



# WIRELESS MUNICIPAL NETWORKS

**A GUIDE FOR DECISION-MAKERS**



# Executive Summary

Perhaps it is fitting that the city of Philadelphia is credited by many as beginning the revolution to provide access for all. Although the ambitious city-wide project was opposed by some carriers, the city's constituency overwhelmingly favors the initiative. And for good reason: Access to the Internet has become necessary—almost like a fifth utility—and a digital divide still exists in most communities.

Dianah Neff, Philadelphia's chief information officer, estimates that the city will save \$2 million annually on telecommunications costs by eliminating the need for certain services, such as leased lines to all remote facilities. Other cities report similar savings and many additional financial benefits, most notably those derived from greater productivity through more efficient operations, as well as from growth through economic development.

Philadelphia's pioneering efforts have cleared the way for other municipalities to implement multi-use broadband wireless networks in their own jurisdictions. As of this writing, according to industry analyst firm *visiongain*, over 400 communities (about half in the U.S.) are deploying or requesting proposals for wireless municipal networks to satisfy a range of needs, from fixed broadband and public Internet access to public safety and video surveillance. A significant percentage of the current deployments are in rural communities that need to connect government agencies, libraries, schools and medical facilities, and provide high-speed network access for residents. And *visiongain* believes that an additional 400 communities will begin planning efforts in 2006.

Some of these initiatives begin as fairly small projects with plans to grow over time. Others are implemented as more determined efforts to blanket entire cities with coverage from day one. In Silicon Valley, for example, MetroFi has deployed infrastructure covering some 40 square miles to serve the communities of Cupertino, Santa Clara and Sunnyvale with broadband Internet access for about the cost of a dial-up service. At only \$19.95 per month per home, residents are expected to save around \$250,000 per year on their collective high-speed Internet access charges.

## **A multi-use wireless municipal network can benefit the entire community in a number of other ways:**

- Local governments gain cost-effective connectivity for both office-bound and mobile workers
- Untethered access helps improve productivity by allowing field personnel to work more effectively and efficiently
- Service providers can cross the digital divide to reach anyone unserved by DSL or cable facilities
- Residents have convenient access from their homes, workplaces and public spaces
- Visitors and tourists can enjoy complimentary access during their stays
- Ubiquitous access facilitates a wide range of economic development initiatives
- Roads and intersections can be monitored to reduce traffic congestion and improve public safety

## **Wireless has become the preferred approach for municipal networking for some very compelling reasons:**

- Wireless standards and systems have matured to afford simple and secure access at broadband data rates
- Wireless networks are remarkably flexible because there is little or no dependency on physical infrastructure, allowing coverage to be extended virtually anywhere
- Wireless mesh technology creates a self-forming/self-healing multi-path backhaul network that scales readily and delivers mission-critical reliability
- Wireless access points can serve a ready-made market since wireless interfaces are now built into nearly all laptop PCs, and many personal digital assistants (PDAs) and smartphones
- Wireless deployments are invariably less expensive than the alternatives because there is no need for costly trenching or monthly charges for leased lines

This guide provides an introductory primer on wireless municipal networks that covers three essential topics: popular applications, pertinent technologies and key business considerations. The material is intentionally non-technical, making the document suitable for policy-makers who are considering a wireless municipal network for its many economic and other advantages.

## Municipal Networking Applications

With the ability to support secure data, video surveillance and voice services at broadband data rates with little dependency on a wired infrastructure, applications for wireless municipal networks are virtually without bounds. These four applications have emerged as being the most popular, and networks supporting more than one in a “mixed use” environment are becoming increasingly common:

- Public Access via HotZones & HotRegions
- Fixed Broadband Internet Access
- eGovernment Initiatives
- Public Safety

### Public Access via HotZones & HotRegions

Public Internet access began with the HotSpot, which is a wireless local area network (WLAN) that serves a single facility, such as a hotel lobby or coffee shop. With the advent of wireless mesh networks eliminating wired backhaul for HotSpots, HotZones became practical. A HotZone provides wireless access throughout a larger area, such as an airport terminal or convention center, by forming a seamless inter-network of HotSpots. Advances in mesh networking technology, such as synchronization, now make entire HotRegions feasible—and remarkably affordable. A HotRegion can provide ubiquitous wireless access throughout an even larger geography, including an entire metropolitan or rural area. Many wireless municipal networks create just such a HotRegion consisting of numerous HotSpots (sometimes called “PicoCells”) and HotZones.

