Industry Predictions (Almost)

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Discrimination Peril

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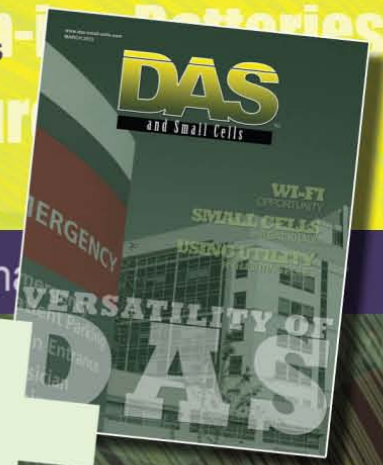
Infrastructure, regulatory and financial information for the antenna



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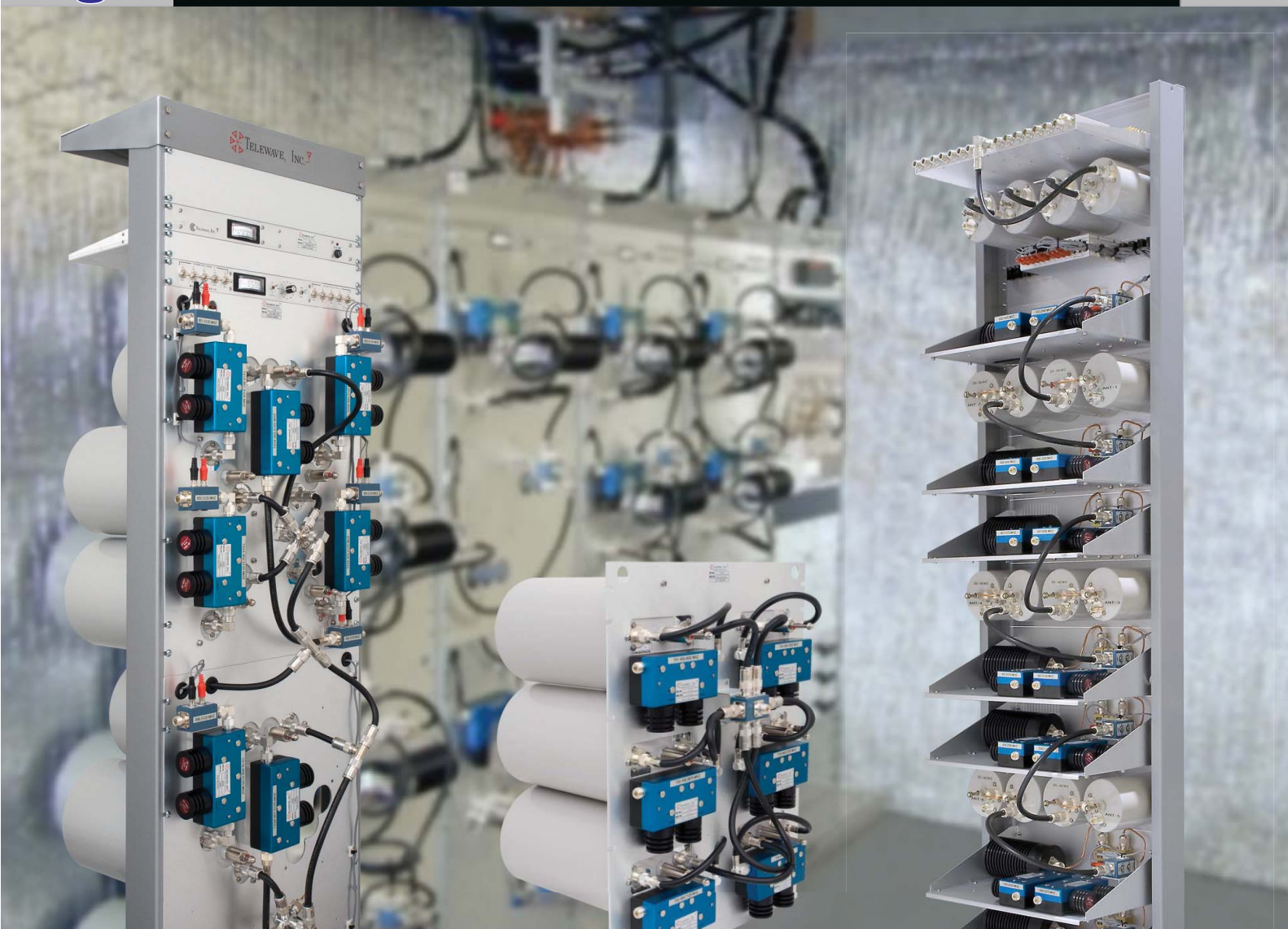

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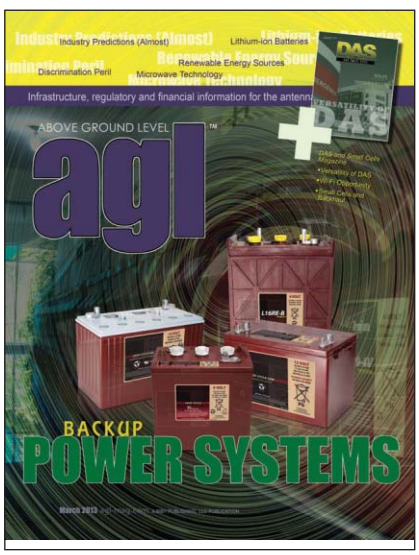

on the cover

Batteries often form a part of a backup power system, sometimes along with renewable-energy power sources such as solar and wind, and motorized electric generators. Photo courtesy of Trojan Battery.

Cover design by Scott Dolash

AGL (Above Ground Level) is published 11 times a year by Biby Publishing LLC, P.O. Box 2090, Ashburn, VA 20146-2090, and is mailed free to qualified individuals in the United States of America.

POSTMASTER: Send address change to *AGL* Circulation Department, 28591 Craig Ave., Menifee, CA 92584

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editorial comment

Who Will Bell the Cats?

