GREENER, SAFER, SMARTER

Building Communications for Intelligent Transportation Systems

A TROPOS NETWORKS WHITE PAPER | JUNE 2009

Introduction

Intelligent Transport Systems (ITS) is an umbrella term for a wide range of information technologies that are applied to transportation infrastructure and vehicles. ITS uses advanced information and communications technologies to improve safety, relieve congestion, enhance productivity and reduce emissions. A metro-scale wireless broadband IP network can provide a cost-effective foundation for securely hosting a wide range of ITS applications across a broad coverage area.

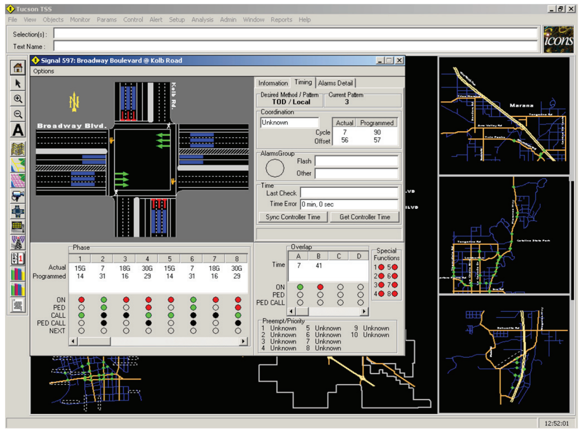
ITS offers important benefits to a variety of constituencies in communities. Public transit systems and their riders benefit from reduced travel time and variability, improved schedule adherence, increased usage and provision of real-time information to transit riders. Public safety agencies and officers, as well as the public, enjoy reduced emergency response times, less aggressive driving, fewer severe accident and improved traffic law compliance. Transportation departments can gather travel time and traffic volume data to better plan street improvements and adjust signal timing. Drivers benefit from decreased congestion, improved traffic flow, shorter travel times and reduced fuel consumption. ITS can also increase parking space availability in prime areas. The environment can benefit from reduced emissions, improving air quality.
This paper describes leading ITS applications and their benefits. It also describes how wireless IP broadband mesh networks have become an increasingly important component in enhancing intelligent transportation systems, offering significant advantages over landline and cellular alternatives.

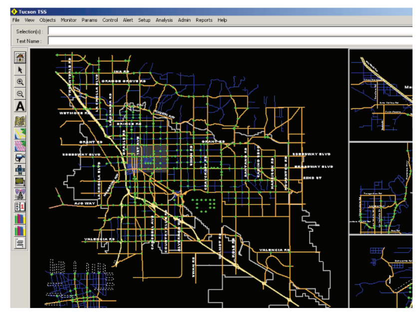
ITS Applications

ITS delivers important benefits in a host of deployment scenarios. This section describes some leading ITS applications and details their benefits.

Intelligent Traffic Signal Management
Intelligent traffic signal management actively manages, coordinates and optimizes traffic signal timing to reduce congestion, moderate traffic speeds, smooth traffic flow and reduce auto emissions. The systems range in sophistication from those where traffic signal timing is adjusted manually based on conditions and events to advanced adaptive signal control systems that perform real-time optimization of traffic signals across a signal network, adjusting signal timing based on prevailing traffic conditions, demand, and system capacity.

Intelligent traffic signal management has many documented benefits, including reducing delays, travel times, accidents, fuel consumption and emissions.





Examples include:

- In Syracuse, NY, an intelligent traffic signal project reduced traffic delays by 14% to 19%.
- Adaptive signal control systems deployed in Los Angeles, CA; Broward County, FL; Newark, DE; Oakland County, MI and Minneapolis, MN reduced delays from 19% to 44%.
- In Los Angeles, Broward County and Newark travel time along corridors with adaptive signal control systems decreased by 13% to 25% after implementation of the systems.
- In Los Angeles, Broward County and Oakland County, the number of stops experienced by vehicles travelling along corridors with adaptive signal control systems was reduced by 28% to 41% compared to before implementation of the systems. Reducing the number of stops decreases the rear-end crash rate.

Integration of intelligent traffic signal management systems across jurisdictions can yield further delay reductions by providing a seamless travel corridor. Interconnecting previously uncoordinated signals and providing optimized timing plans with centralized control can reduce travel time. For example, when several jurisdictions in Denver, Colorado worked together to coordinate signals on arterial corridors, travel time reductions ranged from 7% to 22%.

More sophisticated adaptive signal control systems have been shown to improve travel times in comparison to less dynamic optimized signal timing plans. Field tests performed in Reston, VA and Seattle, WA showed that travel times improved by approximately 5% when adaptive signal control systems were

"By owning the network infrastructure, Tucson is now saving approximately $200,000 per year in telecommunication fees."