The blanket coverage afforded by a municipal wireless HotRegion network can serve a wide variety of needs—from providing Internet access for residents and visitors, to enhancing public safety effectiveness within the jurisdiction. Public kiosks can also be provided at various locations for visitors or residents without PCs. Access for some may be free (possibly supported by paid advertising or funded by the municipal government); others will pay for their usage. Either way, a HotRegion can promote economic development and tourism, save constituents money on their access charges, and help bridge the digital divide for underserved or unserved segments of the population.

One recent innovation is the use of location-based services that give users access to information on resources in their immediate vicinity—a building, city block or neighborhood. Imagine being able to find any restaurant, store, library, police station, post office or whatever within walking distance of wherever you happen to be. And all for free when the service is supported by paid advertising.

### Fixed Broadband Internet Access

Literally every facility in the coverage area can benefit from broadband Internet access with a wireless municipal network: government offices, school campuses, hospitals and clinics (for both routine communications and advanced telemedicine applications), public venues (such as airports, stadiums, shopping districts and malls, open areas, parks, etc.), and even tourist destinations, including RV parks, marinas and convention centers—many of which may have their own HotZones providing Internet access for their patrons.

### Ubiquitous Internet Access in Silicon Valley, California

**MetroFi, Inc., the leader in designing, building and operating metropolitan area wireless broadband networks, has deployed a 40 square mile network covering the cities of Cupertino, Santa Clara and Sunnyvale in the heart of California’s renowned Silicon Valley. By combining an 802.11b/g wireless access point with SkyPilot’s high-capacity 5.8 GHz synchronous mesh backhaul node, MetroFi is able to deliver ubiquitous broadband wireless access cost-effectively. MetroFi evaluated several broadband wireless solutions before selecting SkyPilot as its partner. According to MetroFi’s CEO Chuck Haas, “The SkyPilot carrier-class broadband wireless system was the only solution that met all of MetroFi’s objectives for performance, high availability, security, flexibility, low total cost of ownership, and ease of deployment and operation.”**

MetroFi has plans to expand its coverage throughout the San Francisco Bay Area, as well as deploy networks in other metropolitan areas both in the U.S. and abroad. “There is no doubt we will be equally successful in other locations,” Haas added, “because with the SkyPilot system, MetroFi is able to offer broadband wireless access to residents for about the price of a dial-up service.” The reason MetroFi can compete profitably at these prices is the low cost of deploying the network. MetroFi’s “all in” cost is around \$50,000 per square mile for ubiquitous coverage. And in true Silicon Valley fashion, the 70% costs savings over other wireless solutions are based almost entirely on advances in technology.

Taxpayers benefit in two ways. First, local government agencies will spend considerably less money on telecommunications costs. And second, all businesses and residents will get DSL-like access speeds for about the price of dial-up connections in some locations. For example, MetroFi is helping the residents of Silicon Valley save \$20-30 per month over the going local rate for DSL and cable access. It is important to note that these personal savings to constituents can be considerable, which is why voters tend to support municipal broadband wireless networking initiatives.

Entrenched carriers and some Internet service providers have lobbied against these efforts (and some continue to do so). But despite some recent legislative restrictions, they have essentially lost the battle, clearing the way for a variety of public/private partnerships that protect carriers from unfair governmental competition.

#### **eGovernment Initiatives**

As more and more citizens gain access to networked resources, local eGovernment initiatives become viable. Examples include Geographic Information Systems (GIS), on-line applications for building permits and tax payments, community calendars, digital libraries, distant-independent learning, and more. And to serve residents who do not have PCs, a wireless municipal network makes it cost-effective to deploy public-access “kiosks” at government offices, libraries, community centers, banks and retail establishments, and many other locations frequented by the public.

