InSync Adaptive Traffic Signal Technology:
Real-Time Artificial Intelligence Delivering Real-World Results

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and Chris Gregory
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Abstract

Every year, traffic congestion costs American motorists $115 billion in lost time, wasted fuel and increased greenhouse emissions. On top of this, more than 30,000 people die in traffic accidents in the U.S. each year, and accident-related expenses add another $164.2 billion to traffic’s negative impact. Traffic congestion and dangerous roadways have become so common that most motorists and transportation engineers have grown accustomed to these grim conditions. Yet recent advancements in traffic management technology prove to solve the problem of traffic congestion and substantially improve both roadway safety and quality of life in communities. This paper illustrates how InSync, 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 InSync overlays existing traffic cabinets, controllers and detection devices to enable traffic signals to intelligently and immediately adapt to real-time traffic demand. To illustrate the versatility and performance of InSync’s adaptive technology, four case studies of InSync deployments in different cities, each with a unique traffic control problem, are reviewed. These case studies reveal how InSync’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 InSync reduces traffic stops by 60 to 90 percent, travel times by as much as 50 percent, fuel consumption and emissions by 20 to 30 percent, and accidents by 17 to 30 percent, resulting in significant and quantifiable economic savings for cities using the InSync system.

Mission of Rhythm Engineering

Rhythm Engineering empowers traffic professionals to save lives, save time and save the environment through cost-effective, innovative traffic solutions.

InSync is protected by U.S. Patent Nos. 8,050,854 and 8,103,436, and other patents-pending.
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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. For the last several years there were at least 30,000 traffic fatalities each year with approximately 40 percent of crashes occurring at intersections. 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 InSync, an adaptive traffic control system that uses artificial intelligence to optimize traffic signals in real-time. InSync 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 InSync system is deployed by more traffic agencies than any other adaptive traffic control system. The InSync system is selected for use in over 600 intersections in 18 states.
InSync is 100-percent compatible with modern traffic controllers, cabinets and detection devices. The system is available with different detector options—provided video cameras (InSync), integration with existing detection devices (InSync:Tesla), or a combination of multiple detection types (InSync:Fusion)—depending upon the traffic agency’s preference. In all configurations, the InSync system includes basic hardware and software components such as the InSync processor and a controller-appropriate connection that seamlessly overlay and plug into existing traffic cabinet hardware.

InSync installations that include Rhythm Engineering’s proprietary video detection use digital Internet protocol (IP) cameras for each approach at an intersection. 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 InSync processor, which resides at the local traffic cabinet. Based on information from the detectors showing the real-time traffic demands at the intersection, the InSync processor determines the priority for service for each approach. Because the InSync 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 InSync processor 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 InSync’s detector calls.

InSync’s artificial intelligence is comprised 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 InSync’s activity at each individual intersection. At this level, InSync uses its local optimization algorithm to determine priority for each approach to immediately adapt to real-time traffic demand. InSync then requests the controller actuate the signal accordingly. Using the same algorithm, InSync decides in real-time how to serve all movements – through-traffic on the main corridor, side streets and left turn lanes – so as to minimize delay at each approach. At each intersection, InSync adapts signalization to demand in three different ways: in its phasing, green time allocation and sequencing. Each of these signal control variables adapts to actual demand based on the system’s artificial intelligence.

Global refers to InSync’s synchronization of traffic signals at all the intersections on a given corridor. InSync 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. Tunnel duration, which is the ability to begin or end earlier the green time served to a platoon, is another adaptive quality of InSync. If so configured, InSync can dynamically generate tunnels.

InSync takes advantage of the gaps in time between passing platoons of vehicles traveling in the green tunnels. During these usable gaps, InSync’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, InSync is configured and monitored through a user-friendly web interface using a standard browser such as Internet Explorer, Firefox, Chrome and others. This allows the system to be monitored from any personal computer, smart phone, tablet or similar device with an Internet connection.

InSync can be enhanced and customized to local geographic and traffic conditions by using existing detection devices (InSync: Tesla), a combination of multiple detection types (InSync:Fusion) or integrating with the Intercept Module which accommodates non-standard detection such as pedestrian traffic, railroad crossings, transit system priority and emergency vehicle preemption.