Francisco Leyva
Transportation Project Manager
Tucson, AZ

employed. In Chicago, IL, adaptive signal control dramatically improved travel times by 12% to 53% and decreased delay up to 100% along certain corridors. In addition to the inherent benefit of reducing travel time and delays, these reductions diminish vehicle emissions, improving air quality and decreasing carbon footprint.

Use of a wireless IP broadband mesh network as the communications infrastructure for an intelligent traffic signal management system generates hard dollar savings by avoiding trenching and leased line costs. For example, according to Francisco Leyva, Project Manager for the Tucson (Arizona) Transportation Department, "We used to rely on phone lines to monitor and transmit traffic information. By owning the network infrastructure, Tucson is now saving approximately $200,000 per year in telecommunication fees and also taking advantage of video transmission which was not possible using phone lines."
As Leyva notes, a wireless IP broadband mesh network providing communications for an intelligent traffic signal management system can be leveraged to support other ITS applications including video-based applications such as traffic cameras.

Transit Signal Priority for Public Transit
Transit signal priority (TSP) facilitates the movement of transit vehicles – mainly buses, streetcars and light rail vehicles – through traffic-signal controlled intersections by providing them with priority access to green signals. TSP systems use sensors to detect approaching transit vehicles and provide green signals to the vehicles while providing a red light to traffic on conflicting approaches. TSP improves schedule adherence and transit travel time with minimal impact to other traffic flows.

A popular and effective mechanism to alert the TSP system that a transit vehicle is approaching is to equip each transit vehicle with a global positioning system (GPS). A wireless network can be used to transmit the GPS information and priority requests from transit vehicles to the TSP control system. The same wireless network can be used to communicate between the centralized TSP management system and signal controllers in the field.

Transit signal priority for public transit improves transit system on-time performance, reduces travel time and travel time variability and saves money. Transit agencies report positive results throughout North America.

"The 98 B-Line Bus Rapid Transit service is one of North America's most successful… The latest state-of-the-art intelligent transportation systems are an integral part of the service, which contribute to shorter travel times, real-time "next bus" arrival times, and more reliable, on-time performance, all leading to higher ridership than the previous service."

- R. A. McNally, P. Eng., IBI GROUP Vancouver, BC

For example, a study funded by the U.S. Department of Transportation reported the following measured benefits from transit signal priority systems :

- In Tacoma, WA, the combination of TSP and signal optimization reduced transit signal delay about 40% in two corridors.
- Portland, OR avoided adding one bus by using TSP. The city experienced a 10% improvement in travel time and up to a 19% reduction in travel time variability.
- In Chicago, IL, buses realized an average of 15% reduction in running time. The city realized a savings of one weekday bus while maintaining the same service.
- Los Angeles experienced up to 25% reduction in bus travel times with TSP.
- Transit agencies uniformly reported a small impact to non-priority traffic.

Novax, a leading vendor of intelligent transportation systems, reports similar results from throughout their customer base. Reported benefits include :

- In Toronto, where all buses and streetcars use TSP, transit delays decreased by up to 46%.
- In Vancouver, the 98-B line, which runs between Richmond (where Vancouver International Airport is located) and downtown Vancouver, experienced a 5% reduction in route travel time. The line was able to use one fewer bus (out of a fleet of 28), realizing a CDN$650,000 capital savings and a CDN$360,000 reduction in annual operating costs. The savings equates to an estimated net present value (NPV) of CDN$4 million.

Reducing public transit travel time and variability and improving schedule adherence makes taking public transit more attractive in relation to driving. To the degree that this encourages more people to leave their cars at home and take transit, TSP systems can reduce vehicle emissions, improving air quality and decreasing carbon footprint.

In addition to the hard dollar savings previously mentioned, use of a wireless IP broadband mesh network instead of a landline network as the communications infrastructure for a TSP system enables mobile communications between transit vehicles and the rest of the system. Mobile communications can enhance the operation of the TSP system and support other ITS applications including real-time arrival and schedule information via the Web and at transit stops.

Emergency Vehicle Preemption

Emergency vehicle preemption (EVP) systems use sensors to detect approaching emergency vehicles and provide green signals to the vehicles while providing a red light to conflicting approaches. There are many EVP technologies being employed today including light-based, infrared-based, sound-based, and radio-based systems. Emergency vehicle preemption (EVP) reduces emergency vehicle response times, travel times and accident rates with minimal impact on non-emergency traffic flows. Radio-based EVP systems avoid the line-of-sight limitations associated with light- and infrared-based systems as well as the potential confusion regarding the direction of travel of the emergency vehicle sometimes encountered with sound-based systems.