Much has been said about the extent to which communications towers may be responsible for the deaths of birds that collide with them in flight, mostly small birds during nighttime migration. Changes to FCC rules were made to reflect the result of efforts to quantify and study the problem. People who are concerned about the hazard to birds that communications towers may represent include some whose interest is focused on that issue and some who have other reasons to want to forestall tower construction and who use the question of avian mortality to slow or obstruct tower construction.

The matter has been sorted out by the FCC, and details have been presented in the pages of *AGL*. Why raise the subject again? Because of an article published on Jan. 29 in *Nature Communications*. The article "The Impact of Free-ranging Domestic Cats on Wildlife in the United States" includes an estimate that free-ranging domestic cats kill between 1.4 billion and 3.7 billion birds annually. That cats kill birds doesn't seem to surprise anyone, but maybe the number comes as a surprise.

Anthropogenic mortality

In their abstract for the article, authors Scott R. Loss, Tim Will and Peter P. Marra said, "Un-owned cats, as opposed to owned pets, cause the majority of this mortality. Our findings suggest that free-ranging cats cause substantially greater wildlife mortality than previously thought and are likely the single greatest source of anthropogenic mortality for U.S. birds and mammals. Scientifically sound conservation and policy intervention is needed to reduce this impact."

Meanwhile, a peer-reviewed article published by the Public Library of Science in April 2012 estimates bird kill at communications towers at 6.8 million per year in the United States and Canada combined. The article can be seen here: *www.plosone.org/article/info:doi/10.1371/journal.pone.0034025.*

It seems, then, that cats are responsible for the deaths of about 300 times more birds than communications towers are.

It will be intriguing to see whether the interest groups that aligned to bring about more stringent regulation of towers will similarly align to curb the much larger menace of free-ranging domestic cats and to what extent they may advocate extreme measures such as cat eradication.

Drastic steps — or not

OK, I've had my fun, comparing cats with towers. No one expects the *Nature Communications* article to result in a cat-eradication advocacy, even though some might want to eradicate towers.

Nonetheless, some steps can be taken with towers and with cats that might extend the lives of small birds. With towers, it appears that steady-burning aviation obstruction lights have much to do with drawing birds close enough to towers to collide with them. Switching from steady-burning lights to flashing lights could help, but the change requires modifying federal regulations.

Meanwhile, as reported by the BBC, "A spokeswoman for the animal welfare charity the RSPCA said that a properly fitted collar and bell could reduce a cat's success when hunting by at least a third."

Let's see. Eradicating all communications towers might extend the lives of 6.8 million birds. Belling all of the free-ranging domestic cats might extend the lives of a billion birds. Which step makes more sense? I know, the answer depends on whether you own a cat — or a tower. ■

By Don Bishop, Executive Editor
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Infrastructure, regulatory and financial information for the antenna-siting community

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SUBSCRIPTION INFORMATION: *AGL* (Above Ground Level) is mailed free to qualified persons in the United States working in the antenna-siting industry and related services.

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AGL Circulation Department
28591 Craig Ave.
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Towers That Mean Business

The art and science of tower management

publisher's note

Why Can't We Be Friends?

Spring is upon us, bringing with it the changing season and change in the magazine. I'm very pleased to be able to present a special section called *DAS and Small Cells Magazine* to cover DAS and small-cell technology. *AGL* will be increasing coverage of DAS and small cells in every issue, with an emphasis in *DAS and Small Cells Magazine* four times each year. Obviously, we believe that DAS and small-cell technologies will play an important role in antenna siting in the future, and we intend to keep an eye on it for you!

NATE Conference & Exposition

We're beginning to move into the spring season of trade shows! As I write the beginning of this column, I'm on a plane destined for DFW, yes, Dallas/Fort Worth, to attend the National Association of Tower Erectors conference. NATE is a great organization undergoing a number of changes. I'm very pleased that *AGL* can be in attendance and participate with NATE on its mission of safety. NATE is expanding its outreach, educational and safety programs.

Photograph courtesy of mikefosterphotography.com

By the time you read this, I also will have had the opportunity to speak at the UtiliSite Council's Utilities Joint Use and Wireless Collocation Conference on March 6 in San Antonio. (Sounds like too much Texas inside of a month's time for a Virginian, if you ask me.) If you are a regular reader of this column, you are aware of my trials and tribulations involved with attaching wireless communications equipment to utility poles in New England. That being said, I'm finding it even more fun finding willing backhaul providers in rural areas. I guess there are reasons that most cellular companies don't deploy in rural areas, because it's tough. Oh yeah, and it's sometimes not so economical either. Well, if it was easy, everyone would've already done it, and the opportunity wouldn't exist. Taking that analogy back into the wireless infrastructure industry, the opportunities are still there; however, they are becoming more challenging.

Todd Schlekeway, executive director of the National Association of Tower Erectors, speaks to an audience at the NATE convention in Fort Worth, Texas.

PCIA and CTIA

If you have been paying attention to the high-level battle among giants, you may have noticed what looks like some competition brewing between PCIA and CTIA. This year's spring show is CTIA's last one. In 2014, CTIA is moving its event to the fall. The problem was that CTIA's spring show abutted the largest European communications show, GSMA's Mobile World Congress. I know the larger carriers had a hard time getting their booths, equipment and people to Vegas for CTIA's spring show, if at all. Although some people in the tower industry believe CTIA may have picked the date of its consolidated, 2014 show to give PCIA a hard time (the date falls within weeks of PCIA's annual show), more likely than not it was just to avoid scheduling conflicts with other worldwide conferences. It also may have been the only date Vegas could work a show the size of CTIA into the calendar. But, many of us in the tower industry are still suspicious about this.

