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Heat Hazard Safety
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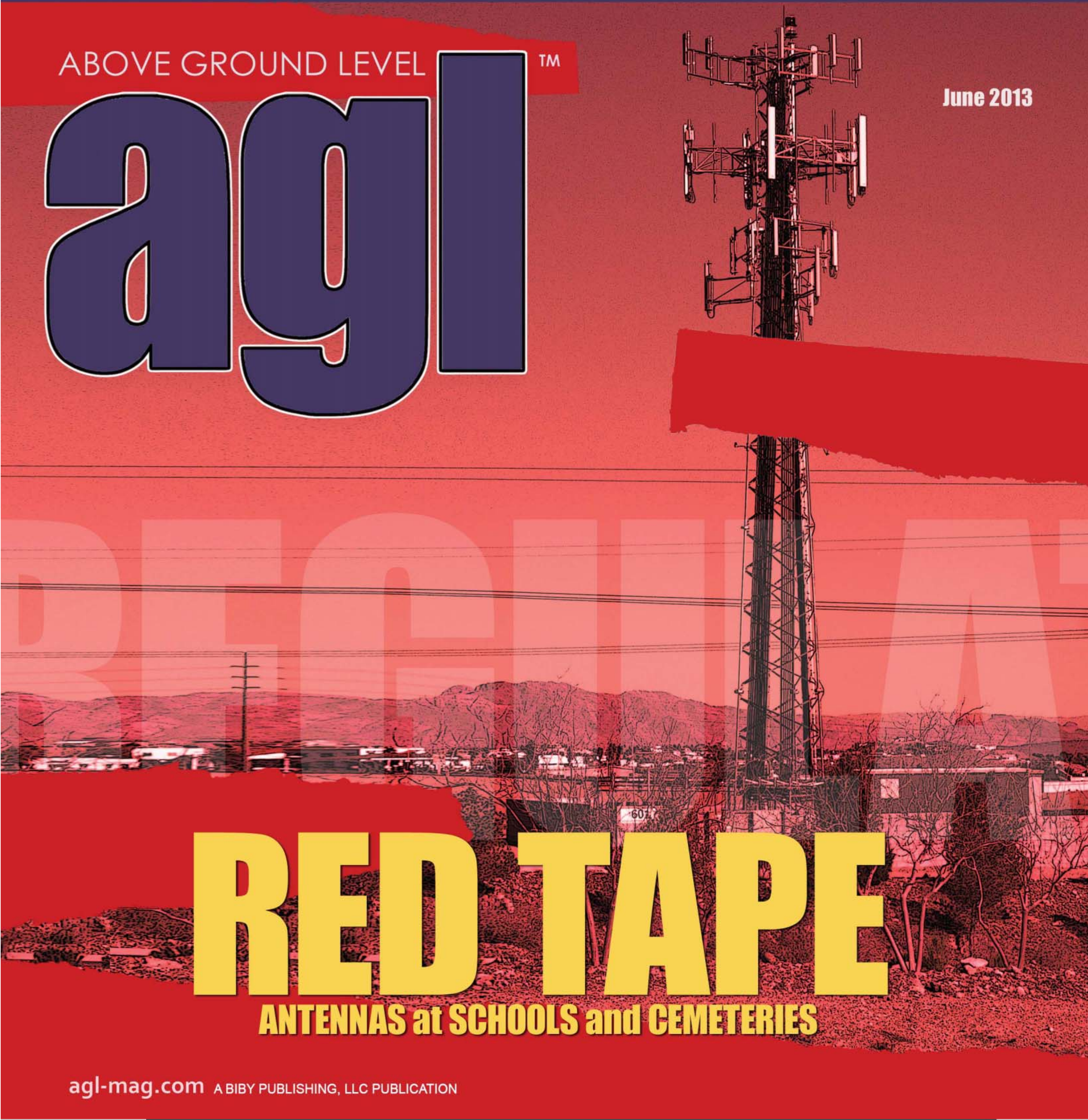
Infrastructure, regulatory and financial information for the antenna-siting community



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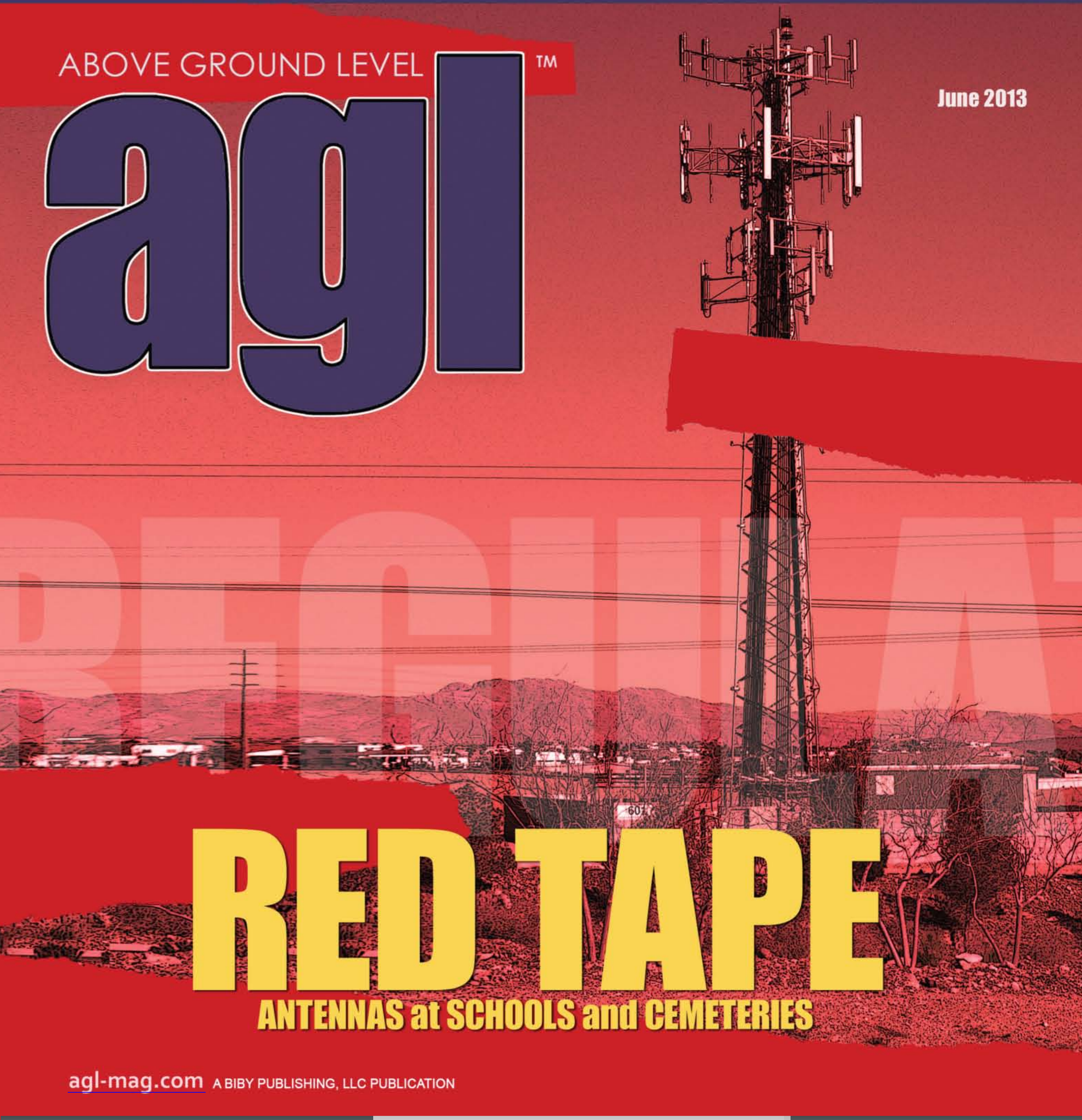

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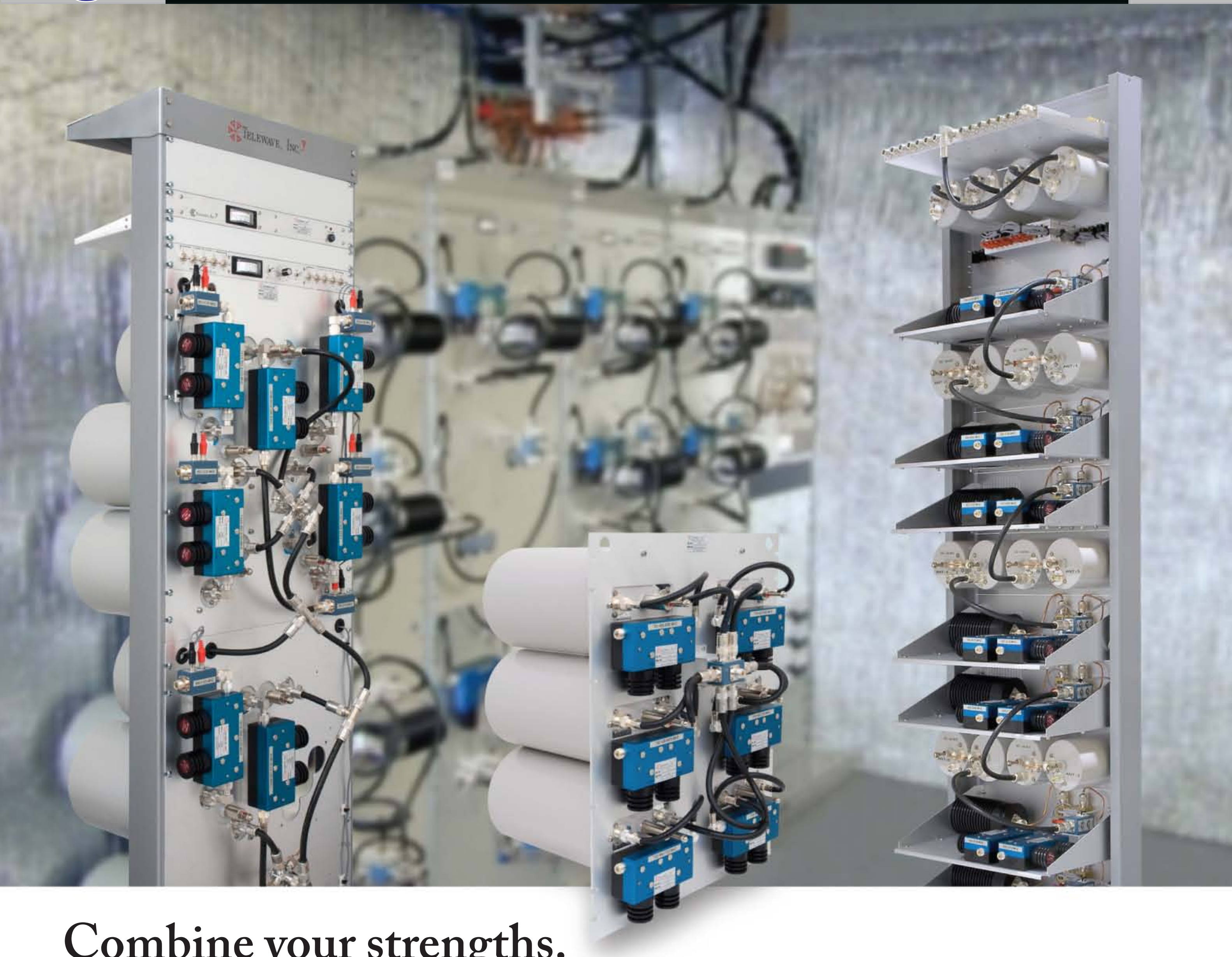

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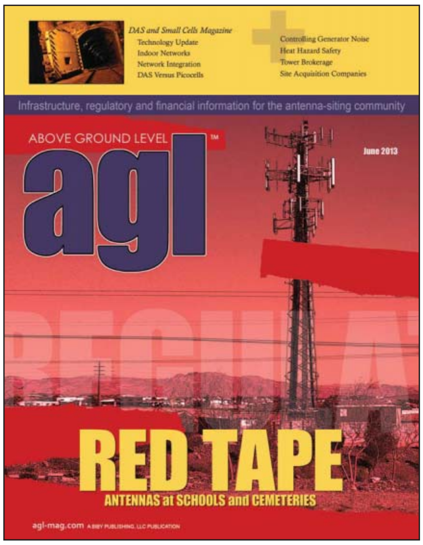
contents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on the cover

You'd think it would be easier, but it isn't. On page 26, see William Sill's article about placing antennas at schools and cemeteries.

Cover photography and design by Scott Dolash.

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Features

8 OSHA Campaigns to Protect Employees from Heat Hazards
By Mark A. Lies II and Meagan Newman

18 How to Control Noise from Generator Sets
By William Bloxsom

26 Obtaining Approval for Antennas at Schools and Cemeteries Remains a Challenge
By William Sill

32 Is "Broker" a Dirty Word?
By Tom Engel

40 *AGL* Tower of the Month
Photography by Don Bishop

DAS and Small Cells

46 Editorial Comment — Edge of Innovation
By Ernest Worthman

52 Update on DAS and Small-cell Technology
By Ernest Worthman

58 DAS and Small Cells for Indoor Networks
By Ernest Worthman

64 Play Nice — The Integration of Small-cell Networks, Cellular and Wi-Fi Technology
By Ernest Worthman

68 DAS versus Picocells
By John Spindler

72 Why the Boston Subway DAS Uses Radiating Coaxial Cable
By Suzanne Kasai

Departments

4 Editorial Comment — Switcheroo
By Don Bishop

6 Publisher's Note — Where Will All the Antennas Go?
By Richard P. Biby, P.E.

36 Buyers Guide — Quick-Guide to Site Acquisition Companies

75 Product Showcase — Small-cell Products

78 Advertiser Index and Professional Directory

editorial comment

Switcheroo

It's not unusual for a former government official to become a trade association chief or the head of a think tank. Two come to mind. Former FCC Commissioner and Rural Utilities Service Administrator Jonathan Adelstein became president and CEO of PCIA, a wireless telecommunications industry group representing carriers and cell site owners. Former U.S. Sen. Jim DeMint (R-S.C.) resigned his senate seat to become president of the Heritage Foundation, a think tank in Washington.

Less usual is for a former trade association chief to become the head of a federal agency that regulates the industry that the trade association represented. But that's about to happen. Tom Wheeler, President Barack Obama's nominee to become chairman of the FCC, once served as CEO of CTIA, a wireless telecommunications industry group that represents a broader segment of the wireless telecommunications industry than PCIA. He also headed the National Cable Television Association.

More recently, Wheeler has been a technology entrepreneur, and he is the managing director at Core Capital, a venture capital firm that manages $350 million. As did outgoing FCC Chairman Julius Genachowski, Wheeler raised funds for the president's political campaign. Wheeler raised $700,000, according to the Center for Responsive Politics. He and his wife also spent six weeks in Iowa in 2008 campaigning for Obama.

Wheeler has experience in representing two of the three largest industries that the FCC regulates, cable TV and wireless communications. However, the biggest industry segment that the FCC regulates probably is broadcasting. There are plenty of issues involving broadcasting and cable TV for a new chairman to spend time with; however, with the president casting a spotlight on broadband communications, Wheeler's attention may be drawn toward the telecommunications side, both wireless and wired.

LightSquared lives!

All right, maybe "LightSquared lives!" is a little bit over the top, but speaking of FCC chairmen, despite having one foot out the door, Genachowski said in early May that he expects LightSquared will eventually win approval for using its radio-frequency spectrum for terrestrial communications. It has been on-again, off-again for LightSquared because it received approval, maybe tentatively, in 2011, and then the FCC yanked it a year later because of concern about interference with Global Positioning System receivers.

A child of Harbinger Capital Partners, a hedge fund run by Philip Falcone, LightSquared would represent new business for tower owners who rent space for telecommunications antennas, so the scent of a LightSquared revival has them sniffing the air.

Falcone himself just reached a settlement with the Securities and Exchange Commission that lets him continue as chief executive officer of Harbinger but that bars him from investing client money for two years. The settlement resolves charges that Falcone improperly borrowed money from his fund to pay his taxes. The hedge fund has been on as much of a roller coaster as LightSquared, with assets under management falling to $3 billion from a high of $26 billion in 2008.

Thus, 2013 rolls on with two "Will he or won't he?" questions. The answers could affect the tower industry. Will Falcone launch LightSquared? Will Charlie Ergen of Dish Network start a new mobile service provider? Wheeler would like to know. ■

By Don Bishop, Executive Editor
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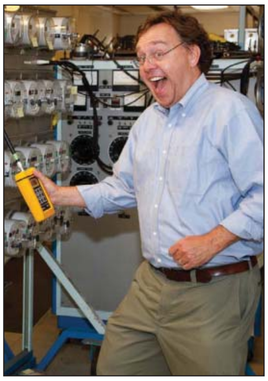
Where Will All the Antennas Go?



Photograph courtesy of mikefosterphotography.com

Double the number of sites? Triple or quadruple? Really? I'm lucky enough to hear some of the industry rumors firsthand, and some predictions are pretty outrageous. Of course, thinking them through in detail can make your head hurt, and surprisingly, sometimes careful thought does justify some of the outlandish predictions.

People have shared with me the prediction of a doubling of the number of cell sites, not counting picocells and distributed antenna system (DAS) sites, of the two major carriers in my area of the mid-Atlantic region. Where in the world are all of those antennas going to go? On rooftops, primarily. It is exciting to think of that many new installations. The towers I see on a daily basis are so full that any new rad centers would be in the clutter, not a great place for any antenna! You can spread sites out geographically, which then requires a duplication of efforts for zoning, backhaul and structural analysis. Or you can have those hubs and well-developed locations. Once the infrastructure is in place for one carrier, most sites are able to accommodate many additional collocaters. This will largely not hold true as sites are pushed down in height and become more geographically diverse. The RF cloud will thicken.

DAS, DAS, DAS! It's everywhere. There were no fewer than three DAS and small-cell events within two weeks in May. DAS seems to be all the rage lately. The funny thing is, we're all still calling just about anything in-building DAS. We have much more work to do to figure out where this market really is, and what technology is going to eventually meet the needs of carriers so we can deploy a single infrastructure for multiple carriers. We're getting there, but much more work is needed. Lately, I've been hearing complaints from, strangely enough, municipalities, about outdated networks, poor maintenance, broken equipment and a lack of responsiveness from network owners and, in some instances, unknown ownership. Why would a municipality care? Economic development and public safety is what I'm hearing. I'm hearing much more of a public safety twist from the crowd I tend to see most often; however, both economic development and public safety are important.

Three more

I have to put in a plug for the AGL Regional Conferences. I guess it is my job🙂. We've had three fantastic regional conferences so far this year. These are regional events with a full day of education and networking. They offer a great chance to hear some of the industry's leaders, ask questions, and get to know some of the other fine folks in our industry. There are three additional events yet this year. Make sure to attend one. We're lucky enough to have teamed up with the National Association of Tower Erectors, which offers a training session at all of our regional conference locations on the day before. NATE's had nothing but great feedback from attendees about its sessions, and we encourage everyone to consider attending the NATE training.

I'm off to Europe sometime soon. I'm looking forward to shooting some tower photos and catching up on the industry from the European perspective. It remains significantly different from the U.S. approach. I do miss my days at Crown Castle. Working in England was like a paid vacation. I just loved it. I guess I'm still lucky to really enjoy what I do for living. But the European model of towers and other infrastructure-sharing remains very different from the U.S. model. "Competitors" are still not afraid to share some resources and perhaps provide a service to another company. I'm eager to return to Europe, if only for vacation this time, and at my own expense.

Questions

I am often able to toss a question out to everyone here in this column, and I often get some great responses.

Could you answer some questions about HD voice services being proposed by the wireless network operators? I hate to admit it, being in the tower industry and all, but I can rarely understand anyone when I'm on a cell phone. I can't understand most of the calls I'm on. Of course, I'm usually driving, and the world of Bluetooth is far from polished, in my humble opinion; however, it seems we are far from having good-quality phone calls. Good quality, from the industry perspective, is simply a call that is not dropped and that has no clear noise bursts. But what about actually clearly hearing and understanding the other person? HD is supposed to fix that. Heck, I can FaceTime with my kids while in a car (someone else is driving), and the audio is actually better than it would be on a cell call. Let's not discuss how much bandwidth that uses, but the experience, even if short, is so much better than asking "What?" repeatedly. I've taken to carrying two phones, one CDMA and one GSM. I've learn that the intelligibility of a call increases greatly when you call someone from a carrier of the same technology. I can actually understand my parents when I call their Sprint phone from a Verizon phone. ■

By Rich Biby, Publisher
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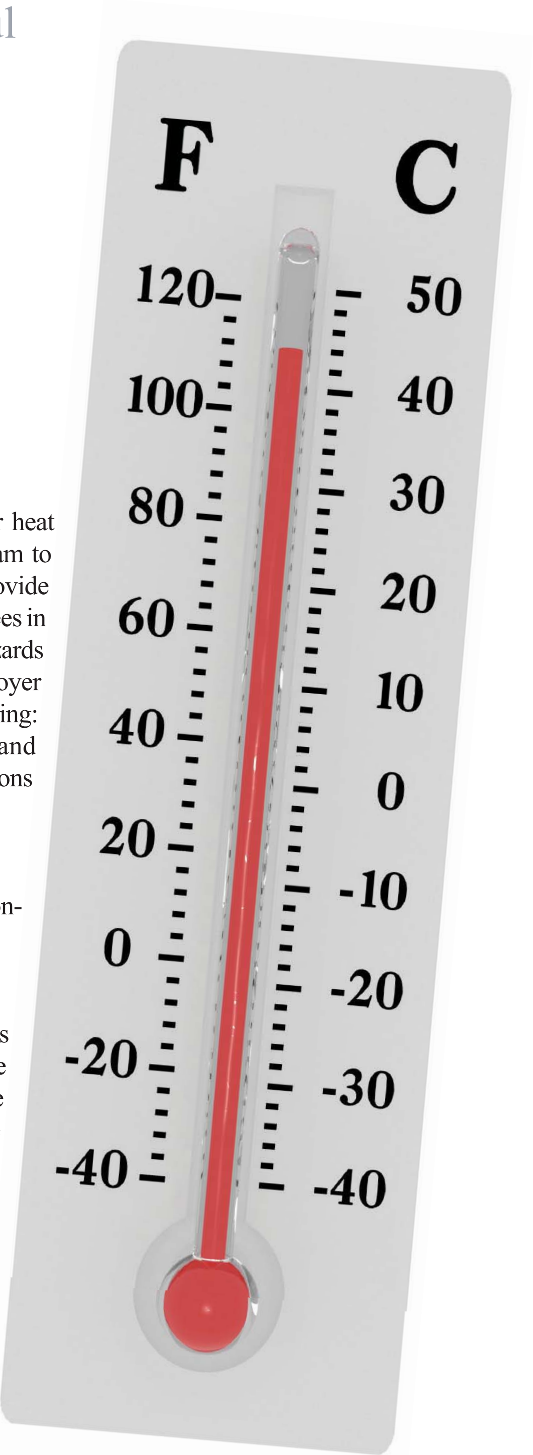
OSHA Campaigns to Protect Employees from Heat Hazards

The federal Circuit Court Of Appeals for the D.C. Circuit has overturned numerous willful OSHA citations and has clearly reminded OSHA and the OSHA Review Commission that willful citations are difficult to prove.

By Mark A. Lies II and Meagan Newman



As seasonal temperatures climb along with OSHA's aggressive enforcement efforts, employers must consider their potential liabilities for not protecting employees against the hazard of heat. OSHA has developed its Campaign to Prevent Heat Illness in Outdoor Workers. The campaign includes a website, public service announcements and materials for workers and their employers. In announcing the campaign, Hilda Solis, U.S. secretary of labor, remarked that heat "can be a real danger for workers in jobs ranging from agriculture and landscaping to construction, road repair, airport baggage handling, even car sales." Thus, OSHA can be expected to enforce this agenda across the entire spectrum of industries where heat is a factor in the workplace. For those employers who do not have employees working outside, the same potential liabilities exist for operations within a facility where there are inadequate HVAC resources.OSHA's agenda regarding heat illness has also focused upon what OSHA believes to be a disproportionate number of Latino worker injuries and fatalities due to outdoor heat exposure in certain occupations. For this reason, it is especially important for employers to evaluate their work sites and conditions for heat hazards and to implement a program to address any such hazards and to provide training and information to employees in a language they understand. The hazards of heat exposure can involve employer legal duties under many laws, including:

- OSHA (Occupational Safety and Health Act), state OSHA regulations
- Americans with Disabilities Act
- Criminal Law
- Worker's Compensation
- Third-party liability (outside contractors)

OSHA liability — federal

Although federal OSHA does not have a standard relating to the hazard of heat, it regulates the hazard of heat exposure in the workplace under the General Duty Clause (Section 5(a)(1)). Heat is a "recognized" hazard to human safety and health. Its effect on employees ranges from nausea to death, depending upon exposure. OSHA requires that employers evaluate whether a heat hazard exists by evaluating the temperature and humidity conditions

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within the workplace. If a heat hazard exists, employers must develop means and methods to protect employees from heat hazards. These range from changes in work practices (rest breaks, job rotation), to personal protective equipment (cooling vests) to engineering controls (ventilation, cooling rooms). Employers who fail to take such steps are subject to citations and monetary penalties. When an employee becomes incapacitated by heat and requires medical treatment, loses consciousness, has days away from work or restricted duty — or dies — this information must be recorded on the OSHA 300 Log. Widespread heat-related illnesses may prompt an employee to contact OSHA, resulting in an on-site inspection.

Heat-related illness can temporarily diminish an employee's mental capacity and physical coordination, and excessive heat can cause employees to lose focus or muscle control, possibly leading to them injuring themselves or coworkers. This is a particularly acute problem when operating mechanized equipment or working around hazardous machinery.

OSHA also mandates there be adequate first-aid assistance to provide emergency medical assistance to heat-stricken employees. First aid must either be provided by the employer or reasonably available from third-party responders (e.g., EMTs, fire department) within three to five minutes after the emergency occurs.

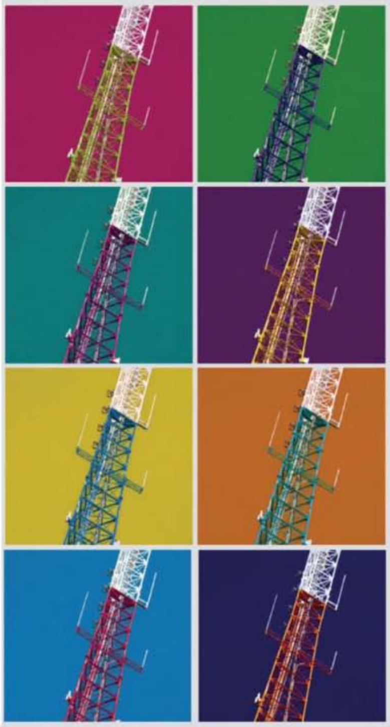
The likelihood of OSHA enforcement in this area is very high — OSHA has continued to conduct inspections and issued citations or notices of alleged hazards to employers in both the manufacturing and outdoor landscaping industries. These efforts, in conjunction with the Campaign to Prevent Heat Illness in Outdoor Workers, as well as OSHA's enforcement directive on training non-English-speaking workers, mandate that employers take immediate steps to address the potential hazards posed by heat exposure.