Additionally, radio-based systems can be integrated with other ITS-related systems such as transit signal priority systems.

EVP systems have delivered positive results throughout the United States, including:

- Plano, TX increased service area for fire/rescue stations from 5.6 square miles to 7.5 square miles, reducing the number of fire/rescue stations from a forecast of 13 to an actual of 10 resulting in a capital cost savings of approximately $9 million and an annual operating cost savings of approximately $7.5 million. A high standard of public safety was maintained as the city preserved its Insurance Services Office Class 1 Fire Suppression Rating - the highest possible rating on a scale from 1 to 10.
- Houston, TX reduced emergency vehicle travel time by 16% to 23%.
- Denver, CO reduced response time by 14% to 23%, saving approximately 70 seconds per response on a typical route.
- Denver also successfully defended against a six-figure lawsuit by demonstrating that the driver of an emergency vehicle had the green light at the time of an accident in an intersection
- Fairfax County, VA reduced emergency response times, saving 30 to 45 seconds per intersection.
- St. Paul, MN emergency vehicle accident rate fell by 71%.
- Plano, TX reduced the number of emergency vehicle crashes from an average of 2.3 intersection crashes per year to less than one intersection crash every five years.
- Minimal impact on non-emergency traffic flow – Leesburg, VA modeling indicated that preemption increased non-emergency vehicle travel time by only 2.4% when priority requested.

As with transit signal priority and intelligent traffic signal management, using a city-owned wireless IP broadband mesh network for communications generates hard dollar savings, enables mobile communications and supports other ITS applications running on the same network.

Automated Parking Meters

Municipalities are increasingly moving away from antiquated, coin-operated, single-space parking meters to automated parking meter systems that feature multi-space payment kiosks integrating advanced technology. Automated parking meters are especially important in heavy traffic areas where demand for convenient parking outstrips supply.

Automated parking meter systems range from stand-alone kiosks that require a technician with a laptop to visit them for service to sophisticated systems that incorporate two-way wireless communications technology. Automated parking meters offer a wide variety of benefits to cities, businesses and parkers, with the more advanced systems providing the most benefits. They can help cities increase revenues, decrease downtown congestion and cut costs while offering new conveniences to residents and visitors as well as increasing the prosperity of local merchants.

TROPOS networks

"Now that they are in place, we see that meter transactions over the network perform well. The Tropos network is quicker and more reliable than cellular, and the cost savings is huge."

Dan Zack
Downtown Development Coordinator
Redwood City, CA

A wireless network is key to fully realizing the benefits of automated parking meters. Wireless enables valuable features such as centralized monitoring and control, programmable variable parking meter rates, automatic broken meter identification, meter full alerts and violation notification. Wireless can also provide citizens with payment options, including pre-paid parking cards and credit cards, by enabling communications between the parking kiosk and the city's central parking office for credit card verification and transaction processing.

Key benefits of automated parking meter systems using wireless communications include:

- Reducing meter downtime and preventing fraud. For example, Digital Paytech estimates that Houston, TX will gain more than $100,000 in additional revenue annually by reducing meter down time though automated reporting of meters' functional status and prevent more than $100,000 in lost revenue annually by reducing credit card fraud.
- An example is Redwood City, CA where after just eight months after initiating their Automated Parking System and adjusting parking rates by time and day, downtown visitor attitudes had changed from negative to positive. They went from shoppers chronically complaining "there's no place to park" to being able to find a spot at most times of day and in prime areas.
- Charging different parking fees at different times of day also decreases congestion by reducing the number of cars circling to find an open spot. For example, a study found that 41% of Saturday traffic on Prince Street in New York City consisted of motorists searching for parking.
- Providing operational savings and efficiencies such as notifying parking enforcement personnel of expired meters
- Offering convenient payment options: cash, credit cards, debit cards, cell phones, payment over the Internet, and prepaid parking cards
- Providing real-time information about parking availability in specific areas saving visitors time and frustration
- Facilitating cultural diversity with multilingual meters

By reducing the driving time spent looking for parking, automated parking meters with variable rates diminish vehicle emissions, improve air quality and decrease the carbon footprint.

Use of a city-owned wireless IP broadband mesh network as the communications infrastructure for an automated parking meter system, instead of cellular data communications, generates hard dollar savings by avoiding the cost of monthly cellular service fees.