I recently had the opportunity to sit down with Jonathan Adelstein, PCIA's new president and CEO. He was a most gracious host, and I can officially state that I am a member of the Adelstein fan club. Jonathan is going to bring a new energy and focus that will truly benefit PCIA. Long-time readers will remember when *AGL* used to publish monthly updates received from PCIA. We have a little work to do to see whether it may be possible for PCIA to provide updates once again. However, things are looking good for *AGL* and PCIA to resume closer cooperation.

As I write the following, I am on a return flight from the NATE conference, and I would like to say that the show was great! The presentations were excellent, the attendance was very good, and Todd Schlekeway, NATE's new executive director, slipped right into his role of cheerleader, emcee, host and all-around NATE leader. Todd also pulled off a speaker booking of a kind I've not seen before and likely will not see again for some time — he had the heads of both PCIA and CTIA (Jonathan Adelstein and Steve Largent, respectively) as keynote speakers.

Both gentlemen gave great speeches on the state of the industry from their perspectives. As you might have expected, Adelstein's speech had a little more to do with nuts and bolts, the details of siting issues, and Largent spoke more about the number of users and the growth of data use on wireless networks.

Congratulations to Todd and all of the NATE staff and members for a first-class show. ■

By Rich Biby, Publisher
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CCI Systems: In Wireless at an Exciting Time

By the AGL Staff

During its Wireless Infrastructure Conference in Dallas, AGL *interviewed Peter Murray, director of wireless solutions at CCI Systems. Here are his remarks, edited for length and style.*

***AGL*:** Tell us a little bit about CCI Systems.

Peter Murray: CCI Systems is based in Iron Mountain, Mich. We have about 450 employees. Our genesis was working in the cable industry. We built a lot of the infrastructure that exists in the cable TV industry. CCI has the capabilities to build, design and engineer new networks and upgrade existing networks. It has almost 60 years of experience and the engineering know-how to do so easily.

Today, we're seeing a lot of video on demand for wireless, so our skillset is matching up quite well.

We focus a lot on Cisco technologies for all portions of the network. We deliver Wi-Fi and DAS solutions, and we are busy with LTE upgrades right now.

***AGL*:** What do you do with LTE upgrades?

Peter Murray: The wireless group of CCI sometimes works with system integrators and sometimes directly for the actual carriers. Most of our business is east of the Mississippi River. We do everything from civil work to tower climbing, adjusting radio heads, mounting antennas.

Some carriers are easy to work with, but some carriers pose specific challenges, depending on their business models. In that case, we work for their general contractors. We have long-term, loyal employees, and our cost of labor is pretty good.

***AGL*:** The new world of small cells has less to do with towers and more to do with electrical work. How well-positioned is CCI Systems for that type of work?

Peter Murray: The world of small cells and DAS is an exciting business space. The demand right now is 80 percent indoor. With the evolution of Wi-Fi and the movement toward small cells, CCI Systems is uniquely positioned. We have a great partnership with Cisco and hold the Service Provider Signature Partner certification. Our experience with building Wi-Fi, DAS and communication networks and now the evolution into small cells gives me a good feeling that we're in the right place at the right time.

***AGL*:** With the emergence of corporate DAS and small cell networks, is that something you're doing with individual buildings or companies, or are you doing all that for carriers?

Peter Murray: Our focus is almost exclusively on the service provider. In a few of our markets, we extend outside of that because it works for the community. Our focus is service providers, the cable industry, telcos and cell carriers. Big cities are terrific, but we have a long history in the rural markets as well, and we have locations in the rural markets.

***AGL*:** It seems to be a good time to be in the services business. Has there been

a change in the number of sites you feel that need to be touched? Are we going to see the models change in how the sites are maintained?

Peter Murray: I recently attended a powwow with all the major integrators working with the major carriers, and they sure feel that there is a sea change happening, and companies are going to have to adapt to that sea change. We are flexible and able to accommodate most situations. We're also employee-owned. There are some types of work in which we can engage and make our customers happy without having to provide everything to everybody.

AGL: What is your involvement with backhaul?

Peter Murray: We are doing quite a bit of fiber construction, fiber to the cell. As you know, the carriers can't get enough of it. My boss, Stu Lahti, vice president of access networks, has 250 employees working for him with about 100 strictly focused on fiber deployment. Fiber backhaul is a wonderful business right now.

AGL: Is there a trend toward the public safety end of the market?

Peter Murray: Public safety is unique. In some ways it is easier because you don't have to coordinate the carriers. But it is really not our specialty. We're seeing it more and more, but our business has been focused on the cell signal more so than on public safety.

AGL: You mentioned Wi-Fi and Cisco and all this other stuff. Are you installing servers and things at cell sites, or is it mostly the cabling?

Peter Murray: Since we work nationwide for service providers, we have a large skillset in all types of technologies. We are handling anything from advanced packet optical networks to long-haul dense wavelength division multiplexing transport. All of this also relies on strong core Ethernet networks in order to have an intelligent network.

AGL: With regard to the fiber on the tower, have you been well-positioned to go after some contacts with the fiber experts?

Peter Murray: Not so much the fiber on the tower, more of the fiber to the tower. We're doing the heavy lifting when it comes to tower work, and then it is more just the cable going up and down right now. We think we are going to see more and more of that. One of the challenges is how do we staff, where do we put the resources, because you can't do it all, for everybody. But you could do it all for a few. We want to be a trusted resource.

AGL: What do you see at conventions that you hadn't thought of or known before that you want to learn more about?

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Peter Murray: I have a fun job. I get to go to most of the major trade shows. I get to sit in the really smart sessions like I did here at AGL, and I get to hear the perspective of just about everyone across the ecosystem. Right now, it's the small cell. The definition of small cell is different by carrier and by manufacturer, but I'm watching it, and it fits this niche that's there where Wi-Fi does what it does, and that's not really a competition to the small cell, it enhances it.

What DAS is doing, what the macro is doing, the small cells are this slice that is going to come in and enable better cell penetration in much smaller buildings. That business is going to explode, and if we get on the front end of that, it's always a fun time, because you get your people trained right in the beginning and get a first-mover position.