State regulation — California

California has promulgated a regulation for Heat Illness Prevention (T8 CCR §3395) that contains extensive requirements to protect employees who may be exposed to the hazard of heat illness. The regulation was initially intended to apply to agricultural employment but the Division of Occupational Safety and Health has attempted to expand its application beyond such employment activities. Federal OSHA has also looked to the California OSHA heat illness standard as a framework for general duty clause enforcement. In announcing the campaign, Secretary Solis stated that California OSHA's "efforts to address this issue have provided a valuable platform for federal OSHA — an agency at the U.S. Department of Labor — to launch a nationwide campaign to prevent heat illnesses, injury and death." Thus, even employers outside of California should consider and implement, to the extent feasible, the requirements of the California standard.

The regulation includes requirements for the following:

- Potable drinking water, at least one



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- Specific training for supervisors regarding procedures the supervisor must follow when an employee exhibits symptoms of heat illness, including emergency response

PPE — a heat hazard

OSHA regulations require that employees in many workplaces wear personal protective equipment (PPE). Often overlooked is that PPE can create a heat hazard. For example, employees in a foundry may be required to wear flame-retardant clothing or painters in a spray booth may wear protective clothing. Either of these activities can prevent the release of an employee's body heat, thereby causing the employee's internal temperature to become elevated. In developing a heat illness program, the employer must consider the possibility that PPE will create heat hazards.

ADA

Employees react to heat in a unique fashion. This reaction depends upon the individual's physical characteristics or health. For example, an employee's ability to tolerate heat can depend upon a combination of some or all of these factors: medication, obesity, cardiovascular conditions, diabetes, the use of alcohol or drugs, and other medical conditions.

Under the ADA, employees with physical impairments that can be considered to be disabilities may be protected from discrimination and may be entitled to workplace accommodations to be able to continue to work in a workplace where they are exposed to heat. It is likely that employers are unaware of a number of these conditions because of restrictions imposed by the ADA. The Equal Employment Opportunity Commission (EEOC) has issued extensive regulations regarding an employer's duty to accommodate employees who may have disabilities. For a description of the major life activities see 29 CFR 1630, section 1630.2(i), on page 23 of the following link *www.gpo.gov/fdsys/pkg/FR-2011-03-25/pdf/2011-6056.pdf*. A program to protect employees against heat illness must be designed to determine whether employees require assistance at work because of their personal health conditions, without violating the ADA. In this regard, the employer has a right to inquire as to whether employees may need assistance to protect them against hazards to their health in order to comply with OSHA. The employer may, in fact, have a legal duty to make such inquiry if it can objectively observe that the employee is showing signs or symptoms of heat illness.

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In the event an employee actually sustains a heat-related illness, the employer may have the right to require the employee to undergo a fitness-for-duty evaluation to determine whether the employee can continue to perform the essential functions of the job with or without an accommodation. In addition, the employee's inability to tolerate the heat may create a direct threat to the employee's safety or health, as well as to the safety or health of other employees who may sustain injury by reason of the affected employee's inability to operate machinery or perform critical plant operations, which may require the employer to disqualify the affected employee from performing the particular job.

Criminal liability

An employer also faces criminal liability for failing to protect employees against heat hazards. For example, in Illinois, an employer was criminally prosecuted because employees were exposed to high levels of heat resulting in injury. In *People v. Chicago Magnet Wire Corporation*, 126 Ill.2d 356 (1989), the Illinois Supreme Court held that a corporation and its officers and agents could be indicted for aggravated battery and reckless conduct for exposing employees to inadequate ventilation and dangerously overheated working conditions. In this case, employees were using steam and chemicals to clean electric motors. Temperatures in the plant reached 140° F, and employees became nauseated and ill from the exposure.

Workers' compensation

In the event an employee sustains a heat-related illness, the employer will face workers' compensation liability. The gravity of the claim may be substantially enhanced if the employee is overcome while operating machinery and sustains additional injury by falling into or off of equipment.

Third-party liability

An employer's liability may extend to employees of third parties on the worksite if they are exposed to heat hazards. If these employees can establish that the employer was in a position to control the hazard to which they were exposed and failed to take appropriate action, liability may attach. This derivative liability can arise under OSHA's multi-employer workplace doctrine or under state law premises liability doctrines.

Compliance recommendations

Heat illness can be insidious. For example, an employee who is sweating heavily can lose up to 6 quarts of water in a workday — approximately 13 pounds. In high-heat atmospheres, normal heat responses, like thirst, are inadequate. By the time the body signals its thirst, the individual is already partially dehydrated.

In order to prevent heat illnesses, the employer should develop a program which includes the following elements:

- Hazard identification — Identify potential heat hazards (job functions, equipment, etc.). Employees should be consulted in this process.
- Hazard correction - Correct, or reduce

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the heat hazards identified.

- Employee Training to encompass
    - description of various types of heat illness
    - information on how heat illness occurs, including
        - environmental conditions
        - working conditions
        - individual employees' health conditions or work practices (e.g., failure to consume adequate water or to acclimatize to heat)
    - how to recognize the common signs and symptoms of heat illness
    - duty to promptly report to a supervisor if the employee or co-employee is experiencing the signs and symptoms of heat illness and to obtain assistance
    - documentation of the training
    - training must be provided in the employees' native language
    - in indoor environments (where feasible), implement an acclimatization program that gradually increases employee exposure to heat over time.

- **Supervisor Training**
    - Train supervisors to recognize the signs and symptoms and how to respond.
    - Explain employer's program and how to implement it.
    - First aid — Adequately train and provide readily available first aid services, using either in-house or outside providers.
    - In outdoor environments, consider where and how fresh cool water and shade or air conditioning are available in the event an employee exhibits signs of heat stress illness.
    - Though they are not standards that are strictly enforceable by OSHA, the National Institute of Occupational Safety and Health (NIOSH) and the U.S. Environmental Protection Agency (EPA) provide additional guidance regarding heat stress hazards. Visit *www.cdc.gov/niosh/topics/heatstress* and *www.epa.gov/oecaagct/thel.html*. OSHA also plans to introduce a heat illness lesson plan, along with a smartphone application. Employers should evaluate the tools provided by OSHA and those provided by their industry and trade associations in formulating a heat-stress program that best suits their workplaces.

Conclusion

If the employer follows these recommendations, it will substantially reduce the potential for heat-related illness by its employees along with its potential legal liabilities associated with heat illness. ■

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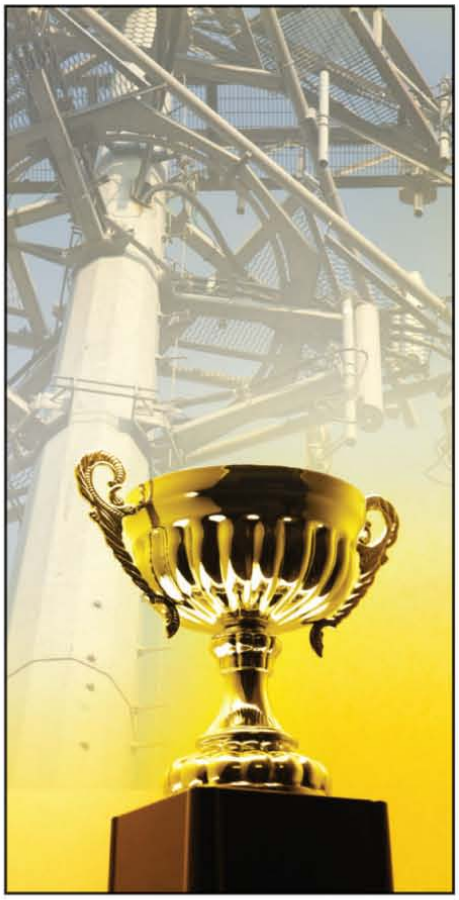

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How to Control Noise from Generator Sets

The principles of generator set noise control are well understood, leaving economics as the primary limiting factor in implementing noise reduction strategies for specific applications.

By William Bloxsom

With the expanding use of diesel generator sets for emergency standby power, peak shaving and demand response, there is an increased focus on controlling generator noise. Whether generator sets are located within enclosures outside a facility, inside a facility or on the roof, design engineers are working to control generator set noise and vibration in order to reduce the effect generator operation has on neighbors and building occupants. And whether generator sets run continuously in prime-power applications, intermittently in demand response applications, or occasionally in emergency standby situations or testing, their operating sound levels may require remediation.

Although local codes and zoning laws often require nominal noise-reduction strategies, end users are behind the demand for quieter generator set installations to the extent that their budgets allow. The cost to make modest reductions in noise is generally quite low, and generator set manufacturers have made the job easier by making engines that run quieter and with less vibration. In addition, a large aftermarket exists in advanced noise control solutions. However, the cost of noise control is not linear. The first 10 decibels (dBA) of reduction may be relatively inexpensive, but the last 10 dBA may be prohibitively expensive. That's why the current strategy is to control as much noise as possible without losing control of the budget. The following information examines the science behind generator set noise control and explains a variety of solutions that will help consultants and design engineers achieve optimum noise control solutions.

What is noise?

Vibrating objects induce pressure waves that travel through the air and reach our ears as sound. Noise, by definition, is merely unwanted sound. When the amplitude of the pressure waves becomes too high, the amount of sound becomes uncomfortable. In addition to being annoying, excessive sound can cause permanent hearing

Photo 1. This generator set enclosure includes acoustic barriers and sound insulation enclosures with foam.

damage. This is why the Occupational Safety and Health Administration (OSHA) established safety standards for workers exposed to loud noises. Local ordinances and zoning laws also establish rules regarding the amplitude of unwanted sound, but the standards are geared toward reducing public annoyance rather than promoting safety.

The human ear has such a wide dynamic range that the logarithmic decibel scale was devised to express sound levels in a convenient way. The ratio between the softest sound the ear can hear and the loudest sound it can experience without damage is approximately a million to one or $1:1x10^6$. By using a base-10 logarithmic scale, the whole range of human hearing can be described by a more convenient number that ranges from 0 dB, the threshold of normal hearing, to 140 dB, the threshold of pain (see Figure 1).

Two dB scales, A and L, are used to describe sound.

- The dB(L) scale is linear and treats all audible frequencies as having equal value. However, the human ear does not experience all frequencies the same way. Our ears are particularly sensitive to frequencies in the range of 1,000 Hz to 4,000 Hz, and they are less sensitive to sounds in lower or higher frequencies.
- To adjust the sound pressure levels to more accurately reflect what the human ear perceives, engineers use an "A-weighting filter." This results in the frequency-weighted dB(A) scale, which was adopted by OSHA in 1972 as the official, regulated, sound-level unit.

Sources of generator set noise

Two major frequency bands not only emanate from different moving components on the generator set but also require different methods to control. Frequencies below 300 Hz are generally considered low-frequency; frequencies above 300 Hz are considered high-frequency. Furthermore, there are no universal standards for the amount of permissible generator set noise. Rather, each application is different, and each locale sets its own standards for noise emanating from a property.

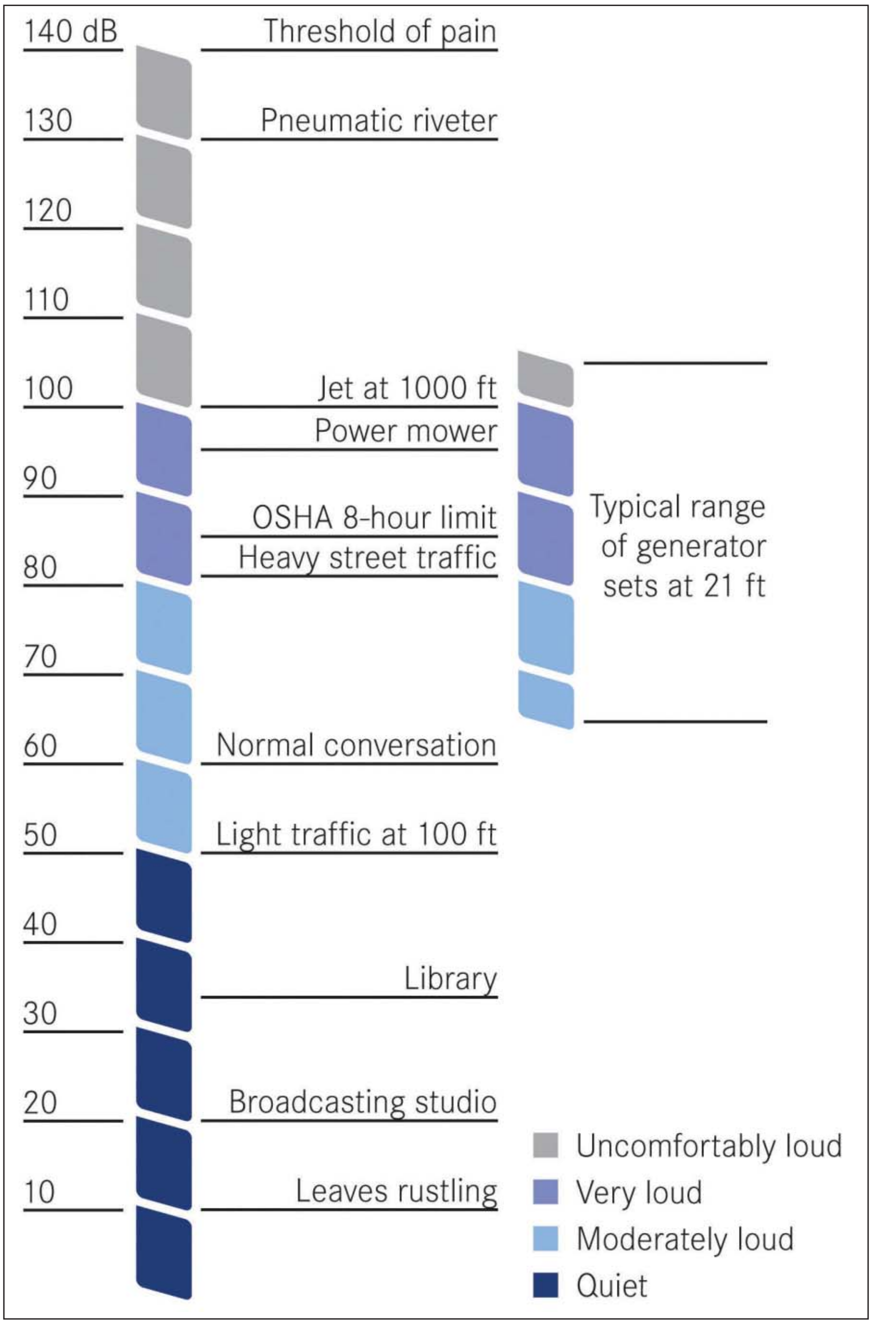

Figure 1. Decibel levels of typical sounds show the difference in which sounds may be objectionably loud.

Engine mechanical noise: With the advent of high-pressure common rail fuel injection, advanced turbocharging and better combustion control, manufacturers have significantly reduced overall mechanical noise from diesel engines. The amount of sound varies with the size of the engine and its load, and can be as high as 110 dB(A) measured at one meter. High-horsepower engines are actually quiet for their size because the V-configuration of the cylinders makes them self-balancing. Engines with more cylinders have more power strokes per revolution and therefore deliver a smoother flow of power with less vibration. Smaller engines tend to be harsher in operation and produce more noise and vibration for their size.

Exhaust noise: Engine exhaust is a major contributor to overall sound levels and, when measured without an exhaust

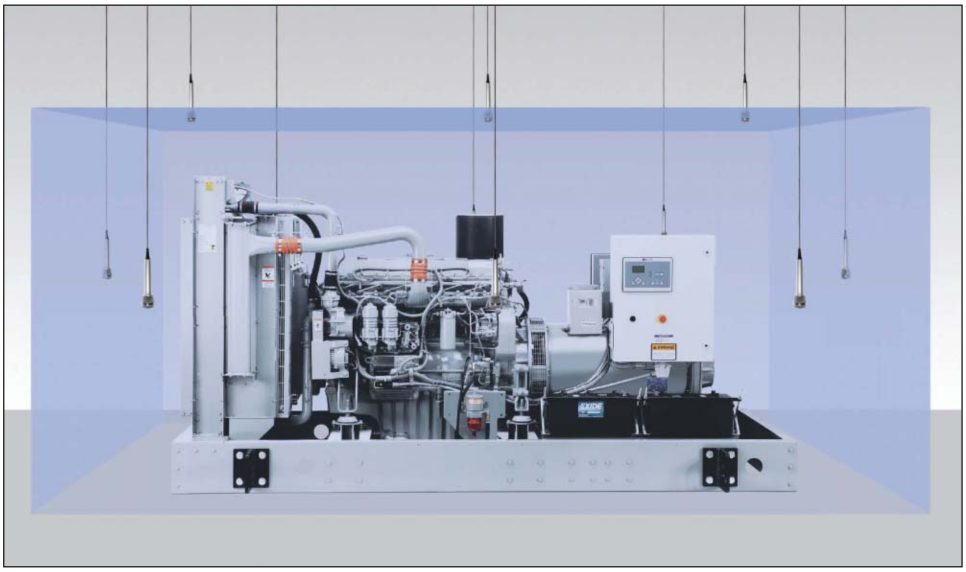

Figure 2. To establish sound pressure levels, calibrated microphones are placed at regular intervals around the perimeter of an imaginary box one meter larger than the envelope of the generator set. These measurements are later converted into standard sound power levels at 7 meters (23 feet).

silencer, can be 120 dB(A) or more, depending on the size of the engine. The sound level can be reduced by up to 24 dB(A) and up to 40 dB(A) depending on the silencer.

Cooling fan noise: Sound emanates from turbulent air as the cooling fan moves it across the engine and through the radiator. The amount of sound varies with the speed and volume of air being moved as well as with the design and distortion of the fan blades. The amount of sound can be as high as 95 dB(A) at one meter.

Alternator noise: The alternator has an internal cooling fan, and the combination of cooling air movement and brush friction produces a sound level that is always small compared with the driving engine.

Induction noise: Current fluctuations in the alternator windings create mechanical noises that add to total noise when load demand changes.

Structural and mechanical noise: This is caused by mechanical vibration of various structural parts and components that is radiated as sound. Elastomeric isolators between the engine, alternator, controls and other components help to reduce the amount

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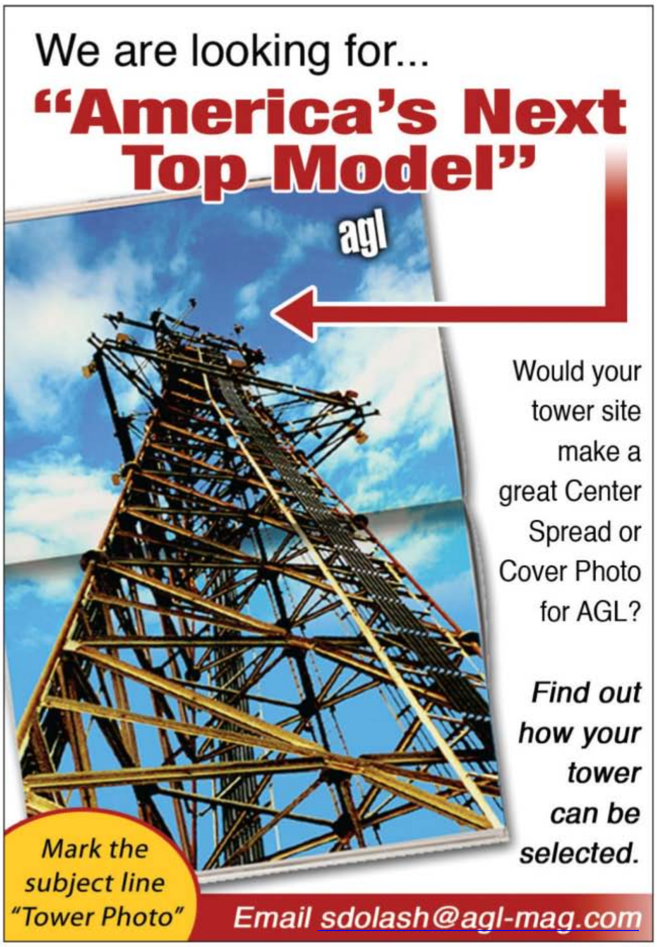

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of vibration that gets converted to noise.

Measuring noise

During design and manufacture, generator sets are tested at the factory and sound levels are recorded using a process defined in ISO 3744. Sound measurements are sometimes done in the field, but usually only to verify compliance with a specific local code or noise-reduction objective related to the installation. In the factory, the manufacturer develops sound measurement profiles for each model of generator set rather than testing every individual unit. Test results are recorded and kept on file for each model in case there is a need to revisit the information for a specific installation.

To obtain accurate sound data, measurements must be taken in a "free-field environment." As differentiated from a "reverberant field environment," a free-field environment is a location with negligible effects from sound reflected from obstacles or boundaries. In practical terms, this means being about four to six feet away from a wall. Closer surfaces reflect sound and cause higher, erroneous readings.

In a typical factory test, technicians take sound measurements at 12 to 19 locations (depending on the size of the generator set) on the outside of an imaginary box, one meter (39 inches) larger than the generator set profile. This procedure standardizes the measurements so that end users can rely on the data for installation and site planning. Usually, the measurement is done with a handheld, calibrated microphone, one point at a time, but more sophisticated arrangements with multiple simultaneous measurements are also used. Measurements are recorded as sound pressure readings and are later converted into sound power levels from each of the positions (see Figure 2).

Although factory sound measurements are taken at one meter from the unit for the sake of convenience, the standard distance quoted in specification sheets and used by the industry is 7 meters (23 feet). Unless otherwise stated, all published generator set sound data is calibrated to what one would measure at 7 meters. Manufacturers simply use an algorithm to convert the 1-meter readers to 7-meter readings.

Noise-reduction strategies

Noise-reduction strategies vary depending on whether the generator set is located in a building or outdoors in an enclosure. In any case, it is vitally important to not let noise-control solutions interfere with the flow of cooling air to the generator set. Low-frequency noise is the most difficult to attenuate and is best controlled by the use of rigid barriers that have substantial mass. High-frequency noise can be controlled by the use of acoustic foam and other types of sound-absorbing insulation.

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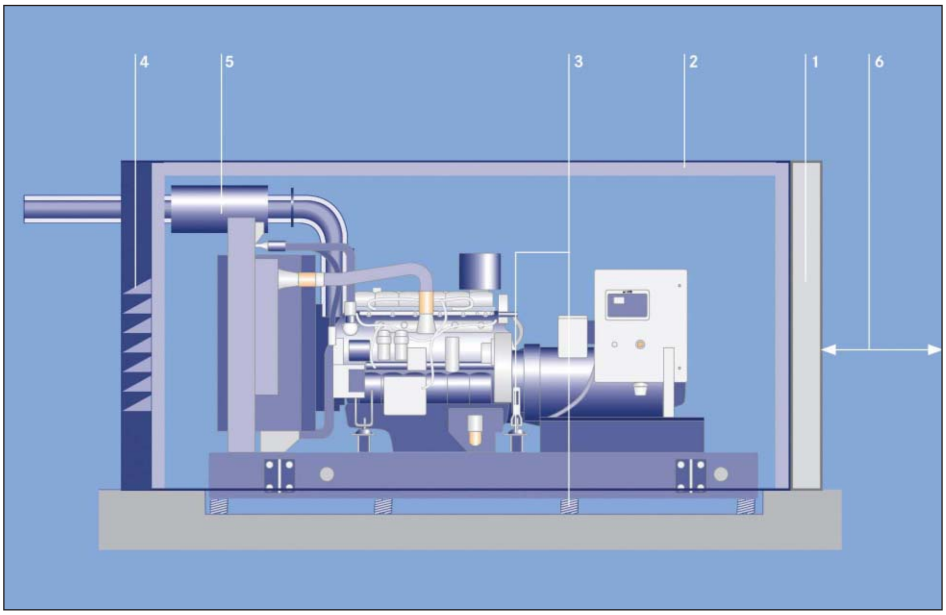

Figure 3. Various barrier and absorption sound-reduction strategies are effective in indoor installations and outdoor installations in enclosures.

offer sound-attenuating enclosures for units up to about 2,000 kilowatts. Typically, these factory drop-over enclosures are offered in three grades of sound control, from a basic sheet metal enclosure (Level 1) to units with substantial sound-attenuating capability (Level 3). A basic Level-1 enclosure will typically reduce noise by approximately 3 dB(A), and a Level-3 enclosure can achieve reductions of 14 dB(A). For generator sets larger than 2,000 kilowatts, many custom-made sound-attenuating enclosure solutions are available in the aftermarket.

Overall, there are six basic strategies for controlling noise (see Figure 3).

Acoustic barriers: Rigid barriers that have substantial mass and stiffness reduce the transmission of sound energy. Examples include sheet steel typically used in enclosures and sand-filled block walls or poured concrete walls used in indoor locations. As there has been a trend toward the use of lighter-weight sheet steel for enclosures as a cost-saving measure, it is sometimes necessary to install reinforcing ribs when steel enclosure walls lack sufficient stiffness. Steel panels can also be covered with a barium-filled rubber mat that adds mass and that is highly effective at preventing the

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transmission of low-frequency sound. It is also important to eliminate sound paths by sealing seams around doors, panels, exhaust ports and conduit channels.

Acoustic insulation: Sound-absorbing acoustic foam is effective for controlling high-frequency noise and is used extensively in outdoor enclosures. In indoor installations, it can be highly effective at reducing noise when used to line air ducts or when used as a wall or ceiling covering. Fire-retardant urethane foam is the most common material used in enclosures; however, fiberglass is also effective (see Photo 1).