But the locations need not be fixed. Indeed, a wireless network gives mobile field personnel online access to centralized resources, along with real-time reporting capabilities from anywhere in the coverage area. For example, building inspectors would be able to access plans, reports, building code reference materials and other project-related information, then enter a report on their inspection—all while on site. Similar capabilities can exist for vehicle fleet communications

**Wireless works,  
and works well,  
in the municipal  
environment.**

and tracking. Note that some of these mobile applications may require special (and inexpensive) software in the laptop or PDA to handle “roaming” from access point to access point.

With ubiquitous coverage of wireless access, major cost savings can be achieved in applications that are currently quite labor-intensive, especially those involving utilities and other public service infrastructure. For example, remote data can be collected electronically from utility or parking meters (so-called automatic meter reading or AMR), traffic or bio-hazard sensors, toll gates or fire alarms. Wireless sensors can be used to monitor equipment, water or natural gas lines, tank levels, and more. This capability can provide an immediate alert, which helps prevent a minor situation—such as a fire starting or a tank beginning to leak—from turning into a major disaster.

#### **Public Safety**

To minimize and potentially eliminate any dependency on commercial infrastructure, such as the public switched telephone network (PSTN) and cellular services, many public safety agencies long ago began utilizing narrowband data communications in various licensed spectrums. With the advent of municipal broadband wireless networking, both first responders and their chains of command can now benefit from some much more powerful capabilities. These “multimedia” (voice, video and data) applications include ad-hoc incident communications and reporting, full situational awareness for improved command and control, around-the-clock video surveillance, and more.

Wireless networks are particularly well-suited for video surveillance applications. With no wires to pull, cameras can be placed literally anywhere indoors or outdoors—either permanently or in rapid response to a temporary situation. And without monthly leased line expenses, cameras can be operated in more places more cost-effectively. Such complete

### **Enhanced Public Safety In Boulder City, Nevada**

**Triad Wireless, a systems integrator specializing in broadband wireless networks, chose the SkyPilot Public Safety synchronous mesh solution for Boulder City, Nevada based on SkyPilot's superior performance, range of operation and ease of deployment. By utilizing the licensed 4.9 GHz spectrum for access and the unlicensed 5.8 GHz spectrum for backhaul, the city's police department will be able to install video surveillance cameras in squad cars to monitor activity and transmit real-time images while the officers patrol the large jurisdiction that extends 45 miles to the neighboring city of El Dorado, Nevada. The squad cars will also be equipped with mobile access to motor vehicle information and other centralized law enforcement databases. In addition, the mesh network will internet work all 16 of the city's buildings, which were previously either isolated or employed a VPN over costly wired connections. The new city-wide wireless municipal network now provides the performance, security, dependability, quality of service and other capabilities needed to support voice over IP (VoIP) when the city upgrades its phone system.**

Economic development  
Digital divide  
Location based services



**Wi-Fi HotZones**

Emergency response  
Video surveillance  
Communications



**Public Safety**



**eGovernment**

Wireless meter reading  
Remote monitoring  
Field report filing



**Fixed Broadband**

Municipal building connectivity  
Leased line alternative

## Municipal Multi-Use Networks

*A wireless mesh network offers an economically compelling solution for providing broadband services to mobile municipal workers, residents and small businesses.*