***AGL*:** How long have you been in the industry?

Peter Murray: I've been in the industry for quite some time. Let's just say I started pre-divestiture. I have about 30 years of experience. I've seen it all. I've worked for a couple of major carriers. I've seen some disasters and I've seen some huge successes. I think we're in that same space right now.

***AGL*:** In the wake of Hurricane Sandy, I get the reporter calls with the question as to why weren't the carriers better prepared? After Katrina, after Sandy, are there any things we've learned? Are there things we are going to do better next time?

Peter Murray: When you get a disaster like that, generators maybe shouldn't be in the basement. That would be one that everyone has to acknowledge. We just put 135 people into the Northeast to repair networks that got knocked off by trees. So, do you bury the fiber everywhere or is it prohibitive to do that in certain markets? Those two, I guess: generators, not below ground, nor on the roof with no ability to get fuel up to them. I heard a story about a New York hospital that had people pulling buckets up the stairwells. Someone has to think that through better.

AGL Online Video

Watch Peter Murray's interview online at *www.agl-mag.com/aglvideos.*

***AGL*:** Looking back, what surprises you most, something that you thought would take off but didn't?

Peter Murray: As I look at the industry, I think we're moving in the right direction. There's still a shortage of qualified labor. The carriers are all under water right now with the demand that they have to meet. But what surprises me, when I was general manager of Winstar, we had this 38 gigahertz, and our stock went up to about $8 billion in market capitalization, and then it disappeared, it went to zero. That was a surprise — both the up and the down.

Right now, where I work, CCI Systems, is extremely stable. It's a fun place to work with nice folks who have been there for a long time. The company has been in business for 60 years. I don't like surprises, and I don't feel like I'm going to get too many right now.

***AGL*:** Make a prediction about the future.

Peter Murray: The bandwidth demand is going to be realized. Cisco has these great numbers. But all you have to do is look at your teenagers and see their behavior. I have a hard time talking with my son, man to man, because he wants to text me. Hopefully, I can at least do some face time with him perhaps. It's just going to be insatiable. As we move more toward the video world, on your computer, now, when you look up a news story, there's a video attached to it, if not three. The bandwidth is just going to keep getting eaten up, all you can eat. ■

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Almost Predicting Industry Activity for Mobile and Wireless

It isn't actually predicting, but the act of selecting topics for research this year comes very, very close. What's being studied serves as a surrogate for predicting what may actually happen.

By Iain Gillot

Now that we have collectively survived the Fiscal Cliff and the end of the Mayan calendar, we can all breathe a sigh of relief and look forward to the rest of the year. If you thought things would end on Dec. 21, 2012, and therefore did not plan ahead, it is time to get back to work!

Mobile industry predictions are a funny thing. Everyone has some, and usually about 50 percent come true. To ensure that we are 100 percent correct in our 2013 prognostications, rather than tell you what we believe will happen, we will tell you what we will be researching this year and why. These are the subjects and topics *i*GR believes will be relevant. We hope the subjects will coincide nicely with activity in the wireless and mobile industry and we will look like geniuses — that is the plan, anyway.

Virtualization: Virtualization is common in enterprise IT departments and the IT industry as a whole. But because mobile networks have relied on tight standards and vendor-specific solutions, the idea of representing a mobile network in software and hosting it in a commercial data center was alien to most. 2012 saw serious discussion of mobile network virtualization both in the evolved packet core (EPC) and in the radio access network (RAN). Although *i*GR does not expect mass deployment of virtual solutions in mobile networks in 2013, we are seeing more trials and more proof-of-concept experiments. For the incumbent infrastructure original equipment manufacturers (OEMs), the discussion will be as to how they play in this market and retain their revenue and margin from traditional network infrastructures over the long term.

Many smaller U.S. operators have yet to start LTE deployment. This is likely to change in 2013 as more LTE networks are built and Release 10 (LTE Advanced) equipment is deployed. Other regions of the world are also likely to push ahead with LTE.

Phablets and BANs: It seems that few smartphones aim to become smaller these days, Instead, the newer designs are becoming bigger as tablets become smaller. The middle ground is the phone-tablet, something that by definition is too big to fit in your pocket while also being *too small to actually use as a tablet.* Seriously, as the smartphone and tablet markets mature, OEMs are searching for the next niche they can exploit, and they hope to get there before Apple does. *i*GR plans several primary research surveys during the year to identify exactly what consumers want and what is really the ideal size of combination devices.

Body-area networks (BANs) are also likely to increase in 2013, with the smartphone as the body's hub. Wearable devices were all the rage at the Consumer Electronics Show, and now that the Pebble watch has actually started shipping, attention is likely to move toward the new wearable devices that can be linked to the smartphone, phablet or tablet. And yes, each device is likely to require its own case and charger.

Network migration: LTE network deployment is, of course, in full swing in the United States, Japan and a few

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other markets. But while the big operators are pushing ahead, many smaller U.S. operators have yet to start LTE deployment. This is likely to change in 2013 as more LTE networks are built and Release 10 (LTE Advanced) equipment is deployed. Other regions of the world are also likely to push ahead with LTE. On a global scale, LTE is just getting started. 2013 is really the end of the beginning and not the beginning of the end.

Spectrum issues: In general, we do not see spectrum issues going away anytime soon. As the bandwidth demands increase on the network, operators need more spectrum. *i*GR believes that one key capability enabled by Release 10 is carrier aggregation, allowing operators to glue separate chunks of spectrum together into a single LTE carrier. In order to deliver higher network speeds, operators will need more spectrum. And because large blocks of spectrum are increasingly rare, are priced to be unobtainable or both, carrier aggregation becomes more important. This will come into focus in 2013 with more operators working out where and how to deploy.

