye radar technology delivers nearly 100% vehicle detection accuracy while introducing a new universe of data granularity through a powerful reporting and visualization module. The Hawkeye ASPM features delay and advanced queue reporting, vehicle speeds, volume, and other relevant metrics that help traffic practitioners in providing a safer and improved travel experience to motorists.
The ASPM data intelligence module gives traffic professionals the power to efficiently observe travel patterns, bottlenecks, and other traffic issues. The data capture rate has a very high resolution. The data feed is processed instantaneously, enabling traffic engineers to analyze and optimize traffic signals in real-time and make their transportation infrastructure safer and more efficient.

Figure 9 – Hawkeye ASPM is a comprehensive solution for collecting and visualizing high-resolution traffic data.

The Hawkeye Automated Signal Performance Measures module provides advanced data visualization per lane, movement, phase, approach or per intersection for arrivals, volume, delay, LOS, and others.
In|Sync in the Real World: Three Case Studies

Independent studies throughout the nation confirm that In|Sync has a lasting impact on the lives of the communities where it’s deployed. These studies illustrate that the real-time adaptive traffic technology employed by In|Sync can reduce congestion and provide significant safety and economic benefits for motorists and traffic agencies. Because In|Sync makes moment-to-moment decisions about how best to serve traffic in real-time, the system is able to adapt to the unique traffic demands of each corridor to provide optimal travel conditions for motorists.

In|Sync’s adaptability and the power of its artificial intelligence technology are evidenced by its successful deployments in varying climates, geometries, city sizes, traffic cultures and traffic agency philosophies. The following three case studies demonstrate In|Sync’s ability to adjust to unique traffic demands in real-time to reduce stops, reduce travel time, increase motorist safety and decrease the economic and environmental costs of congestion to cities.

Traffic Engineering Challenge #1: Reducing Congestion on a Corridor with Rural and Urban Characteristics to Create a Greener Environment

Figure 10 – Schematic of the synchronized corridor along SH 119, Longmont, CO
Rather than using traditional time-of-day coordinated signal timing plans to improve their signal timing and traffic flow challenges, The City of Longmont, Colorado decided to use innovative new technology — the In|Sync adaptive traffic control system. Based on previous successful deployments of In|Sync along the 10th Street in Greeley, Colorado and the U.S. Highway 85, Colorado DOT staff chose the same adaptive system on 13 signals along SH 119 to reduce congestion and maximize benefits of signal timing.

The traffic on the corridor caters to local traffic, visitors, pass-through trips, and shopping center visitors. The corridor provides direct access to most of the major North-South arterials serving the area, the downtown central business district, and residential areas located directly adjacent to the highway.

The City of Longmont hired an independent engineering firm, Atkins North America, Inc, to collect before-and-after data on the intersections on which In|Sync was deployed.

**The Benefits of In|Sync**

Following its installation on 13 signals along SH 119, In|Sync reduced driver delay by 52%, traffic stops by 41 percent, and travel time for motorists by 22 percent. The stop reductions and improvements in travel time seen on this individual corridor reflect similar positive results deriving from In|Sync’s previous deployments in Colorado. By reducing stops and improving traffic flow, In|Sync creates significant reductions in traffic accidents as well as in wasted time and fuel for motorists passing through Longmont. Accordingly, the reductions in wasted fuel and time, as well as the reduction in stops, created an equally significant economic benefit to the city of Longmont. All of this was also translated into 5% reduction in pollutant emissions and 6% reduction in greenhouse gases.

Larry Haas, a Traffic Operations Engineer at Colorado DOT, says that the city was so impressed with the In|Sync technology, they will be installing the adaptive system on other roads within the city. “Our primary goal was to reduce congestion and gain efficiency of traffic flow. With the installation of In|Sync on SH 119 and US 287, we see significant reduction in travel time and delay. We experience smoothly flowing traffic and the best part is that we have fewer public complaints.”
Traffic Engineering Challenge #2: Managing Seasonal Traffic and Special Events

Over four million residents call Maricopa County, Arizona home and travel its roads daily. As the fourth-most populous county in the United States, Maricopa County is well familiar with the traditional approaches to signal timing strategies. Aiming to reduce recurring and non-recurring congestion on Bell Road and to improve freeway and arterial operations, the county decided to implement an adaptive system. In a multi-jurisdictional project, Maricopa deployed the In|Sync adaptive traffic control system on 13 intersections along Bell Road’s 99th Avenue to 73rd.

The project area straddles the Bell Road interchange with State Route 101 Loop (SR 101L), and has 3 signals operated by MCDOT, 4 operated by the City of Peoria, 1 operated by ADOT, and 5 operated by the City of Glendale. Between 99th and 73rd Avenue, the road covers the cities of Peoria and Glendale.
In|Sync in the Real World: Three Case Studies

The Arrowhead Mall and the Peoria Sports Complex positioned near the 13 signalized intersections created intense traffic volumes and the existing traffic management system could not adequately address the traffic conditions during special events. Heavy congestion on the arterial was a regular occurrence as a result of the inability to clear queues during peak travel periods.