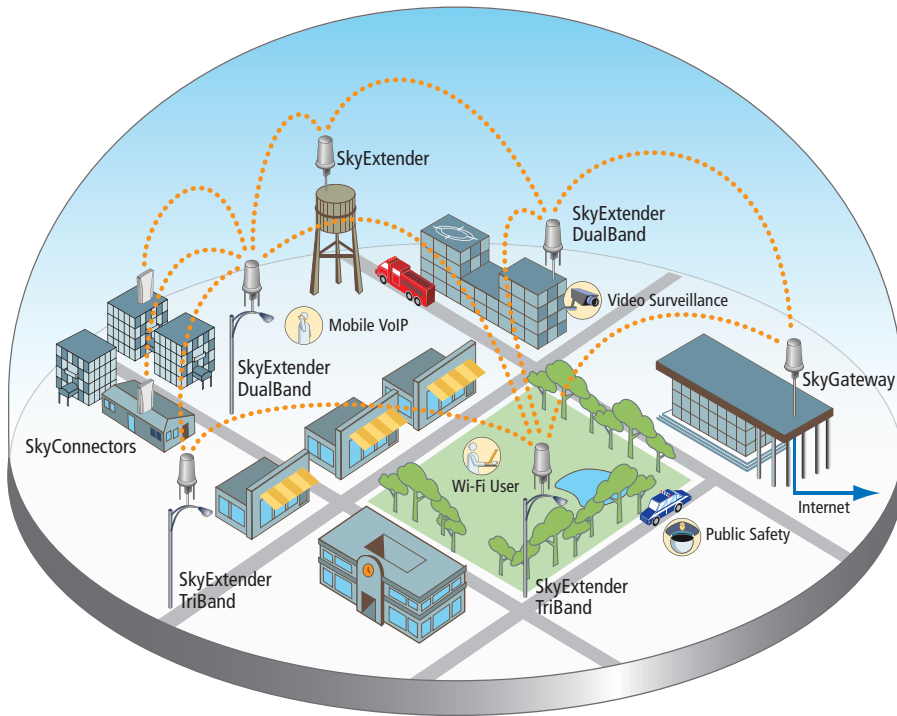
and constant surveillance can alert officials to any imminent situation as mundane as a traffic jam, or as serious as a fire or a crime in progress. Recorded video can then be used for forensic purposes, or during criminal prosecution.

The potential to enhance public safety with more powerful broadband wireless communications throughout an entire city or county has motivated governments to allocate spectrum specifically to satisfy such needs. In the U.S., for example, the Federal Communications Commission recently licensed the 4.9 GHz spectrum for exclusive use in public safety applications. Utilization of licensed spectrum enhances security and minimizes potentially disruptive RF interference in those situations when communications matters most.

### **Multi-use, Multimedia Networks— with Multiple Benefits**

Or deploy all of the above in a single wireless municipal network. Next-generation technology enables both Wi-Fi (2.4 GHz) and public safety (4.9 GHz) access with mesh backhaul in yet another, separate spectrum (5 GHz). Traffic can be partitioned with virtual private networks (VPNs) or Virtual LANs (VLANs) to assure privacy, and then prioritized to deliver a satisfactory quality of service. The economies of scale involved can reduce costs dramatically without sacrificing performance.

The benefits combine to make the case even more compelling for multi-use municipal deployments. Fixed broadband and public Internet access reduce government expenditures and promote economic development. Better situational awareness in public safety services improves responsiveness and, ultimately, lowers crime and saves lives. eGovernment initiatives increase productivity and foster better relations with the voting public. And the ubiquity enables mobility throughout the municipality.



### Municipal Wi-Fi HotZone

*For highest performance and scalability, the mesh backhaul and Wi-Fi access should be provided in different RF spectrums.*

## Wireless Networking Technology

Radio frequency (RF) communications involves numerous enabling technologies extending from the tip of the antenna through the gateway to the wired Internet connection.

Presented here are those aspects of wireless communications that are particularly relevant to municipal deployments.

Advances in wireless networking technology now enable communications at broadband data rates (11-54 Mbps) via industry-standard protocols (e.g. Wi-Fi, short for Wireless Fidelity, based on IEEE 802.11b/g standards). To maximize performance, users generally access the network at one set of unlicensed frequencies (normally 2.4 GHz) with backhaul provided on another (5 GHz). This arrangement leverages the Wi-Fi interfaces built into most laptop, notebook and handheld computers, while minimizing RF interference to achieve better backhaul performance. In the U.S., public safety agencies are allocated exclusive use of the licensed 4.9 GHz spectrum; many other countries have made similar allocations.

With the relatively low-powered Wi-Fi interfaces built into laptop PCs and PDAs, Wi-Fi access points have a range of about 500-600 feet (150-180 meters). This requires a spacing of approximately 1000-1200 feet (300-360 meters)—more or less depending on the terrain—to gain ubiquitous coverage. This spacing, in turn, results in a density of around 30 nodes per square mile (or 12 nodes per square kilometer) when blanketing an area with total coverage. The range can be

extended for users who install a higher-powered external Wi-Fi interface in their PCs, and extended further yet with an outdoor antenna. This configuration may be necessary for some users accessing the network from the inside of a building owing to the attenuation of RF signals through walls and windows.