Vibration isolation: Vibrating generator components induce pressure waves as sound into the environment. Also, anything that is attached to the generator set can cause vibrations to be transmitted into the building structure or foundation. These attachment points include skid anchors, radiator discharge air ducts, exhaust piping, coolant piping, fuel lines and electrical conduit. Mounting the generator set on isolation springs or on a base fuel tank helps reduce the transmission of vibration into the foundation (see Photo 2). Pouring a separate mounting slab also helps isolate vibrations from the building. Flexible connectors on fuel lines and exhaust and electrical conduits effectively eliminate

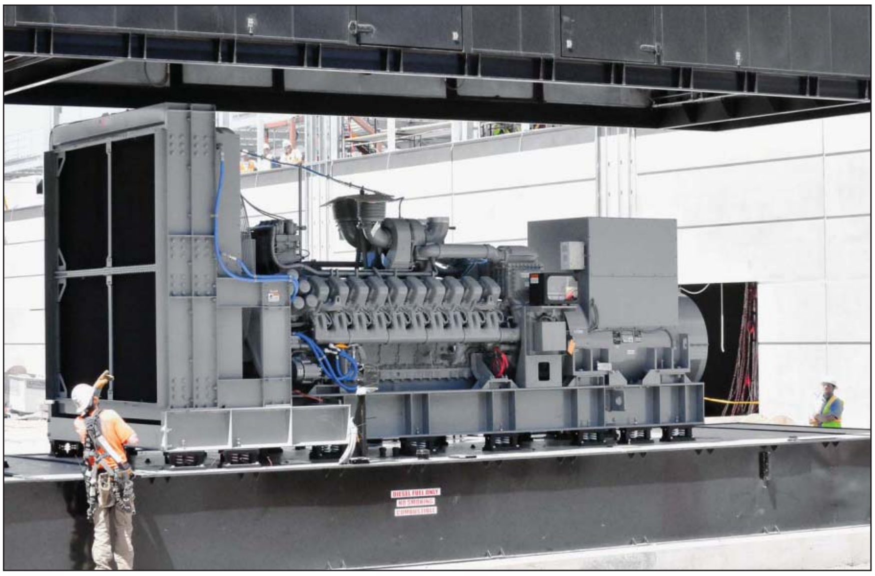
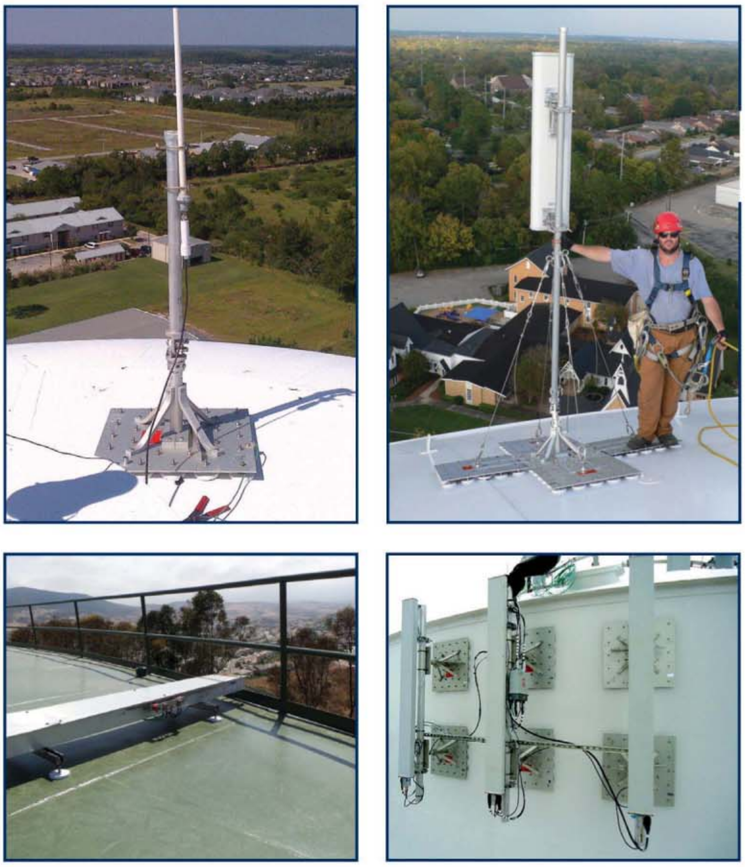


Photo 2. This generator is pictured as its enclosure is being lowered onto it. The generator rests on vibration springs that help to mitigate noise.



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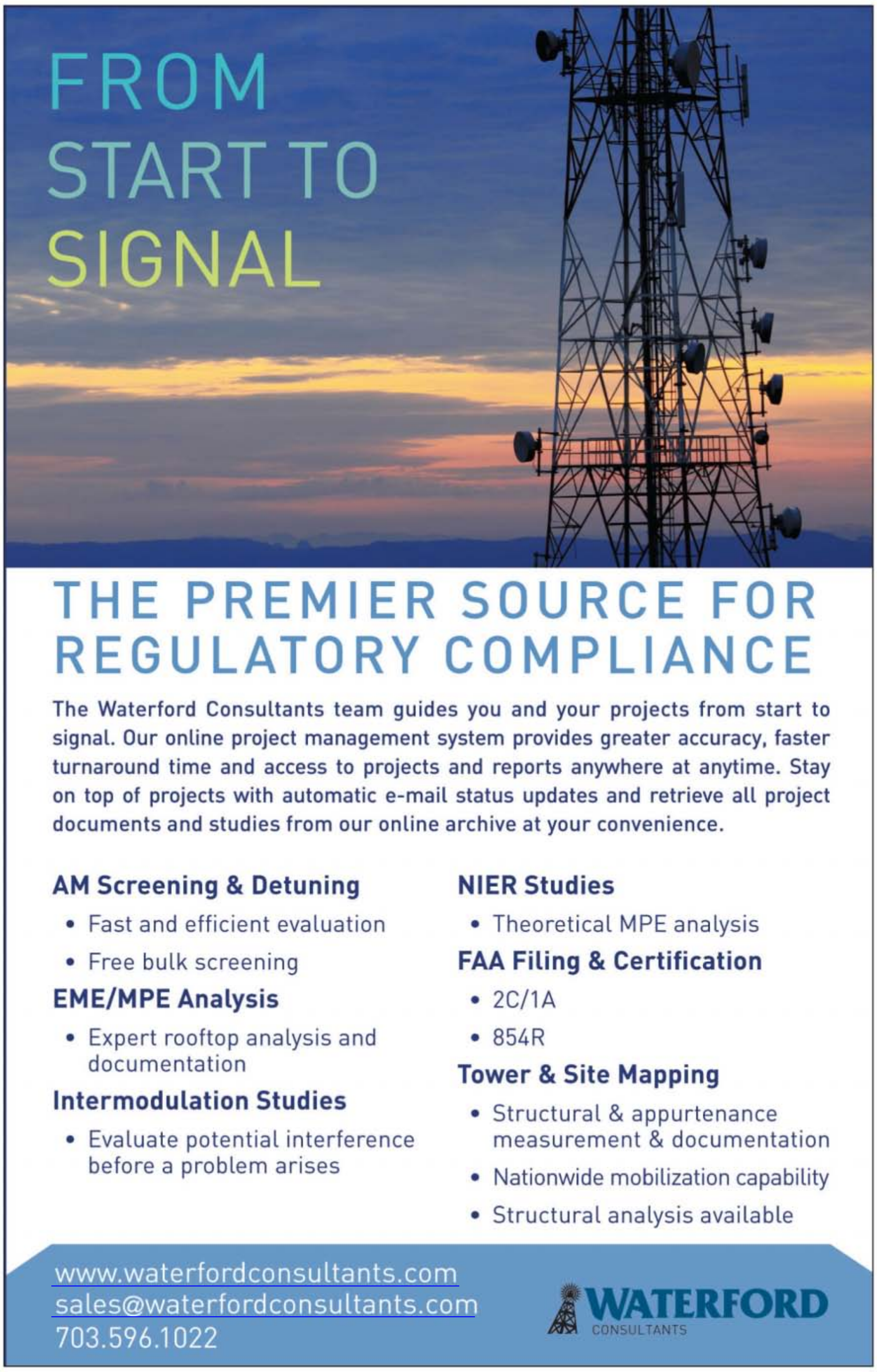
the transmission of vibration.

Attenuation of cooling air noise: The movement of cooling air is a significant source of high-frequency noise, but restricting its flow is detrimental to generator set cooling efficiency. More than 20 cubic meters per second of air are required for cooling a 50-liter diesel engine. In indoor installations, high-frequency noise can be reduced by making the air flow turn two 90-degree angles as it enters and leaves the power room. In Level-3 outdoor enclosures, cooling air is drawn in from the roof near the rear of the enclosure and turned 90 degrees in order to flow over the engine and through the radiator. It is then turned 90 degrees again and ejected upward out of the roof of the enclosure. In this way, much of the air flow sound at ground level is reduced and is directed upward, away from people and other structures.



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Maximize the distance from the source: Noise zoning ordinances typically set noise limits based on what can be measured at the property line. Because sound diminishes as the square of the distance from the source, simply increasing the distance from the property line may be enough to meet local regulations.

Conclusion

Today, the science of noise control is well understood, and generator set noise can be controlled to a significant degree in both indoor and outdoor installations. The trend toward greater noise reduction of generator sets is driven by a combination of local ordinances and the desire of end users to have a more quiet work environment. Generator set noise control is mostly limited by economics. The first 10 dB(A) of sound reduction is relatively inexpensive, while the last 10 dB(A) may strain the budget. When controlling noise, it is important to not compromise generator set cooling or overall performance and reliability. Barriers that contain noise also tend to contain heat, and any restrictions in cooling air flow over a generator set can reduce its performance or threaten its longevity. By working with generator set manufacturers or aftermarket enclosure suppliers, end users will be able to achieve the maximum sound reduction for the available budget. In addition, end users should involve local zoning and regulatory agencies to make sure that the installation meets all applicable noise regulations. ■

Dr. William Bloxsom, P.E., is a mechanical engineer with MTU Onsite Energy, Mankato, Minn. Visit *www.mtuonsiteenergy.com* for more information.

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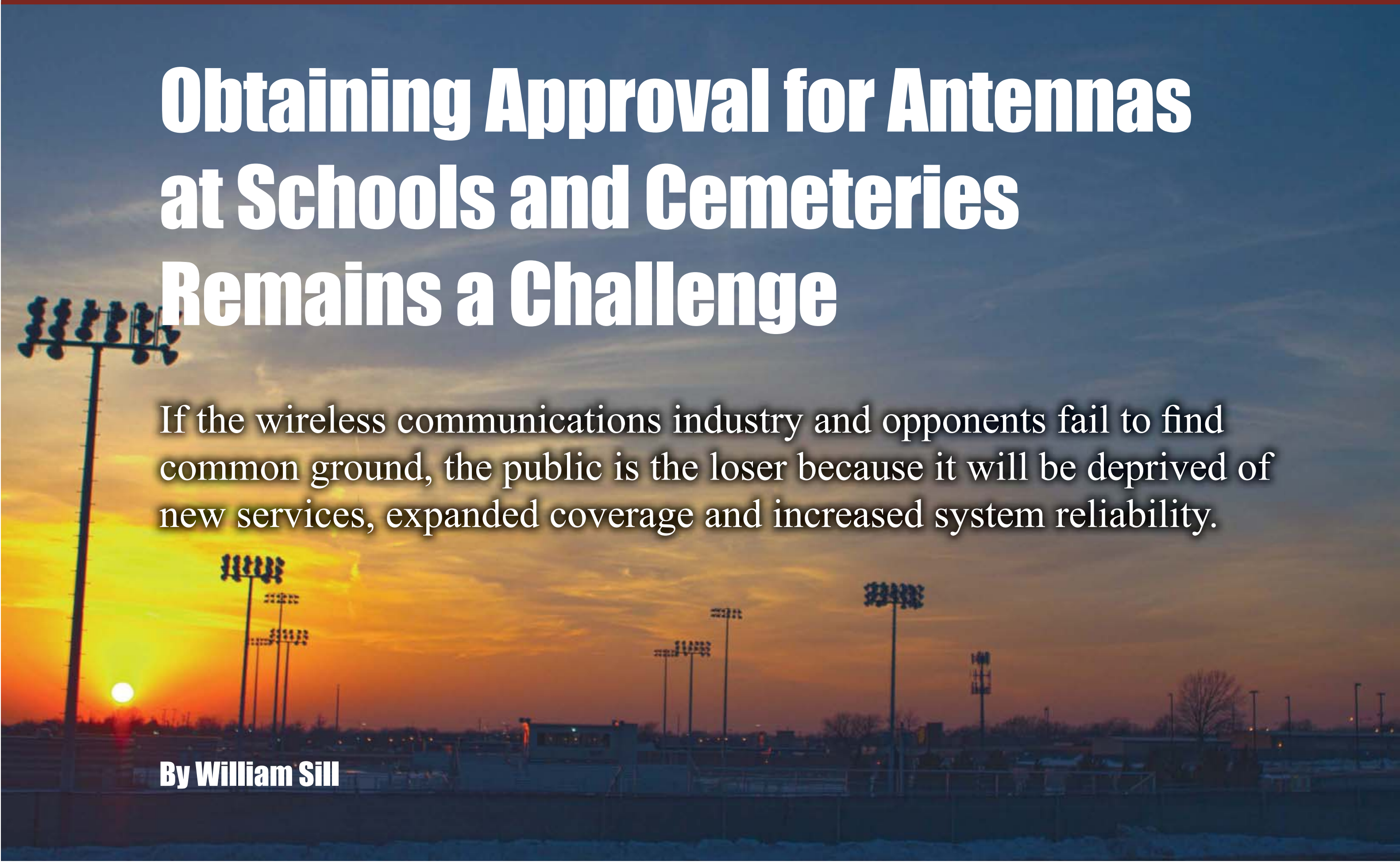

Obtaining Approval for Antennas at Schools and Cemeteries Remains a Challenge

If the wireless communications industry and opponents fail to find common ground, the public is the loser because it will be deprived of new services, expanded coverage and increased system reliability.

By William Sill

At the very time that tower companies and wireless carriers are called upon to quickly roll out fourth-generation (4G) wireless service to meet the increased public demand, it is increasingly challenging for the industry to site new towers and other wireless infrastructure. In addition to the delays associated with obtaining the required local authorizations, tower companies and carriers can face significant opposition when seeking approval to site towers and antenna structures in and around schools and cemeteries.

Siting at schools

Siting a new tower, or collocating a new antenna structure, near or on school premises can be an economic win-win for both the local school district and the tower company or carrier. Siting or collocating on school premises offers many cash-strapped educational institutions the opportunity to raise much-needed revenue through leasing arrangements that provide a steady stream of income. This money might be put toward purchasing new textbooks or other materials, improving school facilities, retaining or hiring additional teachers, or simply satisfying outstanding financial obligations. At the same time, school sitings afford tower companies and carriers a much-needed means of addressing coverage gaps and providing additional capacity to improve the quality and reliability of service.

Unfortunately, there are a number of instances across the country where local residents have strongly opposed these arrangements because of concerns about the potential effects of radiofrequency (RF) emissions, noise, and the perceived aesthetic impact of a tower or antenna structure. For instance, as detailed by the *Easton Courier* in stories published in October 2012, residents of Easton, Conn., opposed a proposal to construct a 150-foot tower at a site located approximately four-tenths of a mile from Samuel Staples Elementary School. Despite one Easton resident's testimony at a hearing that the new tower would provide those who lack cell phone service a means of reaching emergency responders when landline service is down, opponents continued to fight the proposal, citing health concerns and fears about the potential effect on property values.

DeKalb County

In Georgia, Karla Drenner, a member of the state House of Representatives, encouraged DeKalb County residents to vote against a nonbinding referendum that asked whether local public schools should place towers on school property. A July 2012 report from Fox affiliate WAGA-TV in Atlanta told of supporters who said that rent from the cell towers could help address the school system's budget problems.

Public misconceptions about RF are not limited to proposed school sitings. When a new facility is proposed, RF often is an issue, either spoken or unspoken. For example, in May 2012, KNBC, a Los Angeles affiliate of NBC, reported that residents of a Burbank neighborhood opposed a plan to construct a tower atop a local church due to concerns about a perceived potential for adverse health effects. One resident was quoted as saying, “We’d rather look foolish in 10 years and say maybe we overreacted — but we’re healthy — than to look back in 10 years and say, ‘You know these brain tumors some of us are getting? Maybe we can trace them back to those cell phone towers we live underneath.’”

In response to proposals to site towers on or near schools in Maryland, state and local legislators have repeatedly drafted legislation seeking to curtail such efforts. Since 2007, at least three bills have been introduced at the state or local level that would prohibit the siting of wireless telecommunications towers on certain public school property. Two of the bills — Senate Bill 379 and House Bill 1055 — were introduced in the Maryland General Assembly between 2007 and 2011, but neither was enacted.

The third bill — Bill 12-0170 — was introduced by Baltimore city council members last December and is under consideration. The bill would ban placement of radio transmitting and receiving devices “on property that is owned or controlled by the City of Baltimore and is used for the recreation, care, or education of children.” The ordinance has been assigned to the council’s Land Use and Transportation Committee and has been referred to the city solicitor, the school system, the planning commission and various departments. The city solicitor and the Baltimore City Public School System expressed concerns about the bill, including its lawfulness and its necessity in view of FCC requirements. Thus, it is possible that the third bill could share the fate of its predecessors.

Opposition

Experience has shown that some residents fervently oppose cell towers and persist in their opposition to towers even years after towers have been constructed and placed into operation. Last year, in California, residents banded together to pressure the local school board to remove a tower that was installed between a middle school and an elementary school in 2006. The group sought to dismantle the tower, which had been stealthed to resemble a pine

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How obvious is the cell tower at Westridge School in Overland Park, Kan.? It depends on where you stand. Looking across the athletic field from the street that fronts the school (facing page), the tower blends in among light poles. Viewed from a point near the property line (right), far from the school building, the tower is more obvious. In that position it is closer to stores in a nearby shopping center than it is to classrooms.

tree. In October 2012, the *Pasadena Sun* reported that one parent, a neurosurgeon who specializes in treating brain tumors, referred to several studies that suggest radiation from cell phones and towers might interfere with DNA reproduction and affect the human brain. In a subsequent report on the same story, the *Pasadena Sun* reported that opponents' fears about the effects of radiation were not quelled by evidence that the radiation levels near the towers were hundreds, even thousands, of times lower than the limits set by the FCC.

As tower companies and carriers have found in other contexts, sometimes residents simply refuse to compromise. A news story published in August 2012 by the *Crescenta Valley Weekly* described a situation in California where residents opposed the erection of a 55-foot free-standing monopine tower in a grove of existing trees that ranged from 40 to 71 feet tall. Unfortunately, sometimes stubborn residents' efforts to foil plans for a new tower or antenna structure can add years to the local approval process. An August 2012 news story on the HowellPatch website reported that one carrier's application to build a cell tower in Howell, N.J., was delayed for nearly two years when several residents opposed the tower on visual and aesthetic grounds.

A tower in a cemetery in New Orleans.

RF emissions

Jurisdictions often take pains to state that their actions are not based on concerns about RF emissions, even if testimony or opinion on the topic is voiced at local hearings. The reason for this is that Section 332 of the Communications Act of 1934, as amended, prohibits state and local authorities from making tower land use determinations based on the environmental effects of RF emissions of facilities that comply with FCC standards. In other words, the FCC's exclusive jurisdiction to regulate RF radiation pre-empts a local authority's ability to base its denial of a permit on RF concerns.

Court precedent

However, there is court precedent holding that Section 332 does not pre-empt a local government authority from setting limits on RF emissions when the government is the lessor. In this instance, courts reason that the government agency is acting as a property owner and not as a regulator, which would trigger pre-emption. See *Sprint Spectrum LP v. Mills*, 283 F.3d 404 (2d. Cir. 2002). Nonetheless, courts may be reluctant to enforce a property use restriction against a local authority on the basis of residents' RF concerns when the authority has approved the construction of the tower on its property. See *Perrin v. Bayville Village Board*, Index No. 9468-07 (N.Y. Sup. Ct. Aug. 13, 2008), *aff'd in part and modified in part*, 894 N.Y.S.2d 131 (2010) (affirming a lower court's dismissal of plaintiff's claim that a proposed tower would violate restrictive covenant and modifying the lower court's judgment to find that installation would not violate covenant).

Siting at a cemetery

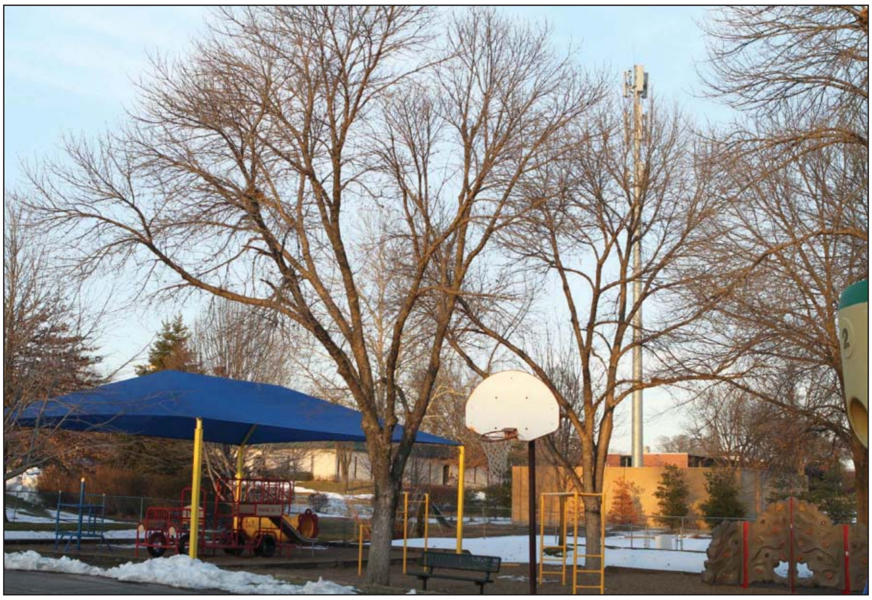
Cemeteries have also been used as locations for wireless facilities. As with schools, leasing space to a tower company or wireless carrier can be a win-win for cemeteries. These businesses are often hard pressed to meet the significant economic burden of providing perpetual care, which could include lawn care and costs associated with gravestone and grave plot conservation, totaling as much as $18,000 to $20,000 a year, according to a news story published on the BaskingRidgePatch website in May 2010. Leasing space to tower companies and wireless carriers can provide cemeteries with much-needed funds while affording the tower or other wireless company access to a site that is critical to providing new service, increasing capacity and system reliability.

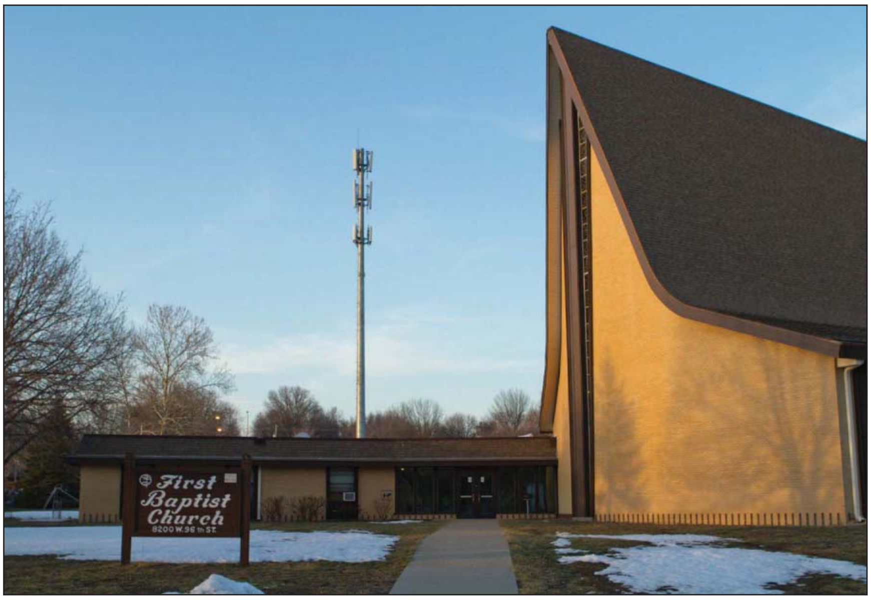
Using a far corner of a cemetery to site a wireless tower would seem to skirt community opposition based upon RF concerns. However, opponents do emerge, objecting to such proposals based on their perceived effect on the character of the neighborhood. For example, a member of a local zoning board, reacting to the proposal to build a cell tower in the Hillside Cemetery in Scotch Plains, N.J., stated that the tower would have a "devastatingly negative impact on the character of the neighborhood." The story, published in October 2010 by the Newark, N.J., *Star-Ledger*, also reported that another board member, who is a real estate agent, echoed the concerns of several residents who complained that the tower would depress their property values.

Some opponents object to such proposals on religious grounds. A news story on the website of KCRG-TV, Cedar Rapids, Iowa, quoted one resident who described a proposal to construct a tower in a cemetery as "an affront to the people buried there." In a news story published by the *Philadelphia Inquirer*, a rabbi opined that a proposal to erect a 160-foot tower at a cemetery in Bensalem, Penn., would violate the two most central themes of Judaism — honor the dead and comfort the bereaved.

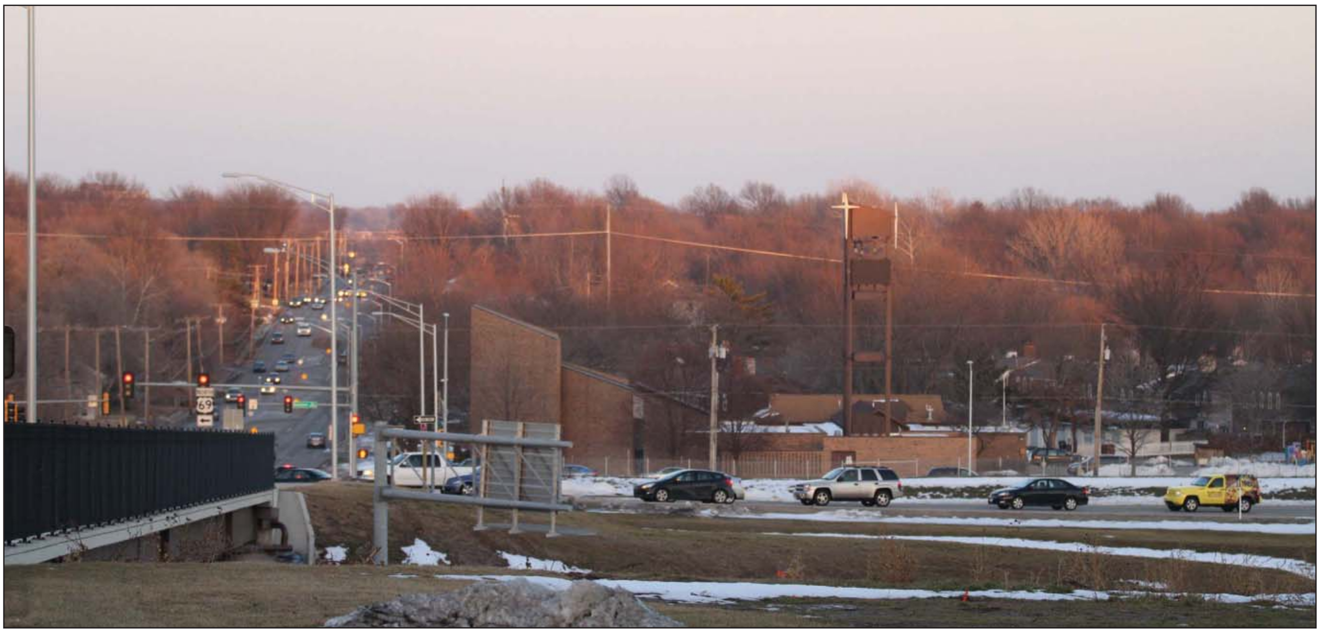
It is important for tower companies and wireless carriers to bear in mind that, although opposition to such facilities does occur, it is also true that cemeteries continue to provide a source of sites for tower owners and wireless carriers. Just last November, the Raleigh, N.C., city council unanimously approved a tower company's application for a permit to

Jurisdictions often take pains to state that their actions are not based on concerns about RF emissions, even if testimony or opinion on the topic is voiced at local hearings.





These are two views of the same tower. One shows its position adjacent to a school playground. The tower stands on property belonging to a church.



Where it stands at a church near a freeway, a cell tower with a cross at the top blends into the background. Several wireless communications carriers share the tower with their antennas concealed behind panels extended between the tower's legs.

build a 150-foot slim-line monopole tower at a site owned by the Oakwood Cemetery Association. The city's website reported that the State Historical Preservation Office supported the request, and that no one appeared at the council meeting to speak in opposition.