Independent studies conducted on various deployments throughout the U.S. indicate the real-world success and capability of InSync’s traffic optimization technology. Furthermore, these studies prove InSync can manage a wide range of corridor traffic issues.
The City of Grapevine, Texas, located in the Dallas-Ft. Worth area, struggled with variable traffic flow resulting from freeway incidents and construction, as well as event traffic. Although the city has 50,000 residents, 300,000 vehicles travel through it on an average weekday. Within days of its installation, InSync reduced peak-time traffic stops in Grapevine by up to 63 percent and decreased peak-time travel time by up to 42 percent. The significant reductions in wasted fuel, time and stops created an equally significant economic benefit to the city of Grapevine.

In Upper Merion Township, Pennsylvania, a suburb of Philadelphia, the Pennsylvania Department of Transportation deployed InSync to mitigate congestion on the corridor adjacent to the King of Prussia Mall. The corridor suffered from variable traffic patterns and high volumes. Under the previous closed loop system, the northbound and southbound left turn lanes were unable to clear their queues the majority of the time, leaving motorists waiting through several cycles. The independent study conducted indicates after InSync’s deployment, each of the movements were able to completely clear their respective queues during each signal phase. Not only was service improved for these minor movements, but InSync reduced stops and travel time on the main corridor up to 44 percent and increased average speed by up to 79 percent in peak times.

In Evans, Georgia, InSync was deployed to coordinate intersecting arterials: Washington Road, a one-mile long corridor and North Belair Road, another major arterial. InSync was installed at ten intersections on these two corridors. Washington Road experiences an average daily traffic (ADT) of more than 40,000 vehicles. An average of 41,000 vehicles travel North Belair Road daily, making it difficult to efficiently move traffic through the arterials’ common intersection. InSync reduced peak-time travel time by up to 48 percent and stops by up to 100 percent on Washington Road. Average speeds on the arterial increased by up to 93 percent. In total, the study estimates that due to installing InSync on just the five-signal Washington road corridor, Evans experiences an economic benefit of $2.6 million per year in saved fuel, stops and time.

The City of Salinas, California, installed InSync at five intersections to manage the combination of high pedestrian and vehicular traffic along Main Street. Prior to InSync’s installation, the corridor was running in free mode, delivering green time based solely on the presence of traffic. With no coordination, the corridor’s traffic control system consistently disrupted traffic flow to serve pedestrian movements, exacerbating congestion along the corridor. InSync reduced peak-time stops by up to 91 percent, delay by up to 89 percent and travel time by up to 46 percent.

InSync is successful 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 InSync adaptive traffic control system. In its deployments nationwide, InSync has decreased travel time by up to 50 percent, fuel consumption by up to 32 percent and stops by up to 90 percent. More importantly, InSync has reduced crashes by 17-30 percent, which prevents injuries, saves lives and creates better communities.
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.”1 Additionally, 3.5 million American workers commute 90 minutes or more.2 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 congested roads rely on traffic signals to manage traffic. Yet 70-90 percent of traffic signals in the U.S. use outdated technology, 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. Congestion and poor 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 2009, congestion cost American motorists $115 billion in wasted time and fuel.3 On an individual level, time wasted at traffic signals costs each motorist $808 per year.4 Taking into consideration all transportation-related expenses, families now spend more money on transportation each year than they do on groceries.5

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.6 Furthermore, studies show that regular exposure to air pollution increases the occurrence of asthma, cancer, lung and cardiovascular diseases and the related fatalities from these illnesses.7

Poor signal timing and congestion also compromise roadway safety. Every year, there are 30,000 traffic fatalities with approximately 40 percent of all crashes occurring at intersections.8 According to AAA, car accidents cost the U.S. population $164.2 billion annually, or more than $540 for every man, woman and child in the U.S.9 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 is so pervasive that most motorists and transportation engineers consider it a necessary evil. Saturated roads are thought to be the unsolvable result 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 chance of getting home quickly and safely by catching a series of green lights in a row is so rare that it's considered luck.