Wi-Fi access can be asymmetrical; that is, the downstream data rate (from the Internet) is higher than the upstream data rate. This is rarely, if ever, a problem, which is why most forms of broadband access operate in this same fashion, including Asymmetric DSL (ADSL), cable and satellite. Although Wi-Fi protocols operate at “raw” data rates of 11 Mbps to 54 Mbps, the actual per-user throughput is often specified at around 1 Mbps downstream and 256 kbps upstream. These rates can vary, and are dependent on a number of factors beyond the scope of this document. Suffice it to say: 1 Mbps is more than adequate for the vast majority of residential subscribers.

Many businesses have more demanding needs, however. Which is why some wireless solutions offer special customer premises equipment (CPE) to provide a higher throughput

than is possible with Wi-Fi. These systems may access the backhaul portion of the network directly (at 5.8 GHz, for example) to achieve a throughput of up to 10 Mbps, and the link may be symmetrical (with the same data rate both downstream and upstream). Businesses need the higher downstream bandwidth to support multiple users. And for those who host their own Websites or utilize voice over IP (VoIP) for an entire office, a higher upstream data rate is required.

A similar business-like situation exists for multi-dwelling unit (MDU) and multi-tenant unit (MTU) facilities, such as apartments and office buildings, respectively. In these situations, the property manager may arrange for high-speed “business class” symmetrical connection with the municipal network, then provide access (via wired connections or a wireless HotZone, or a mix of both) for all occupants.

Backhaul is usually provided by a wireless mesh network. The mesh topology is ideal based on its high resiliency and flexibility, which is why this same topology is employed in both the Internet and the PSTN. Most wireless mesh solutions are self-forming and self-healing, allowing them to be deployed and operated with remarkable ease. Next-generation wireless mesh networking technology builds on this foundation to offer enhanced quality of service (QoS), better security provisions, superior traffic management capabilities and more. QoS is especially important when supporting VoIP and video applications throughout the wireless mesh network. Normally, QoS is implemented by assigning a higher priority to delay-sensitive traffic and utilizing some form of end-to-end traffic control, such as a synchronized mesh protocol.

It is important to note that the backhaul portion of the network is almost always over-subscribed. If every single user logged in at the same time, this could present a problem. The same is true of the PSTN, which is also over-subscribed. Fortunately, usage patterns are well understood and quite consistent. For example, business usage is heaviest during normal business hours; residential usage is at its highest during the evenings and on weekends. Other factors, such as

statistical multiplexing gains and robust end-to-end protocols that regulate traffic flows, mitigate the effects even during peak periods. For these reasons, over-subscribing by a factor of three to five is a fairly common practice.

Because wireless municipal networks are implemented mostly outdoors, they present two additional challenges: mounting locations and power. Access points and other network nodes usually get mounted on light/power/sign poles, special communications towers, tall buildings or any other permanent structure that provides a good line of sight. Finding suitable mounting locations is generally not a problem, because the municipal government probably owns (or has right-of-way access to) most of the necessary facilities. Depending on the business model used for the network (see discussion below), these rights may need to be conveyed to one or more service providers. Of course, rights-of-way may also be obtained from the private sector in separate agreements where these facilities afford better coverage. The best mounting locations also have AC power available, such as light poles or buildings. But because the power is provided on an un-metered basis, a special contract may be required with the local power company.

Advances in wireless networking technology now enable communications at broadband data rates via industry-standard protocol.

## 21<sup>ST</sup> Century Access for 12<sup>TH</sup> Century Communities

**Canterbury, one of the United Kingdom's oldest and most Medieval of cities, may seem like an unusual setting for state-of-the-art networking technology. But for Telabria, a privately-held regional network operator based in Kent, UK, the city seemed ideal—and anxious for the change. With its eclectic mix of historic dwellings, many dating back as far as 1100, the setting posed a number of connectivity hurdles. Which is why the county of Kent remained underserved by traditional land-based broadband technologies, such as DSL and cable. With SkyPilot's unobtrusive and carrier-class synchronous mesh solution, however, Telabria's Skylink network is able to serve Kent's 60,000 businesses and 1.5 million residents with wireless broadband communications for both data and voice over IP (VoIP) applications. The Skylink “Regional Area Network” (or RAN) is now available in several tiers of service, including Skylink Home (an asymmetrical residential service at 1 or 2 Mbps downstream), Skylink Pro (a symmetrical 1.5 or 3 Mbps service for small and medium businesses) and Skylink Ultra (a symmetrical 5 or 10 Mbps service for larger enterprises).**