The ABC's of compromise

"Efficient deployment of wireless infrastructure is essential to building the wireless networks that deliver the many benefits of mobile broadband to millions of consumers across the country, including new opportunities for improved health care, education and public safety," said Jonathan Adelstein, PCIA president and CEO. The challenge, then, for both the industry and the public, is to avoid emotional encounters that polarize positions rather than open a meaningful dialogue. Although it may be therapeutic for participants to vent, the parties must move beyond that if progress is to be made and a solution is to be found. A cornerstone of productive discourse is for both sides to recognize that the goals of the other must be listened to and addressed. Industry participants would be well advised to avoid having this initial discussion at a hearing, which, by its very nature, creates an "us versus them" mentality. Whether the concerns voiced by opponents are based on aesthetics, property values or RF emissions, the industry would be best served by listening to these concerns and searching for ways to accommodate legitimate concerns, while allowing a tower to be built that will meet public demand. For their part, opponents need to accept that if they have concerns about the FCC's RF emissions standards, the appropriate place to raise those concerns is at the FCC, not at the local jurisdiction. If opponents remain open to a compromise, they may find that most of their concerns can be addressed. What both the wireless communications industry and opponents of antenna sites need to accept is that without compromise, the only certainties are that: a) lengthy and expensive litigation will occur, and b) the public will lose out, because every day a tower is delayed, the public is deprived of new services, expanded coverage and increased system reliability. Abraham Lincoln, the 16th president of the United States and the hero of two recent big-budget films, once said, "Discourage litigation. Persuade your neighbors to compromise whenever you can. Point out to them how the nominal winner is often a real loser — in fees, expenses, and waste of time." Without compromise, a win-win situation will become a lose-lose situation, with the public the poorer for it.

Although it may be theraputic to vent, the parties must move beyond that if progress is to be made.

Editor's note: William Sill's original manuscript contains footnotes with hyperlinks to the news stories and other sources mentioned in the article. It isn't feasible to publish numerous footnotes in a magazine format. Plus, if you are reading the printed version of AGL*, you would be unable to use the hyperlinks without keystroking them into your computer, tablet or smartphone, and lengthy URLs make that inconvenient and subject to error. I found the source material to be most interesting, and* AGL *would like to make it available to you if you want it. If you do, please send an inquiry to the author or to me (*AGL *Executive Editor Don Bishop), and you will receive a Word document with the footnotes and hyperlinks to use to access the sources for the article.* ■

William Sill is a partner in the law firm of Wilkinson Barker Knauer. He chairs the firm's Tower Group, and his email address is wsill@wbklaw.com. Chris Clark, an associate with the firm, contributed to this article.

Of all the things Shea's dog is trained to do, the most important is opening doors.

A rare muscle disease keeps Shea confined to a wheelchair. But thanks to her best friend Mercer, she's not confined *by* it. Mercer is at Shea's side 24 hours a day to help her do all sorts of things on her own, from picking things up off the floor to opening the refrigerator and turning on the lights. How inseparable are Shea and Mercer? Take a look in her school yearbook and you'll find his picture right there next to hers.

For more than 30 years, Canine Companions for Independence has been teaming people like Shea with dogs like Mercer completely free of charge. To find out more about making a donation, volunteering, or applying for a dog of your own, visit www.cci.org or call 1-800-572-BARK.

CANINE COMPANIONS
FOR INDEPENDENCE®

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Is "Broker" a Dirty Word?

A good broker levels the playing field and provides the seller with the insight, knowledge and experience gained from many transactions.

By Tom Engel

I have been kicking around in the communications sector for 40 years. In 1972, an engineer from the space program convinced me that there was a future in cable television. Since then I have had the privilege of participating in cable television, broadcast, publishing, the advent of cellular, and now the consolidation of wireless infrastructure. I ascended from management to senior management, but I realized early on that the thing I liked best about what I was doing was buying or selling major assets. It is either black or white. You either win or lose. In most cases, the party with the best resources comes out on top. As time went on, I realized that there could be a win-win in most transactions if both parties were equally represented. So, in the mid-1980s, I began to represent buyers and sellers of cable systems, broadcast stations, newspapers, spectrum, telephone companies, Internet service providers and, now, telecommunications tower sites.

Bill Daniels, sometimes referred to as the godfather of cable television, wrote, "Why is it that when people enter into business negotiations they feel they have to act in a certain way? A plaque in my office reads, 'Neither a scrooge nor a patsy be.' This motto has taught me a lot of lessons. You have to be solid and upstanding in your principles and ideals. You have to be strong in the boardroom and shrewd in negotiations. But also make it a point to be compassionate and understanding. Listen to what the other person has to say. And, give more than you have to. If you're really going to find success in this world, you need to remember that there's a time to be tough and a time to be tender."

If we look up broker in a thesaurus we find: dealer, agent, middleman, intermediary, mediator, liaison. The dictionary defines broker as a person who buys and sells goods or assets for others.

Similar to the brokerage of commodities, hotels, banks, insurance, commercial and residential real estate, the brokerage of communications assets requires specific knowledge of the financial, regulatory and technological aspects associated with the assets that are acquired or sold. A network of relationships and recurring experience with the buyers and sellers provides an added benefit.

Unlike the brokerage of real estate, investments and insurance, there are few if any licensing requirement for the brokerage of cable systems, publications, spectrum, broadcast or towers. Some brokers, especially those involved in stock transactions and financing, hold a security dealers license, and most states require any party dealing with any transaction involving a real estate interest to hold a real estate license. Because the sale of communications assets usually involves assets in multiple jurisdictions purchased by companies rather than individuals, licensing is difficult. The downside to the lack of licensing requirements is that anyone from any background can instantly become a broker. All that's needed are a business card and a website.

During the mid-1980s, the cable industry was consolidating at a rapid rate. By 1985, a handful of established brokerage companies serviced thousands of cable systems owned by hundreds of companies. I estimate that by 1988, just before the rules about highly leveraged transactions brought cable deals to a screeching halt, there were over 100 brokerage companies with nearly 300 brokers chasing about 2,500 to 3,000 cable systems. Independent cable sys-

What to expect from your broker

The right broker should do the following:

- ☑ The broker should meet the sellers personally so both parties have a comfort level with one another.
- ☑ The sale process should be thoroughly explained to the seller, from engagement to closing.
- ☑ The seller should be given a realistic expectation of market value and a time frame for completion (closing) of the transaction.
- ☑ The broker should provide a simple, clear, easy-to-read, one-page listing or engagement agreement with a fee payable only at closing.
- ☑ The broker working with the seller should assemble all of the information related to the technical aspects, cash flow and nature of the assets.
- ☑ The broker should review the information and gather additional details related to issues that he knows the sellers will request.
- ☑ The brokerage company should put together a request for proposal (RFP) and an executive summary of the asset being sold.
- ☑ The RFP should include terms and conditions for the proposed transaction (and any allowable variances), a time frame for completion of the various steps, and special assumptions that the various buyers may want to consider.
- ☑ The broker and seller should work together to collect, categorize and present the due-diligence documentation required for the sale.
- ☑ The broker should select the best possible potential purchasers for the particular assets.
- ☑ Once all the proposals (usually in the form of a letter of intent) have been received, the broker should present a quantitative and qualitative analysis to the seller to provide a basis for final selection. In many cases, the broker will go back to the best two or three proposals to qualify certain issues or enhance the proposals.
- ☑ Once the letter of intent has been executed, the broker should begin work with the purchaser's due-diligence staff to resolve any open issues.
- ☑ Upon receipt of a definitive purchase and sale agreement, usually referred to as an asset purchase agreement (APA), the broker should redline (with comments) various areas that would benefit the seller. That redline agreement should be sent to the seller's counsel to allow the counsel to create or remove language as necessary.
- ☑ The purchaser should coordinate all information requests and site visits through the broker for site inspection, surveys, tower inspection and environmental reports in order to maintain the confidentially of the transaction until closing.
- ☑ Once the due-diligence defects have been resolved and the APA has been executed, the broker should coordinate the closing and either produce a draft settlement statement or review the draft settlement statement produced by the buyer.
- ☑ On the day of closing, the broker should work closely with the seller and his counsel to facilitate document execution and transfer sufficient to justify funding.

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Charles Universal Broadband Enclosures (CUBE)
Multi-Purpose Enclosures
CUBE MP Series houses a wide range of remotely deployed copper and fiber electronics
Small Cell Enclosures
Compact cabinets for small cell / pico cell radios, routers, rectifiers and batteries.
Site Support Enclosures
CUBE SS Series supports VRLA or Ni-Cd batteries, various rectifier and power distribution options
Charles
www.charlesindustries.com
INNOVATIVE ENCLOSED SOLUTIONS

tem owners were receiving several calls a week from brokers who were soliciting listing agreements.

Many of these brokers would promise an unrealistic price and ask the seller to sign a listing agreement. The agreement would provide long-term protection of the broker's fee, so they would simply send the information to all (hundreds) of the possible buyers and sit back and wait for something to happen. A similar scenario took place in the broadcast sector when the FCC eliminated ownership limitations.

In the communications sector, "broker" became a dirty word.

So, why use a broker?

The broker levels the playing field and can bring a non-emotional perspective to the transaction. If the broker is experienced, knowledgeable and well connected, the small, first-time seller can be as well represented as the large company that closes multiple transactions per year or per month.

Based on numerous previous transactions, the experienced broker will understand what makes the assets of any particular transaction more or less attractive to certain buyers. Experience with previous transactions with various buyers will provide the broker with a basis of understanding as to the language and provisions of the various purchase-and-sale documents, and a knowledge of which provisions are negotiable and to what extent they have been negotiated in the other transactions.

Technical and financial knowledge related to the assets being sold can be invaluable in negotiating the best price possible for the seller. Most transactions include unique relationships and complex issues that can usually be resolved based upon the knowledge of previous deal experience. Knowledge of tax issues, potential engineering concerns and environmental issues allows the broker to refer the seller to professionals who can provide appropriate advice.

The well-connected broker has built a network of relationships with the purchasing companies, attorneys practicing in the sector and service companies, including title companies, contract engineering firms, surveyors, and environmental firms. If the broker has earned the respect of these entities, it can go a long way toward mitigating issues that could crater a transaction or result in significant value loss.

Finally and most importantly, if both parties trust the broker, a good broker can mitigate the emotion on both sides of the transaction to resolve complex differences. Although the broker's fiduciary duty is to his client, in most cases he can provide a neutral perspective on complex issues that can sideline or crater a transaction. By presenting a fair and neutral perspective on these issues, in most cases a compromise can be reached and the transaction can be consummated.

Selecting a broker

A number of resources list individual brokers and brokerage companies specializing in the sale of communications infrastructure, including tower sites, DAS networks and fiber. Select two or three companies and talk with representatives of each of them. It is vital that the firm is experienced and knowledgeable, but it is equally important that the seller and broker have a comfortable working relationship.

When selecting a broker, the most important factors in the seller's selection decision are trust and integrity. Obtain and check three references. Meet the broker. Ask questions.

No, "broker" is not a dirty word.

There may be some companies or individuals who are not qualified or who lack integrity, but the same is true in many disciplines, including doctors, attorneys, mechanics, accountants and repairmen.

A good broker levels the playing field and provides the seller with the insight, knowledge and experience gained from many transactions. The competitive experience created by a qualified broker maximizes the value of the assets for the seller and minimizes missteps, terms and conditions that might otherwise devalue or crater a sale. ■

Tom Engel is director of Milestone Media. His email address is *milestone.te@gmail.com.*

"SURE, AT FIRST I WAS A LITTLE TAKEN ABACK BY THE WHOLE PEEING STANDING UP THING. BUT I TAUGHT HIM TO THROW A STICK AND NOW HANGING OUT WITH HIM IS THE BEST PART OF MY DAY."
– EINSTEIN
adopted 12-09-10
A PERSON IS THE BEST THING TO HAPPEN TO A SHELTER PET
adopt
theshelterpetproject.org
Ad Council
THE HUMANE SOCIETY OF THE UNITED STATES
MADDIE'S FUND

Quick-Guide to Site Acquisition Companies

As a supplement to January's 2013 Buyers Guide, here is a list of site acquisition companies, where they operate, the types of sites they provide and additional information on the types of services they provide.

Aarcher
910 Commerce Road
Annapolis, MD 21401
jason losjlos@aarcherinc.com
(410) 897-9100 x108
www.aarcherinc.com
Area served: national
Types of sites: tower
Service offered: 1
Other: Phase I environmental due diligence, NEPA screening, and cultural and natural resources support services
Company description:
Aarcher provides Phase I environmental due diligence, NEPA screening, and cultural and natural resources support services for antenna and tower installations throughout the United States. Since 1997, the company's team of environmental scientists, conservation specialists and architectural historians has supported thousands of installations from offices in Colorado, Georgia, Maryland and Texas.

Antietam Wireless Services
103 Carnegie Center, Suite 300
Princeton, NJ 08540
Michael E. Shine
info@antietam-wireless.com
(973) 454-0302
www.antietam-wireless.com
Areas served: DE, GA, IN, MD, MI, NC, PA, SC
Types of sites: tower, rooftop, DAS, small cell
Services offered: 2, 3, 4, 6, 7, 8, 13

Black & Veatch
10950 Grandview
Overland Park, KS 66210
Kevin Bukaty
bukatyk@bv.com
(913) 458-7967
Area served: national
Types of sites: tower, rooftop, DAS, small cell
Services offered: 2, 3, 4, 5, 7, 8. 9, 10, 11, 12
See ad on page 13

Cellective Solutions, LLC
Site Acquisition, Zoning and Permitting

Cellective Solutions
1736 Westpark Center Drive,
Suite 201
St. Louis, MO 63026
Russell S. Been
russ@cellectivesolutions.com
(314) 989-9810
www.cellectivesolutions.com
Area served: national
Types of sites: tower, rooftop, DAS, small cell
Services offered: 1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12
Other: Photo simulations, all due diligence, project management, construction management, balloon tests, utility coordination, site audits, lease amendments and FAA, FCC and SHPO approvals.
Company description:
Cellective Solutions has provided clients with the fastest, most cost-effective, and permitted telecom sites in the industry. Over the past five years the company has completed site acquisition services on over 1,000 sites in seven states. Most of those are difficult sites that other companies were unable to complete. When a network needs to be built, improved or expanded, Cellective Solutions can be what it calls a client's "selective solution."

1. Environmental assessments
2. Land acquisition
3. Lease acquisition
4. Right of way procurement
5. Site Design
6. Site management
7. Site prequalification
8. Site selection
9. Site survey
10. Title services
11. Tower mapping
12. Tower rental and collocation
13. Zoning and permitting

CIS COMMUNICATIONS LLC

CIS Communications
749 Old Ballas Road
Saint Louis, MO 63141
Brick P. Storts IV
brick@ciscomm.com
(314) 569-2275
www.ciscomm.com
Areas served: AZ, AR, IL, IN, KS, MO, NM, OH
Types of sites: tower, rooftop, DAS, small cell

1. Environmental assessments
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3. Lease acquisition
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8. Site selection
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11. Tower mapping
12. Tower rental and collocation
13. Zoning and permitting

Company description:
CIS Communications has provided site acquisition services to the wireless industry since 1995. The company has deployed systems for major carriers throughout the Midwest. Its seasoned professionals are recognized as lease negotiation and zoning experts. CIS' professional team delivers consistent and successful results to select clientele.

Compass Technology Services
5449 Bells Ferry Road
Acworth, GA 30102
Keith Pennachio
kpennachio@compassts.com
(404) 427-7902
www.compassts.com
Areas served: AL, FL, GA, KY, LA, MS, NC, SC
Types of sites: tower, rooftop, DAS, small cell
Services offered: 2-5, 7-9, 11-13
Other: P.E.-licensed in 25 states plus the District of Columbia. Site design and structural engineering. In-house tower and technical crews.
Company description:
Compass is a life-cycle services group that focuses on the design and development of telecommunications networks. With more than 15 years of tested experience, its teams are skilled in delivering high-quality projects on time with a focus on the highest customer satisfaction. The company slogan is, "We get the job done. Reliable. Efficient. Delivered."

ComSites West
2555 Third Street, Suite 200
Sacramento, CA 95818
Charlie Feick
charlie@comsiteswest.com
(530) 414-4376
www.comsiteswest.com
Area served: national
Types of sites: tower, rooftop, small cell
Services offered: 2, 3, 6, 12
Company description:
ComSites West develops, owns and operates wireless communications sites in California and Nevada, including tower and rooftop communications facilities. The company develops towers jointly with land owners and acquires towers through outright purchases and through purchase-leaseback programs.

Crown Castle
2000 Corporate Drive
Canonsburg, PA 15317
(877) 486-9377
www.crowncastle.com
Area served: national
Types of sites: towers, rooftops, DAS
Services: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
Company description:
Crown Castle's line of site development services and in-market resources allows it to deliver to customers flexible deployment solutions. The company's understanding of local zoning and permitting processes, supported by relationships with municipalities across the country, helps ensure compliance and accurate documentation to move more efficiently through the collocation process.

CST II
323 S. Hale St.
Wheaton, IL 60787
Elizabeth Erbes
elizabethe@centralstatestower.com
(630) 221-8500
www.centralstatestower.com
Area served: national
Services offered: 5, 12

Dietz Brothers
12185 51st St. NE
Spicer, MN 56288
Alan Dietz
alan@dietzbros.net
(320) 796-2281
www.dietzbros.net
Areas served: IA, MN, ND, SD, WI
Types of sites: tower
Services offered: 11, 12

Faulk & Foster Real Estate
1811 Auburn Ave.
Monroe, LA 71201
Joe Derry
joe.derry@faulkandfoster.com
(318) 376-0840
www.faulkandfoster.com
Area served: national
Types of sites: tower, rooftop, DAS, small cell
Services offered: 2, 3, 4, 6, 7, 8, 9 ,10, 11, 12, 13
Other: Project management, construction management, program management, sublease management, property management, market analysis, right of way services for fiber deployments

Global Tower Partners
750 Park of Commerce Blvd. #300
Boca Raton, FL 33445
Michael Belski
mbelski@gtpsites.com
(561) 866-7949
www.gtpsites.com
Areas served: national, Puerto Rico, Mexico, Costa Rica
Types of sites: tower, rooftop, DAS, small cell
Services offered: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
Company description:
GTP is the largest privately owned tower operator and the fourth-largest independent operator in the United States. GTP owns, manages or master-leases over 16,000 wireless sites and 40,000 miles of railroad rights of way. GTP leases space on towers and rooftops to telecommunications carriers and other users of wireless technology.

Phillips Lytle
3400 HSBC Center
Buffalo, NY 14203
Doug Dimitroff
ddimitroff@phillipslytle.com
(716) 847-5408
www.phillipslytle.com
Area served: national
Types of sites: towers, rooftops, DAS
Services: 1–4, 10, 12–13

SBA Communications
5900 Broken Sound Parkway NW
Boca Raton, FL 33487-2797
information@sbasite.com
(800) 487-SITE
www.sbasite.com
Area served: national
Types of Sites: tower, rooftop
Services offered: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
Company description:
The SBA slogan, “building better wireless,” reflects the company’s desire to be a customer’s first-choice provider of wireless infrastructure solutions and to set the standard for customer satisfaction. Clients depend on SBA to provide for their wireless infrastructure needs at all stages of site development and operation. SBA focuses on tower ownership, leasing, site management, site development, construction and technical services.
See ad on the back cover

Site ID
103 Carnegie Center, Suite 300
Princeton, NJ 08540
Michael E. Shine
mshine@siteidinc.com
(973) 454-0302
www.siteidinc.com
Areas served: DE, GA, IN, MD, MI, NC, PA, SC
Types of sites: tower, rooftop
Services offered: 2, 3, 4, 6, 7, 8, 13

Subcarrier Communications
139 White Oak Lane
Old Bridge, NJ 08857
John Paleski
subcom1@subcarrier.com
(732) 607-2828
www.subcarrier.com
Area served: national
Types of sites: towers, rooftops
Services: 6, 12
See ad on page 5

Tectonic Engineering & Surveying Consultants
70 Pleasant Hill Road
P.O. Box 37
Mountainville, NY 10953
Edward Frawley
efrawley@tectonicengineering.com
(518) 783-1630
www.tectonicengineering.com
Area served: national
Types of sites: tower, rooftop, DAS, small cell
Services offered: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13
Other: Program and construction management
Company description:
Tectonic Engineering & Surveying Consultants provides a spectrum of site acquisition, architectural and engineering professional services and program management. Tectonic’s staff of 450 is located in regional and project offices across the country, providing site acquisition services including site identification, due diligence, leasing, zoning and planning analysis, zoning and planning permitting, title cure resolution, building permit application, construction management, and architectural and engineering coordination.

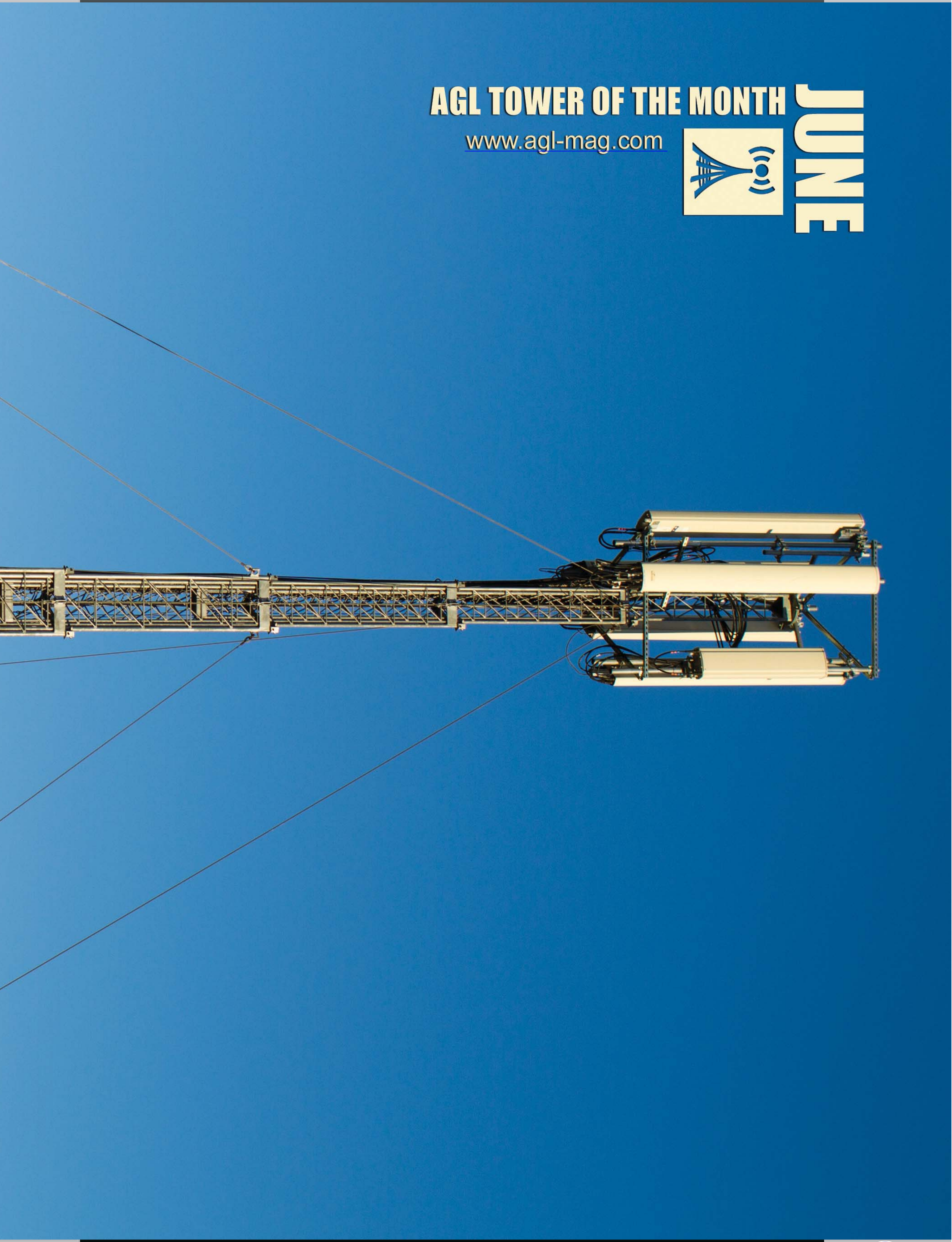
Tower Economics
700 Route 130 North, Suite 204
Cinnaminson, NJ 08077
Len Stevens
len@towereconomics.com
(856) 786-7200
www.towereconomics.com
Area served: national
Types of sites: towers, rooftops
Services: 6, 12
See ad on page 17

1. Environmental assessments
2. Land acquisition
3. Lease acquisition
4. Right of way procurement
5. Site Design
6. Site management
7. Site prequalification
8. Site selection
9. Site survey
10. Title services
11. Tower mapping
12. Tower rental and collocation
13. Zoning and permitting

TowerCo
5000 Valleystone Drive, Suite 200
Cary, NC 27519
Todd Boyer
TBoyer@towerco.com
(919) 625-5160
www.towerco.com
Area served: national
Types of sites: tower
Services offered: 3, 5, 6, 11

Utility Service Communications
535 General Courtney Hodges Blvd.
Perry, GA 31069
Debbie Sullivan
dsullivan@utilityservice.com
(478) 988-5255
www.utilityservice.com
Area served: national
Types of sites: water tanks

Wireless Edge
270 North Ave., Suite 809
New Rochelle, NY 10801
John Arthur
arthur@wirelessedge.org
(914) 712-0000
www.wirelessedge.org
Area served: national
Services: 1, 6, 7, 12, 13



JUNE

AGL TOWER OF THE MONTH

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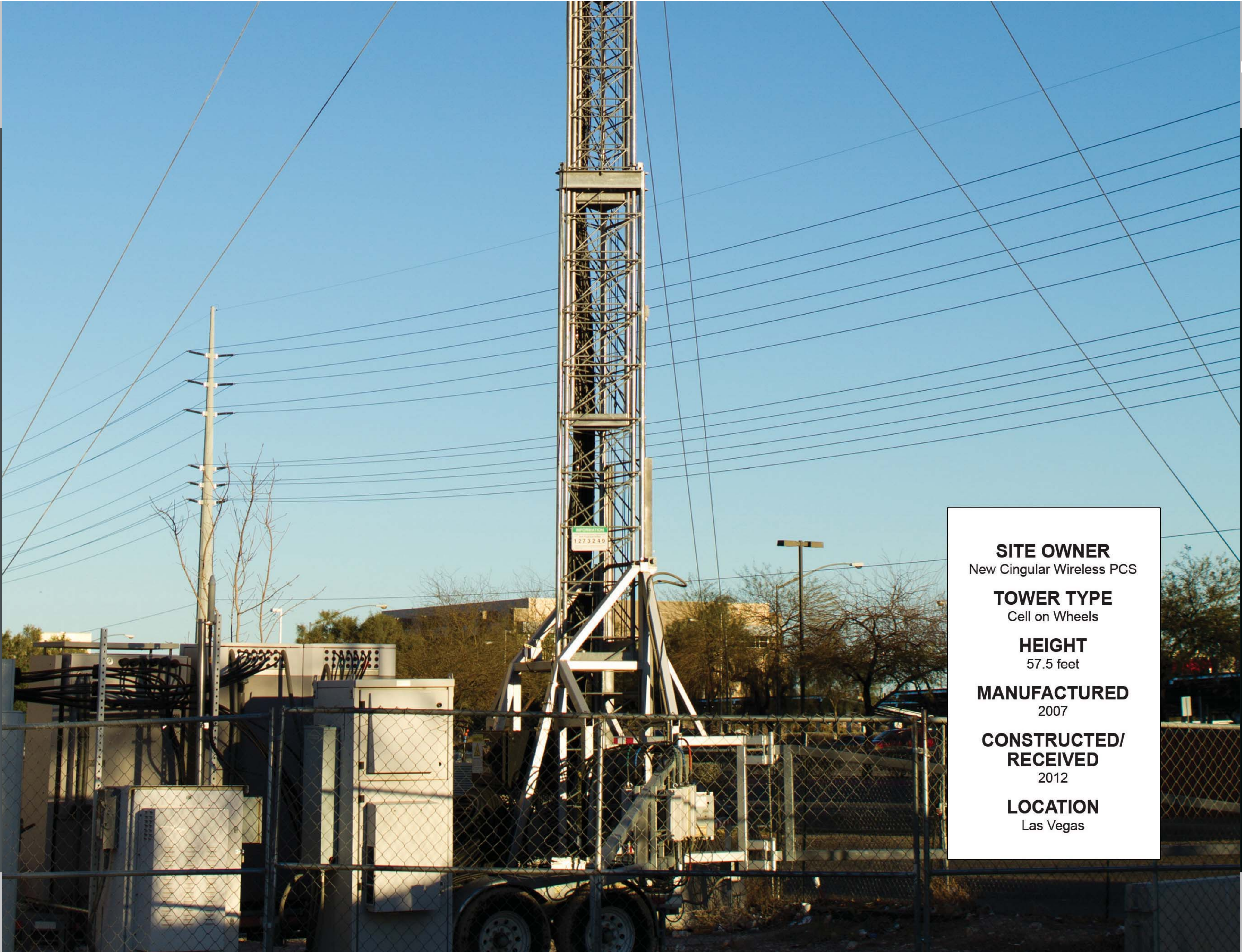

SITE OWNER
New Cingular Wireless PCS

TOWER TYPE
Cell on Wheels

HEIGHT
57.5 feet

MANUFACTURED
2007

CONSTRUCTED/ RECEIVED
2012

LOCATION
Las Vegas

When you join the Wisconsin Wireless ahelp to make a difference.

