Reliable Wireless Networks for Critical Infrastructure

Wireless Transmission Solutions for Utilities, Oil & Gas, and Transportation

Microwave radio has long been used by utilities, pipelines and transportation systems for their critical communications. Traditionally this has been low to medium capacity systems for voice, low speed data, and analog video transmission.The communications requirements of today's businesses now demand much higher bandwidth and multiple circuit interface options. Digital microwave radios combine these requirements with extremely high signal reliability, to yield ultra-secure end-to-end circuit availability.

Traditional applications

One of the more common applications of microwave radio has been for connecting SCADA (supervisory control and data acquisition) remote terminal units (RTU) to centralized operations centers. These are the systems that automate and centralize the monitoring, control, and alarming of remote equipment. SCADA provides a critical function in the operation of the power grid, gas and oil pipelines, and the nation's railways. Microwave radio's high availability and reliability provides operators with a secure link to all remote sites.

Power utilities also use transfer trip or relay switching systems to protect their infrastructure and to prevent large scale electrical outages. When these systems sense a fault due to a downed power line or other event causing a short in the power grid, they cause relays to trip and automatically isolate the fault. A failure in the transfer trip network could cause irreparable damage to expensive transformers and isolate millions of customers. Microwave radios are used in power networks to provide extremely fast and reliable

Microwave Communications Site

connections for these transfer trip devices

Furthermore, microwave radio is used to backhaul voice signals from land mobile radio (LMR) base stations. LMR is the "push to talk" radio technology found in utility trucks and trains as well as hand-held radios. Most often, it uses radio frequencies in the range of VHF and UHF bands to communicate between radio base stations and mobile units. Often this is the only communications available to the “front line” crews that maintain the utility infrastructure. To provide optimal coverage, the radio base stations often are located on a mountain or hilltop. These remote locations often preclude use of leased telephone circuits or private lines to relay voice communication signals back to a central radio dispatcher. Instead, communications departments prefer the high reliability, lower cost, and full control associated with using microwave radio for this backhaul application.

Another common application for microwave within critical infrastructure systems is interfacility voice communications. Microwave radio offers a cost effective and reliable alternative to leased lines, providing direct links between headquarters, branch offices, and facilities such as power plants, substations, and switchyards. They may carry everyday telephone conversations between distributed PBX systems, or they may provide critical linkages between centralize operations and major facilities.

For most traditional microwave applications such as those described above, microwave radio capacity requirements are relatively low. A few T1s are typically all that are needed. Channel banks are often supplied with the microwave to break the T1 circuits down to the lower-speed voice and data circuits. However, microwave is not limited to just these narrow band functions.

New applications

Just as the public telecommunications sector has been impacted by the demand for more bandwidth, utilities, pipelines and transportation systems are also requiring higher speed communications. Field personnel can save time and respond to emergencies more effectively when they have easy and instantaneous access to up-to-the-minute data about the utility infrastructure, available resources, or information about a crisis event. New technology in land mobile radio communications is being deployed to bring data and video to and from mobile units. Consequently the bandwidth requirements between mobile radio base stations and the core network is increasing. However, with capacity up to OC-3 (155 smbps), microwave radio is still capable of supporting these needs with the same high reliability.

Interfacility communications are also becoming more complex and requiring higher bandwidth. Voice is still king, but real-time video is gaining a lot of impetus, as well as data – primarily IP traffic to support departmental LANs and interdepartmental WANs. Furthermore the trend to share data across disciplines is accelerating the demand for more bandwidth. Today's digital microwave radios are capable of carrying high speed data up to 155 Megabits per second in a single RF channel, which – in addition to traditional voice traffic – can support T1/T3, ATM, digital video, and IP-based LAN/WAN circuits. Again, microwave radio can cost effectively support all of these applications while providing the security that critical infrastructure systems require.

Reliability hard to beat

One of the key features that makes microwave radio so attractive to critical communications networks is the high reliability it provides. Often the mistaken perception is that since microwave travels through the air, it is regularly degraded by weather and climate conditions that cause it to fade – resulting in data errors and outages. While atmospheric factors are definitely something to be dealt with, microwave paths can be engineered to provide availability better than 99.999% – the so-called “5 nines”. This benchmark equates to less than 5 minutes of outage per year. In fact, many microwave paths are engineered for even higher availability – often better than 99.9999%, or less than 30 seconds annually of down time! And for the rest of the time, they transmit data error free for crystal clear communications.

Often, critical communications network designers desire an even higher level of fault tolerance. This can be accomplished by designing networks with ring or "loop" architectures. Microwave radios easily adapt to this design. In fact, since the interfaces to the radios are standard DS1, DS3, OC-3 and Ethernet circuits, the microwave system can interact with fiber based SONET ring switching algorithms or IP/MPLS fast reroute protocols to provide media-diverse traffic protection. This often comes in handy when a fiber ring cannot be closed due to some geographic obstruction such as a lake, river, or mountain, or even a "virtual" obstruction such as a territorial boundary, high cost easement or private property.