More Wi-Fi: Specifically, iGR expects there to be more managed Wi-Fi services in 2013 and further integration with the mobile networks. In the last few years, public Wi-Fi services have moved from being seen as the stepchild of the licensed mobile networks to become a fully adopted member of the wireless family. With more mobile operators offering Wi-Fi services to subscribers, the next step is for fully integrated Wi-Fi services, where the consumer is unaware that Wi-Fi is being used. Hotspot 2.0 promises seamless connectivity, and devices are expected this year.

Some of the big operators (especially those using CDMA) are making a big push to get voice-over-LTE (VoLTE) implemented as soon as possible, while others seem content to wait.

Small-cell experimentation: Small cells are needed and are coming to a mobile network near you, but not just yet. Large deployments of managed picocells or metrocells are unlikely in the next 12 months. Instead, we are likely to see trials and initial deployments not simply to prove the technology but also to determine the business plan and the most efficient way to deploy. Many issues have yet to be addressed before small cells can be deployed en masse. 2013 is the year to get some answers.

VoLTE push: Some of the big operators (especially those using CDMA) are making a big push to get voice-over-

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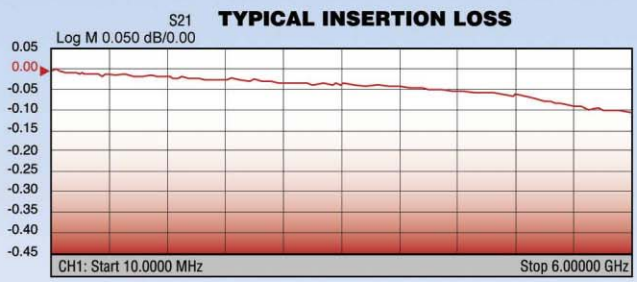

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LTE (VoLTE) implemented as soon as possible, while others seem content to wait. And yes, I know that MetroPCS has already launched with a couple of handsets. But in general, *i*GR sees 2013 being the year to get the initial kinks out of VoLTE, with commercial deployments toward the end of the year. 2014 will then be the year in which VoLTE is pushed commercially with multiple handsets likely available from some of the largest operators.

Mobile content delivery networks: Some of the larger operators have started deploying CDNs in the mobile network in order to increase efficiency and improve the consumer experience. 2013 will see more deployments together with the operators working with the over-the-top (OTT) content providers to improve the experience. So it would not be crazy, for example, to see a content provider such as Netflix working with an operator such as AT&T or Sprint (and no, I do not know this example is happening; it is just an example). For the operator, the upside is the ability to stay in the value stream and not get completely sidelined as a bit pipe provider.

Backhaul: It is impossible to overestimate how critical backhaul has become to the wireless industry. Not only do LTE eNode Bs require quality backhaul (for throughput as well as for the IS-1588 timing requirements), but also extending backhaul to small cells in a cost-effective way has proven to be one of the barriers to wider deployments. Many vendors focused on backhaul solutions in 2012, and 2013 will see more solutions being trialed and field-tested. *i*GR does not believe the backhaul issues will be solved anytime soon, but instead, baby steps toward wider solutions will be made this year.

Bandwidth demand at the local level: *i*GR completed several projects in 2012 looking at bandwidth demand at the local level and published a report on how the bandwidth demand shifted around a metro market throughout the day. For 2013, we already have more projects of this nature. It is clear that understanding that bandwidth is simply increasing is not enough, and understanding how bandwidth changes at specific points in a metro market is what is required.

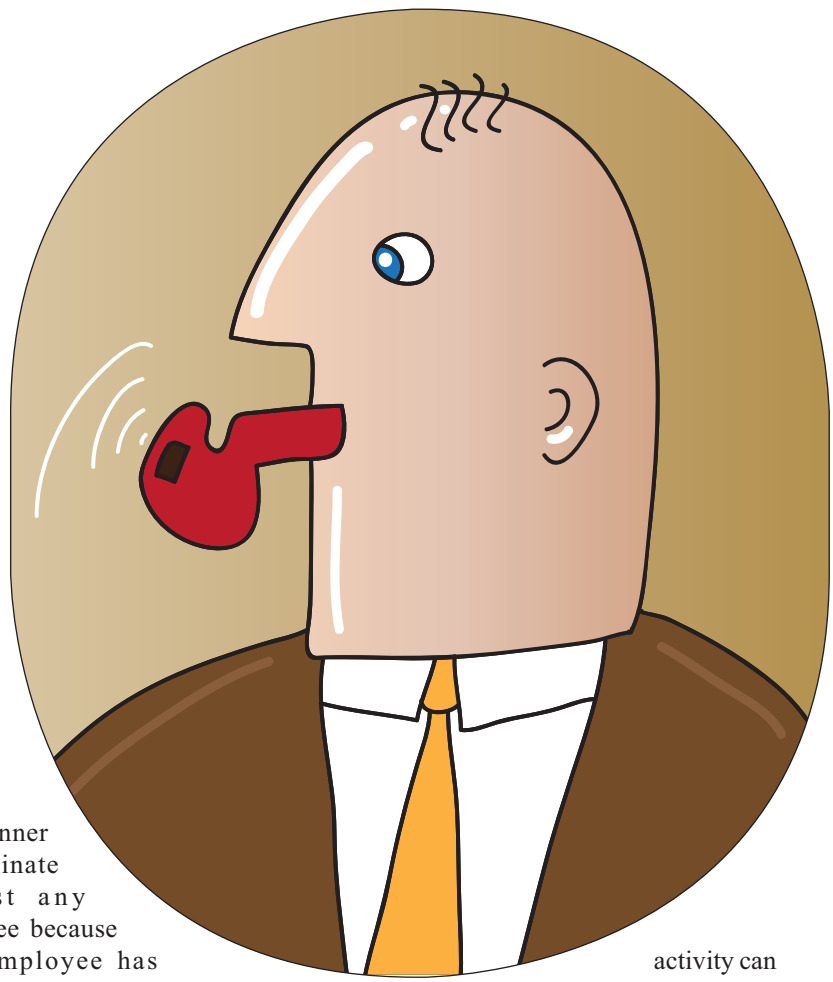
This information can be used to determine where small cells or Wi-Fi hotspots are required and how much capacity is needed.