Pediatric Pack

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Oct. 16	League of Wisconsin Municipalities in Green Bay
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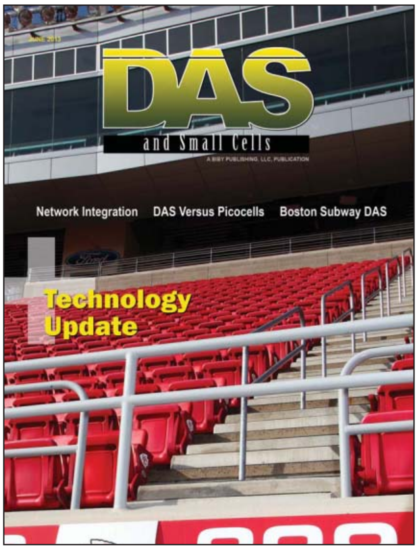

on the cover

Stadiums and arenas offer big opportunities for neutral-host DAS and for Wi-Fi systems installations.

Cover design by Scott Dolash

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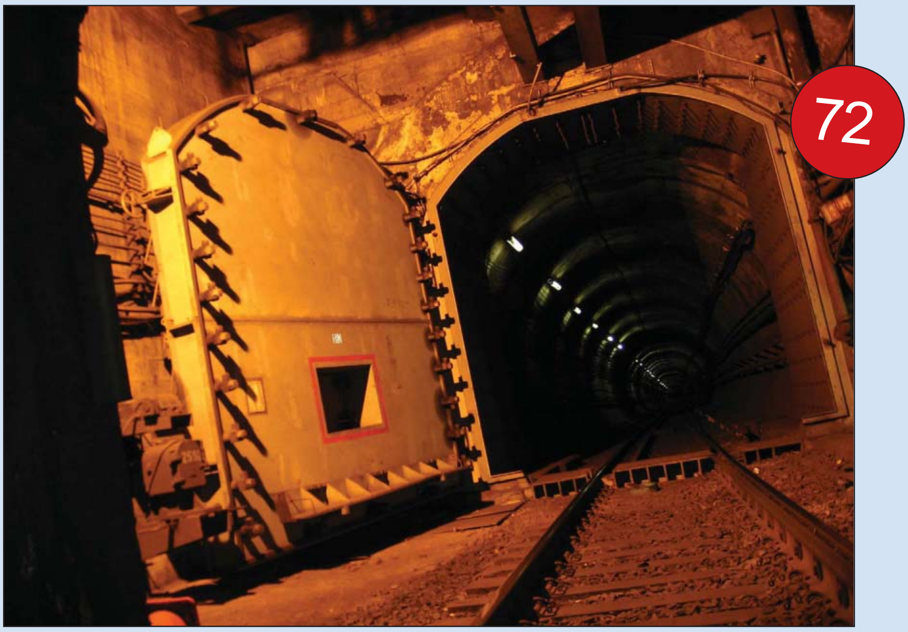

Features

52 Update on DAS and Small-cell Technology
By Ernest Worthman

58 DAS and Small Cells for Indoor Networks
By Ernest Worthman

64 Play Nice—The Integration of Small-cell Networks, Cellular and Wi-Fi Technology
By Ernest Worthman

68 DAS versus Picocells
By John Spindler

72 Why the Boston Subway DAS Uses Radiating Coaxial Cable
By Suzanne Kasai

Department

46 Editorial Comment — Edge of Innovation
By Ernest Worthman

advertiser index

AGL Wireless Infrastructure Conference........................6–9
Alabama Wireless Association ....inside front cover
Cellular Specialties..29
Huber + Suhner..15
New Jersey Wireless Association....................................25
Radio Frequency Systems ....back cover
Radio Waves 13
Solid...21
Stealth 5
Tessco 19
U.S. General Services Administration 27

Edge of Innovation

DAS and Small Cells Magazine stands at the edge of innovation.

Much of what is happening with DAS and small cells has to do with three things: the technology, the administration and the implementation.

Technology: It falls largely to Wi-Fi to handle the data segment of small networks. Wi-Fi has become the de facto small network data standard. Wi-Fi is universally accepted, and the user is comfortable with it for just about any web-related activity. Wi-Fi will be the platform for data, and some of the voice-over-Internet Protocol (VoIP) technology in small cells. Wi-Fi's big problem is how to make it "roam-able" with transparent handoffs between cells and the macro network, but that will be the easy part.

Administration: Unlicensed Wi-Fi-based small networks will have to integrate with the macro network. So far, no easy solution exists. Among the parts of the business that pose problems that remain unresolved are ownership, liability and responsibility. The economics of Wi-Fi-based small networks have yet to be clarified, meaning the cost of deployment and the return on investment are not yet clear.

The wireless communications carrier is used to being the 1,000-pound gorilla with total control of the network. However, unless the carriers build them, enterprises own the Wi-Fi networks on their properties. Even when carriers build them, Wi-Fi networks use an open standard, and their success relies on cooperative efforts. My money is on the carriers and Wi-Fi venue owners eventually smoking a peace pipe and working out a win-win for everybody.

Implementation: The big question is: Who is going to deploy the Wi-Fi networks? It may be a venue's IT department, a management company, a maintenance group or independent subcontractors. Generally, who deploys Wi-Fi networks depends on the size and charter of the enterprise.

Colleges, unified business campuses, city centers and venues that control their own data and voice systems are likely to place the burden of Wi-Fi network deployment on their IT departments. Stadiums, malls and independent office complexes might place the deployment responsibility on the management or maintenance company. The deployment of Wi-Fi in smaller properties such as apartment and condominium buildings is likely to be subcontracted.

Much is at stake for companies such as Cisco Systems, Alcatel-Lucent and Ericsson, all the way down to "Two Chucks with a Truck." All are gunning for a piece of the pie.

In any event, this market is going to explode as the wrinkles are ironed out. Whether you are on the supply side as an original equipment manufacturer or on the demand side as an IT department, management company, maintenance organization, integrator or service shop, you need to keep up on DAS and smal-cell technology.

Knowledge is power. For that, keep an eye on *DAS and Small Cells Magazine*, where the goal is to offer information and knowledge that you can put to use.

DAS & Small Cells Congress

Thank you to the American Conference Institute for the opportunity to attend the DAS & Small Cells Congress in Las Vegas April 29 to May 1. Attendance was up 33 percent from last year's Congress, and the number of exhibitors was up 50 percent. The content-heavy agenda attracted a large number of executives and other decision-makers. A nod to iBwave for its awesome hospitality suite, the best networking at the Congress. ■

By Ernest Worthman, Editor
eworthman@agl-mag.com

DAS and Small Cells™

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Infrastructure, regulatory and financial information for the antenna-siting community

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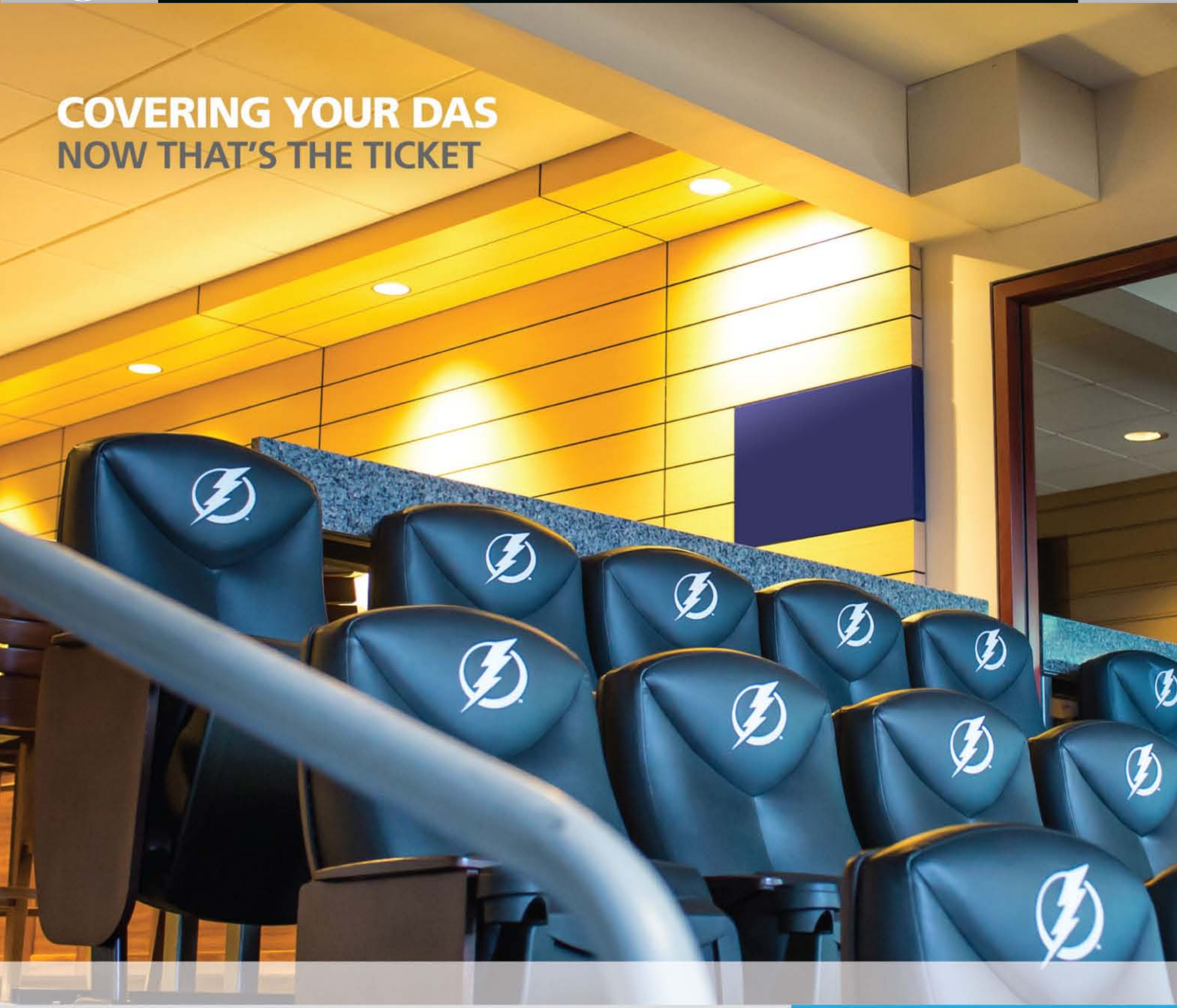

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Update on DAS and Small-cell Technology

Evolving distributed antenna system (DAS) and small-cell technology will make true on-demand wireless access anywhere and anytime a reality.

By Ernest Worthman

The vision of 4G is to make the wireless communications device, whether it is a smartphone, tablet, wearable computer, integrated heads-up display, portable gaming console or other point of access, the virtual interconnect to the world. However, if this single-point-of-access thesis is to become the de facto methodology, then, above all else, two conditions, bandwidth and access, must be guaranteed anytime and anywhere. There will be little margin for error.

Distributed antenna system (DAS) networks are an elegant solution for addressing wireless dead-zone problems, and they are a final piece of the wireless coverage puzzle. The evolution of DAS and its contribution to advanced small-cell networks has the potential to become the enabling technology for true anytime, anywhere, all-condition, all-encompassing wireless access.

The global market just for in-building wireless will reach an estimated $2 billion by the end of 2013. According to ABI Research, active DAS equipment has a current, overall compound annual growth rate (CAGR) of 15 to 20 percent in North America alone. For passive equipment, the CAGR is expected to hit 6 percent. By 2015, 48 percent of mobile data traffic will be offloaded from the macro network. Such an alluring return on investment with DAS and small cells has many companies taking a long, hard look at becoming players.

The reasons behind deploying DAS and small cells are many. On the user side, smaller cells powered by DAS bring the wireless access point close to the user. There are fewer users per cell, making access quicker and more reliable. Smaller cells offer cleaner handoffs, lower user power requirements and faster throughput.

The result for wireless telecommunications carriers is that they have happier customers, more reliable service and multiple-band, multiple-carrier and multiple-technology integration. This gives the carrier multiple deployment strategies, which is advantageous for both the end user and the carrier

Technology update

Beginning with early dual-antenna diversity schemes, DAS now boasts a variety of devices to make virtually any area wirelessly bulletproof. From the home to a metropolis, DAS technologies are extensible and scalable. Today's hardware, coupled with cutting-edge, intelligent software, optimizes bandwidth, access schemes, device loading and many other network attributes to make the most efficient use of radio-frequency spectrum.

The most significant advancements in hardware offer a wider range of frequency bands, higher power output, tighter specifications and smaller, more-efficient footprints. Such equipment is ideal for integrating multiple frequency bands, carriers and technologies, and it allows carriers to share resources.

Many of today's DAS and small-cell system components are built using a modular approach and in accordance with the standard open systems interconnect (OSI) layer model (see Figure 1). The approach allows tremendous flexibility in what equipment can be installed and what services can be offered. It is a must for supporting multiple wireless service provider (WSP) channels. This edge-of-the-envelope equipment includes such technological advancements as adaptive power management and multiband filtering capabilities and provides a platform for a multiplicity of signals to coexist within the system without any degradation of performance.

The most visible infrastructure to implement future small-cell technology is 4G (also known as long-term evolution – LTE). It is based on the Global System for Mobile Communications (GSM), Enhanced Data rates for GSM Evolution Communications (EDGE and EDGE+), Universal Mobile Telecommunications System (UMTS) and High-Speed Packet Access (HSPA) network technologies. These technologies improve the capacity and increase the data speed using a different radio interface together with core network improvements. 4G introduces the principal of heterogeneous networks (hetnets). In this implementation, the mobile network

Layer 7 — Application

This layer supports application and end-user processes. Communication partners are identified, quality of service is identified, user authentication and privacy are considered, and any constraints on data syntax are identified. This layer provides application services for file transfers, email and other network software services. Tiered application architectures are part of this layer.

Layer 6 — Presentation

This layer provides independence from differences in data representation (e.g., encryption) by translating from application to network format and vice versa. It works to transform data into the form that the application layer can accept, and it formats and encrypts data to be sent across a network, providing freedom from compatibility problems. It sometimes is called the syntax layer.

Layer 5 — Session

This layer establishes, manages and terminates connections between applications. It sets up, coordinates and terminates conversations, exchanges and dialogues between the applications at each end. It deals with session and connection coordination.

Layer 4 — Transport

This layer provides transparent transfer of data between end systems, or hosts, and is responsible for end-to-end error recovery and flow control. It ensures complete data transfer.

Layer 3 — Network

This layer provides switching and routing technologies, creating logical paths known as virtual circuits, for transmitting data from node to node. Routing and forwarding are functions of this layer, as well as addressing, internetworking, error handling, congestion control and packet sequencing.

Layer 2 — Data Link

At this layer, data packets are encoded and decoded into bits. The data link furnishes transmission protocol knowledge and management, and it handles errors in the physical layer, flow control and frame synchronization. The data link layer is divided into two sublayers: the media access control layer and the logical link control layer.

Layer 1 — Physical

This layer conveys the bit stream — electrical impulses, light or radio signals — through the network at the electrical and mechanical level. It provides the hardware means of sending and receiving data on a carrier, including defining cables, cards and other physical aspects.

Source: Cisco Systems

Figure 1. Open systems interconnect (OSI) layer model and layer descriptions.

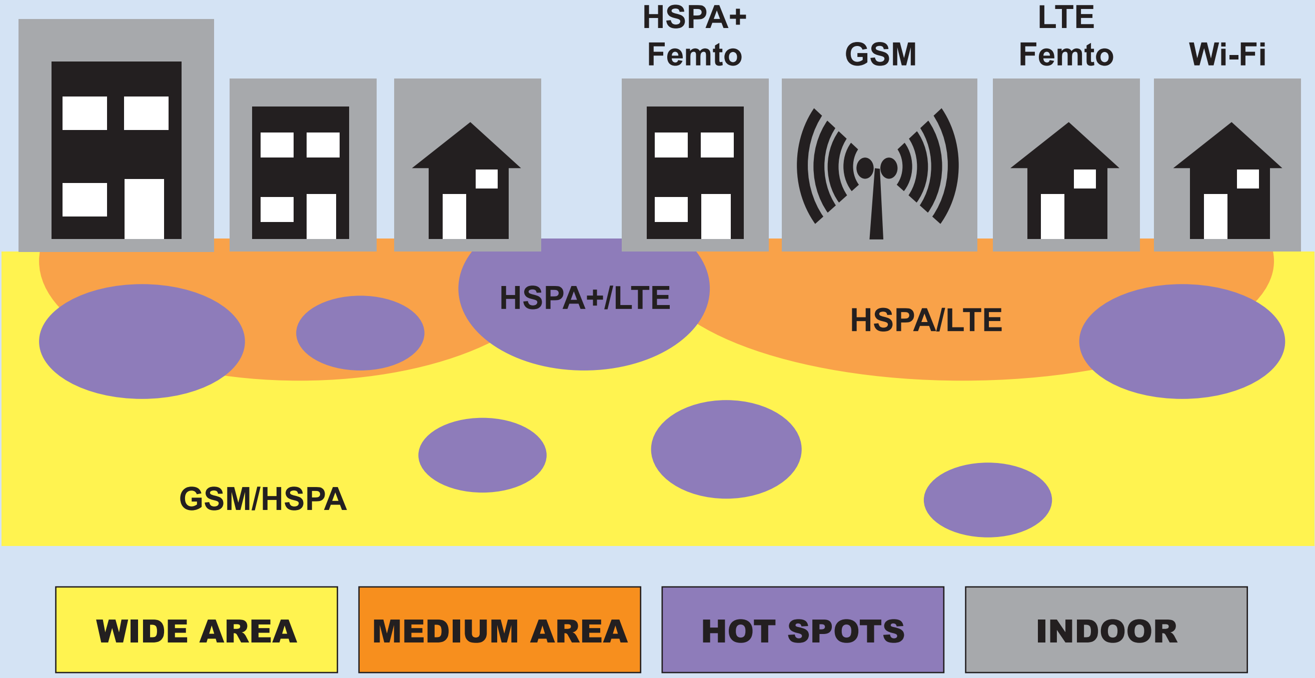


Figure 2. An example of heterogeneous network (hetnet) components.

is constructed with layers of small and large cells that are self-organizing, based upon the principles in current Home NodeB (HNB) access protocols (see Figure 2). Of particular note is that 4G is accelerating the transition to all-Ethernet backhaul transport from the mobile core to the cell site to support the high-bandwidth demands expected to materialize during the next few years.

The most likely scenario for near-future DAS and small-cell technologies is to offload local, small-cell traffic, primarily onto Wi-Fi networks. The result will be to free up macrocell bandwidth and loading. Using macro cells to handle small-area wireless voice and, especially, data, promises to become one of the biggest reasons for DAS and small-cell deployments.

Small-cell categories include:

Femtocells: These cells consume about 250 milliwatts of power and can supply about four users. The primary deployment of femtocells is to residences. They can also be deployed in small businesses by placing several cells in the desired coverage are to serve the desired number of users. Examples could be small bookstores, coffee shops and waiting areas in service businesses.

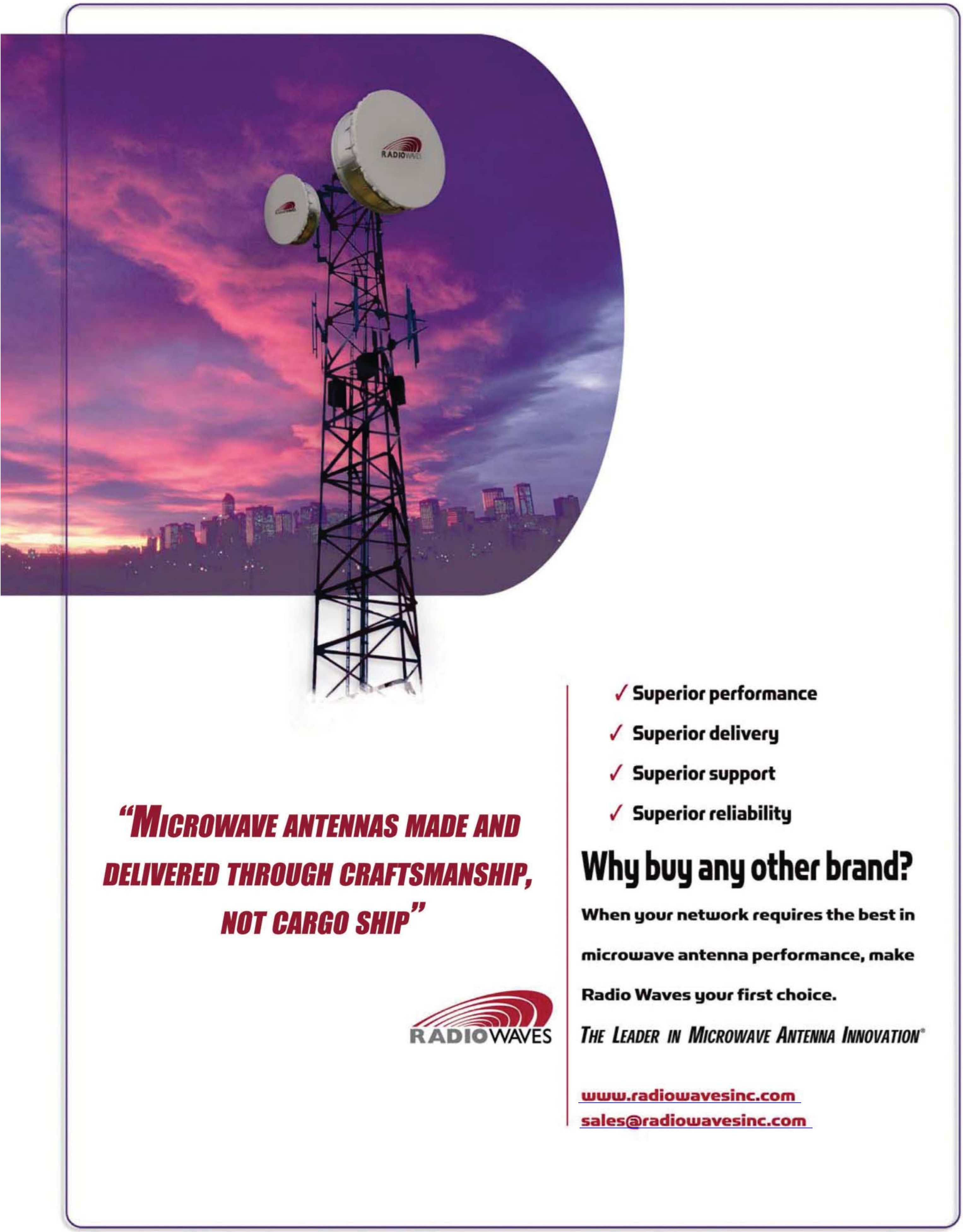
Picocells: These cells use up to 1 watt of power and can deliver service to about 64 users. Picocells are also primarily designed for indoor installations, but they can be weatherproofed for outdoor use. Picocells are typically used in larger public places such as small offices and businesses. They can also be linked to provide wider coverage areas with better user loads.

Microcells: These cells consume up to 5 watts of power and can provide service for hundreds of users. Microcells are generally designed for outdoor installations. Typical venues for these cells are stadiums, amphitheaters, malls, corporate and educational campuses, public parks and metro centers.

The golden child

One of the most promising technical solutions is to integrate a 4G LTE base station with Wi-Fi hot spots. Such a configuration can deliver up to 100 Mbps/mile to 100 users or more. On a large scale, this approach is more cost-effective than splitting macrocells and offers better throughput, resulting in faster speeds and better user experiences. This drop-in type of solution has the ability to deliver capacity where the network demand is highest. It is small and unobtrusive, and it can be installed virtually anywhere. It can be scaled down to femtocells. Another solution is to offload network traffic to a Wi-Fi hotspot. The more seamlessly Wi-Fi is integrated with a cellular operator's network, the better the result. Wi-Fi offloading with seamless integration enables the network operator to manage network performance and the subscriber experience.

The present thinking for integrating small cells, Wi-Fi access and WiMAX access calls for integrating them either in the radio access network (RAN) or the access point (AP). Each method has a following, and each has its advantages and disadvantages. The integration effort is in its infancy, and there is insufficient data to indicate which method is better or more efficient. Moreover, the enterprise segment of the marketplace has yet to embrace integration on a large scale. Nevertheless, companies such as Cisco Systems that offer both Wi-Fi and small-cell technology are showing interest. Photo 1 shows what a typi-



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cal 3G microcell access point might look like.

Most deployments are public Wi-Fi hotspots. Their owners include mobile network operators (MNOs), cable TV companies, wireline telephone companies, companies in business for the purpose of providing Wi-Fi, and businesses that offer Wi-Fi as an extra service to their customers. It is a somewhat tenuous amalgamation, and numerous details remain to be worked out before a generic, wide-scale model for Wi-Fi access points emerges. There is much money to be made in each segment, and how control over the market for Wi-Fi access will evolve is uncertain. For example, macro operators will have to be willing to use small cells, and the backhaul providers will want their piece of the pie.