- Scalability & Extensibility
- Security
- Reliability
- Performance & Quality
- Ease of Deployment and Operation
- Low Total Cost of Ownership

## Critical Success Factors

When evaluating different wireless solutions for municipal networks, the following capabilities are the most critical to the success of the project:

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**Scalability & Extensibility** – The solution should have the ability to expand coverage, increase capacity and add new applications. At a minimum, access and backhaul should be provided in different RF spectrums to minimize potentially crippling self-interference. Ideally, the solution will also provide a means for optimizing the utilization of available RF spectrum (known as spatial or spectral reuse) to effectively eliminate all self-interference, thereby maximizing performance throughout the mesh backhaul.
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**Security** – The security provisions should protect the wireless network itself, and ensure the privacy and integrity of all user traffic through a mix of user authentication, access controls and packet encryption. The most robust user authentication is based on the IEEE 802.1x standard, but many others are satisfactory for municipal deployments. Encryption should be “strong” (at least 128 bits), preferably based on the Advanced Encryption Standard (AES).
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**Reliability** – The mesh topology is ideal in large, outdoor networks based on its inherently self-healing operation. Some of the better solutions also provide load-balancing with automatic failover at the gateways to the Internet or other wired network(s). Multiple gateways are invariably needed to increase overall throughput; load balancing and automatic failover take advantage of this basic configuration to maximize overall uptime.
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**Performance & Quality** – Acceptable levels of performance require both high throughput and robust traffic management capabilities to support multi-use voice, video surveillance and data applications. Full control over throughput and quality of service (QoS) requires, at a minimum: network segmentation (via Virtual LANs or VLANs), traffic filtering (to block abusive usage), rate limiting (to block excessive usage) and traffic prioritization (to accommodate different types of traffic). These capabilities are needed to ensure that voice and video traffic get handled at a higher priority to minimize latency (delay) and jitter (variations in delay). The same capabilities also permit “premium” services to be provisioned—normally at a “premium” price.
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**Ease of Deployment and Operation** – In an urban environment full of tall metal and/or concrete structures, the solution must have the ability to overcome “line of sight” (LOS) obstacles to RF transmissions, and a means to mitigate the inevitable RF interference. Mesh topologies are ideal for non-line-of-sight (NLOS) operation, especially with their self-configuring and self-healing capabilities. But many first generation mesh solutions are notoriously poor at mitigating interference. Mesh nodes that integrate access and backhaul in a single unit (at different frequencies, of course) dramatically simplify the installation and operation of the network. Optionally, support for Power over Ethernet (PoE) can eliminate the trouble and expense of providing separate AC power for some nodes.
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**Low Total Cost of Ownership** – The solution should have the ability to start small (possibly in a pilot deployment) with pay-as-you-grow expansion to ubiquitous coverage. Some solutions offer special customer premises equipment (CPE) that also serves as a mesh backhaul node, which helps reduce costs and potentially “subsidizes” the rollout. Of course, the initial and subsequent investment in mesh backhaul should be fully protected as the network’s footprint grows, or as newer access technologies, such as WiMAX, are introduced. Conversely, avoid solutions that require over-designing the network, especially those with short transmission distances or an inability to overcome LOS obstructions.

## Business Models and the Business Case

Depending on the arrangement—the *business model* for the deployment—the financial *business case* may or may not be important to the municipality. In fact, under some business models, there may be no up-front cost at all to the city.

The flexibility of wireless solutions permits a wide range of potential business models. The business model essentially determines who owns and operates the network infrastructure, which has ramifications on how the arrangement is structured legally, logistically and financially.

The municipal government can own and operate the network. Or, the municipality can own the network, but subcontract its installation and operation to a company specializing in wireless networks. Except for public safety applications, however, such arrangements may be opposed by entrenched carriers. For this reason, other business models that involve some form of public/private partnership tend to be favored.