Managing EPC: The RAN for LTE is pretty well understood, but what appears to be causing problems for the operators is sizing and managing the EPC and, specifically, the handoff to and from the incumbent 3G network. LTE is a complex technology that needs careful planning and execution, especially in the EPC. ■

Iain Gillot is the founder and president of *i*GR and *i*GR Semiconductor Research. His email address is iain@iGR-inc.com. *i*GR published a report on the importance of backhaul to small cells, and it offers a free white paper on the importance of effective management of the EPC.

Discriminate at Your Peril: Supervisor Personal Liability Under OSHA

Although courts have not yet decided the full scope of individual liability for discriminating against OSHA whistleblowers, supervisors can be ordered to pay money to successful whistleblower plaintiffs.



By Mark A. Lies II
and Ilana R. Morady

Most supervisors are not aware that a court can find them to be personally liable for money damages to a whistleblower under the Occupational Safety and Health Act. The typical assumption is that only employers can be held accountable to OSHA whistleblowers, but a recent court opinion from a federal court in Colorado debunks this notion and clarifies that liability extends to all "persons."

Statute

It is important to be aware that the Occupational Safety and Health Act contains specific provisions prohibiting retaliation against employees for engaging in "protected activity," as follows:

"No **person** shall discharge or in any manner discriminate against any employee because such employee has filed any complaint or instituted or caused to be instituted any proceeding under or related to this Act or has testified or is about to testify in any such proceeding or because of the exercise by such employee on behalf of himself or others of any right afforded by this Act." 20 U.S.C. § 660(c)(1) (emphasis added)

Some examples of protected activity include filing a complaint with OSHA, participating in an OSHA inspection and testifying against an employer. What many employers do not understand, however, is that protected activity can extend to complaints made by an employee at the workplace relating to safety and health concerns. It is also important to note that the employee does not have to use any "magic" language in order to fall within the category of protected activity. As the following analysis of case law indicates, the whistleblower provisions are an area of potential expanded liability for employers and supervisors.

Cases

In *Secretary of Labor v. Brighton*

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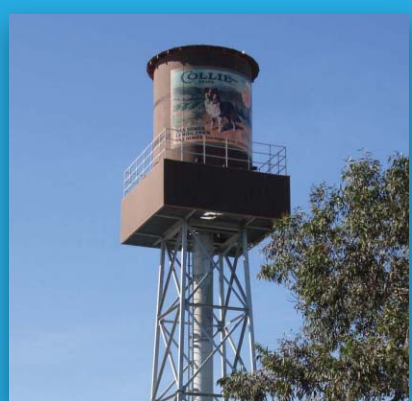

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Medical Clinic et al., No. 1:11-cv-02786 (D. Co., Sept. 25, 2012) the employee claimed she was unlawfully terminated after she complained to OSHA about her unsafe work environment. The secretary of labor sued employer Brighton Medical Clinic and the doctor who owned the clinic and supervised the employee. The doctor attempted to dismiss himself from the lawsuit on the basis that he was not the employer. The judge declined to dismiss the doctor because the whistleblower provisions of the Occupational Safety and Health Act state that "**no person** shall discharge or in any manner discriminate against any employee because such employee [has exercised her rights under the Act]." 20 U.S.C. § 660(c)(1) (emphasis added)

The judge further held that if Congress had intended that this provision of the Act only apply to employers, Congress would have said so.

There are only two other published cases that interpret Section 660(c)(1) of the Occupational Safety and Health Act, both of which came to the same conclusion as the *Brighton Medical Clinic* case. In *Donovan v. Diplomat Envelope Corp.*, 587 F.Supp. 1417 (1984), the judge refused to dismiss the employer's vice president from the case after a former employee claimed he was terminated by the vice president for complaining to his union about OSHA violations at the company. The judge stated that the decision to keep the vice president in the case was easy because Section 660(c)(1) uses the term "person," not "employer."

Reich v. State Credit, Inc., 897 F.Supp. 1014 (1995), a case involving somewhat bizarre circumstances, illustrates how attenuated this liability can become. A woman made a comment at a family event about health and safety issues at her workplace. Unbeknownst to the woman, her daughter related her comment to the city building department. After learning that a complaint had been made to the city building department, the manager of day-to-day operations at the mother's workplace held a staff meeting and described the unknown complainant as a "low-down person" or a "lowlife." Incredibly, the manager somehow erroneously concluded that the mother complained to the city building department and confronted her. When the mother denied making the complaint, the manager called her a "dirty double-crossing liar" and told her to clear out her desk, leave the office, and find another job. Despite the fact that the mother never made a safety complaint, the secretary of labor sued the mother's employer and the manager. When the manager at-

The question many supervisors may have is what kind of damages they can be liable for.

tempted to get dismissed from the suit, the judge held that he was not excused from liability simply because he was not the employer.

Potential damages

The question many supervisors may have is what kind of damages they can be liable for. The judge in *Donovan v. Diplomat Envelope Corp* pointed out that not all of the damages available to whistleblowers would be applicable to supervisors (for example, reinstatement and back pay) because supervisors cannot reinstate employees to employment nor are supervisors responsible for paying wages. However, OSHA frequently takes the position that if a supervisor is also the owner of the employing business, such as the doctor in the *Brighton Medical Clinic* case, then he should be liable for all available damages including back pay and reinstatement. Other potential damages such as monetary damages for emotional harm and even punitive damages can be assessed against all supervisors. Although the full scope of individual liability for discriminating against OSHA whistleblowers has not been decided by the courts, it is clear that supervisors can be ordered to pay money to successful whistleblower plaintiffs.