**Traditional Traffic Control Methods and Drawbacks**

But 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 InSync, 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 the appropriate approach a green signal but only serves signals in a predetermined sequence regardless of the distribution of demand across the various approaches. While a coordinated series of actuated signals is the best traditional method of progressing traffic along an arterial, many actuated signals are not coordinated with their adjacent 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. 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. Because timed and semi-actuated timing plans are fixed, they are unable to adequately respond to varying traffic conditions.

The U.S. Federal Highway Administration 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 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 Thursday. 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 up to three intersections each day. 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/she 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 load from his/her office. The less fortunate have to
go out in the field to each controller and manually load 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. Creating traffic timing plans
relies on the Webster Equation. However the equation is flawed in that it assumes uniform arrival of
the queue, when in actuality cars arrive randomly. The engineer has to spend countless hours 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 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

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a company founded on this imperative. Concerned with the number of fatalities resulting from traffic
accidents as well as congestion’s negative impact on communities, Rhythm Engineering developed
InSync, an adaptive traffic control system that uses artificial intelligence to optimize traffic signals
in real-time. InSync has been selected by dozens of state and local traffic agencies to intelligently
optimize over 600 intersections in the United States.
Independent studies reveal that InSync reduces stops by up to 90 percent, which in turn can reduce fuel consumption by up to 25 percent and harmful emissions by up to 30 percent. Most importantly, this reduction in stops decreases the likelihood of traffic accidents, which saves lives and prevents injuries. The City of Springdale, Arkansas reported InSync is responsible for a 30 percent crash reduction, the City of Topeka, Kansas reported a 27 percent crash reduction, and the City of Lee’s Summit, Missouri reported a 17 percent crash reduction. The artificial intelligence InSync employs saves lives, helps motorists get to their destinations quicker and more safely and positively impacts communities.

**InSync: Solving Real-World Traffic Problems in Real-Time**

When developing the InSync system, Rhythm Engineering used creative approaches and technologies that were new to the transportation engineering industry. The InSync 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 InSync 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. InSync 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.

InSync relies on detectors and artificial intelligence to move traffic in the most efficient manner possible. In effect, InSync 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. This complex decision-making process happens instantly, constantly and in real-time, as the system adapts moment by moment to actual demand on the road.

Rather than changing signalization in future cycles or "cycle by cycle," InSync’s adaptability to demand happens intra-phase; even the current phase being served is lengthened or shortened based on the presence or absence of vehicles.

**Installation and Configuration of InSync**

As an overlay system, InSync’s hardware components plug into existing traffic cabinet hardware. The system is Ethernet- and web-based, compatible with all modern controllers, cabinets and detection devices and does not require removal or upgrades of any hardware or software.

Installation of the InSync system consists of installing in each cabinet a processor, equipment panel and method to transmit detection calls (such as cabling or detector cards). If InSync’s video detection is used, installation also includes installing cameras for each approach. If existing detection methods are preferred (InSync:Tesla), Rhythm Engineering will integrate these inputs with the adaptive system. Once cables are pulled from the camera locations 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 Engineering 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.

Depending on the options chosen by the deploying agency and other factors, the total product cost for InSync (not including installation and communications) usually falls within $25,000 to $35,000 per intersection. All sales include two years of warranty, support and upgrades. Extended support plans are available.
InSync is available in three detector options to best accommodate the transportation agency’s preferred detection methods.

- **InSync** uses Rhythm Engineering’s proprietary video detection (up to four IP cameras per intersection are included in the base system).
- **InSync:Tesla** uses existing or preferred detection devices such as inductive loops, radar, magnetometers, microwave or other video cameras.
- Finally, **InSync:Fusion** combines multiple detection sources. Fusing together data from Rhythm Engineering’s video detection cameras and existing detectors gives InSync unparalleled detection accuracy which can improve adaptive operations.

(See “Detector and Input Options” for more information on how InSync:Tesla and InSync:Fusion differ from the base system.)
The three main components of the standard InSync system are digital IP cameras for each approach, an InSync processor for each intersection and a method to transmit detection calls (such as specific cabling or plug-in detector cards). Ancillary equipment includes cables, a networking switch and an equipment panel.