For example:

- Houston, TX estimates that, by spending $300,000 to build its own wireless IP broadband mesh network for its automated parking meter system, it will save $125,000 per year in telecommunications fees. "Within three years we will have paid less, and we will own the network," said Liliana Rambo, assistant director of Houston's Department of Parking Management.
- Redwood City, CA determined that they would break-even on their investment in a wireless IP broadband mesh network within twelve months. Dan Zack, Downtown Development Coordinator for Redwood City said, "We were originally going to use GSM [cellular] technology to connect each meter to the network. While less expensive to install, at $50 per month per meter it was expensive to operate. After evaluating [wireless IP broadband mesh} network options from Tropos, we saw that the return on investment would be less than one year compared to GSM."

Additionally, wireless IP broadband mesh networks provide true broadband capacity, offering the bandwidth necessary to support multiple municipal applications simultaneously. Mesh is further advantageous over cellular in multi-use networks that serve many clients because, with cellular, the monthly operating costs rise linearly with the number of end-devices in use. When an agency owns a wireless IP broadband mesh network, monthly operating costs are not tied to the number of devices on the network and new clients can be added for little or no incremental operating cost.

Automated Vehicle Location

Automatic vehicle location (AVL) systems enable vehicles' locations to be tracked from a central site. Real-time location information from each vehicle is provided by an on-board GPS and sent to the AVL system using wireless communications.

AVL is an application in and of itself, an application used in conjunction with other applications such as computer-aided dispatch (CAD) and silent alarms, as well as an enabling technology for still other applications such as emergency vehicle signal preemption and variable message signs.

In transit systems, AVL is used to monitor on-time performance, reduce bus and train bunching, and improve adherence to schedules. AVL also enhances transit signal priority (TSP) performance by detecting transit vehicles as they approach intersections.

Many AVL systems include silent alarms, which allow vehicle operators to alert transit management and police of emergency situations aboard their vehicle. Because the vehicle's location is displayed, emergency response times can be reduced, whether in reply to a silent alarm, radio communication, or other in-vehicle notification system.

AVL systems can enable real-time information to be provided on a transit agency's website and to variable message signs at transit centers. Such a system can provide information regarding expected arrival times to transit passengers waiting at stops. AVL can also be integrated with in-vehicle automated stop announcements for disabled passengers.

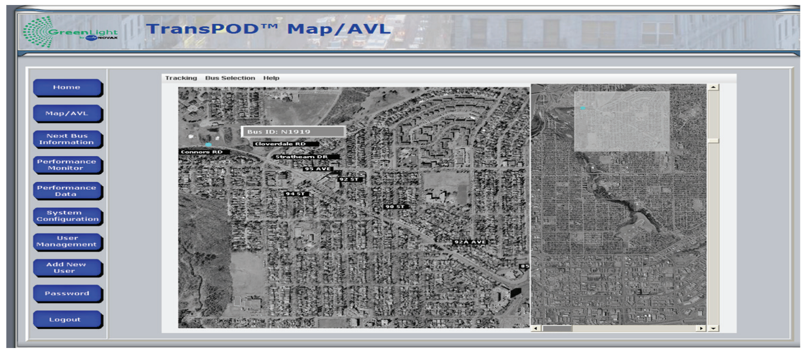


Photo courtesy of Novax Industries Corporation

AVL can also reduce the need for on-street supervision employees. It enables more targeted use of field supervisors and schedule checkers.
Examples of the benefits of AVL, when used alone or combined with related applications, include:

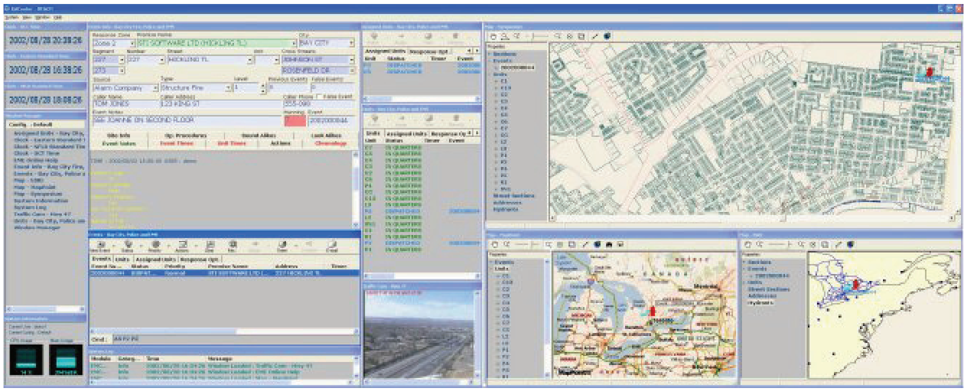
- Reduce fleet size by 2% to 5%.
- Baltimore, MD reduced its fleet size while meeting the same level of service, resulting in savings of $2,000,000 to $3,000,000 per year.
- The Kansas City, MO and Kansas City, KS metropolitan area saved $1,600,000 with its fleet reductions
- Atlanta, GA saved $40,000 per year in data-collection costs.
- Improved on-time performance by 9% to 23% in large cities.
- Denver, CO reduced early arrivals by 12%, late arrivals by 21% and schedule-related complaints by 26%. The city also experienced a 33% reduction in assaults on passengers.
- Portland, OR improved on-time performance by 9%, reduced variability by 5% and decreased run-time by 3% .
- Decreased emergency response times for transit-related incidents by up to 50%.