Recommendations

In order to avoid these potential liabilities, it is recommended that the employer take the following actions:

- Develop a program that prohibits retaliation against any employee who makes safety-related or other complaints.
- Ensure that all supervisors are properly trained in this policy and understand that retaliation is prohibited.
- Ensure that all safety-related complaints are fully investigated by the employer before any adverse or negative action is taken against any employee.
- Before terminating or otherwise disciplining an employee, determine whether the employee has engaged in any protected act, and if so, make sure that the discipline that is imposed is based upon a reason having nothing whatsoever to do with protected activity, for example, that the employee would have been terminated or disciplined irrespective of whether he engaged in any protected activity.

Conclusion

If employers implement the recommendations, they can significantly reduce the risk of their supervisory-level employees being found liable for monetary damages to OSHA whistleblowers. ■

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Why You Should Use Lithium-ion Batteries for Telecom Backup Systems

Cutting-edge lithium-ion batteries can improve performance and reduce total cost of ownership compared with lead-acid batteries for telecommunications backup systems.

By Bill Shank

The growing global demand for mobile services has significantly increased the need for new infrastructure, including cell towers, base transceiver stations and controllers, in turn creating demand for reliable wireless telecommunications backup power equipment.

The demand is especially evident in emerging and expanding markets such as India, Africa and Southeast Asia, where, according to analysis from the GSMA Development Fund's Green Power for Mobile program, an estimated 300,000 new cell tower sites are built each year. About 75,000 are built off-grid, and many of the others are in areas that often experience grid instability, resulting in long periods without grid power.

To limit disruptions to service in these areas, operators deploy backup power systems that typically integrate valve-regulated lead-acid (VRLA) batteries along with a diesel generator. This approach is proving to be inefficient and costly, however, because VRLA batteries suffer from a number of constraints, including high recurring replacement and maintenance costs and long charging times. This, in turn, increases the frequency of operation of and run time of the diesel generators.

Despite their limitations, lead-acid batteries have persisted for telecom backup applications, primarily because a viable alternative hadn't come to market, but now it has.

In recent years, new lithium-ion battery technologies — in particular, lithium iron phosphate — have emerged that are proving to be a more efficient, longer-lasting and lighter-weight alternative for lead-acid, delivering improved performance and lower total cost of ownership for many telecom backup applications.

Lithium-ion versus lead-acid

Today, a variety of commercially available lithium-ion battery chemistries with unique formulations that deliver different performance capabilities is available. The typical advantages of lithium-ion over lead-acid include longer cycle and calendar life, lighter weight, higher power and greater charge acceptance. For telecom backup systems, the most applicable comparison of specific technologies is lithium iron phosphate ($LiFePO_4$) versus VRLA.

Solutions built on $LiFePO_4$ battery technology are capable of delivering longer calendar and cycle life than VRLAs. Leading lithium-ion solutions last about four times longer than VRLAs, and they can also be deeply cycled thousands of times with virtually no effect on performance. In comparison, lead-acid batteries begin to show signs of degradation and deteriorating performance after just a few hundred cycles. The significant improvement in calendar and cycle life offered by $LiFePO_4$ batteries minimizes and in some cases eliminates the need for replacement batteries over the life of the system, which reduces costs and improves total cost of ownership.

$LiFePO_4$ chemistry is also capable of charging five or six times more quickly than VRLA, which increases the availability of the battery for backup power, resulting in improved wireless network reliability. For towers built off-grid or in locations with unstable grid connectivity, this improvement in charge times also decreases the reliance on diesel generators, translating into significant fuel cost savings and reducing total cost of ownership.

Figure 1 uses these and other metrics to compare $LiFePO_4$ battery technology with VRLA technology as deployed for a telecom backup application in India. As highlighted in Figure 1, the $LiFePO_4$ battery delivers significant advantages over the VRLA battery, even at elevated temperatures.

As a result of these and other performance advantages, advanced $LiFePO_4$ battery technology is becoming a superior solution to VRLA batteries for a number of telecommunications backup applications, including base transceiver stations in areas with minimal or no grid connectivity and at sites in developed regions in which minimizing physical size and

	Leading $LiFePO_4$	Leading VRLA	Improvement
Volumetric energy density	163 Wh/L	80 Wh/L	2x
Gravimetric energy density	100 Wh/kg	29 Wh/kg	3.5x
Charge time (to 80% of rated Ah)	42 minutes	4.2 hours	6.5X
Charge time (to 100% of rated Ah)	48 minutes	5.2 hours	6.5X
Calendar life (25° C; 100% SOC)	20 years	5 years	4x
Calendar life (45° C; 100% SOC)	3 years	9 months	4x
Cycle life (25° C)	8,000 cycles	600 cycles	17x
Cycle life (45° C)	2,700 cycles	360 cycles	15x

Figure 1. Lithium iron phosphate ($LiFePO_4$) lithium-ion batteries deliver increased energy, faster charging and longer calendar and cycle life than valve-regulated lead-acid (VRLA) batteries.

weight is crucial.

As was mentioned, demand for mobile access in developing markets is rapidly increasing, and telecom operators continue to build towers and other infrastructure to keep pace. A challenge, however, is that many of these areas have limited or no access to the electric grid, which requires operators to implement robust backup power systems to avoid disruptions to service.

Commonly, these backups systems consist of a lead-acid battery bank, typically a VRLA battery bank, coupled with a diesel generator. Although this setup is generally satisfactory for supplying the cell tower with consistent power, it is proving to be inefficient and costly.

Short VRLA battery life

The relatively short calendar and cycle life of VRLA batteries results in added operational and replacement costs because these batteries must be replaced as often as every 18 to 24 months. Furthermore, the noted inability of VRLAs to charge quickly means that, at sites that experience frequent power outages, they will not be able to recharge in time to supply sufficient power for the next outage.

If the VRLA battery banks have not recaptured a charge of sufficient magnitude to withstand the duration of the next outage, the diesel generator must activate. This increases emissions from the site and adds potentially significant operational cost. The operational cost is exacerbated by what normally are higher fuel delivery charges for sites in remote locations.