InSync:Fusion 330s-Style Cabinet
The digital IP cameras monitor the traffic at each of an intersection’s approaches. Installed in weatherproof enclosures usually on the mast arms of traffic signals, the cameras measure occupancy, queue length and delay for configured detection zones. Approaches generally have between ten and thirty 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, InSync’s cameras use progressive CMOS scan sensors, which enable moving images to be presented without distortion. The accuracy of the InSync cameras in detecting the presence of demand is competitive with other major video detection systems on the market.

By measuring the percentage of occupancy in each detection zone, InSync serves green time commensurate with actual demand thus not wasting green time by overserving 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 InSync processor via a local Ethernet connection. Unlike even the latest solid-state traffic controllers, the InSync processor is a nonlinear and nonsequential 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 or an InSync detector card. The InSync 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 InSync’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.)
InSync dynamically serves phase pairs based on demand without the constraints associated with a cycle, dial or fixed sequencing. By immediately adapting the signalization to actual traffic conditions, InSync does not suffer the effects of transition associated with standard traffic control devices. There is no cycle for the system to align with, and there are no timing plans to switch between.

Because the processors reside at the intersection and InSync does not depend on a central server to make decisions, the traffic controller can respond to 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. InSync’s bandwidth requirements are low enough that the system is able to operate on Ethernet-over-copper, wireless Ethernet and Ethernet-over-fiber. Once Ethernet communication is established to the local intersections’ processors, InSync can be configured, monitored and managed using a standard web browser such as Internet Explorer or Firefox. Thus, the system can be monitored from any personal computer, smart phone, tablet, or similar device with an Internet connection. There is no need for software to be installed on a computer’s hardware for monitoring, no ongoing licenses to obtain and no dependency on a central system for regular operation.

CentralSync, the software companion to InSync, is a Windows-based corridor configuration program that gives control to the local traffic engineers if desired. The software enables engineers to easily and quickly create and modify a number of traffic management variables and strategies using a Google Maps-based interface of their adaptive corridors.

CentralSync’s features include time-space diagram views, editing of progression protocols, geographic mapping of intersections, adjustments to phasing, and viewing and editing of other configuration settings. Modifications can be uploaded and downloaded remotely by the operator.

The CentralSync software companion to InSync enables local traffic managers, such as engineers and technicians, to visualize the configuration of the InSync system and adjust it if needed.
InSync works at both the local and global level to mitigate traffic congestion on arterial roadways and high-demand roadways of a grid geometry. In effect, InSync operates as “intelligently fully-actuated” intersections paired with the best possible progression coordination along the entire corridor. By using green time in the most efficient manner, level of service for all approaches can be increased.

In many ways, InSync’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.

Local Optimization: Intelligent Actuation

InSync has three different adaptive characteristics at the local intersection. The system can adapt its phasing, green time allocation and sequencing. InSync’s flexibility with each of these signal control variables enables the system to adapt to actual demand.

Phasing – At each individual intersection, InSync 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 were standing at each intersection with full control of the signals. The InSync processor assigns priority to approaches based on the queue volume and the delay for each vehicle in the approach, making it more intelligent than traditional fully actuated intersections. Unconstrained by cycles, InSync then 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 next highest priorities and distributes green time accordingly.

InSync 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, InSync’s local optimizer determines how to most efficiently distribute green time. Based on queue length and delay, InSync serves the approach with the greatest need. It then reassesses demand in real-time to service the approach that then has the greatest need. It not only detects demand in real-time, it adjusts signalization in real-time.

Green time allocation – In addition to actuating phases, InSync 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.

Sequencing – The third parameter that InSync adjusts to adapt to actual traffic demand is sequencing. The local traffic engineer can select allowable sequences using CentralSync. InSync draws from the available sequences but can skip a particular phase pair in the sequence whenever there is no demand for service. This provides the best possible use of green time for vehicles waiting at or approaching the intersection.
Global Coordination: Ensuring Progression

Likewise, InSync 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 based on demand. In these tunnels, arterial traffic experiences synchronized bands of green lights that progress platoons of vehicles through the corridor. Upon activating a green light to commence a green tunnel, InSync 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 to green signals, green time is not wasted on standing and accelerating vehicles. Instead, green time 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 creates additional benefits, such as reducing fuel usage, emissions and circumstances conducive to traffic accidents.

