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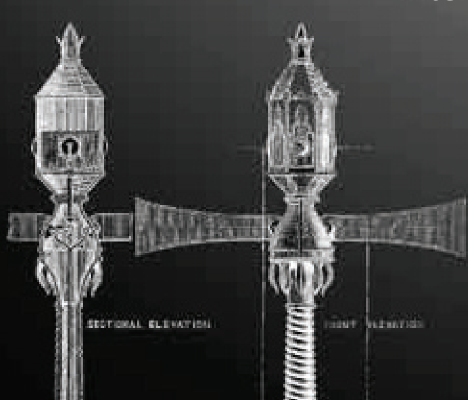
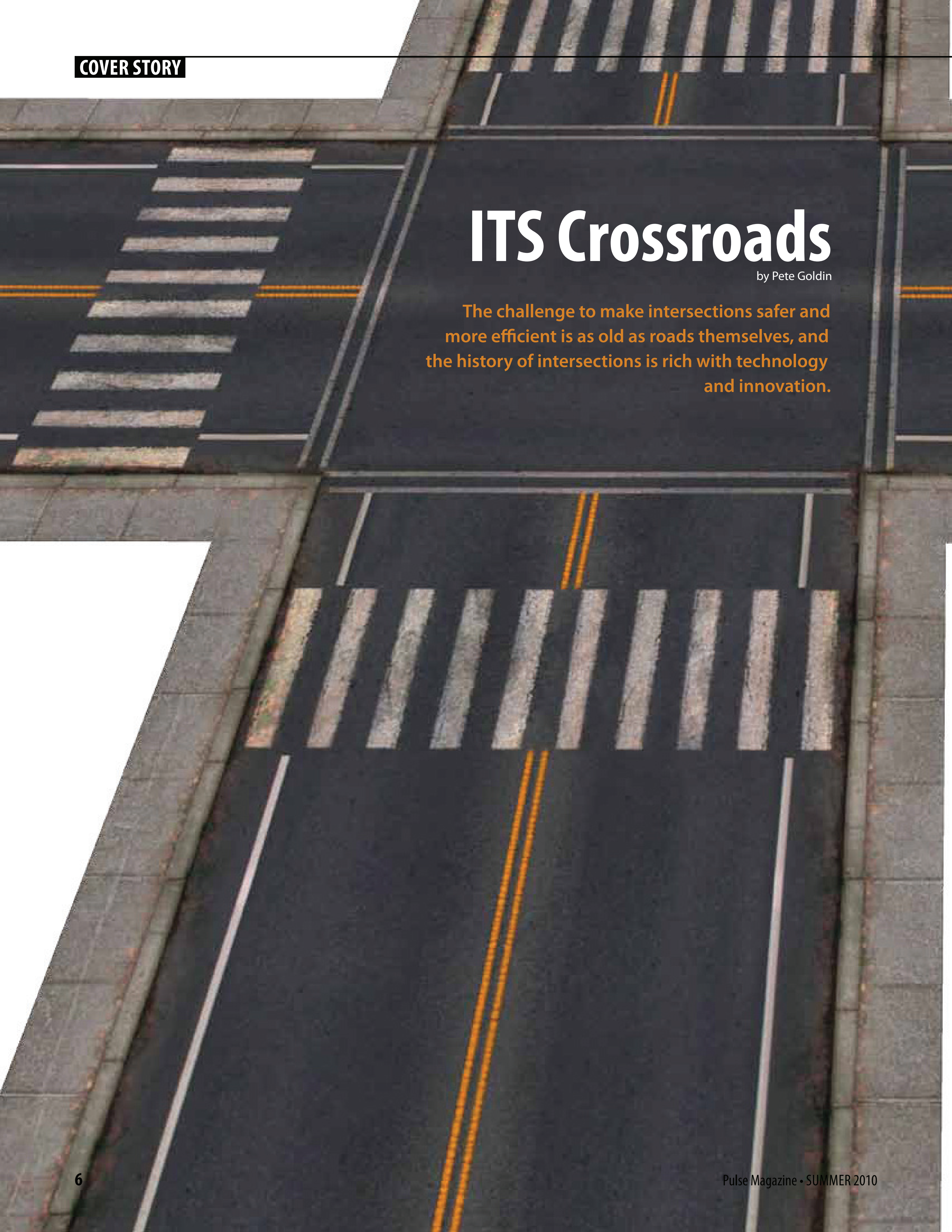
GETTING THE SIGNAL