Scaled to fit

Microwave radio is a point to point technology. That means that each link operates independently. Therefore it is easily scalable for simple systems connecting two sites, all the way up to large interstate networks linking hundreds of sites. Also, modern microwave digital radios are capable of scaling in capacity from 2 DS1 (T1) circuits up to 16 DS1, then from 1 DS3 up to 3 DS3, and ultimately OC-3 capacity. For data traffic, radios offer Ethernet, Fast Ethernet and Gigabit interfaces (electrical or optical) with throughput defined by the RF channel capacity.

Furthermore, the newest radios feature capacity keys, which allow a radio hop to be upgraded from one capacity to another. If the circuit type is the same (i.e. 2 DS1 up to 16 DS1, or 1 DS3 up to 3 DS3), and if the radios are equipped with hot-standby redundancy (common in critical communications networks), then this upgrade can be accomplished while in service. In some cases, multiple radios may be combined on the same antennas to provide even higher capacity across a link.

Licensed or unlicensed?

Traditionally, microwave radios have occupied spectrum that requires a license to operate on a specific frequency. The licensed spectrum most used by utility, pipeline and transportation systems is governed by FCC rules under Part 101. The most commonly used bands are lower 6 GHz, upper 6 GHz, 10.5 GHz, 11 GHz, 18 GHz and 23 GHz.

The process for getting a pair of licensed frequencies is neither difficult nor time consuming. The FCC has authorized several frequency coordination bodies to assist users in finding and reserving spectrum for use in point to point communications. The standard frequency coordination process takes 30 days, after which an operator can submit his license application, and in most cases, immediately begin operation. The FCC has also put the Universal Licensing System on-line, allowing for easy and fast processing of license applications.

In addition, the Federal Communications Commission has authorized use of spectrum that does not require a license. Unlicensed spectrum is governed by Part 15, with primary bands being at 2.4 GHz and 5.8 GHz, with additional spectrum allocations being discussed.

The chief benefit of unlicensed spectrum is the ability to turn up a channel virtually anywhere at any time. The drawback, however, is that the operator is left to his own devices to mitigate potential interference from other unlicensed systems in the area. Spread spectrum modulation has been found to have little benefit in this area, so operators must opt for more conventional interference countermeasures such as selecting (larger) antennas with narrower beamwidths, or designing shorter paths.

That doesn't mean that unlicensed radios should not be used for critical communications applications. Certainly there is a fit for temporary requirements, low-priority communications, and disaster recovery. Long term solutions serving vital infrastructure should look more toward licensed operation. Some manufacturers even provide microwave radio equipment that can be installed as unlicensed then converted to licensed operation at a later date with minimal cost, thus allowing the ultimate in flexibility.

Planning a Microwave System

At first glance, planning for a microwave system can seem complicated; however, well established practices and expertise within the radio manufacturers and industry consultants make the process straight forward. Boiling it all down into five steps we have:

1) Network Design,

2) Site Selection,

3) Path Design,

4) Equipment Selection, and

5) Services.

Network design is easy to overlook, but is the core to good microwave system planning. This is the process of consolidating all the current circuit requirements and traffic routing patterns, with an eye on future requirements and expansion. This is also the time to define a general network topology, such as linear or ring architecture. From this information, the engineer should be able to produce a functional block diagram that defines the quantity and capacity of circuits from origin to destination.

The next step is site selection. Since microwave radio links require unobstructed line of site between the transmitter and receiver, it is crucial to know the basic lay of the land. The circuit termination points from the network design process are clear candidates for sites, but geographic obstructions or other limitations such as easements, tower restrictions and expensive roof rights may dictate finding additional repeater sites or alternate routes. In an urban environment with relatively short distances between sites, this is conveniently determined by a trip to the sites with a pair of binoculars. For long haul routes, topographic maps, on-line satellite imagery, and a variety of affordable software packages make selecting sites easy. Once the sites are selected, this information can be combined with the initial network design to finalize the required number and capacity of microwave links.

Path design is the process of determining what is required to meet your path availability objectives. As previously stated, microwave links can be engineered to provide better than 99.999% availability. This involves selecting the microwave radio parameters such as frequency band and transmitter power, as well as the height and size of antennas. Software programs are available to assist in the process; however, there is a healthy dose of art and science involved in good path design, so experience is essential. Fortunately, radio manufacturers are willing and able to lend their expertise, as are a number of wireless systems integrators and consulting engineers.

An important aspect of path design to consider is the field survey. The initial path design, or feasibility study, can be performed using terrain measurements from maps or extracted from electronic data.

However, these resources don't show heights of buildings and trees, or other current conditions. Therefore, it is highly recommended that a field survey be performed – especially on networks with longer paths. Seemingly minor changes in site and antenna locations can have dramatic impact on path performance and licensing. Ultimately it costs less to have the path survey done up front rather than when equipment is arriving on site and deadlines are fast approaching.