AVL systems require that real-time location information from each vehicle's on-board GPS be sent to the system's central monitoring system using wireless communications. As noted previously, using an agency-owned wireless IP broadband mesh network as the communications infrastructure, instead of cellular data communications, generates hard dollar savings by avoiding the cost of monthly cellular service fees.

Computer-Aided Dispatch

Computer-aided dispatch (CAD) systems, often used in conjunction with AVL, dispatch transit vehicles (generally non-fixed route services such as paratransit vehicles) by sending messages from a computer system in a central dispatch office to drivers in the field whose vehicles are equipped with mobile data terminals (MDTs) or laptop computers. CAD systems are more efficient, more accurate and provide more complete audit trails than older, manual systems using two-way voice radio communications.

CAD can rationalize operations, result in cost savings, and improve service. It assists schedulers in preparing efficient vehicle schedules, optimizing the number of trips that each vehicle can provide each day while minimizing nonrevenue miles and passenger wait times. CAD can also facilitate reservations, billing and reporting activities.



Examples of the benefits of CAD, when used alone or combined with AVL, include:

- Portland, OR improved on-time performance by 9%, reduced variability by 5% and decreased run-time by 3% .
- Santa Clara, CA reduced its paratransit fleet from 200 to 130 vehicles after implementing CAD with AVL, saving $488,000 per year.
- Peoria, IL eliminated a dispatcher position and increased on-time arrivals from 72% to 81%.
- San Jose, CA used CAD and AVL to increase ridership, better on-time performance and reduce annual operating costs by $500,000. The number of shared rides increased from 38% to 55%. The cost per passenger mile decreased from $4.88 to $3.72. Anecdotally, a driver noted that the CAD system was useful in settling driver-passenger disputes concerning on-time performance.
- Sweetwater, WY increased ridership 80% without requiring an increase in dispatch staff. Per passenger-mile operating expense decreased 50% over a 5-year period.
- Winston-Salem, NC doubled its client list in 6 months, reduced per vehicle mile operating expenses by 9% and decreased passenger wait time by more than 50%.

CAD systems require wireless communications between the central dispatch office and vehicles in the field. As noted previously, using an agency-owned wireless IP broadband mesh network as the communications infrastructure, instead of cellular data communications, generates hard dollar savings by avoiding the cost of monthly cellular service fees. A wireless mesh network can also be leveraged to support other municipal applications for little incremental cost.

Variable Message Signs

Variable message signs (VMS), also known as changeable message signs (CMS) or dynamic message signs (DMS), are electronic signs used on roadways and in transit systems to give travelers information. The signs have a wide variety of applications, including warning drivers of bad weather, dangerous road conditions, road closures, traffic congestion, accidents, incidents, roadwork zones, or speed limits; suggesting alternative routes; guiding drivers to available car parking lots and spaces; disseminating AMBER Alert messages; and informing transit riders of delays and the arrival times of buses and trains. The signs can be permanent or portable.

VMS are often used in conjunction with other ITS systems, such as metering lights, vehicle detectors and speed sensors as well as informational radio broadcasts and Web updates.

Examples of the benefits of VMS, when used alone or combined with other forms of ITS, include:

- An I-40 work zone in Arkansas had a 33% lower fatal crash rate compared to similar sites without VMS.
- Minneapolis/St. Paul, MN experienced reduced confusion and aggressive driving, decreased queue lengths, and reduced congestion during lane closures.
- California Department of Transportation District 2 experienced a 73% decrease in truck accidents over a 30-mile stretch of the Sacramento River Canyon section of I-5
- Speed-activated VMS with warning messages reduced speeding vehicles by 50% or more in Virginia work zones.
- In Copenhagen, Denmark posting travel time and alternative route information prompted 12% to 14% of drivers to divert onto less congested alternative routes.
- In Toronto, ON a traffic monitoring and VMS system on Highway 401 decreased the average incident duration from 86 to 30 minutes per incident.

Integrating variable message signs with a communications network enables remote, real-time updates of their messages. Updates can be triggered automatically using inputs from sensor systems or by human operators remotely monitoring conditions.