A then-and-now look at signalized intersections, p. 6

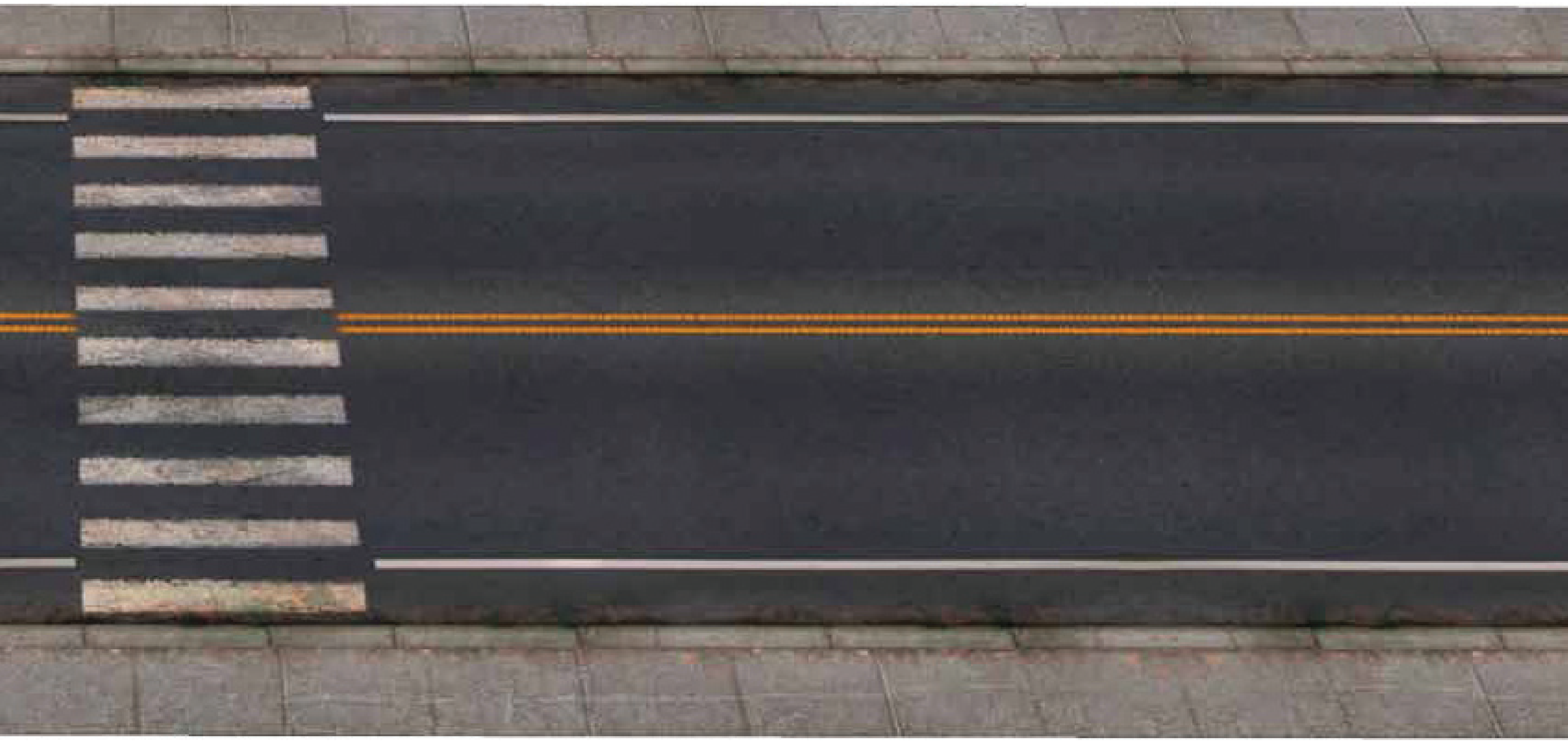




ITS Crossroads

by Pete Goldin

The challenge to make intersections safer and more efficient is as old as roads themselves, and the history of intersections is rich with technology and innovation.