Still, the advantages are many, and there is likely to be some impetus from the fact that the macro cells are being flooded with local, short-hop data. The amount of data on networks is increasing by orders of magnitude, and some solution for handling the volume of local data will have to be implemented. Wi-Fi is the frontrunner because it is universally deployed, and it is the de facto technology for small-cell communications.

Photo 1: A 3G microcell access point. Photo courtesy of Cisco Systems.

High-tech DAS components

DAS has brought about a fundamental change in how people think about wireless coverage. Not only will it fill in the coverage holes, but in doing so, it will change the mindset of macro network operators. For one thing, DAS enables system capacity agility and scalability. DAS allows the WSP to expand the network according to capacity loading. This means the WSP doesn't have to put up another macro site that will serve just a few users until enough users come on the system to load the new cell and make up the costs.

DAS consumes little power, which means spectrum efficiency is optimized, interference is reduced, RF levels are lower and throughput is better because access points are closer to users and there are more of them.

Latest-generation DAS technologies use fiber optics. A DAS can support multiple-operator network sharing with independent operation of multiple frequency bands and multiple protocols across a single access network. Advanced digital DAS solutions allow multiple WSPs to be autonomous on a single system. With digital systems, there is no RF performance degradation because transmission is over a fiber link. This means that there is no performance reduction that otherwise might stem from the link length, fiber quality or environmental conditions. The bit-error rate (BER) of the fiber cable has a negligible effect on the RF performance of the air interface.

Active DAS drilldown

Active DAS consists of a master unit (MU) and multiple expansion units (EUs) connected with optical fiber cable. The MU is responsible for the control of the DAS and monitors its performance. Generally, the distance between them is a maximum of 6 kilometers, but that is steadily being improved upon.

Connected with the EUs are multiple remote units (RUs). The connection is made with thin coax or CAT5 cable with a distance limit of about 400 meters. Beyond that, signal degradation becomes a problem. The EUs are distributed throughout the building, and the remote units are installed close to the antenna. Active DAS uses internally calibrating signals and amplifiers, which provides the capability for automatic compensation for component cable losses. This configuration eliminates the problem caused by the distance between the antenna and the base station. In an active DAS system, all antennas will have similar performance — the same noise figure and downlink power.

In a digital DAS, the link delay can be individually calibrated for each cellular system sharing the same interconnection link. Individual calibration provides independence of time-delay calibration settings for each WSP, which improves multiple-WSP operation because each WSP can adjust its own time delay calibration without degrading the operation of other WSPs sharing the same DAS system.

DAS has become the ace in the hole for stand-alone coverage systems and for enabling small-cell technologies. A wideband, active DAS can support multiple radio services, GSM, personal communications systems, UMTS, enhanced voice-data optimized or enhanced voice-data only (EVDO), WiMAX and Wi-Fi, making it the technology of choice to resolve many potential coverage problems.

Passive DAS drilldown

Advancements in passive DAS are not, unfortunately, as exciting and opportunistic as the advancements in active components are, but some passive DAS segments are advancing faster than others. Many new passive-DAS designs might be said to represent incremental advancements, rather than exponential advancements, when compared with active-DAS devices. Passive DAS components include coaxial cable, power splitters, combiners, directional couplers, filters and antennas, both integrated and stand-alone.

Board-type passive-components materials are evolving to enable smaller device footprints, improved device integration, higher power and greater reliability. Using modern process design helps to fine-tune existing designs to improve device responses to waveforms and boost frequency-band rejection and isolation characteristics.

Perhaps the most exciting development is in micro electromechanical system (MEMS) technology, not only in passive devices but in all types of RF communications. For example, RF MEMS switches simultaneously improve insertion loss, isolation and linearity compared with conventional devices. Components based on MEMS technology promise new levels of performance and will deliver superior RF performance and tunability over a much broader range of operating frequencies than present devices do, and that's a must for multiband, wideband DAS systems. MEMS will bring a new paradigm to the form, fit and function of DAS technology, but it is still years out for wide-scale implementation.

On the antenna side, cutting-edge technology-based multiple-input, multiple-output (MIMO) communications antennas enable increased bandwidth for DAS by using spatial antenna diversity. MIMO technology is incorporated into IEEE 802.11n specifications for wireless local area networks and the 802.16 specifications for broadband wireless access (BWA). Because it is likely that Wi-Fi technology will be integrated with DAS, especially for in-building wireless systems, MIMO antennas seem to be ideal solutions. On the cellular platform, fiber-optic-based MIMO antenna systems make LTE capacity more robust. DAS systems are likely to use MIMO over multiple spatial antennas for the same reason.

Conclusion

DAS and small-cell platforms are likely to see explosive growth as 4G becomes widely adopted. There are some pieces of the 4G and unlicensed technology puzzle that are still somewhat fluid. Most of them involve the integration of technologies, business models and regulatory schemes. Some segments, such as LTE, need to become more widespread before, or even if, Wi-Fi integration can happen. There is some sparring in the antenna sector between MIMO and diversity technology. To date, a deep well of hard research data has been lacking that would indicate what to use, and where, and when.

The movement to make the 4G communicator the beginning and end of all wireless communications has tremendous momentum. History has shown it is hard to slow the technology train. Consumer and business demand to have instant access, anywhere and at any time is a powerful reason for 4G deployment and everybody knows 4G will happen. The only question is how big a role DAS and small-cell technology will play. ■

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DAS and Small Cells for Indoor Networks

Mushrooming demand for a wide variety of wireless technologies indoors leads venue owners and wireless carriers to turn to distributed antenna system (DAS) and small-cell technology.

By Ernest Worthman

An estimated 70 to 80 percent of voice and data mobile traffic originates indoors. With current 3G and even 4G networks, the macro base stations must generally be within a few hundred meters of the structure to provide sufficient RF signal levels to penetrate it. Of course, this varies from building to building, depending upon its construction and makeup.

Few commercial buildings can boast basement-to-rooftop and wall-to-wall wireless coverage. Steel-framed office towers and concrete warehouses interfere with and block wireless signals. The way to have in-building coverage is to install an in-building wireless system; however, even under the most favorable conditions, in-building wireless systems may still have a dark spot or two where wireless coverage is nonexistent or intermittent. Short of sticking an antenna in every nook and cranny, it is unrealistic and uneconomical to overbuild a system to ensure every closet and bathroom has full signal strength.

System varieties

In-building systems come in a variety of configurations depending upon the building or campus requirements. Figure 1 shows a typical in-building DAS and its components.

Indoor networks can include malls,

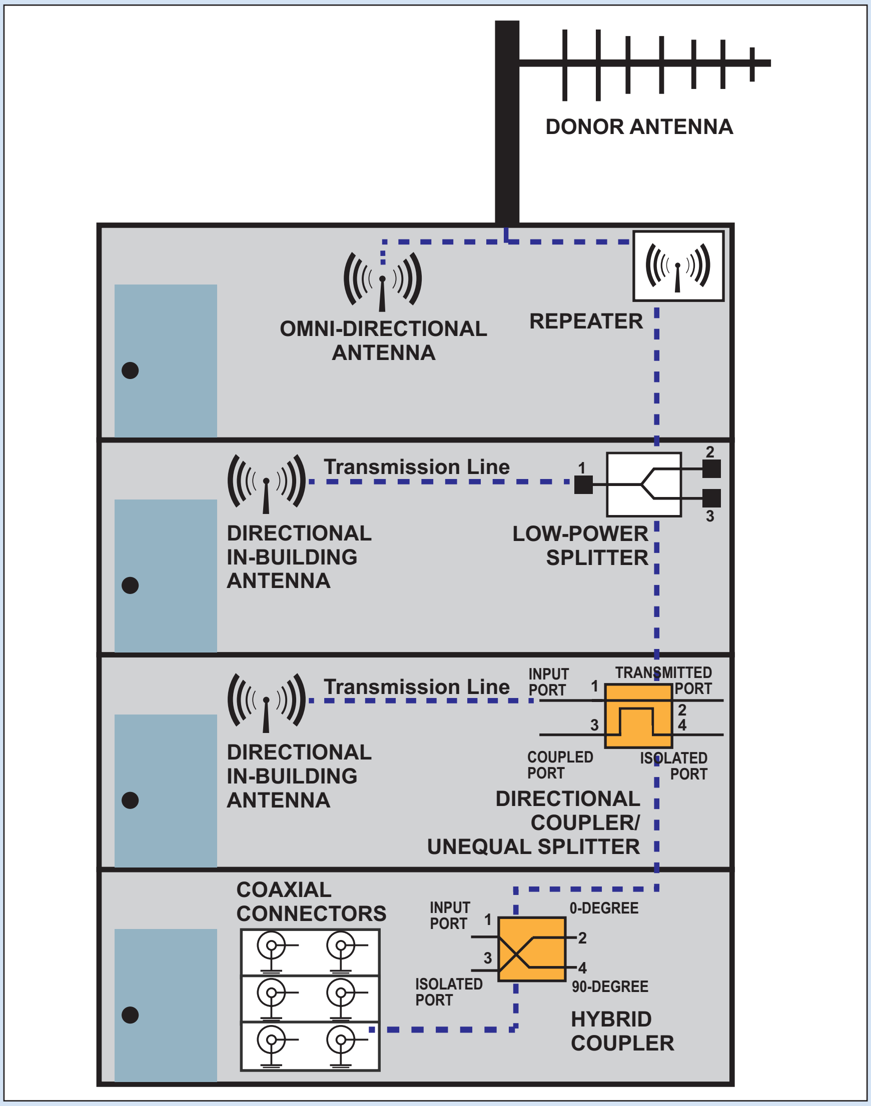
DONOR ANTENNA
OMNI-DIRECTIONAL ANTENNA
REPEATER
Transmission Line
1
2
3
DIRECTIONAL IN-BUILDING ANTENNA
LOW-POWER SPLITTER
Transmission Line
INPUT PORT
1
TRANSMITTED PORT
2
3
4
COUPLED PORT
ISOLATED PORT
DIRECTIONAL IN-BUILDING ANTENNA
DIRECTIONAL COUPLER/ UNEQUAL SPLITTER
COAXIAL CONNECTORS
INPUT PORT
1
0-DEGREE
2
3
4
ISOLATED PORT
90-DEGREE
HYBRID COUPLER

Figure 1. A typical in-building distributed antenna system (DAS) and its components.

airports, college campuses, sports and entertainment venues; however, the following information applies to single buildings with a contiguous structure.

Most in-building systems must be frequency- and technology-agile. The old method of dropping a cell repeater close to or into a problem location and running leaky coax everywhere works, but it is a single-carrier solution. Dropping in multiple repeaters, one for each carrier, is not practical.

With multiple carriers and access schemes, any indoor system must be host-neutral. An indoor system must integrate multiple wireless services and multiple standards. The design must also consider the economies of scale of sharing DAS resources among carriers.

Wi-Fi is an ideal platform for offloading local data, and it's a suitable small-cell technology for local short-hop communications. Despite Wi-Fi's proven track record, when it uses unlicensed spectrum, it can be difficult to regulate. If the in-building system needs to integrate technologies other than cellular, such as personal or public safety communications, the network considerations become more complex.

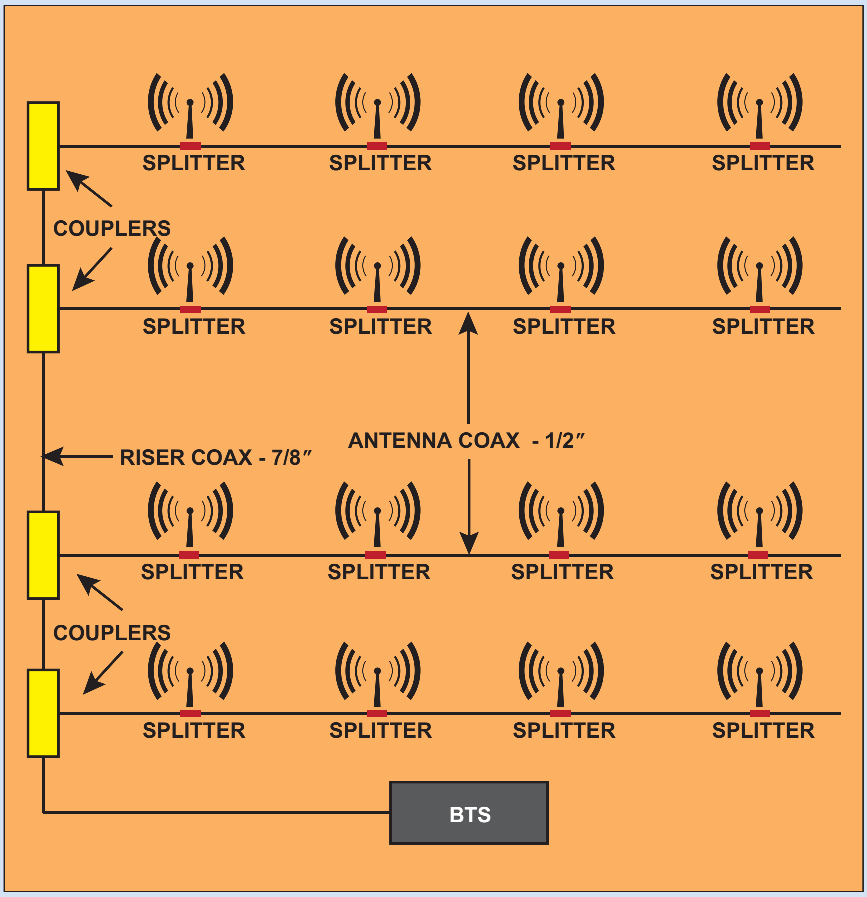

Figure 2. Passive DAS schematic.

Types of in-building DAS

In-building and small-cell technologies have come a long way. With advanced multiple-input, multiple-output (MIMO) antennas, wideband, multiple-frequency modular component designs, multifunctional integrated transmission components and compact footprints, no challenge needs to go unmet.

In-building wireless options include passive and active DAS deployments and the potential to integrate both into a hybrid system. Passive DAS generally utilizes rigid, large-diameter coax to distribute the signals vertically in building risers. At junction points, couplers divert RF energy along the building floors, generally using 0.5-inch coax. These systems are called passive because they are simple signal distribution systems that rely on non-active components. There is no amplification or signal conditioning (see Figure 2). Passive DAS is inherently broadband. The cable can carry multiple frequencies and coding schemes. Its lay-it-and-go installation is especially good for small areas with limited coverage requirements.

Passive DAS can become increasingly unsuitable as the deployments scale upward. Power loss, lengthy cable runs and signal splitting become important factors. The longer the runs and the farther they get from the base transceiver station (BTS), the bigger the hit in decibels. The practical limit to the size of passive systems, in cable runs and antenna counts, typically is a few hundred feet and a maximum of 16 antennas.

Additionally, with passive DAS, the power fluctuates between antenna points, a phenomenon directly related to the line losses. The farther down the cable an antenna is, the lower the output power in the downlink. This translates into a proportionally higher noise figure in the uplink with the more distant antennas than with the closer-in antennas. Thus, the coverage map for the specific antennas in the system will vary in proportion with the distance from the RF source. At the fringes of such systems, the higher noise figures will demand higher output power from mobile devices on the system, which tends to create interference on the macro cell network.

Active DAS technology piggybacks on the local area network (LAN) deployment architecture, typically in a double-star network topology. This approach works well for in-building systems because the Tx/Rx nodes can be scattered throughout the building in a nonlinear fashion. That means that nodes can be put where they are easily accessible, installation-friendly and most economical. With passive systems, there may be only one ideal spot for the antenna and a few feet one way or the other can mean coverage or not. With active DAS, there are no restrictions on the maximum number of nodes or cable runs, and it is easy to add or remove nodes. In many cases, an active system can be piggybacked onto existing single- or multi-mode fiber-optic cable (see Figure 3).

Active DAS also overcomes problems associated with signal strength and with cable and splitter losses. That means that

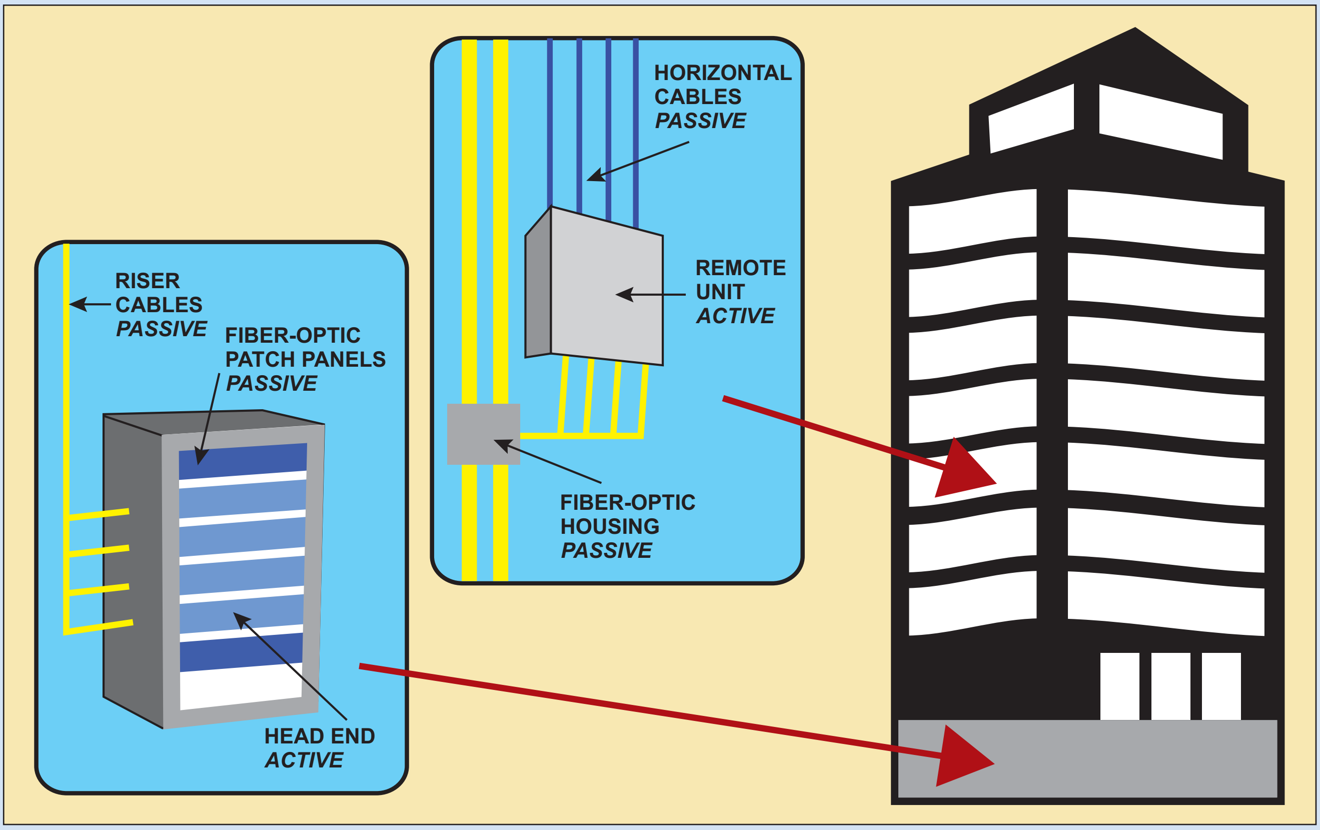

Figure 3. An active in-building wireless system.

all antennas have the same signal power, and coverage is much more uniform. The most dramatic advantage of an active DAS system is its performance. By placing small, remote active units (RAUs) with amplifiers at the outer edges of the network, active DAS provides high, uniform power at each antenna point. For data, that keeps the bandwidth wide and makes it much easier to enable high-speed data coverage at higher frequencies.

A third contender for in-building schemes is something called hybrid DAS. It offers the economy of scale of passive systems and uses some of the elements of active DAS, mainly the fiber interconnect and active remote heads. Hybrid systems are an ideal solution for those "in betweeners" where a passive system can't provide adequate coverage and an active system is overkill. They are best for simpler installations where there is a fair amount of latitude for placing antenna nodes, and the building itself is not heavily RF-shielded.

Hybrid systems improve on the signal loss along the vertical sections of the deployment by using fiber instead of coax. Using fiber eliminates cable losses in these sections. Horizontal deployment uses coax to connect remotes and antennas, so losses are a consideration for these segments. The designer has to keep in mind that signal attenuation within the cable may limit coax cable lengths. Unless all coax is of the same length, cable power losses will be incurred and the antenna effective radiated power (ERP) will be affected proportionately. However, when considering the cost of the system, if some dark spots can be tolerated, the costs of hybrid systems are certainly an attractive alternative.

In-building complexities

From single-carrier, single-building, passive systems to multiple-carrier systems in multiple-building complexes, in-building systems have diverse requirements. The more complex systems may have to handle integration of multiple commercial carrier wireless services coupled with small cells running under Wi-Fi, personal communications systems, WiMAX or other small net technologies. Most will include a blend of dissimilar small cells (metro, micro, pico, femto), each with its own coverage and interconnect nuances. Some systems might have to integrate public safety, homeland security or utility communications.

Several models of systems address the challenges of the more complex in-building DAS and small cell systems. The first, a host-neutral system, uses advanced technology to handle any radio-frequency bands and technologies. Among its performance metrics are frequency, protocols, coverage sectorization, RF power and interference engineered to provide best-of-class performance and to be compatible with all carriers and local nets within the system. On top of that, they must be sharable among principals. Using this type of DAS deployment requires the participating parties to understand and take responsibility for specific carrier and tenant services. Everyone should be in agreement before any hardware goes in and contracts are signed. It's also important to have metrics that each responsible party can access to determine system performance and costs.

As daunting as these complex systems may seem, most of today's working

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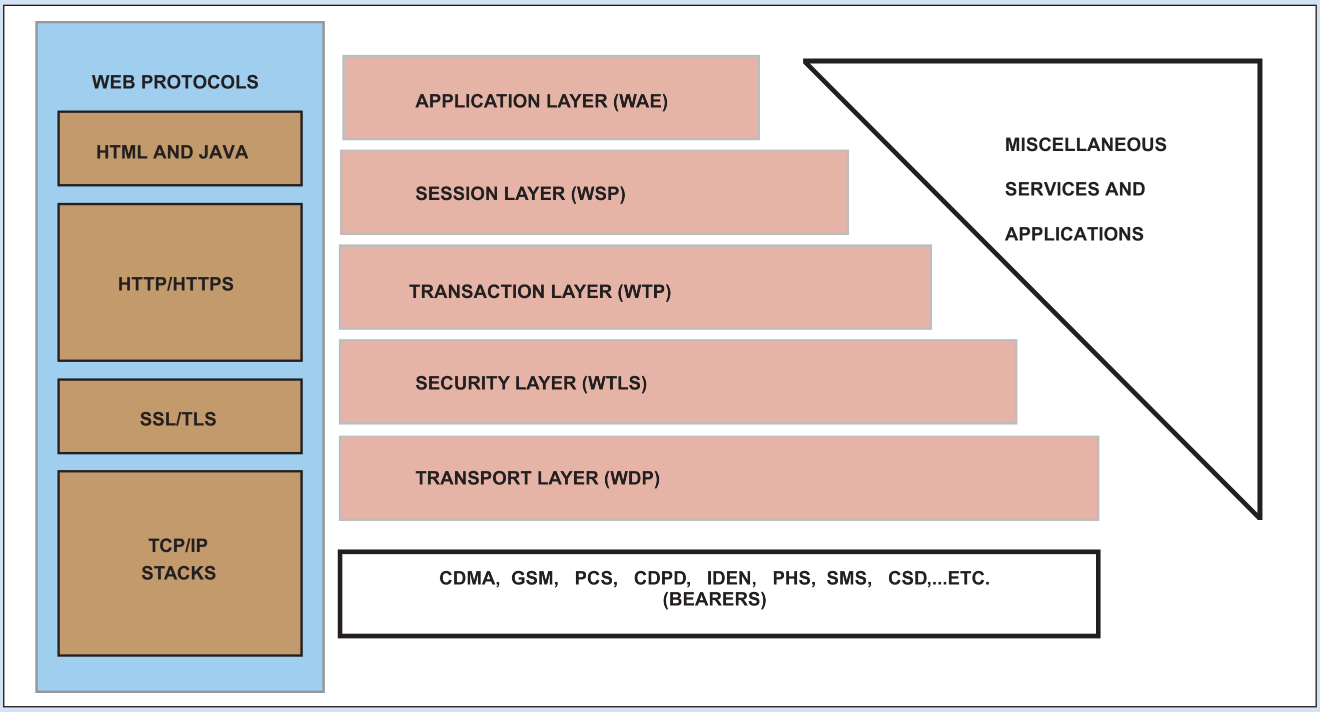

Figure 4. Typical protocol and layer diagram.

DAS and small-cell systems are on the lower and middle end of technological integration, and the top-shelf scenarios are few and far between. Not that many uber-complex systems are out there yet.

Shared system panorama

Several approaches can be implemented in a shared system, each with advantages and disadvantages. Typically, the more independent the systems become, the more the cost rises. Systems can have nearly any level of complexity desired. For example, the most flexible type of deployment puts all of the hardware and software technology in independent layers (see Figure 4). This approach has maximum flexibility and configurability, and each principal has full and unique control of its resources. The downside is that it is the most expensive configuration and total technological anonymity per layer means that redundant equipment may be required and the probability of inter-system interference is high.

On the other side of the equation is the integration of multiple technologies on a single layer. This is the most cost-effective approach and the most limited. It offers the smallest equipment profile but requires the most cross integration of service providers. This means that there is limited flexibility with hardware and software, and what affects one provider is likely to affect all or some of the others. Because much of the equipment is shared, the probability of system degradation is much higher because of strains on the equipment and bandwidth, and because all users are on common hardware.

There are some other options between the crème de la crème and the bargain-basement options. They take elements from both camps and comingle them for the installation — things such as antenna-only sharing or some layer-sharing versions, for example.

The real choice is the one that will fill the need while optimizing the value proposition. Single in-building systems have more manageable challenges. Larger deployments such as airports or business campuses add layers of complexity because of the interaction with macro cells, interconnect among small cells, redundancy and environmental conditions. However, reaching the next level of technology in shared systems will require a step up to intelligent, self-aware and autonomous networks.

Intelligent cells

Today's cutting-edge technological hardware and software environments create the potential for integrating mind-boggling artificial intelligence in a variety of technologies and networks. Fortunately, that is exactly the ticket that will make future complex networks run autonomously, at peak effectiveness and efficiency.

Several methodologies can be implemented in making small-cell and DAS networks intelligent. The major players are the same chip and software giants that are seen in the IT networking segments. This is because the topologies of small cells and computer networks are remarkably similar.

In small-cell development, deciding where to put the intelligence is a significant challenge. The most notable direction that artificial intelligence is taking in wireless communications is the move to build self-organizing networks (SONs, also referred to as self-realizing or self-aware). SONs will be the great enabler for 4G and LTE.

SON principles are being driven by the 3rd Generation Partnership Project (3GPP) and the Next Generation Mobile Networks (NGMN) initiative. But don't look for it in most wireless networks until 4G and LTE become the standard for macro networks. Then, renditions of SONs will make their way into small-cell integrated systems, and eventually, there will be totally assimilated, macro-to-femto, fully autonomous networks.