Using wireless for VMS communications eliminates the trenching costs and monthly service fees associated with landline installation and operation. It also supports remote updating of portable VMS.

When wireless is employed, using an agency-owned wireless IP broadband mesh network as the communications infrastructure, instead of cellular data communications, generates hard dollar savings by avoiding the cost of monthly cellular service fees. A wireless mesh network can also be leveraged to support other municipal applications for little incremental cost.

Red Light Enforcement Cameras

Red light enforcement cameras placed at intersections are activated by detectors and take pictures of vehicles that enter an intersection after the light has turned red. These pictures, which include the vehicle's license plates, are sent to the violator with a request to pay the appropriate fine. Because a photo is not taken until the law is broken, these cameras do not pose a threat to privacy.

Red light cameras are currently used by more than 300 U.S. communities in 25 states and the District of Columbia. Recent studies show that photo enforcement cameras lead to a 25% to 30% reduction in intersection injury crashes.

Red light enforcement camera benefits include:

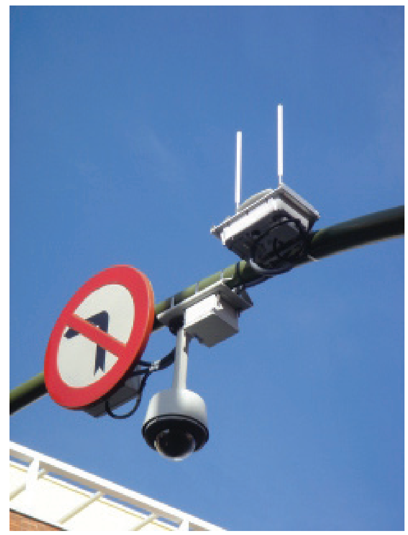
- Crash reduction benefit of approximately $39,000 per site year.
- Reduction of red light violations by 40% to 50%.
- Overall injury crash reduction of 25% to 30%.
- In Oxnard, CA automated red light enforcement reduced crashes by 7%, decreased right-angle crashes by 32%, lowered injury crashes by 29%, and reduced right-angle injury crashes by 68%.

- In Scottsdale, AZ, right angle crashes were reduced 17% and left-turn crashes were reduced 40%.
- In Raleigh, NC right-angle crashes dropped by 42%, rear-end crashes dropped by 25% and total accidents dropped by 22%.

Red light enforcement cameras are transitioning from older, film-based systems to new, digital systems. Digital cameras eliminate the need for truck rolls to retrieve and replace the film in the camera. However, they require communications mechanism for the digital photo information to be uploaded for processing. Using a wireless network eliminates the need for trenching associated with installing landline communications. A city-owned wireless network also eliminates the fees associated leased lines. As noted previously, Tucson, AZ is saving approximately $200,000 per year in telecommunication fees by employing a city-owned wireless IP broadband mesh network instead of leasing phone lines.

Video Surveillance Cameras

Video surveillance has a variety of applications in ITS. Traffic cameras can provide route planning information to drivers via the Web as well as visual information that operators can use to modify VMS messages, traffic light timing and emergency vehicle routing. Infrastructure surveillance cameras can monitor key transportation facilities for security purposes.



The benefits of surveillance cameras are difficult to quantify because they are generally used in combination with other ITS technologies. One example is Milpitas, CA where emergency response times have been slashed up to 30% by emergency dispatchers using surveillance cameras in combination with CAD and AVL.

Use of an agency-owned wireless IP broadband mesh network, instead of a landline network, to carry the video streams from cameras in the field to the central monitoring location, which will also house the video servers if traffic cameras are viewable via the Web, generates hard dollar savings by avoiding trenching and leased line costs. A mesh network can also be leveraged for other fixed and mobile applications.