An independent evaluation study prepared by AECOM provides a comprehensive comparison of the before and after traffic conditions on the 13 intersections on which In|Sync was installed.

The Benefits of In|Sync

According to the aforementioned study, the system accomplished both goals. In|Sync reduced weekday driver delay on Bell Road by 51 percent and increased speed by up to 10 percent. Travel time was reduced by an average of 11.5 percent on weekdays. Additionally, the reductions in fuel consumption, stops, and travel time were translated into significant economic benefits with daily user savings of up to $25,900.

April Wire, Maricopa County DOT’s Arterial Operations Program Manager, commented on the noticeable reduction in travel time and stops along the corridor, saying, “Rhythm Engineering has helped our region bridge the gap for improving signal coordination across jurisdictional boundaries when there are fluctuations in traffic conditions. They have provided great technical support for all of our regional partners ensuring the operations of our regional adaptive signal control technology system stay effective now and into the future.”

-11.5% ON WEEKDAYS
Reduction in Travel Time

10% ON WEEKDAYS
Increase in Average Speed

-16.7% SPECIAL EVENTS
Reduction in Delay

-51% ON WEEKDAYS
Reduction in Delay
Traffic Engineering Challenge #3: Oversaturated Urban Corridor and Cross Streets with Heavy Traffic Demand

The Florida Department of Transportation (FDOT) District 6 in cooperation with Miami-Dade County is dedicated to improving the efficiency and safety of SW 8th Street, a major east-west travel corridor in Miami-Dade County, Florida. Aiming to enhance safety, mobility and to address the increasing traffic demand, the county deployed the In|Sync adaptive traffic control system at 30 intersections along SW 8th Street, between SW 67th Avenue and SW 142nd Avenue.

Because SW 8th Street is one of the county’s main thoroughfares and serves both pass-through and residential traffic, the corridor experiences high traffic volumes at all times of the day, averaging 51,288 vehicles per day. Additionally, heavy daily traffic also travels along the corridor’s side streets, making it difficult to efficiently move traffic through the arterials’ common intersections.

Aiming to improve the efficiency of traffic operations on SW 8th Street, to use sustainable signal technology to minimize congestion, and to increase throughput where possible without compromising safety for all users, Miami-Dade County chose to install In|Sync. The results of the technology’s installation at the 30 signalized intersections along the corridor were measured and analyzed in an independent evaluation study by the Florida International University.
The Benefits of In|Sync

One of the main takeaways of the analysis illustrated that In|Sync’s artificial intelligence technology allowed the system to advance traffic along the arterial while also better serving the side streets and left turns. The eastbound and westbound left-turn movements are now able to consistently and completely clear their queues under In|Sync’s management.

All data sources report that In|Sync achieved substantial improvement in the travel time on SW 8th Street and significantly reduced cross street delays in terms of vehicles per hour (veh/hr), which translated into an increase in the overall corridor throughput of about 6 percent throughput improvement.

In|Sync reduced main street travel time by 7.3 percent and main street delay by 11.8 percent, according to the performance study conducted by Florida International University. Additionally, the average cross street driver delay was cut by 17.3 percent. All of this resulted in a safer traffic environment with crashes on the main street reducing by 9.7 percent. In total, the independent study estimates that In|Sync’s benefit to cost ratio to Miami-Dade County, Florida is 6:1. 15

-19.7% EASTBOUND
-28.5% WESTBOUND
** Reduction in Time in Congestion**

-7.3% Reduction in Travel Time

-11.8% Reduction in Delay

-9.7% Reduction in Crashes*

* The safety of the corridor has been assessed over a longer period of time, combining the before and after conditions of Phase I with those of Phase II.

** Based on HERE data during the PM peak.
Conclusion

The In|Sync system from Rhythm Engineering represents progressive technology that delivers profound results with minimal costs. By employing artificial intelligence to emulate the decisions a traffic engineer would make, the system approaches traffic management in a revolutionary way.

In|Sync’s real-time adaptive traffic control system provides significant benefit to motorists and transportation agencies as a solution to a number of congestion causes on arterial roadways. In its deployments nationwide, In|Sync has decreased travel time by 24 percent, fuel consumption by 17 percent and stops by 60 percent. More importantly, In|Sync has reduced crashes by 23 percent, making roadways safer for motorists and pedestrians alike. Reductions in travel time and delay have also saved motorists and cities millions of dollars by cutting down on the fuel and time wasted at poorly timed traffic signals.

Cities, traffic agencies, citizens and motorists all benefit substantially from an investment in In|Sync.
References


4 Ibid.


6 Ibid.


We trust that the information here is helpful and if you have any further questions or require further support please don’t hesitate to reach out to us at:

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