Wireless in Vegas

Nevada uses microwave to bridge the imformation gap

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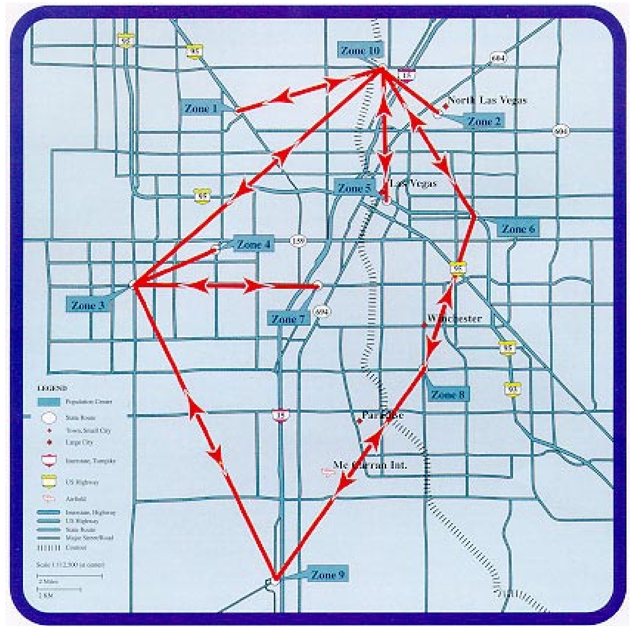
Supporting a road network with over 100,000 vehicles per day, a new traffic control system in Las Vegas incorporates a wireless connection linking cable and fiber technologies-a cost-effective communications backbone that has had to meet some unique local challenges

The latest in wireless traffic management systems is installed and operating in Clark County, Nevada . The Las Vegas Area Computer Traffic System (LVACTS) is designed to monitor and control the busiest intersections in an 850-square-mile area known as the Las Vegas Valley, including the cities of Las Vegas, North Las Vegas and Henderson.

On July 29 1997, after successfully completing a continuous 30-day system verification test, the customer accepted the microwave trunk network used for signal coordination. Developed by AML Wireless Systems in partnership with the Nevada DOT, Barton-Aschman Associates and Fischbach and Moore Traffic Systems Group, the network exceeded customer expectations with a reliability of 99.99 per cent over the test period. During the test, analog video C/N (carrier-to-noise) and C/CTB (carrier-to-composite triple beat) were monitored and a BER (bit error rate) of 10^{-6} was maintained on the digital data.

The microwave network integrates with cable and fiber technologies to create a seamless solution that supports LVACTS's efforts to improve traffic flow through the Valley. Real-time multichannel video and data in a full duplex configuration are being transmitted using microwave technology. Significant savings in construction costs and deployment time were realized from a wireless solution compared to the efforts involved in breaking new ground to run cable. The overall impact on the existing environment is minimized, and areas with terrain restrictions can effectively be incorporated into the system. The wireless solution to traffic control in the Las Vegas Valley uses proven technology from the communication industry, bridging the gap between the two commerce sectors.

A PLAN FOR THE VALLEY



Communications ring for the LVACTS control system

In conjuction with DKS Associate, the Nevada DOT have developed an aggressive ITS strategic plan for the fastest-growing city in the USA. The population of the Las Vegas Valley is estimated to grow at a rate of 4.5 per cent a year, to approximately 1.4 million by the year 2000. Combine this with a flourishing tourist trade that currently brings 30 million visitors to the area each year and the need to effectively manage vehicular traffic volumes is apparent.

The arterial network in the Las Vegas Valley carries up to 100,000 vehicles per day, significantly higher than other typical urban areas. One of the greatest demands is for a 3.5 mile stretch of roadway called 'The Strip' where most of the casinos/hotels are concentrated. The congestion is exemplified by the 22 lane Tropicana Avenue/Las Vegas Boulevard intersection that passes an estimated 150,000 vehicles every day, distinguishing itself as one of the busiest intersections in the world. It is estimated that one in fifty vehicles on the road is a rental vehicle, representing a significant number of drivers who are unfamiliar with the local roadways. Population growth and the sheer volume of visitors have contributed to the traffic congestion that has resulted in an increase in traffic incidents of almost 50 percent since 1991.