Crossroads have been around as long as we have had roads, and the modern intersection has leveraged technology almost as long as the automobile has driven on those roads. High volumes of traffic, crossing paths while moving at high speeds, has always necessitated the implementation of intersection control measures to ensure order and safety. Many of the innovations that have shaped the intersection over the years are the foundations of our modern transportation system.

Lighting the Way

The technological centerpiece of the intersection is the traffic signal. Surprisingly, the first recorded traffic signal actually predates the automobile; it was designed in 1868 by J.P. Knight, a British railroad signal engineer. Knight's semaphore-style traffic light was installed at the London intersection of George and Bridge Streets near Parliament to regulate horse and wagon traffic, and to protect pedestrians. Essentially, it was a tall post with moveable arms: the arm indicated "stop" when extended horizontally; at night, a gas lantern utilized a red lens for "stop" and a green lens that meant "proceed with caution."

The first recorded automobile traffic light was invented almost a half-century later in 1912, by Lester Wire of the Salt Lake City Police Department. Wire's manually-operated signal was basically a large wooden box on a pole, with holes for red and green lights and wires attached to overhead trolley lines for electricity. This first traffic signal was installed in Salt Lake City at the intersection of Main Street and Second South.

In the early days of intersection control, traffic police usually operated semaphores and traffic lights manually. Signal timing was based on the operator's judgment, and the officers would often blow whistles to warn drivers that the light was about to change. But the need grew for a more automated approach, and traffic signals quickly became more sophisticated. In 1914, an electric traffic light was installed in Cleveland, Ohio, that is considered the prototype of the modern signal. The red and green lights could be controlled manually or by an automatic timer, and were supplemented by warning buzzers.

Over the next 10 years, as traffic signals became more popular, they were accompanied by a wave of innovation. One major milestone was the first use of the four-way, three-color traffic signal — introducing the yellow light — installed in Detroit in 1920. This blueprint for the modern signal design was invented by Detroit police officer William Potts using railroad signals; the basic idea is still in use today.

Another milestone was the invention of the fixed-time controller, which led to the development of the first traffic signal networks. The first effort at networking intersections came in 1924, when 31 signals in downtown Los Angeles were operated from a central station — the first known traffic control center in the world.

"Los Angeles has a long history in managing its network of traffic signals," says John Fisher of the Los Angeles Department of Transportation. "The [Automated Traffic Surveillance and Control] system is the current expression of that legacy and builds on previous historic efforts in signal system control."

According to Fisher, that first signal system was generally operated on a time-of-day basis, although it could be manually changed from the center. "However, due to the standardization of traffic signals that would soon follow, this system became obsolete," Fisher says.

That standardization began at the first National Conference on Street and Highway Safety, held in Washington, DC in December 1924. The conference convened at the request of then Secretary of Commerce Herbert Hoover, who called for "the devising of means and the making of recommendations toward the lessening of the numberless accidents which now kill and maim so many of our citizens."

"The conference made many recommendations for improving highway safety, including recommendations addressing the use of signs, signals and markings," says Gene Hawkins, associate professor of Civil Engineering at Texas A&M University. This included the adoption of a code of colors for signs and signals, which established the three-color traffic light as the official standard.

Getting Actuated

Almost from the beginning, traffic engineers recognized the benefits of activating signals based on vehicle demand; as manually-operated traffic signals were replaced by automatic, pre-timed signal control devices, they realized they needed a method of collecting the traffic data previously obtained visually by traffic cops. One of the first attempts at an actuated, or traffic responsive, intersection was invented by Charles Adler, Jr., a railway signal engineer from Baltimore, Maryland. Adler developed a sensor that was activated when a driver sounded his car horn. It consisted of a microphone mounted in a small box on a nearby utility pole; the sound of the horn caused the sensor to trigger the green light. "First installed in 1928 at a Baltimore intersection, Adler's device enabled the first semi-actuated signal installation to assign right-of-way by means of a vehicle sensor," reports the Federal Highway Administration's Traffic Detector Handbook.