Market fairness can be assured where one or more Wireless ISPs (WISPs) is permitted to deploy and operate the network(s) under an agreement similar to those made with cable operators. In these models, the WISP owns and operates the network. The WISP may lease mounting locations from the municipality, or provide certain network services in exchange for using these facilities. The agreement may also require a single WISP to offer network access wholesale to other service providers.

The versatility of wireless communications facilitates many additional forms of cooperation between the public and private sectors. The resulting “hybrid” business models may involve loans or loan guarantees, grants to help defray the initial costs, commitments from government agencies as “anchor tenants” to lower risks, streamlining of the permitting process, low or no charges for mounting locations (perhaps for a limited period of time), and assistance in forming a multi-provider consortium. Or a revenue-sharing arrangement, for example, would place the municipality in a position to share in and subsequently recover some of the implementation costs. These and other types of partnerships can be constructed to benefit all parties: government, service providers, and taxpaying businesses and residents.

The general “rule of thumb” is this: When public safety is the only application, the municipal government should own and operate the network; when Internet access is the principal application, the network is best owned and operated by one or more service providers specializing in wireless municipal networks. This rule of thumb has the twin advantage of leveraging economies of scale where possible (while avoiding controversy), and preserving total control when necessary.

As previously mentioned, the municipality may or may not care about the business case that takes into account total cost of ownership (TCO) and return on investment (ROI). Naturally, the business case will be very different for a public safety network (justified for non-financial reasons and potentially funded by a state or federal grant) vs. an Internet access network (requiring a satisfactory ROI under any business model).

TCO involves both capital expenditures (CapEx) and operational expenditures (OpEx). CapEx covers the initial cost of all equipment and its installation, including the planning, engineering, deployment and testing involved. With the revenue normally generated from Internet access, the pay-back period for CapEx generally ranges from one to three years. Advances in technology and greater efficiencies from increased integration have caused prices to drop recently—from \$150,000 per square mile for coverage to a more palatable \$50,000 per square mile—causing the payback period to shorten to within a single year.

OpEx includes ongoing network maintenance and management costs, rent/lease charges for mounting locations and power, Internet backbone connection fees, network services (such as a portal), and customer support. Because the mesh network is self-healing, OpEx for network management is often the lowest ongoing expense. Nevertheless, the situation requires creating and staffing a 24x7 network operations center (NOC), and many WISPs are able to support networks (and subscribers) anywhere in the world with a single, centralized NOC.

The revenue side of the ROI equation includes user access fees (monthly subscriptions or per-use at HotSpots) and paid advertising. If desired by the municipality, access charges can be lowered or even eliminated for some constituents, such as low income households and visiting tourists. The municipality itself may get some access “free” in exchange for mounting rights or other favorable contract provisions.

As mentioned above, the multi-use, multimedia wireless municipal network makes for the most compelling business case. Economies of scale minimize the collective costs, while maximizing the revenue potential. So if it becomes too difficult to cost-justify each application individually, consider deploying a single network that supports public access via HotSpots, fixed broadband Internet access for residents and businesses, e-government initiatives and public safety.

The versatility, scalability and affordability of wireless networking normally make the business case fairly convincing today for most wireless municipal network applications of any scale or extent. Whether funded by grants, taxes, bonds or assessments, the expenditure is a responsible use of public monies. And where the private sector makes the investment, the service offering can be competitive while producing a satisfactory return. Either way: Wireless works—and works well—in the municipal environment.

## Conclusion

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For many businesses and individuals, broadband Internet access has become a “fifth utility” that is nearly as important as water, sewer, gas and electricity. For this reason, industry analyst visiongain believes “... it is fast becoming a city or state duty to provide at least the means for widespread broadband service to the citizenry.”