While the concept and functionality are similar in all networks, small cells are more of a challenge because they integrate more platforms. That means small cell architectures require more intelligence. Watch for individual platforms for the macro and small-cell segments. As the use of artificial intelligence becomes more pervasive, a common platform or glue technology will also be developed for full-scale integration.

SON technology

Self-aware technology places a distributed-architecture layer over a network of dumb, unaware cells. It's like taking command of a disorganized group of military units and bringing them under a central command. The intelligent architecture continuously monitors an incredible number of network characteristics, such as power, cell load, signal strength and path attenuation, and optimizes them. It analyzes the edges of the coverage and talks with other cells to coordinate optimal, seamless handoffs. It is a self-healing network, so it dynamically and autonomously redistributes the load within the network when there are problems with any of the cells.

The technology is also smart in the sense that it will be able to uniquely identify each user on the system and pass that data on to other systems when the user migrates. Each mobile device will report its behavior back to the host. The host will know where the mobile device is at any time, what it is doing — what websites it is visiting, for example — and its usage patterns. The technology's operation will resemble the way your computer logs your activity and supplies the vendors on websites visited with tracking data. There is a fair amount of controversy about privacy issues with artificially intelligent objects.

The pervasive capabilities of SON technology are yet to be fully realized. Although the intention in the immediate future is to put this technology into the higher levels of the networks, eventually it will extend much further into our lives. It's just a matter of time as to when and how much of the artificial intelligence will be enabled.

Conclusion

If you listen to the purveyors of wireless communication devices and systems, you get the impression that the wireless device is the end-all and be-all of our existence. The ultimate control of and for everything lies in that device — and to that tune, technology is marching. If it happens for the devices, global, integrated, smart wireless networks have to happen, too. That means that the smallest femtocell and the largest macrocell will have to be connected to every other cell on the planet. For that to be successful, virtually every habitable spot on earth will have to have wireless coverage, and that bodes well for indoor DAS and small-cell networks. ■

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Play Nice — The Integration of Small-cell Networks, Cellular and Wi-Fi

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Mushrooming demand for a wide variety of wireless technologies indoors leads venue owners and wireless carriers to turn to distributed antenna system (DAS) and small-cell technology.

By Ernest Worthman

Ultimately, the heterogeneous wireless network will be the highway upon which all future mobile communications will ride, and small cells will be the enabling infrastructure within these networks. Technological and ideological problems remain to be resolved before a single, homogeneous and platform-independent wireless net can exist.

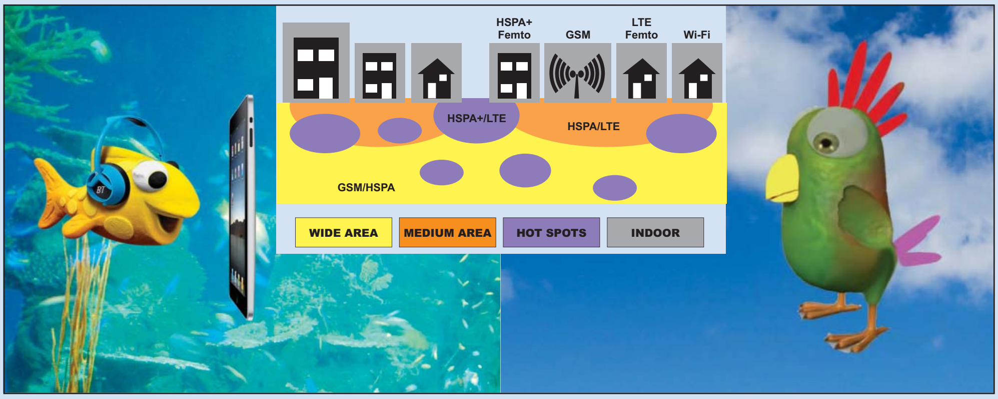
The move to integrate Wi-Fi with cellular networks is fast gaining traction. Data has already surpassed voice, and the public's insatiable appetite for data is expected to increase exponentially. Cisco System's Global Mobile Data Forecast predicts that by 2017, a whopping 11-plus exabytes of mobile data will be flying around the cellular airwaves. Such an enormous data number will tax cellular networks to their limits, even with next-generation 4G and LTE. Seeing this "datageddon" heading right for them, carriers are seriously looking for a way to offload the data to local, noncellular networks.

On the unlicensed side, Wi-Fi has become the de facto standard for small-cell private data networks. Small-cell Wi-Fi networks are simple to deploy and manage, they represent an efficient way to handle Internet traffic, and they are multiplying rapidly. Carriers are looking at Wi-Fi as an attractive partner to handle the massive amounts of data on their networks, and they are looking at how to integrate Wi-Fi with licensed systems.

Wi-Fi is the only practical game in town. Small cells based upon Wi-Fi already outnumber macro cells. Virtually all smart, wireless communicators such as cell phones, tablets, game consoles and laptops come with integrated Wi-Fi. It's available nearly everywhere — and, it's free. With the exception of voice calls and mobile texts that include embedded pictures, audio and video, most users prefer to use Wi-Fi to access the Internet, rather than use packet data services offered by cellular carriers. By 2015, according to Coda Research Consultancy, downloading movies, TV programs and YouTube video is expected to reach 224 petabytes per month. There is no way the cellular networks can handle the video and other data without interminable delays, if they can handle it at all.

But, all that glitters is not necessarily gold. As enticing as Wi-Fi is, it is not without problems. First of all, it's unlicensed, which makes it difficult to regulate. Although the Institute of Electrical and Electronics Engineers has done an outstanding job of setting up the 802.xx specifications, in the end, Wi-Fi's being unlicensed dredges up a number of potential problems like network ownership and network maintenance. Additionally, Wi-Fi, although it is pervasive, does not have nearly the coverage map that macrocells have. Emerging technologies, such as making laptops and tablets act as Wi-Fi hotspots, hold some promise to close that coverage gap.

Even though Wi-Fi network coverage is not as extensive as cellular coverage, it has compelling advantages that make it attractive as a small-cell, licensed, carrier-partner technology. Wi-Fi has faster connection speeds than cellular digital packet data (CDPD) or other protocols. It does not cost anything, and it is a well-received technology that consumers are comfortable using. And, most importantly, it is capable of handling voluminous amounts of data. A majority of analysts and industry pundits seem to agree that Wi-Fi is the most likely candidate to fuse into the cellular infrastructure. For example, the Wireless Broadband Alliance (WBA) and the Small Cell Forum (SCF) announced that they will work together to integrate Wi-Fi hotspots with licensed cells.



A trip down memory lane

Data was never a consideration when the original cellular technology came online. If not for the orders of magnitude by which technology has advanced since the early days of cellular, mobile data would have been more likely to evolve as separate technologies. Cellular data systems will always be restricted by bandwidth, which was partitioned when voice was king. Carrying data over cellular systems will remain problematic, at least until heterogeneous networks are available.

Making technologies play nice

The number of data layers that can be overlaid onto cellular networks is finite. New technologies keep adding bandwidth, but eventually, the wall will be hit. One answer is called "carrier Wi-Fi," seamless integration of cellular and Wi-Fi networks. It promises to make the user experience for voice and data transparent by automatically transitioning from cellular to Wi-Fi and back. If the user has a better signal on the Wi-Fi network, then that is what will be used. If the coverage is better from 3/4G or LTE than Wi-Fi, that will be automatically selected. Carrier Wi-Fi also monitors the networks, and if the data rate on the assigned network becomes sluggish, an automatic, seamless handoff can occur.

Carrier Wi-Fi integrates small-cell, next-generation hotspots designed to simplify Wi-Fi access by removing the need for user names and passwords. It is based on open standards. The user won't have to fumble around with logging onto a service or randomly guessing which one will work better.

Another platform is called "carrier-grade Wi-Fi," which provides licensed carriers with the tools to manage Wi-Fi networks in the same way that they can manage their own 3/4G or LTE networks. The Wi-Fi Alliance supports delivering carrier-grade Wi-Fi solutions using the Hotspot 2.0 profile and the associated PassPoint certification program.

Perhaps the most promising idea is that of heterogeneous networks. Such networks are designed to move traffic across platforms, intelligently, based on loads. This approach treats unlicensed and licensed spectrum as a single pool of network capacity, to be used as required by different users and traffic types. The use of heterogeneous networks is seen as the best scenario, short of completely redesigning and integrating the voice and data networks. This platform designs native intelligence into the network instead of layering it on top, as is done with existing systems. This approach makes network functions such as handoffs much faster and more reliable because no additional middleware is required to handle both sides of the network interface.

It is too early to predict which, if any of the current scenarios will become the standard. In fact, with the highly advanced state of today's technology, it is not inconceivable that more than just a single methodology might be used until a single, homogeneous network emerges.

Small-cell and Wi-Fi networking

Unless a single, homogeneous network emerges, the various iterations will vary in complexity. Most will start with what is called the loose networking model, which consists of common authentication, access control and billing interfaces. It enables the cellular operator to offer small-cell Wi-Fi access services to subscribers. Authentication is performed using the subscriber identity model (SIM) standard in today's cellular platform. It will extend the SIM model of level verification and billing based on the subscription or service level to the Wi-Fi network. However, the Wi-Fi network is still data-only, and all other services are still routed through the carrier.

As more and more players come to the table, this loose networking model has the option of becoming more complex. For example, adding a second layer to this model upgrades the network to allow service community. This means that all of the subscriber's cellular services, including text, voicemail, video and audio data, also will be available on the Wi-Fi network. Unfortunately, this layer will not support seamless handoffs between Wi-Fi networks. If the user travels outside of the current Wi-Fi network, the session would end and a new session would be established in the new Wi-Fi network. This would cause a notable lag in service during the handoff and would have a negative effect on the subscriber's experience. To alleviate that problem, a third layer can be added to the network that provides session continuity. This layer resolves the handoff issue and makes handoff as transparent as it is with cellular networks.

To tackle the problem of transparency between Wi-Fi hotspots, the interconnect is being addressed in the Hotspot 2.0 program. From a technical perspective, the 2.0 profile relies on the universal subscriber identity module (USIM) authentication protocol. Similar to SIM protocols, Hotspot 2.0 implements access network query protocol (ANQP) and seamless authentication via Extended Authentication Protocol-Subscriber Identification Module (EAP-SIM/AKA) technical specifications (see Figure 1). The Hotspot 2.0 specification deals with hotspot handoffs only. It still has to be worked into the various integration schemes to make the entire network seamless.

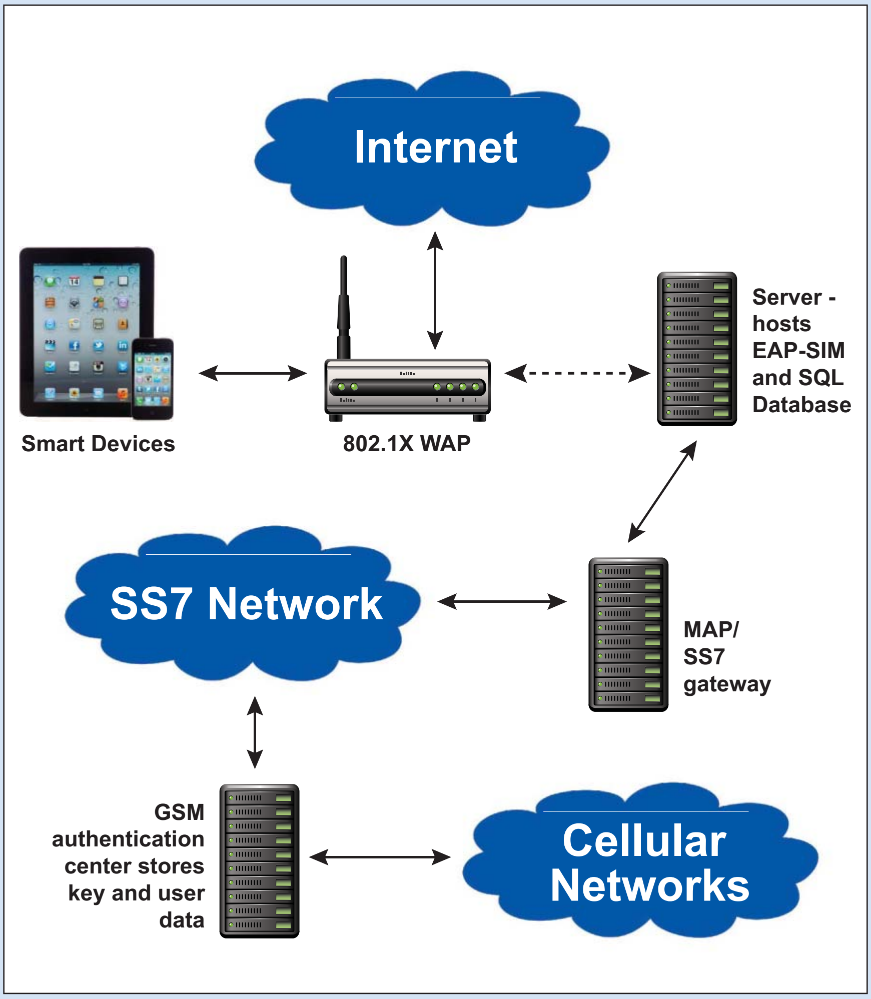

Internet
Smart Devices
802.1X WAP
Server - hosts EAP-SIM and SQL Database
SS7 Network
MAP/ SS7 gateway
GSM authentication center stores key and user data
Cellular Networks

Figure 1. Components of an EAP-SIM WLAN authentication system.

Many consider small cells to offer the only long-term solution for cellular networks to handle the data flood. Small-cell Wi-Fi networks are being seen as the best solution for providing continuous, unlimited bandwidth for all users. Work on this platform is being performed by the 3rd Generation Partnership Project (3GPP) small-cell forum. As more 4G and LTE systems come online, they will be integrating Wi-Fi subsystem layers and bringing heterogeneous networks one step closer to reality.

Conclusion

Cellular Wi-Fi is a moving target. Carriers are studying a number of approaches, most of which are in the development or beta stages. Some have been deployed as special trials or as installations intended for specific purposes. Presently, there are no real models that can be universally implemented.

Building a universal, seamless, transparent, data and voice network is a formidable challenge. Data has been added to voice networks, but because Wi-Fi is a native, data-centric network, bringing voice to it becomes an afterthought along the same lines as bringing data to cellular was. Voice over Internet protocol will be a factor in solving the problem.

Heterogeneous networks are on the drawing board, and a single, homogeneous network is an even more distant vision for the future. The road to them is likely to have any number of unseen corners and speed bumps. The potential revenue at stake is staggering, and the possibilities for the end user are seemingly unlimited. ■

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New Jersey Wireless Association members pose with a $10,000 check for the Wounded Warrior Project.
From the left: Jim Kudless, Rob Ivanoff, Matt Bartlett, Peter Broy, Dominic Villecco, Tony Suppa, Gail Goldman, Michael Lee Foster

The mission of the Wounded Warrior Project is to honor and empower wounded warriors. The purpose is to raise awareness and to enlist the public's aid for the needs of injured service members, to help injured servicemen and women aid and assist each other, and to provide unique, direct programs and services to meet their needs. Thousands of wounded warriors and caregivers receive support each year through Wounded Warrior Project programs designed to nurture the mind and body, and encourage economic empowerment.

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DAS versus Picocells

The way to overcome the limitations of using picocells alone while providing strong and consistent mobile service in the enterprise is to combine these devices with a DAS. Picocells provide the capacity, and the DAS distributes it throughout the building.

By John Spindler

Picocells have caught the attention of mobile operators as a solution to coverage and capacity challenges. But as with many technologies that receive a lot of attention, there appears to be a gap between the hype and what picocells can actually deliver. The following information explains the differences between picocells and distributed antenna system (DAS) networks and how picocells and DAS can work together to address the problems of those trying to implement effective and reliable wireless communications networks.

Picocell challenges

The picocell was originally designed to deliver coverage and capacity over a relatively small area, similar to a Wi-Fi access point (AP). In a wireless local-area network (LAN), if architects want to cover a larger area, they can deploy multiple APs to facilitate this. With picocells, the idea is that carriers or enterprises can deploy multiple picocells in the same way to cover large buildings or outdoor areas. But it is not as simple as that. The mobile network is not a private, unlicensed wireless LAN, and using multiple picocells to provide coverage over a wide area can present challenges.

An obvious challenge with picocells is that today they are single-frequency, single-service devices. To deploy more than one frequency or more than one mobile operator's services, it will be necessary to deploy multiple picocells in each location where they are distributed. Because each picocell will require its own backhaul and power, this can be a complicated and expensive arrangement.

Another main issue that affects those trying to scale coverage with multiple picocells is figuring out how to reduce interference with cell towers and other picocells. When such interference occurs, network performance is inevitably reduced (see Figure 1).

Avoiding interference with the outside macro network is the more challenging problem to address. To ensure sufficient coverage along the inside building perimeter, picocells are placed close to the outer walls. However, because of these cells' proximity to the building exterior, a certain amount of interference between the cells and the macro network is almost unavoidable. To minimize picocell interference,

DAS-picocell Combination Advantages

- DAS is multifrequency.
- There is no interference.
- There is one dominant signal.
- There is no need to over-provision.
- Deployment is less expensive.
- Operating expenses are lower.

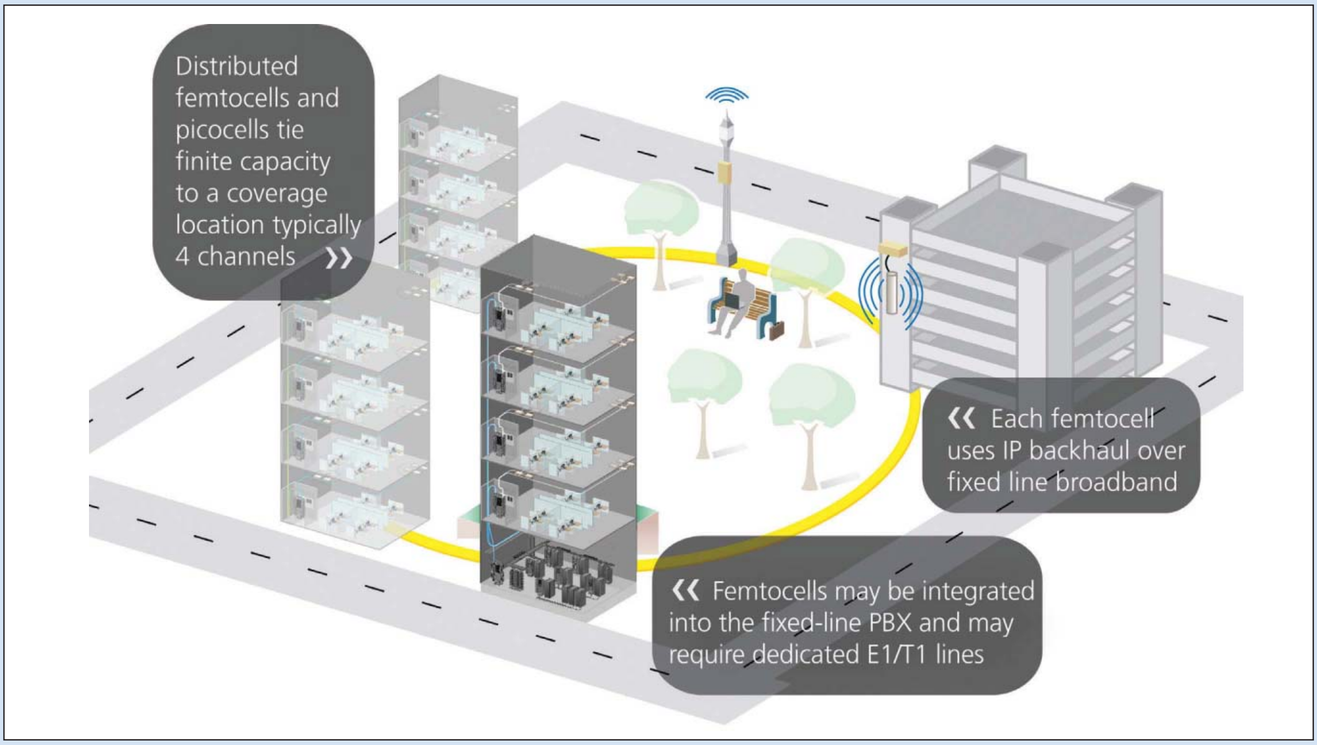
Distributed femtocells and picocells tie finite capacity to a coverage location typically 4 channels
Each femtocell uses IP backhaul over fixed line broadband
Femtocells may be integrated into the fixed-line PBX and may require dedicated E1/T1 lines

Figure 1. Making multiple picocells work well together takes a lot of RF engineering, and it isn't easy. Even in an open industrial space, the delicate interaction of multiple picocells can be thrown off when a piece of equipment is moved.

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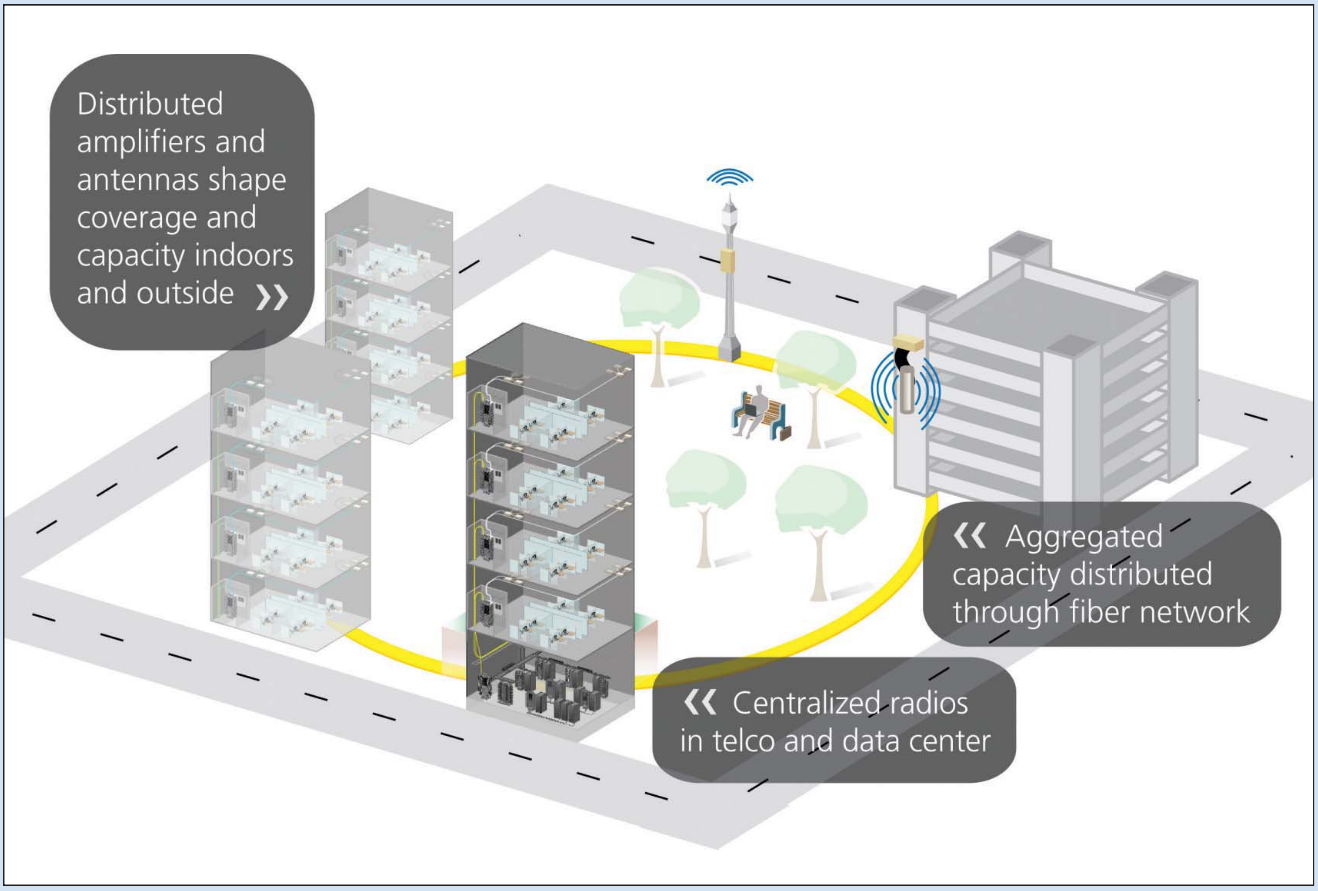
Distributed amplifiers and antennas shape coverage and capacity indoors and outside ❯❯
❮❮ Aggregated capacity distributed through fiber network
❮❮ Centralized radios in telco and data center

Figure 2. The way to overcome the limitations of using picocells alone while providing strong and consistent mobile service in the enterprise is to combine these devices with a DAS. Picocells provide the capacity, and the DAS distributes it throughout the building. A DAS that can accept baseband signals from picocells can provide a solution in such a scenario.

some mobile operators are considering deploying picocells on a different (perhaps dedicated) RF frequency from macro cellular networks, but this chews up precious spectrum at a time when spectrum is scarce and acquisition of additional spectrum assets is costly.

When more than one picocell is used, interference among them will cause performance problems that degrade the quality of service. Making those multiple picocells work well together will take a lot of RF engineering, and it won't be easy. Even in an open industrial space, the delicate interaction of multiple picocells can be thrown off when a piece of equipment is moved and thereby changes the RF characteristics of the area.

In a multiple-picocell environment, additional issues can include handoffs. In such an environment, the user's handset has to hand off the connection from one cell to the next as the user moves through the building. This drains handset battery life (and thus reduces the usefulness of the device), and it occurs with far greater frequency than in the macro network because of the picocells' small cell size (coverage areas of typically 5,000 square feet or less). In buildings covered by a DAS, in contrast, there are no handoffs because the entire area is essentially one large cell.

When more than one picocell is used, interference among them will cause performance problems that degrade the quality of service.

Another challenge is signal dominance. To function properly, an in-building system must establish signal dominance in order to minimize the potential for handoff between the indoor and outdoor signal sources. This is particularly critical in high-rise buildings. Such hunting can adversely affect the surrounding macro performance, as well as reduce device battery life and create a poor user experience. But it is difficult to establish a dominant signal source with picocells because of their extremely low output power. With a DAS, however, it is easy to deliver enough power through the antennas to create a dominant signal source and minimize hunting.

Peak traffic engineering is yet another challenge. This refers to the need for high-user-density locations (conference rooms, staff restaurants and other communal areas) to be over-provisioned with picocells in order to provide enough capacity for peak usage times. During low usage, this investment in extra picocells (and capacity) is effectively wasted. Over-provisioning issues are also more effectively managed with a DAS because all of the system's capacity is available to every antenna within the coverage area. As such, there is no need to account for movement of people and devices throughout the day. And with a DAS, if capacity needs increase in the future, additional radios can be easily added at the DAS head end to increase capacity throughout the coverage area rather than deploying multiple picocells in distributed locations.

Those are some of the problems with distributed picocell architecture, but lest we dismiss picocells entirely, let's consider a better way to use them. The solution involves centrally locating picocells at the DAS head end and distributing their signals efficiently through the DAS.