Just weeks after Adler's semi-actuated signal installation, a pressure-sensitive detector was installed in New Haven, Connecticut. Invented by Harry Haugh, a Yale University professor, the in-pavement detector consisted of a rubber pad set into a metal frame, flush with the road surface. Two metal strips embedded in the rubber served as electrical contacts which were brought together by the pressure of wheels, identifying the passage of a vehicle. Traffic-actuated local controllers using pressure detectors grew in popularity and were used for the next 40 years — unlike Adler's horn-activated traffic signal, which was considered a nuisance by Baltimore residents and quickly became history.

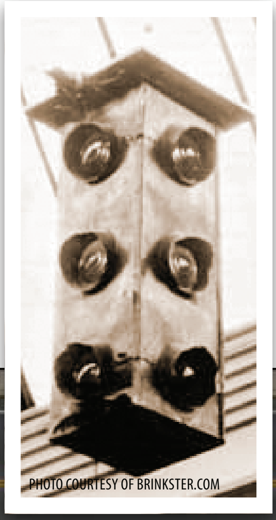
Over the years, traffic-actuated controls have grown with the development of detection capabilities. Pressure-sensitive detectors led to inductive loops, which are simply one or more turns of insulated wire embedded in a shallow slot cut into the road surface. Loops, which first appeared in the 1950s, have become a common form of detection and are still widely used today. For the next four decades, detection continued to evolve, resulting in several innovative new sensor options, including non-intrusive technologies like microwave radar, video and infrared sensors.

The Computer Age

Initially, actuation was only used at isolated intersections, but in the 1950s, emerging computer technology allowed the use of actuation to expand to networks of signals. In 1952, Denver, Colorado, became the first city to use an analog computer system to apply actuated intersection control to a signalized network. Using traffic flow data from detectors, the system automatically adjusted timing based on demand rather

▼ Traffic cops often wore white gloves and blew whistles before the move to semiphore-based signals.

▼ An example of the first electric traffic signal developed by Lester Wire in Salt Lake City, Utah, 1912.



▼ The first three-color, four-way traffic signal was invented by William Potts in Detroit, Michigan, 1920.

than the time of day. Over the next 10 years, more than 100 similar systems were installed throughout the United States.

Eight years later, Los Angeles experimented with a computer-controlled signal network known as the Pro Rata system. LADOT's John Fisher says the name "Pro Rata" meant the "equitable distribution of green time." The system featured cable interconnected pressure detectors for sampling traffic volumes; three radio towers; and a central computer. "The radio system transmitted traffic volumes to the central computer, which identified the appropriate signal timing program," Fisher explains. "The computer would then use radio transmission to implement the revised timing at all of the controllers." According to Fisher, the pressure detectors were expensive to maintain and were replaced by inductive loops in 1965; Los Angeles also experienced reliability issues with the analog computers.

While Los Angeles experimented with analog computer controls, the city of Toronto conducted a pilot study using a digital computer to perform centralized intersection control functions. The successful study led to a full-scale implementation in 1963, with 20 intersections under computer control. A year later, IBM became involved and began delivering computerized traffic control systems to cities from San Jose to New York City.

"By the mid-1970s, microprocessors made their debut, fiber optic cable started to be used by communication utilities, and inductive loop detectors had become commonplace," Fisher says. "These technology advances offered a new opportunity to revisit automated traffic signal systems control."

Driven by these advancements, The Bureau of Public Roads, now the FHWA, developed the Urban Traffic Control System (UTCS) Project, which was installed in Washington, DC, in 1972 to develop and test advanced traffic control. The system contained 512 detectors used to determine signal timing at 113 intersections. Meanwhile, the digital computer and microprocessor continued to propel the advancement of intersection technology with adaptive signal control, a method of forecasting traffic based on current conditions and proactively adjusting signal timing.