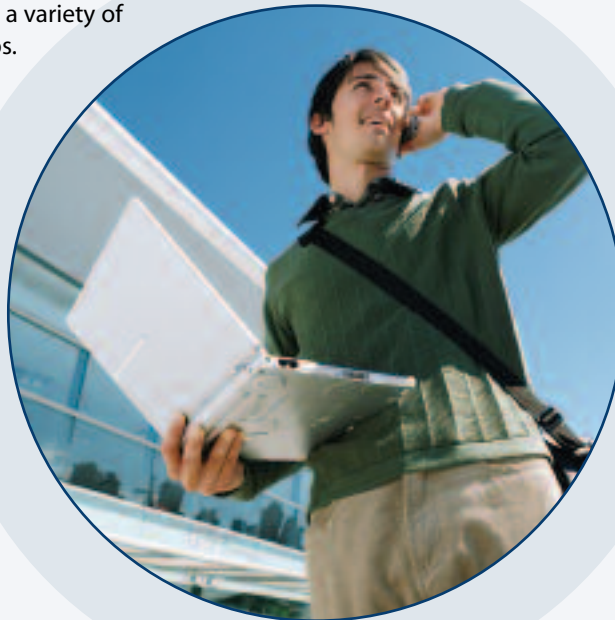
This 21<sup>st</sup> century reality is why a growing number of municipalities are taking steps to ensure that such access is both available and affordable. Municipalities (and taxpayers) also stand to benefit directly, of course, from enhanced public safety, lowered telecommunications costs, improved worker productivity, increased tax revenue through economic development, and more.

Today, hundreds of communities around the world are already realizing these and other benefits by going wireless. Wireless communications is fast, dependable, secure and affordable. Wireless is also remarkably flexible, allowing for scalable, ubiquitous coverage in a variety of different public/private partnerships.

Wireless mesh networking offers a metro-scale solution that will drive the development of mobile metropolitan networks.

- The Yankee Group, February 2006

These pioneering efforts have shown that the real key to success in municipal networking is the structure of the public/private partnership. A win/win partnership keeps the municipal government out of the “telecom business” to avoid unfair competition. A win/win partnership gives service providers access to the network and its subscribers, facilitating the delivery of affordable value-added services that residents and businesses now require. And a win/win partnership helps keep both costs and risks at an absolute minimum.



## About SkyPilot Networks

SkyPilot Networks is the leading provider of next-generation synchronous mesh networking solutions for broadband wireless access in both metropolitan and rural environments. By designing the industry's first wireless mesh networking solution to operate as a complete system, SkyPilot has set a new standard in price/performance that enables broadband wireless services to compete effectively and affordably with DSL and cable access.

To overcome the problems inherent in "shared air" wireless communications, SkyPilot Networks designed an end-to-end solution purpose-built for the mesh topology. The resulting Synchronous Mesh Architecture overcomes limitations of previous generations of mesh technology—cost, complexity, poor performance, excessive interference and inadequate scalability—while preserving the many advantages of mesh networking and wireless communications.

The SkyPilot synchronous mesh protocol coordinates traffic flow throughout the mesh network in a way that eliminates disruptive collisions caused by self-interference to deliver superior performance with a deterministic quality of service. The intelligent eight-way directional antenna array enables longer distances between nodes (up to 10 miles or 16 kilometers) to lower deployment densities and costs without sacrificing throughput or reliability.

Other SkyPilot innovations that improve overall price/performance include dynamic route optimization with variable modulation, mesh-wide spectral management, higher power levels for better penetration through obstacles that attenuate radio frequency (RF) transmissions, support for non-line-of-sight operation, load-balancing with automatic failover among gateways, comprehensive traffic management capabilities, robust security provisions, and more.

SkyPilot's architecture has several differentiating characteristics that can take scalability and performance to the next level.

- The Yankee Group, February 2006

The SkyPilot system-level solution provides a full suite of products for carriers, service providers and municipalities deploying broadband wireless networks. The SkyPilot suite includes the:

- SkyGateway to connect to the Internet or other wired networks,
- SkyExtenders that expand the synchronous mesh, and also serve as multi-band access points or customer premises equipment,
- SkyConnector to provide outdoor wireless access for residents and businesses, and
- SkyProvision and SkyControl for network management and monitoring.

To date, over 200 municipalities and service providers in 40 countries have deployed the SkyPilot solution based on the many advantages of the Synchronous Mesh Architecture.

**To learn more about how your community can benefit from the next-generation Synchronous Mesh Architecture in your wireless municipal network, visit us on the web at [www.skypilot.com](http://www.skypilot.com), email us at [sales@skypilot.com](mailto:sales@skypilot.com), or call 866-SKYPILOT (866-759-7456).**



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