InSync initiates green tunnels throughout the day; their frequency and duration are determined by traffic demand. As traffic needs change, InSync varies the duration and frequency of green

Based on demand, InSync 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.
tunnels to best support traffic conditions. InSync’s flexibility with these two variables, tunnel duration and period length, when added to the three adaptive variables used for local optimization, total five different ways in which InSync is adaptive. InSync can adapt to real-time traffic demands by beginning or ending green time earlier or later at each intersection. InSync has the option of enabling the dynamic commencement of green tunnels.

In the periods between green 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**

Typically, Rhythm Engineering project engineers, using input from local traffic professionals, spend 2-3 weeks configuring the adaptive intersections using an in-house simulator before the equipment is fully installed. Once installed, turned on and switched into adaptive mode, InSync immediately optimizes traffic. There are no timing plans to create and upload.

Installing InSync can take as little as a single day in the case of InSync:Tesla, or less than a week with InSync or InSync:Fusion. In either case, installation requires minimal time and is supported by Rhythm Engineering’s on-site installation training.

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 zone adjustment. Maintenance is similar to that of standard video detection systems.

Because InSync is driven by rich data, the data collected can also be analyzed for trends. Data for volume, delay and level of service can be viewed for any timeframe with a few clicks.
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.

Failure Mitigation Mechanisms

InSync has a failure mitigation plan that allows it to control traffic even when the system experiences some form of reduction in operation.

When cameras are disabled by severe weather, such as fog or a lightning strike, InSync accesses its historical optimization data collected from the previous four weeks of operation. Using this data, InSync determines the optimal way to move traffic through the corridor based on past demand.

If communications are interrupted or lost, InSync continues both its local and global optimization. Delay will continue to be minimized at each individual intersection and scheduled green tunnels will continue uninterrupted.

In case of power failure, communications failure or any other unusual activity detected, InSync attempts to send 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 through a standard web browser, rather than having to make an emergency trip to the troubled traffic signal or the traffic management center. The InSync system can revert back to a timing plan programmed in the local controller. In a worst-case-scenario, manual calls to controllers can be placed through the web interface.

CentralSync empowers agencies to create alerts and alarms. The system sends emails and/or SMS to the proper personnel when triggered by the specified events. The alerts can be configured by time-of-day, day-of-week and other conditions.
InSync’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 InSync system, traffic professionals can dedicate their time and energy to other important projects.

The CentralSync software companion to InSync 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 minutes.

Detector and Input Options

InSync

The standard InSync system uses Rhythm Engineering’s proprietary video detection. Up to four digital IP cameras per intersection are included in the base system. The cameras detect and measure traffic demand and allow remote monitoring from any web browser. InSync offers great value because it is comparable to the price of video detection alone, but includes both video detection and adaptive traffic control. The system is compatible with all traffic controllers and cabinets.

InSync:Tesla

Traffic professionals desiring to achieve InSync’s adaptive results using their own detection devices will find their needs best met by InSync:Tesla. This detector option enables traffic agencies to quickly and easily access the benefits of InSync by simply integrating their existing detectors with the adaptive system. InSync:Tesla works with all forms of detection including inductive loops, radar, microwave, magnetometers and other video detection systems, as long as stop-bar detection is provided in each lane.

Rather than four video detection cameras, InSync:Tesla includes one panomorph 360-degree camera per intersection for remote monitoring. Since there is no need to install new detectors, InSync:Tesla installs along an entire corridor in only days or hours. This option lets the traffic agency switch their busy signalized intersections to adaptive traffic control in as little as just one day, a clear break with the time-consuming, labor-intensive legacy systems of the past.