The premiere centralized adaptive control system debuted in the 1980s under the name SCOOT, an acronym for the Split Cycle and Offset Optimization Technique. It was developed by Great Britain's Transport Research Laboratory (TRL) and was implemented in several cities, including Glasgow and Toronto. At the same time, another advanced system known as SCATS (Sydney Coordinated Adaptive Traffic System) was developed in Australia and was deployed in many cities worldwide.

"Use of the computer has become the accepted way to control streets and highways and has been accelerated by the revolutionary advances and associated cost reductions in computer, communications and electronic technology," explains the FHWA's Traffic Control Systems Handbook.

Signal Coordination

Today, intersections are usually part of a centrally-controlled network. Traffic signals within the same corridor or area can impact each other, and groups of vehicles can flow together from one intersection to the next, so modern traffic engineers often try to coordinate their operation. John Fisher says Los Angeles was one of the pioneers in this type of networking.

"In 1984, the City of Los Angeles implemented the initial phase of ATSAC just one month prior to the Los Angeles Olympic Games," says Fisher. "It was the first

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▼ This photo shows a transition from manned signal towers to electric signals.

PHOTO COURTESY OF WILLIS LAMM

▼ An early traffic tower on 5th Avenue in New York City.

PHOTO COURTESY OF WILLIS LAM

▼ Traffic signals still follow William Pott's basic design today.

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system to extensively monitor traffic flow in a network and to automatically change timing plans in response to that flow." According to Fisher, the ATSAC concept was very similar to that of the Pro Rata system. "However," Fisher says, "loop detectors replaced pressure pads; microprocessor controllers replaced electro-mechanical ones; fiber optic cable replaced radio tower transmission; digital computers replaced analog ones; and colored computer graphics replaced the map with light bulbs."

The Next-Generation

Intersections continue to evolve as technologies advance and societal needs are addressed. Experts believe new technologies, such as wireless communications and solar power, will become more prevalent in future intersections, and new concerns such as "green" transportation and sustainability will increasingly become a focus of intersection management. Many communities are already beginning to address these issues. Just recently, the City of Portland received a Smart City Award from ITS America for improving traffic signal timing at 135 traffic signals, which improved traffic flow while reducing congestion, fuel usage and more than 157,000 metric tons of CO_2.

Other issues are having an impact on intersection design and the way signal control operations are fine-tuned based on real-time needs within the intersection. Pedestrian-focused initiatives and provisions for individuals with limited mobility have become a priority in many municipalities, as has signal preemption for emergency vehicles. New techniques establish priority schemes for public transit and freight, extending the green light to enable more efficient flow for these vehicles. Meanwhile, new techniques are being implemented to address the growing problem of red light violations.

"There appears to be an increase in red-light running, as drivers seem to push the envelope in minimizing delay at traffic signals and elsewhere," says Dan Middleton, Ph.D., P.E., a research engineer and program manager for the Texas Transportation Institute. "Some jurisdictions have chosen red-light cameras as a solution, while others have investigated signal timing parameters that might reduce red-light violations."

One method gaining increased attention is a system that warns drivers well in advance of the changing signal. "There has been interest in recent years in active systems that help drivers prepare to stop near the termination of the main street green phase," Middleton continues. "A few jurisdictions are even considering extending the red phase upon detection of a straggling motorist."

Many of these new strategies rely on the advancements made in detection over the past decade. The limitations of embedded technologies like loops — lower reliability, damage to roadways, higher maintenance costs — have encouraged the development of new, non-intrusive detection devices such as video image processors, microwave and laser radar, passive infrared, and ultrasonic and acoustic sensors, all of which are being deployed in cutting-edge intersection applications, finding new ways to identify vehicles and streamline intersection operation.

Intersections impact all of our lives, as almost everyone passes through multiple crossroads every day. The efforts of transportation agencies, traffic authorities and technology vendors to drive the evolution of the intersection have had positive impacts on the world we live in. Where will the intersection go next? The possibilities for the future are only limited by the traffic engineer's imagination. ■

Pete Goldin is a freelance journalist specializing in transportation and technology. He has written for magazines such as ITS International, World Highways, Parking World and the ITS Daily News at the ITS World Congress. Mr. Goldin can be reached at petegoldin@gmail.com.