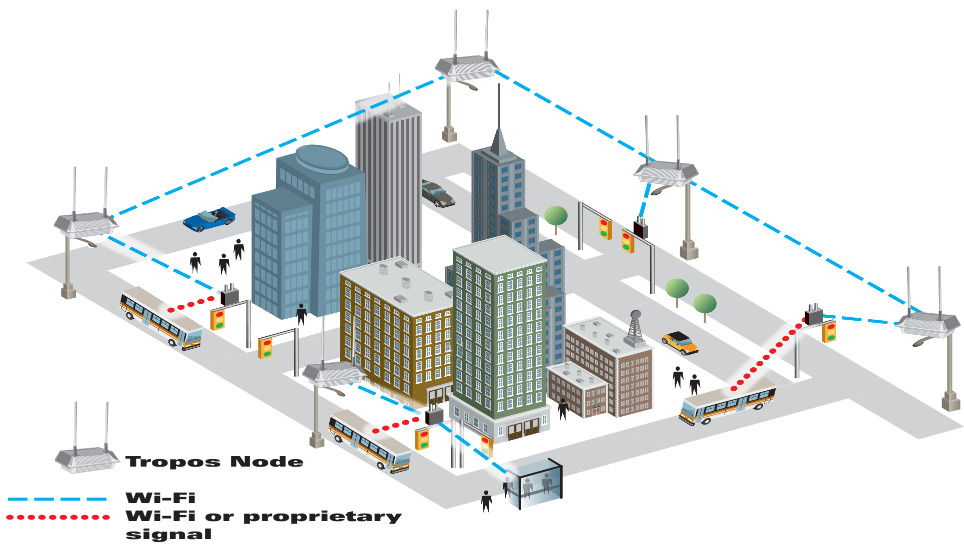
Wireless IP Broadband Mesh Networks: A Cost-Effective Infrastructure for ITS

Metro-scale wireless IP broadband mesh networks enable municipalities and government agencies that want to take advantage of the significant benefits of a large-scale broadband deployment to control their own infrastructure rather than "renting" services from incumbent landline or cellular providers.

Using a wireless IP broadband mesh network instead of or to complement a landline network to communicate between the central control portion of an ITS and fixed, in-field equipment generates hard dollar savings by avoiding trenching and leased line costs. As mentioned previously in this paper, Tucson saves approximately $200,000 per year in telecommunication fees by owning a wireless IP broadband mesh network instead of leasing phone lines.

Many cities and transportation departments have made investments in optical fiber deployments over the past decade, but may be limited by specific routes and splice locations. A wireless IP mesh brings additional flexibility to fiber deployments, by extending the coverage area and functionality for a fraction of the cost and time to deploy additional fiber. Further, wireless enhances the value of existing fiber by enabling mobility applications, which is simply not possible using only landline communications. See Appendix A for an illustration of how a combination of fiber and wireless mesh can be used to cover a six square mile/25 intersection area for less than half of the cost of fiber alone.

After a municipality has chosen to use wireless rather than landline communications for ITS, they similarly face the choice of owning the wireless infrastructure or "renting" cellular data services.



Just as owning a wireless mesh network offers hard dollar savings versus leasing landline services, it also generates hard dollar saving when compared to "renting" cellular data services. As stated previously, Houston, TX estimates that, by spending $300,000 to build its own wireless IP broadband mesh network for its automated parking meter system, it will save $125,000 per year in telecommunications fees for a break-even of less than three years. In Redwood City, CA the break-even point occurred even sooner, in less than one year. The financial benefits of owning the network are magnified when you consider that ownership means true unlimited usage, no overage charges, no limits on streaming applications such as video, and full control over network security.

Another advantage of mesh over cellular is that mesh is better suited for multi-use networks that tend to serve many clients. With cellular, the monthly operating cost rises linearly with the number of end-devices in use. When an agency owns a wireless IP broadband mesh network, monthly operating costs are not tied to the number of devices on the network and new clients can be added for little or no incremental cost.

In addition to financial advantages, owning a wireless IP broadband mesh network confers technical benefits as well. Owning and controlling the infrastructure ensures priority access to the city or operating agency during incidents and events when the cellular network may be overloaded or down.

TROPOS networks

Tropos mesh technology also offers true broadband speeds, on both the downlink and uplink connections. The peak data rates offered by wireless IP broadband mesh networks are an order of magnitude greater than for cellular networks and the available bandwidth is shared by fewer users. True broadband speeds enable deployment of high performance video and other bandwidth and latency sensitive applications that simply do not perform as well on a cellular network. When a city owns its own network, expanding capacity and coverage as needed is not a problem as they control it unlike a cellular network

Owning the network also removes the uncertainty of when the carrier will declare "end-of-life" for their current data technology as they did with CDPD earlier in the decade and will do with GPRS and EDGE in upcoming years as consumer traffic moves to newer, higher revenue services.

Multi-Use Wireless Mesh Networks: A Cost-Effective IP foundation for Communities

Metro-scale wireless IP broadband mesh networks can support multiple municipal applications for low or no incremental cost. By providing a reliable and secure foundation for delivery of multiple simultaneous applications on the same cost-effective physical infrastructure, a single network can be designed to support many applications, in addition to ITS:

- Mobile public safety — Enables police, fire and emergency service personnel to effectively communicate and obtain real-time video and data from the field.
- Automated utility meter reading and Smart Grid — Supports centralized monitoring of water, electric and gas meters, providing fast alerts to problems and accurate meter readings any time.
- Mobile city workforce — Allows fast, easy access to records and filing of reports from anywhere around town, improving worker efficiency and productivity.