InSync:Fusion

InSync:Fusion allows traffic professionals to combine InSync’s video detection with other traffic detection methods to bring detection of presence to an unprecedented level of accuracy. This detector option works in tandem with existing inductive loop detection, radar, microwave and other detection methods to enhance data collection and make traffic management even more efficient. This “fused” approach virtually eliminates the possibility for false calls and overcomes limitations common to video detection systems. This detection redundancy also means that if one detection method fails, the intersections can rely on the other detection method. The result is an adaptive traffic control system that is nearly 100 percent free of detection errors.
Detector and Input Options

InSync: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 InSync’s cameras that are still relied on to calculate occupancy.

Intercept Module

Of course, vehicular traffic is not the only kind of traffic that must be accommodated at signalized intersections. InSync can accommodate other types of traffic needs and special situations using the Intercept Module.

The Intercept Module is a system add-on (consisting of both hardware and software) that allows InSync to intercept and temporarily hold inputs from non-standard detection such as pedestrian push buttons, trains approaching at railroad crossings, transit system priority and emergency vehicle preemption. Depending upon the type of input and how the system is configured, InSync can hold the call for service until the best time or serve it immediately before returning to InSync’s optimization of vehicular traffic.

In the case of pedestrian push buttons, the Intercept Module minimizes the impact of pedestrian calls on vehicular service levels. InSync 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. Instead, InSync intercepts the pedestrian call and waits until it can coordinate the pedestrian movement along with vehicular traffic. In most cases, this creates no noticeable difference for the pedestrian.

The Intercept Module can also be configured for corridors that intersect with or are affected by nearby railroads. To accommodate railroad crossings, InSync 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, InSync continues running in detection mode while adaptive
mode runs in the background. When detection and adaptive modes align, InSync switches back into adaptive mode and continues moving traffic according to its global and local optimization. Detection mode describes InSync’s activity as purely a detection device feeding calls into the controller and allowing the controller to determine phasing. Recovery of traffic conditions is the same as described in the following section.

Finally, the Intercept Module can also be used 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, InSync switches from adaptive mode to detection mode to allow emergency vehicles to move through the intersection without interference. After the emergency vehicles have passed through the intersection, InSync 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. Because InSync recognizes the actual demand at the intersection, it very rapidly resolves traffic conditions historically associated with transition. With InSync, the intersection conditions return to “normal” in seconds instead of minutes.
InSync in the Real World: Four Case Studies

Matt Selinger and Luke Schmidt of HDR, Inc., one of the country’s largest and most respected engineering firms, issued a September 2010 report entitled, Adaptive Traffic Control Systems in the United States: Updated Summary and Comparison. Their report summarizes the effectiveness of various adaptive traffic control systems deployed across the United States, including InSync. Based on feedback from the traffic agencies employing the various systems, the report compared benefits in travel time reduction, stop reduction and reduction in delay amongst other client-critical factors, such as overall cost to implement and maintain and client satisfaction. Of the several systems compared based on feedback from actual users, InSync ranked first in stop reduction, delay reduction, travel time reduction, affordability, up-time, ease of maintenance and client satisfaction. In fact, 100 percent of clients surveyed said given the opportunity to make the decision again, they would repeat their decision to install InSync. It is important in understanding this study to underscore this was an independent research effort drawing inputs solely from actual adaptive traffic control customers operating systems on corridors, not simulations or theoretical research.

The 2010 independent, comparative study on adaptive traffic control quantifies real-word results of various adaptive traffic control systems as reported by the agencies managing them.

The report pointedly acknowledged that the real-time adaptive technology used by InSync provides noteworthy benefits in arterial travel time reduction, stop reduction and reduction in delay: “In the recent past, some adaptive technology experts have downplayed the differences between real-time adaptive architecture and responsive adaptive system architectures. Based on the findings from recent studies compared in this paper, it is clear there is a significant difference that true real-time technology can provide.” Furthermore, the report notes that InSync, the only system included in the study that employs a real-time adaptive architecture, had the “highest operational benefits by a large margin.”

Independent studies of InSync deployments throughout the nation confirm Selinger and Schmidt’s conclusion. These studies illustrate that the real-time adaptive traffic technology employed by InSync can reduce congestion and provide significant safety and economic benefits for motorists and traffic agencies. Because InSync 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.