Among the initiatives of the Nevada DOT's ITS strategic plan is the establishment of a regional traffic management center (TMC) to coordinate traffic flow, traveler information and incident management. Central to the LVACTS's regional system are the digital sensor data and real-time video used to monitor traffic conditions and signal operation in the controlled areas. An unobtrusive design was sought that minimized disruption to the area and its existing infrastructure. The cost of a wireless solution was not only less than fiber, but additional construction was avoided that would have delayed the deployment and further added to traffic congestion.

"The microwave network integrates with cable and fiber technologies to create a seamless solution"

A network of terrestrial microwave links in the SHF (super high frequency) radio band were implemented to carry the information between the controlled areas and the TMC. The microwave solution satisfied the bandwidth requirement of a multichannel video system while offering quick deployment at a fraction of the cost of a hard-wired system. A hybrid ring/star topology of full duplex microwave radios provided the path diversity and integrity at critical network nodes. The redundancy of the design ensured the network satisfied the reliability requirement for the system. The wireless network integrated with the existing environment with minimal disruption, creating a "win-win" solution for both the Nevada DOT and the traveler.

WIRELESS WORKHORSE

Terrestrial microwave relays are one of the most established wireless technologies available today. The entire telecom industry was built on microwave, providing this technology a long history of proven field applications. In today's competitive communications environment they provide a wireless transmission means for telephony, high-speed data and video that is transparent to the end user. Their ability to reach areas that would otherwise be prohibitively expensive to network and integrate with existing hard-wired infrastructures make them an ideal alternative for both broad and narrow bandwidth applications. Licenses for their operation and coordination of the frequencies can be arranged through the appropriate firms and federal agencies. The technology used in LVACTS is in principle, the same workhorse used by the communication industry for the last 30 years.

The higher one goes up in frequency in the microwave spectrum, the more radio signals take on the characteristics of light rays. In the SHF radio band, microwave radio links are a line-of-sight (LOS) technology requiring an unobstructed view and adequate Fresnel zone clearance for point-to-point communication. The primary advantage of using microwave in the SHF spectrum is the increased bandwidth, capable of carrying multi-channel video along with high-speed data. A second advantage is the ability to use high gain, directional antennas. By utilizing antennas several wavelengths wide, it is possible to focus microwave beams in a manner similar to focusing light rays with a lens or reflector. The highly directive nature of a point-to-point wireless system creates a secure link with adequate isolation for a full duplex network of microwave relays.

Optimal microwave system design must not only account for free space loss and antenna isolation, but

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also signal fade. Fading is a weakening of the received microwave signal caused by meteorological conditions or terrain geometry that either absorbs some of the transmitted signal or deflects it from reaching the receive antenna. At higher microwave frequencies the wavelength approaches the size of atmospheric water droplets and rain fade considerations must be accounted for in the design.

The second type of fading that must be considered in wireless design is the multipath effect. Multipath fading is the interference between a direct wave and a reflected wave that combine out-of-phase to cancel each other out. The reflection may be from the ground or thermal gradients in the atmosphere delaying the arrival of the reflected wave. Both fading conditions can effectively be counterbalanced through the use of frequency or space diversity and the incorporation of sufficient fade margin into the path design.

NETWORK DESIGN

The LVACTS signal coordination project brought together wireless products at 13 GHz, 18 GHz and 31 GHz to support different parts of the network. The equipment had to be durable enough to withstand the high winds and extreme temperature ranges this region of the country experiences. The cool desert nights and relentless daytime sun meant the outdoor equipment had to be stable over large temperature swings. Temperature controlled outdoor cabinets housed the remaining equipment at each control zone. Monopoles were erected to provide the line-of-sight necessary for microwave transmission.

The LVACTS microwave trunk network is comprised of 10 control zones connected to the TMC in a hybrid ring/star topology, with link distances varying between 1 and 12 miles in length. The ring design provides a built-in redundancy to five of the 10 control zones. The remaining sites outside of the ring use standby units for redundancy. No more than four primary microwave links are used between the control zones and the TMC thereby ensuring a robust system with little signal degradation.

The LVACTS microwave trunking network relies primarily on the 18.14 - 18.58 GHz spectrum allocated by the FCC for private video transmission. Based on a VSBAM transmission, the 440 MHz of allotted spectrum has the capacity for 72 NTSC video channels. Using technology developed and supplied by AML Wireless Systems, 18 GHz microwave radios currently transport 27 channels of real-time analog video and 22 T-1 data channels using QPSK digital modulation. The ability to expand the initial configuration was also a priority in the original system design. This flexibility has already been well served with an expansion to include the municipality of Henderson into the system.