With the network layout and sites determined, and the paths engineered to the desired availability, it is time to select equipment. This includes the microwave radios and antenna systems as well as multiplexers, channel banks, other networking gear, and power systems. Radio manufacturers often are able to specify and deliver all of the equipment as a complete and interoperable system. This approach nearly always leads to better satisfaction and performance of the system rather than bidding out each element separately and having to integrate it yourself.

Finally, the decision on services must be made – whether to manage installation and commissioning of the system yourself or to have the radio supplier perform this on a turnkey basis. Keep in mind that a variety of disciplines are involved, including civil work (possible tower construction and hanging antennas), administrative (applying for permits and FCC licenses), and technical (installing, testing and turning up the telecommunications gear). By acting as your own prime contractor and managing several subs, you may save some money, but the limitation of risk and assurance of having a complete and functional system provided by one manufacturer has definite merit.

Summary

Microwave radio provides an ideal solution to many critical communications problems faced by network designers for utilities, pipelines and transportation systems. While traditional low to medium capacity requirements for voice and low speed data still prevail, today's digital microwave radios allow planning and deployment in support of broadband applications as well. Furthermore, the extremely high availability contributed by microwave is ideal for critical communications.

Alcatel has been designing networks for the utility, pipeline and transportation industries for over 40 years. We continue to support this vital market sector in these days of intense focus on securing our nation's critical infrastructure.

Alcatel-Lucent offers a comprehensive product portfolio for point-to-point microwave transmission. Our complete portfolio includes more useful frequency bands and greater spectrum efficiencies than any other microwave vendor, and supports network/radio configurations for low, medium and high capacity systems. Alcatel-Lucent's wireless transmission products are fully managed by our integrated network management platforms, as well as through the simplified network management protocol for management by external management systems in multi-vendor fixed or mobile environments. In the last five years, Alcatel-Lucent has installed more than 300,000 microwave radios in more than 150 countries.For more information, visit www.alcatel-lucent.com/microwave or call 1-800-ALCATEL.

Reliable Wireless Networks for Critical Infrastructure

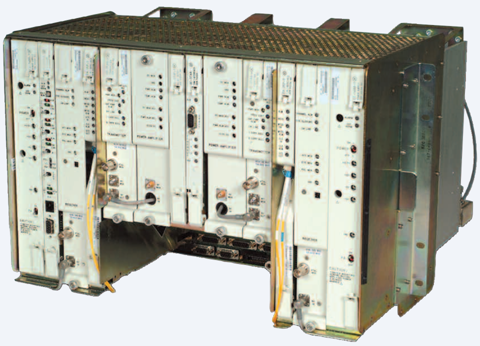
Alcatel-Lucent's MDR-8000 is used extensively within communication systems supporting critical infrastructure such as electric, gas and water utilities as well as for transportation systems and public safety networks.

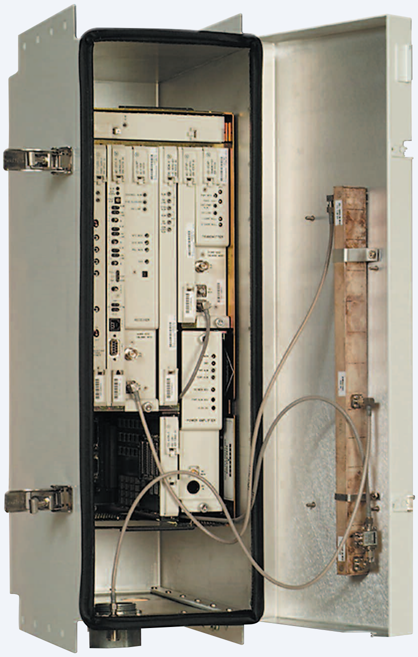
The MDR-8000 operates in licensed point-to-point microwave bands from 2 GHz to 11 GHz as authorized by the FCC and Industry Canada. It also covers US federal microwave frequencies at 1.7, 2.2, 4 and 7-8 GHz. The MDR-8000 may also be used in the license-free 2.4 and 5.8 GHz bands, which offers the unique ability to convert to licensed operation without changing expensive RF components within the radio. This capability allows operators to turn up microwave links immediately then convert to licensed operation once frequency coordination has been completed.

All high speed circuit formats are supported by the MDR-8000. Capacity options are 2-16 DS1, 1-3 DS3, OC-3 and Ethernet (10/100/1000 Base-T, auto-sensing and 1000 Base-T optical). Conversion from one capacity to another is easily accomplished by using one of 4 input/output interface modules (DS1, DS3, OC-3 or Ethernet) and selecting a capacity key which provisions the radio channel throughput from 3 Mb/s to 155 Mb/s.

Mechanically, the MDR-8000 is the most compact microwave radio of its class. A hot-standby radio stands only 12.25 inches tall (7 rack units). This takes up minimal space in equipment racks and it can even be deployed in outdoor enclosures. Additionally, the non-standby Compact chassis is only 7 inches tall (4 rack units) and is optionally equipped in a pole-mount outdoor cabinet.

Alcatel-Lucent's MDR-8000 microwave digital radio is the premier wireless transport solution for critical infrastructure communication requirements.





www.alcatel-lucent.com

Alcatel·Lucent