InSync’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 four case studies demonstrate InSync’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: Variable Traffic Flow

Grapevine, Texas, installed the InSync system in 2010 to manage the city’s variable traffic flow. Although the city has 50,000 residents, approximately 300,000 vehicles pass through Grapevine daily. Traffic volume and flow on Grapevine’s arterials are highly variable as they are frequently a result of freeway incidents, construction on the many highways surrounding the city and event traffic. InSync was chosen to be deployed at 52 intersections city-wide, representing 90 percent of the city’s signals.
Prior to installing InSync, Grapevine used a prominent central-software product to communicate with and attempt to coordinate its signals. The City of Grapevine hired an independent engineering firm, Lee Engineering, to collect before-and-after data on three of the corridors on which InSync was deployed.

The Benefits of InSync

Within weeks of its installation, InSync reduced traffic stops by up to 85 percent and reduced travel time for motorists by as much as 42 percent. The stop reductions and improvements in travel time seen on these individual corridors reflect similar positive results deriving from InSync’s city-wide deployment. By reducing stops and improving traffic flow, InSync creates significant reductions in wasted time and fuel for motorists passing through Grapevine. 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 Grapevine.16

Ramana Chinnakotla, Grapevine’s Assistant Director of Public Works at the time of deployment, says both motorists and traffic professionals are happy with the outcome of InSync’s city-wide deployment. “We have received a lot of positive feedback from our residents; especially people on the side streets have noticed that they do not wait as much. They’re able to get through the intersections much easier. We have also seen a dramatic improvement in the travel time on the corridor itself.”

The study evaluates and compares the travel time, number of stops, speed, delay, hydrocarbon emissions, and fuel usage before and after the implementation of the InSync system in Grapevine, TX.
Upper Merion Township, Pennsylvania, is home to the King of Prussia mall. The 2.8 million square feet of retail space positioned near the intersection of three major freeways created intense traffic volumes. The closed loop timing plan installed in 2008 could not adequately address the traffic conditions. The existing closed loop system on Route 202 was consistently unable to clear its queues during peak travel periods, resulting in heavy congestion on the arterial. An independent study by Pennoni Associates notes that one northbound left turn lane was unable “to clear its queue 87 percent of the time during the afternoon peak hour [and] the southbound left turn movement was not able to clear its queue 67 percent of the time.”17 Because the arterial’s traffic signals could not manage traffic during busy shopping seasons, police officers were regularly stationed at the two intersections along Route 202 to direct traffic through the corridor. Many shoppers avoided the mall because of the difficult traffic.

The InSync system was installed in 2010 to reduce congestion and deliver better service to motorists.

The Benefits of InSync

InSync’s artificial intelligence allowed the system to advance traffic along the arterial while also better serving the side streets and left turns. According to the aforementioned study, the system accomplished both goals. InSync reduced both peak-time stops and travel time on Route 202 by as much as 44 percent and increased speed by up to 79 percent while the northbound and southbound left turn movements are able to consistently and completely clear their queues under InSync’s management.
InSync eliminated the need for traffic cops and solved the city’s struggles with saturation along Route 202. The changes were so substantial that motorists noticed and reported their satisfaction to the Pennsylvania Department of Transportation. “We got rave reviews about InSync not only from public officials, but also from motorists,” said Ashwin Patel, Traffic Signal and Safety Manager for District Six of the Pennsylvania Department of Transportation. “The travel times and number of stops have improved dramatically.”

The study evaluates and compares the travel time, number of stops, speed, delay, hydrocarbon emissions, and fuel usage before and after the implementation of the InSync system in Upper Merion, PA.
Traffic Engineering Challenge #3: Intersecting Arterials

In Evans, Georgia, InSync was deployed to coordinate Washington Road, a 1-mile long corridor that intersects another major arterial, North Belair Road. Because Washington Road is one of the city's main thoroughfares and serves both retail and residential traffic, the corridor experiences high traffic volumes at all times of the day, averaging 40,000 vehicles daily. Additionally, an average of 41,000 vehicles travel North Belair Road daily, making it difficult to efficiently move traffic through the arterials' common intersection.