An elaborate frequency plan was developed that took advantage of alternating polarization modes and frequency reuse to carry the analog video and digital data around the network. A phase-locked microwave system with sufficient fade margin on each link ensures the system will operate in the most extreme weather conditions.

According to Mr. Cliff Gorby, AML Wireless Systems’ President, “The microwave system represents a landmark for future ITS systems. State-of-the-art broadband wireless technology is used to provide a two-way, full duplex monitoring and control system at a fraction of the cost of a hard-wired network. The real time multi-channel video provides LVACTS an advantage in improving the area’s traffic logistics. The design has the flexibility to expand the microwave portion to surrounding areas and integrates with existing fiber and coaxial networks. The system is also ready for digital video should the need arise in the future.”

AML Wireless Systems (formerly Hughes AML) has over 30 years of experience in providing solutions to any video, voice, or data signal distribution requirement. According to Gorby, “this is not a new or untried technology. This same technology has been used by the CATV industry for years to provide signal distribution in cable systems. AML Wireless pioneered this technology in 1969 and has built and installed 100’s of systems worldwide. This is just a natural progression of this technology into emerging markets.”

The advantages of using 18 GHz for ITS applications are the available bandwidth, lower equipment costs and a deployment that requires minimal infrastructure rework. The monopoles used in Las Vegas Valley are 60 to 100 feet above ground level and are designed to handle wind gusts up to 100 mph based on three or four-sided antenna equipment mounting at the top. A commercial telephone outdoor cabinet at the base of each zone’s monopole provides the temperature control and rack space needed for the indoor equipment. The cabinets house the video and data modulation equipment, data multiplexer, a hub computer and modems plus a video matrix switch to increase video capacity at some hubs.

The microwave radios are designed for outdoor use and mount directly behind the antennas to minimize the length of elliptical waveguide runs and associated signal loss. Cross-polarized antennas permit the use of one dish for both upstream and downstream signals. The use of frequency

Monopole used in Clark County

diversification and alternating polarization in a ring configuration provides the system with a two-way capability in a fully redundant design. Control information from the TMC and digital sensor data from the zones use RF modems prior to being injected onto the 18 GHz microwave ring. Groups of T-1 data channels with a QPSK modulation scheme were used in the frequency plan because the equipment was readily available from many sources.

Live video feeds are provided by CCTV cameras installed at critical intersections and near freeways where congestion and incidents frequently occur. The cameras and other field equipment at each control zone are interconnected to the cabinets using existing twisted pair infrastructure where possible. Where no twisted pair wire exists, the use of narrowband FM microwave radios is being explored to transport the video and audio signals. The wireless links provide LVACTS with a low cost alternative to a traditionally hard-wired solution. Single-channel 31 GHz radios with their integrated antennas are ideally suited to traverse the short distances between the remote traffic cameras and the cabinets. A video matrix switch at the control zone cabinet consolidates the video feeds.

Competitive edge

As the world frantically struggles to become wired, a wireless ITS solution may be a practical alternative for many applications. Microwave links can be integrated with other hard-wired systems or used as a stand-alone system. The bandwidth for multi-channel video is available and system reliability requirements can be met through judicious system design.

The biggest benefit of wireless is its ability to cross natural barriers, transit non-contiguous areas or be quickly deployed to serve new areas. A hybrid of analog and digital signals may be transmitted in full duplex at speeds that rival fiber. Compared to negotiating right-of-ways and installing hard-wired systems, the broadband wireless alternative requires minimal infrastructure costs and a shorter implementation timeline. Wireless technology has a proven track record within other industries and projects like LVACTS are proving its viability within the traffic signal coordination and ITS markets.

A wireless future

The need to manage increased traffic flows is obvious and information is the key to its success. By providing timely, accurate information we can reduce traveler transit time, the pollution we generate and traffic incidents on our roadways. What isn't as obvious is the network needed to transport this information. A wireless alternative exists that can be used to integrate with other technologies to create a comprehensive solution. Choosing the 'best' solution almost always relates back to the application and its basic requirements.

Future ITS systems must take full advantage of all aspects of communication technology to serve its needs and satisfy its diverse applications.