Marrying DAS with picocells

The way to overcome the limitations of using picocells alone while providing strong and consistent mobile service in the enterprise is to combine these devices with a DAS. Picocells provide the capacity, and the DAS distributes it throughout the building. A DAS that can accept baseband signals from picocells can provide a solution in such a scenario (see Figure 2).

Here's how this combination solves the problems of using picocells alone.

DAS is multifrequency. A DAS can distribute multiple cellular frequencies to serve more than one mobile operator, so just one set of remote antennas is required, rather than multiple picocells in each location.

There is no interference. Because the DAS simulcasts radio channels throughout the building, there is just one large cell. This eliminates multicell interference along with the need to hand off from one cell to the next as the user moves about.

There is one dominant signal. One signal source means one dominant signal. The DAS simply provides a uniformly strong signal throughout the interior of a building so user devices don't hunt between signal sources.

There is no need to over-provision. All antennas in the DAS have access to all of the feeder cell's capacity, so there's no need to add new picocells for higher capacity requirements in certain areas. If additional capacity is needed throughout the building, additional picocells or radios can be added in a central location at the DAS head end.

Picocells provide the capacity and the DAS distributes it throughout the building.

Deployment is less expensive. It is much less expensive to deploy a DAS for coverage and capacity in a large building than to deploy dozens or hundreds of picocells.

Operating expenses are lower. A DAS is pretty much a set-it-and-forget-it solution, so once deployed it needs little maintenance. With multiple small cells, the cells will require continuous adjustment to function in an optimal manner. In addition, using a picocell as the RF source for a DAS eliminates having to use a much more expensive, full-sized base station. Full-sized base stations require a lot of space, power, and cooling to operate, and using them with a DAS is overkill because much of their output power must be attenuated for use with a DAS.

Backhaul costs are lower. A group of picocells centrally located feeding a DAS head end can be combined to use a single backhaul connection. This contrasts favorably with needing a separate backhaul connection for each of several dozen or several hundred distributed picocells.

There is a lot of talk about picocells making up small-cell networks, but DAS was the original small cell, and it still has many advantages over distributed networks of picocells. Single-frequency operation, limited capacity, lower power, poor frequency management, and the traffic engineering required make distributed picocells a questionable solution for coverage over a large area. A far better idea is to combine the benefits of these devices and DAS to get lower costs, easier deployment, better quality of service and multicarrier coverage. ■

John Spindler was named vice president of product management for TE Connectivity's wireless business in December 2007 through the company's acquisition of LGC Wireless where he served as vice president of marketing. Spindler is responsible for developing and managing an innovative wireless product portfolio for the company's Network Solutions Business Unit.

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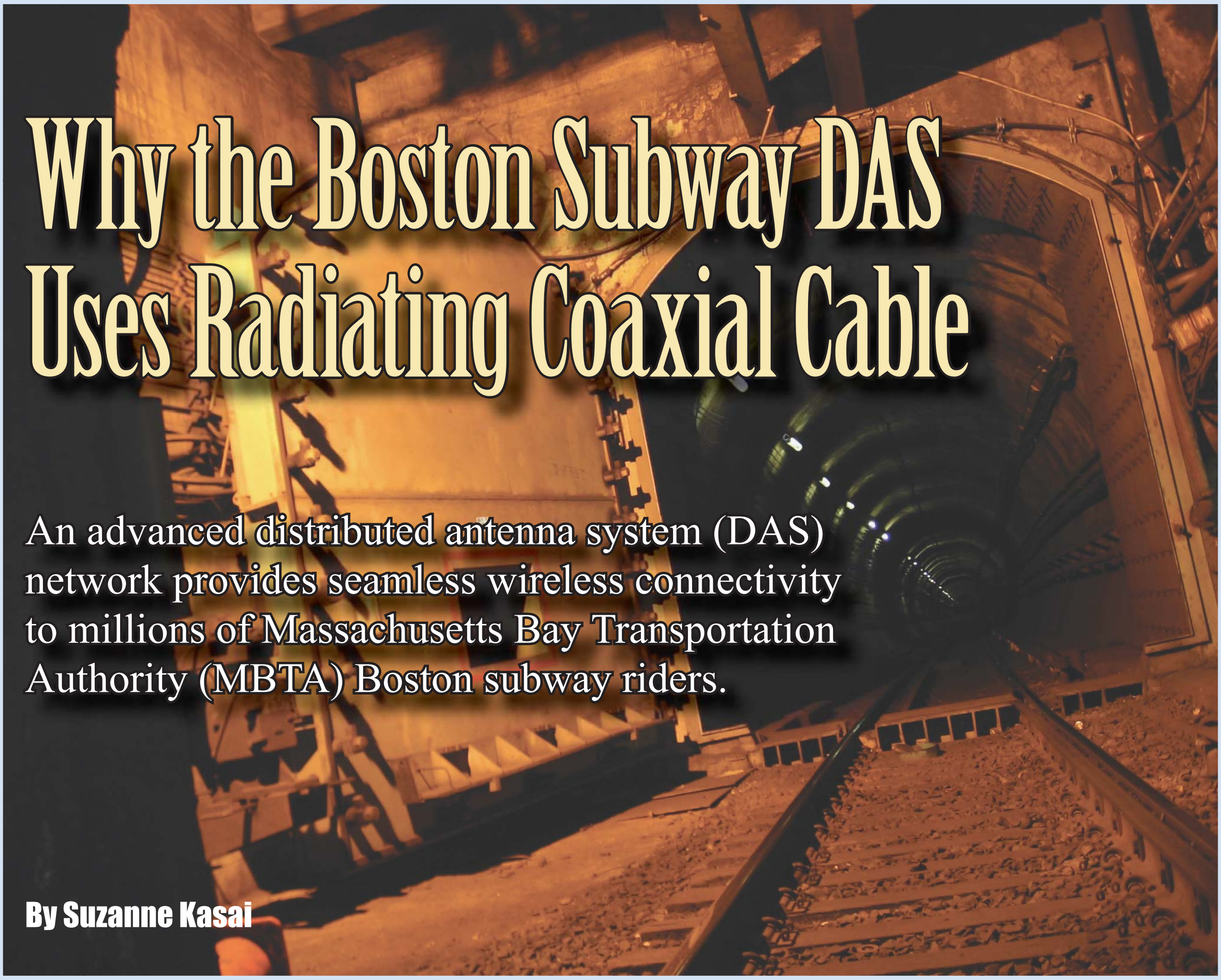

Why the Boston Subway DAS Uses Radiating Coaxial Cable

An advanced distributed antenna system (DAS) network provides seamless wireless connectivity to millions of Massachusetts Bay Transportation Authority (MBTA) Boston subway riders.

By Suzanne Kasai

Rapid growth of wireless communications has resulted in today's transit passengers demanding a seamless wireless experience for the duration of their commutes. For Boston's subway riders, a high-quality user experience includes being able to use wireless devices within the city's highly complex system of underground and underwater tunnels. However, the in-tunnel environment is one of the world's most challenging from an RF perspective. The twists, turns and constrained cross-sections of any tunnel, coupled with the large, fast-moving vehicles it carries, present an onerous RF distribution challenge. Furthermore, the modern wireless communications systems that serve transit passengers must also simultaneously accommodate a variety of commercial technologies from 2G to 3G, 4G and beyond.

As a result of this growing trend, the Massachusetts Bay Transportation Authority (MBTA), the public transportation system of Greater Boston, initiated a project to provide continuous, end-to-end wireless coverage in the underground stations and tunnels of its transit system. After a public bidding process, the MBTA awarded a contract to provide and operate a neutral-host wireless distributed antenna system (DAS) in the subway system. The contract went to InSite Wireless, a company focused on designing, constructing, operating and maintaining shared wireless infrastructure for complex indoor and outdoor environments. InSite specializes in neutral-host DAS utilized by multiple carriers, specifically targeted at customers that seek seamless wireless coverage in the most challenging physical environments such as convention centers, casinos, airports and transit systems, where either the quality of wireless signals is impaired by building structures or the signal capacity is insufficient to meet fluctuating occupancies.

The challenge

During the initial phases of the MBTA project, which included eight platforms in four stations all relatively close to each other (one-quarter mile apart or less, with relatively straight paths), InSite was able to use antennas to provide wireless connectivity. But as the job progressed, the project began to include more complex environments such as narrow tunnels, long curves, up and down hill areas, sections of track under bodies of water and more.

Additionally, there were instances

where space to mount the equipment was not available or there was limited signal propagation. InSite had also reached a point where it had to work around the massive floodgates on one of the system's Red Line routes. These gates are large doors that allow the tunnels to be sealed to prevent water passage during the construction of highway tunnels.

With all of these factors in play, antennas were no longer a viable option.

The solution

InSite engineers had to design a system to accommodate the varied geometry of the tunnels and the different types of trains used on each line, as well as a way to get past the floodgates without interfering with their operation. To solve problem installation areas, the designers specified Radiaflex radiating cable from RFS. Radiating cables facilitate radio communication where the usual free space propagation of electromagnetic waves is hampered, undesired or impossible — in environments such as tunnels, mines, buildings, and large complexes such as exhibition grounds or airports.

Radiating cable is similar to regular antenna cable, with slots cut into the outer conductor that allow the cable to work like a sprinkler hose and "spray out" low levels of signal along its entire length. For example, a single radiating cable extending 1,100 feet to 1,500 feet will spread an RF signal out to serve a long curve.

To work around the floodgates, the InSite team used existing cable sleeves that already had been placed for electric wiring and other existing cabling to thread the radiating coaxial cable through the gates and into the rest of the tunnel, ensuring seamless wireless service.

Time constraints were also a key issue for the cable installation process. Because of MBTA's schedule, installers are only able to work when trains are not running. After the process of shutting down power, work trains and other vehicles coming through, the installers get an average of only 2 to 2.5 hours per night to work.

In this kind of installation process, high-rail vehicles, which are trucks fitted with special train wheels to allow them to drive on the tracks, are used to put hangers on the walls of tunnels. The tunnel walls tend to be crowded, so installers have to be extremely careful about where to place the hangers. The RFS radiating coaxial cables include numerous features to simplify installation. To help installers find the correct position, for example, the cable jacket is equipped with two guides that fit exactly into the rear open part of RFS standard clic-clamps or in the open slots of heavy-duty clamps. This simplification can be critical under tight time constraints.

Furthermore, the highest risk for malfunction, besides cable handling, is poor installation of connectors. RFS one-piece connectors for radiating cable are virtually foolproof, further simplifying the installation process. The company also offers a range of standard and special drums in order to meet specific project needs.

"Given the nature of the DAS business, you don't want to have to worry about the technology in place, so it is critical to have good components and good vendors," said Joe Mullin, vice president of engineering and operations at InSite Wireless. "We have found Radiaflex radiating coaxial cable to be a technically superior cable, and the quality of product and ease of installation have been critical factors in our success."

Future DAS

Rapid growth in wireless usage has brought with it numerous challenges and the introduction of new frequency bands. Whereas connectivity needs were once adequately served at 800 MHz and below, technology systems now have to address a variety of frequencies ranging from 700 MHz up to 2700 MHz.

"In designing a system such as the MBTA neutral host DAS, it is critical to find a cable that will serve all of the relevant frequency ranges efficiently," said Mullin. "Radiating coaxial cable had the peak performance we needed while covering all of the required frequencies."

Furthermore, InSite required a radiating cable solution without stop bands to accommodate a high-performance, future-proof design for the MBTA DAS installation. RFS has the intellectual property and leading-edge technology to suppress stop bands in radiating cables.

The radiating cables feature a patented higher-order-mode suppression technique that allows RFS to offer cables that support current and future in-tunnel and in-building commercial and private radio services from 698 MHz to 2700 MHz for cost savings. As a result of this patented higher-order-mode suppression, selected cables have no stop band from 698 MHz to 2700 MHz. The cables are future-proof with respect to RF spectrum rebanding and refarming, they ensure low insertion loss and suitable coupling performance, and they feature halogen-free, noncorrosive, low-smoke and flame-retardant jacket material for safe and reliable long-term cable operation.

Tom Ellefson, Northeast vice president of engineering, T-Mobile, said that the wireless carrier provides 13 miles of coverage to 26 underground stops on the MBTA subway line. "As a result, our customers are now able to carry on conversations, text and use the web while traveling underground in Boston as seamlessly as they are able to above ground, with no interruption to their wireless service," he said. "Ensuring this user experience for our customers is critical, and it would not be possible without the technologically advanced DAS system installed within the MBTA subway system."

Conclusion

To date, InSite Wireless has used close to 30,000 feet of radiating coaxial cable for the MBTA project, with plans to use approximately 30,000 feet more in the project's final phase. Upon its completion, the MBTA installation will be the first neutral-host DAS offering end-to-end coverage throughout the entire subway, including 35 underground stations and 19 miles of connecting tunnels. ■

Suzanne Kasai is business development manager at Radio Frequency Systems.

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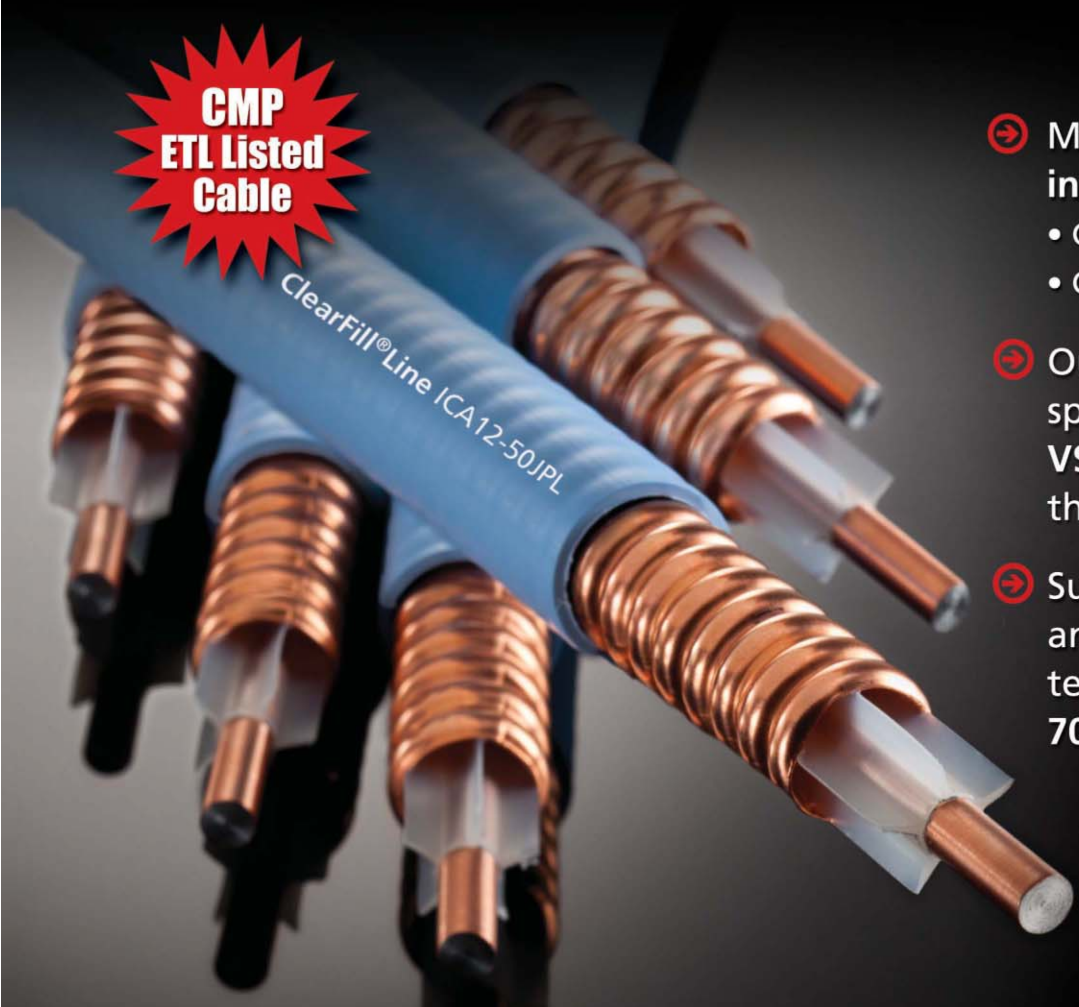

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Tarana Wireless' AbsoluteAir product line enables 3G/4G small cells to be deployed virtually anywhere while meeting mobile carrier requirements for sustained high capacity in both non-line-of-sight and line-of-sight operation. The product is based on Tarana's unique concentrating multipoint architecture that features high capacity and availability. It delivers a 75 Mbps backhaul capacity to each small cell and enables the number of links to scale as data demand grows, without degrading per-link capacity. Leveraging universal frequency reuse, AbsoluteAir products can be deployed across a metropolitan area. Each link uses the same 10-megahertz-wide channel while maintaining link capacity, providing seamless scalability from sparse to dense small-cell deployments. The antenna has a 100-degree aperture that dynamically aligns, eliminating time-consuming manual alignment during set up and ongoing operation. This function also minimizes network planning and installation time and effort. Such nodes require only 15 minutes for installation and commissioning to full operation. Upon power-up, nodes automatically associate to establish the link, and current configuration data is seamlessly downloaded over the air from the central management system.

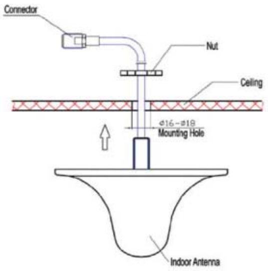
www.taranawireless.com

DC Power System

The Flatpack S high-efficiency DC power system from **Eltek** combines the ability to deliver 100 amps of current in a compact one rack unit form factor. Flatpack S system modules are hot-pluggable and only 8.27 inches long so that they fit into 12-inch cabinet applications, giving them the flexibility to meet higher power demands in tight spaces. The system provides greater than 95 percent efficiency and includes controller, rectifiers, battery and load distribution.

www.eltek.com

Indoor Antenna



A Radio Frequency Systems omnidirectional antenna designed for broadband in-building wireless communications is suitable for long-term evolution (LTE), Global System for Mobile Communications (GSM), personal communications service (PCS), third-generation (3G) cellular, Wi-Fi and wireless local-area network (WLAN) services. The PIM-certified model I-ATO2-698/2700JPL for 698 MHz to 2700 MHz is useful for ceiling mounting. The antenna is made of lightweight materials and features a low-profile, off-white radome that blends into most building aesthetics. The antenna avoids passive intermodulation to ensure high performance for passive DAS applications.

www.rfsworld.com

Directional Antenna

A directional wall-mount MIMO communications antenna for outdoor and in-building applications such as DAS and small cells is available from **Galtronics**. The antenna is dual-polarized and supports MIMO communications for the 698-MHz to 960-MHz band and the 1710-MHz to 2700-MHz band. It contains integrated combiners. The antenna features vertical or horizontal polarization, a VSWR of less than 2:1 from 698 MHz to 960 MHz and less than 1.8:1 from 1710 MHz to 2700 MHz. Typical port-to-port isolation is less than −25 dB. In the lower frequency band, it has 5 dB gain, and in the upper, 8 dB gain. It is rated at 50 watts at 50° C. The antenna offers MIMO communications within an enclosure, and it supports multiple carriers. It can be mounted below or above a standard false ceiling and fits through-ceiling mounts.

www.galtronics.com

Backhaul Digital Radio

Solutelia's Athena A060 point-to-point wireless communication system transports up to 1 Gbps of full-duplex traffic over a distance of up to 1 kilometer. It operates in the 60-GHz unlicensed band and addresses the needs of short-range wireless fiber deployments. The A060 link provides up to five nines of carrier-grade weather availability, depending on the link distance. Its own web interface allows the link to be set up and managed remotely over an Ethernet LAN. It is suitable for small-cell backhaul, campus connectivity, wireless backhaul, emergency services, LAN extension, network redundancy and other short-hop applications. System latency is less than 50 microseconds. The system uses Reed-Solomon FEC, QPSK modulation and has a bit-error rate of better than 10^{-9}. Its antenna offers 37 dB of gain, and the unit is weather-rated from −35° C to +55° C. It is rated for wind loading up to 160 kilometers per hour and operates in 100 percent humidity. Its unique design goes beyond industry tradition with a small form factor and square structure, resulting in an aesthetically pleasing radio system.

www.solutelia.com

product showcase — small-cell products

Hidden Site Hardware

Stealth Concealment Solutions offers products useful for concealing small-cell and DAS site hardware. In most cases, the concealment is 100 percent transparent to the environment. Screenwall rooftop concealments are typical of the company's site hardware cloaking approaches. Such solutions range from a custom-fluted concrete appearance to match the existing building, to stucco facades. The finished product allows great wireless coverage and an aesthetically pleasing solution for a high-profile area.

www.stealthconcealment.com

Backhaul and Wi-Fi Offloading

A fiber-optic solution that offers 16 channels of mixed Ethernet, LTE or Wi-Fi that reduces sparing costs up to 95 percent and that lowers operating expense by 50 to 75 percent is available from **Solid.** The device features zero jitter and packet loss, and ultra-low latency. With central provisioning, it can reduce commissioning from days to hours. The Access OLT delivers 16 independent channels of mixed traffic over a single strand of fiber-optic cable. Resilient optical channels remain online even if the processor card, memory card or combiner card is removed. Its channels remain in sync for two and a half days if the combiner card fails or is removed. The unit offers an on-board SNMP agent with up to 60 kilometers of range without the need for optical amplification or regeneration. Other features include symmetric dedicated bandwidth and QoS for each protocol, secure connections without port sharing, and tunable laser technology.

www.solid.com

PIM Plenum-rated Cable

Times Microwave System's SPP-250-LLPL 50-ohm low-loss plenum-rated coaxial cable assemblies employ a flexible corrugated copper tube outer conductor over a tape-wrapped, low-density PTFE dielectric core, which results in a combination of low loss, light weight and flexibility. Superior in electrical performance to other copper cable assemblies, SPP-250-LLPL cables fit in-building use for PIM-sensitive installations and system interconnects. They meet the fire-resistance requirements of UL 910 for plenum-rated applications and are suitable for in-building jumpers and system interconnects up to 18 GHz. The high-quality connectors ensure reliable PIM performance better than −160 dBc. Cable assemblies are available in 1-, 2- and 3-meter pre-assembled lengths with either N male straight, N male right-angle or N female bulkhead connectors.

www.timesmicrowave.com

3/4G Indoor Signal Booster

An indoor booster for 4G and 3G networks from **Wilson Electronics** provides enhanced signal coverage in buildings up to 80,000 square feet. The AG Pro-Quint boosts signals on 800 MHz, 1900 MHz, AWS and both AT&T and Verizon 700 MHz LTE networks. Its LCD display and push-button controls allow the installer to optimize the gain on each of the five frequency bands for specific booster locations. The booster delivers up to 75 dB of gain and supports CDMA, GSM, LTE, HSPA+ and WCDMA technologies. It can be paired with a variety of Wilson inside and outside antennas to create a custom signal booster system. The booster offers coverage enhancement for five frequency bands integrated in a single device.

www.wilsonelectronics.com

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DAS Platform

CommScope has stripped the complexity out of integrating a distributed antenna system (DAS) into a macro wireless network by upgrading its unified indoor-outdoor, low- and high-power single master unit ION platform. The upgrade reduces space requirements and the number of cable runs while maximizing design flexibility into a simple-to-use plug-and-play solution. The platform features integrated guidance and intelligence, enabling wireless network operators to design, plan, deploy and optimize a DAS more quickly and efficiently and at a lower total cost of ownership. The platform contains built-in intelligence that greatly simplifies installation. The embedded intelligence intuitively guides the design, planning, installation, set up, commissioning and optimization with virtually foolproof simplicity. The remote configuration tools enable operators to re-sectorize and access auto-leveling functions from anywhere in the world or right at the head end, and the built-in monitoring measures network quality and monitors interference and passive intermodulation (PIM). It also conducts detailed uplink/downlink spectrum analysis.

www.commscope.com

All-outdoor Backhaul Radio

Siklu's EtherHaul-600T is a low-cost, palm-sized, all-outdoor small-cell radio operating in the 57-GHz to 66-GHz band. The radio fits small-cell and other backhaul applications in the millimeter wave band. Its compact footprint stems from a proprietary, all-silicon integration technology that is responsible for the unit's compact size and price point. Its small footprint makes it virtually invisible when deployed on open sites such as traffic lights, poles or building sides. Installation can be performed by a single installer with minimal training and limited telecom expertise. Optimized for street-level deployments, the small-cell radio compensates for pole sway, twist and tilt.

www.siklu.com

Interface Panels

Westell's DAS interface panels are designed to be located between the base transceiver station (BTS) and the head end of the DAS where RF signals are converted to optical signals. The panels provide the attenuation necessary to ensure the RF power levels are appropriately adjusted for the DAS head end equipment. The panels provide the proper power levels for the downstream DAS equipment. Both transmit and receive power levels can be monitored and adjusted without disconnecting from the BTS or the DAS head end. They reduce installation time, need minimal rack space, are convection cooled, require no AC or DC power and provide RF power adjustments without interrupting service. The DAS850/1900/700/2100 provides the proper power levels for the downstream DAS equipment and can be connected to two BTSs simultaneously. The 1900 is a 1RU model, while the 850, 700 and 2100 are 2RU models.

www.westell.com

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3G Node

An all-IP, passively cooled 3G Node B suitable for mounting on an outdoor pole or on a wall is available from **Altobridge.** The altoZon 3G Node B has a coverage radius of up to 500 meters. It has been specifically designed to optimize satellite backhaul. With a power consumption of only 23 watts, it is suitable for solar deployments. Key features include passive cooling with minimal maintenance, a fully sealed IP65 environmental rating, a small form factor and seamless 3G-to-2G integration.

www.altobridge.com

LTE Small-cell Router

The **Huawei** ATN 905 LTE small-cell router helps small base stations obtain high-rate media access, allowing operators to extend their backhaul network coverage. It is suitable for both indoor and outdoor use and can be easily installed in a variety of environments. It supports any media access, including fiber, GPON and xDSL, to offer additional resources for the existing network. The router supplies power through Ethernet ports, a method that addresses problems associated with powering small base stations. It also supports plug-and-play and remote service deployment.

www.huawei.com

advertiser index

AGL	20, 71
AGL Bulletin	22
AGL Wireless Infrastructure Conference	48
Alabama Wireless Association	44
Allstate Tower	78
AnchorGuard	78
Anritsu	15
AT&T	9
BB&T – Atlantic Risk Management	10
Black & Veatch	13
Canine Companions	31
Cellular Specialties	71
Charles Industries	34
FieldSense	7
Hanson Pipe & Precast	16
Huber + Suhner	57
Hughey & Phillips	14
Humane Society	35
ITL	22
MasTec	21
Metal and Cable	23
National Association of Tower Erectors	inside back cover
New Jersey Wireless Association	67
Pennsylvania Wireless Association	25
Radio Frequency Systems	74
Radio Waves	55
Salem Communications	78
SBA Communications	back cover
Shulman Rogers	78
Slatercom-WCD	78
Solid	63
Specialty Tower Lighting	20
Stealth	11, 47
Subcarrier	5
Telewave	inside front cover
Tessco	61
Tower Economics.	17
U.S. General Services Administration	69
Valmont Structures	12
Waterford Consultants	24
White Buffalo Environmental	78
Wisconsin Wireless Association	42

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