Columbia County installed a coordinated timing plan on Washington Road in 1995, and it was periodically updated. However, with the intersecting arterials experiencing heavy traffic during peak and off-peak travel periods, Washington Road's coordinated signal system was unable to overcome congestion.

Optimizing traffic signals on intersecting arterials is particularly difficult. Both roadways experience heavy traffic volume and their need for progression is equal. If not perfectly engineered, the needs of the two arterial corridors can be at odds with each other.

To move traffic as efficiently as possible along these especially challenging corridors, Rhythm Engineering installed InSync; they also fused the system's detection technology with the city's existing inductive loops to eliminate the possibility for false calls and ensure efficient traffic movement. The InSync system was able to coordinate and guarantee progression along both corridors including their common intersection.
The Benefits of InSync

InSync reduced stops by up to 100 percent and increased average speed on Washington Road by up to 93 percent, according to the performance study conducted by Columbia County. Consequently, InSync nearly halved motorists’ travel time. Additionally, InSync reduced fuel consumption by as much as 32 percent and cut harmful hydrocarbon emissions by up to 39 percent.

Matt Schlachter, director of the Columbia County Board of Commissioners, commented on the noticeable reduction in travel time and stops along the corridor, saying, “In the past five years, I have driven this corridor several times a day. I can clearly remember only making it through the corridor, without stopping, one time in those five years. We were able to do it three times in a row within 30 minutes of activating the system.”

In total, independent studies estimate InSync’s economic benefit to Evans to be $2.6 million per year in saved fuel, stops and time.
Traffic Engineering Challenge #4: High Pedestrian Traffic

Salinas, California, installed InSync at five intersections to manage the high pedestrian and vehicle traffic along Main Street. Prior to InSync’s installation, the corridor was running in free mode, delivering green time based on the presence of traffic, without prioritizing movements on main or side streets or factoring in queue length at the intersection’s approaches.

With no coordination plan, the corridor’s traffic control system served pedestrian movements upon request from pedestrian button pushes. Consequently, the high pedestrian volume crossing the corridor from Monterey Bay disrupted traffic flow and exacerbated congestion on the busy arterial. City and traffic officials concluded that timing the intersections along the corridor would not solve the problem and installed the InSync adaptive traffic control system shortly thereafter.

Benefits of InSync

InSync incorporates pedestrian calls in its local optimization and global coordination to ensure that pedestrians can cross the street safely without disrupting traffic flow. During InSync’s green tunnels, the system serves pedestrians crossing in the same direction. Likewise, InSync services pedestrians crossing the street in the periods between green tunnels, allowing traffic to flow smoothly along the corridor without disruption from pedestrian releases.

“Other traffic control systems try to work this way, but if there is a high volume of pedestrian calls, it can override vehicular calls and throw the signals out of coordination,” explained Grant Niehus, a Rhythm engineer who worked on the Salinas deployment. “Whereas other systems service pedestrians when they arrive at an intersection, InSync never breaks coordination along the corridor. It may be an additional wait time of ten or fifteen seconds — not long enough that pedestrians notice it — but InSync doesn’t stop what can be dozens of vehicles driving at 30 miles per hour or more just to serve one pedestrian.”
Niehus also noted that InSync’s universal compatibility allowed the City of Salinas to capitalize on their existing infrastructure instead of installing new Ethernet wiring to connect the corridor’s intersections: “Salinas had an existing copper infrastructure that tied their controllers together, which was outdated. Rhythm engineers were able to install an Ethernet over copper device, which in turn saved them quite a bit of money to install the system. Also, with other systems, traffic agencies have to buy brand new controllers and use the same controllers at every intersection. InSync can work with 20 different traffic controllers at 20 different intersections.”

InSync’s compatibility and ability to incorporate pedestrian movements into its global coordination and local optimization created significant safety and economic benefits for the city of Salinas, California.

The study evaluates and compares the travel time, number of stops, speed and delay, before and after the implementation of the InSync system in Salinas, CA.
Conclusion

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

InSync’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, InSync has decreased travel time by up to 50 percent, fuel consumption by up to 32 percent and stops by up to 90 percent. More importantly, InSync has reduced crashes by up to 30 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 InSync.
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