TROPOS networks

- Resident and visitor access – Fosters economic development, digital inclusion, education and tourism.
- Hundreds of additional applications…

These goals are not mutually exclusive – in many cases they overlap. Furthermore, having a single wireless network that is capable of achieving all these objectives simultaneously further enhances the return on investment (ROI) of owning versus "renting" the network.

Conclusions

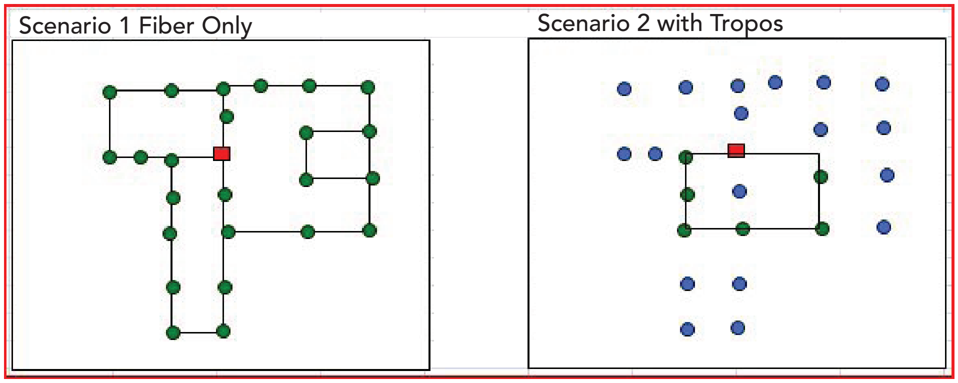
Intelligent transport systems offer important, measurable, and proven benefits to a wide variety of constituencies. Using an agency-owned metro-scale wireless IP broadband mesh network to support ITS applications offers financial and technical advantages over "renting" service on landline and cellular networks. Additionally, mesh networks can be leveraged to support multiple municipal applications for low or no incremental cost.

About Tropos

Tropos® Networks is the worldwide market leader in wireless IP broadband mesh networks. Its solutions create greener, safer, smarter IP foundations for deployment of high-value applications that increase efficiencies and reduce operational costs. Greener – smart grid, automated meter reading and intelligent transportation systems. Safer – mobile public safety communications and IP video surveillance. Smarter – enabling mobile workers to easily access the same information in the field as from their office. Tropos delivers the highest levels of reliability, scalability, and security in the industry with more than 750 customers in over 30 countries. Founded in 2000, Tropos Networks is headquartered in Sunnyvale, California. For more information, please visit www.tropos.com, call 408-331-6800 or write to info@tropos.com.

Appendix A: Example of Fiber/Wireless Mesh Cost Savings vs. Fiber Alone

Using a combination of fiber and wireless mesh to cover a six square mile/25 intersection area can result in a greater than 50% cost reduction when compared to using fiber alone as illustrated below.



Square Miles	6
Number of Intersections	25
Fiber Cost per Foot (loaded)	$175
Scenario 1: Fiber Only	
Fiber miles	10
Total Cost	$1,848,000
Scenario 2: Fiber plus Tropos Mesh	
Fiber Miles	4
Tropos Mesh Routers	30
Cost per Mesh Router Installed	$5,000
Fiber Cost	$739,200
Wireless Cost	$150,000
Total Cost	$889,200
Overall Savings	$958,800
	52%

Notes:

$35 is all in cost per foot of fiber, including electronics, for installation on utility poles; underground installation will be more expensive by 2-5X

Diagrams are illustrative and not to scale

End Notes

1. http://www.itsdocs.fhwa.dot.gov/jpodocs/repts_te/14073_files/14073.pdf, p. viii

2. http://www.itsbenefits.its.dot.gov/its/benecost.nsf/0/B56A52DA1C256C8E8525725F00691912

3. ibid

4. ibid

5. ibid

6. http://www.itsbenefits.its.dot.gov/its/benecost.nsf/SummID/B2008-00509

7. http://www.tropos.com/pdf/success_stories/tropos_success_story_tucson.pdf

8. http://www.itsa.org/itsa/files/pdf/TSPHandbook2005.pdf

9. Novax Industries

10. http://www.itsdocs.fhwa.dot.gov//JPODOCS/REPTS_TE//14097_files/14097.pdf

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GREENER, SAFER, SMARTER

555 Del Rey Avenue
Sunnyvale, Ca 94085
408.331.6800 tel
408.331.6801 fax
www.tropos.com
sales@tropos.com

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