Conversely, leading lithium-ion battery solutions, and $LiFePO_4$ batteries, in particular, last up to five times longer than VRLAs, requiring fewer or perhaps no replacements over the life of the system. They also charge much more quickly, which increases battery availability, reduces reliance on diesel generators and minimizes the costs for maintenance, battery replacement and fuel transportation.

In fact, data collected from a real-world site in India during 2012 showed that using lithium-ion batteries instead of lead-acid batteries supported by a generator reduced the run time of the diesel generator by 92 percent and reduced diesel fuel consumption by 90 percent. Data from a second, comparable site in India showed similar results, with a reduction in generator run time of 81 percent and a reduction in diesel fuel consumption of 70 percent.

As a result of these and other benefits, total cost of ownership (TCO) studies have shown that telecom backup power solutions built with leading $LiFePO_4$ batteries save a typical tower site 40 to 60 percent in TCO over the life of the system (see Figure 2 on page 26).

A second telecom backup power application for which lithium-ion batteries demonstrate a significant advantage over lead-acid batteries involves rooftop wireless base stations, even in developed markets with robust and stable electric grids.

For instance, many major metropolitan areas have cell-tower sites on the rooftops of large buildings. As demand for wireless connectivity increases and operators upgrade their networks, with some adding the infrastructure necessary to support 4G LTE, these rooftop sites are built out. The placement of new telecom equipment and battery banks for backup power adds a significant amount of weight that a building inspector must approve.

Structural reinforcement

If adding the equipment would exceed the structure's weight limit, the inspector can halt the installation until the carrier reinforces the structure. This burdens the network operator with additional up-front capital cost. In one example, the carrier was required to spend $180,000 to reinforce a rooftop wireless base station site. The reinforcement could become a stranded investment if the carrier spends what is necessary to reinforce a structure and then decides to move the site, perhaps in response to the building owner raising the rent for the rooftop space. The carrier would have no way to recuperate the cost

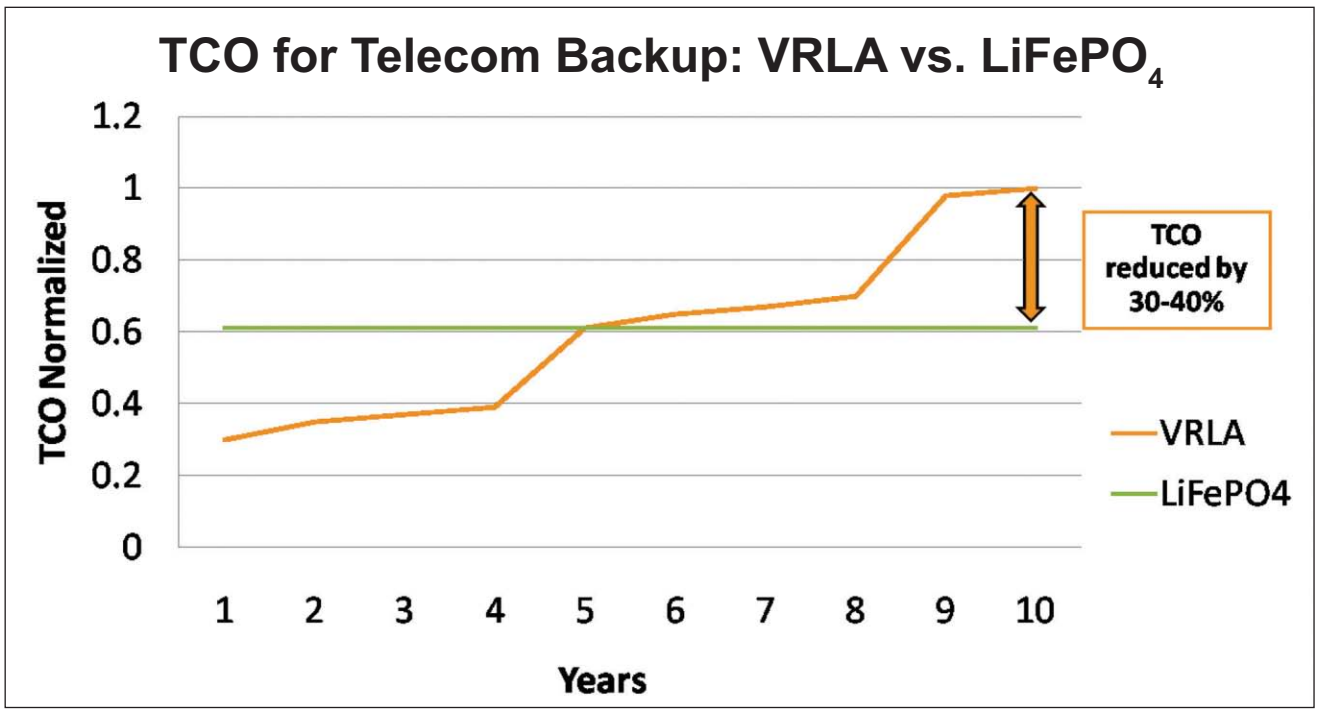


Figure 2. Telecom backup power systems built with leading $LiFePO_4$ batteries deliver a lower TCO over the life of the system as compared with VRLA batteries.

of the building upgrade.

Alternatively, lithium-ion batteries for telecom backup applications weigh two or three times less than lead-acid batteries, a factor that may enable operators to eliminate the cost of reinforcing a rooftop site where weight is a potential problem. When upgrading or adding equipment, the carrier can replace the lead-acid bank with a lithium-ion bank, thus keeping the weight down and avoiding the additional costs. Moreover, the up-front cost of this process can be minimized if the carrier reuses the lead-acid batteries at a different site, and the longer life of lithium-ion batteries should result in lower maintenance costs at sites that can be difficult to access.

Conclusion

These are two of the many applications and scenarios in which lithium-ion battery solutions can prove to be a more cost-effective, efficient and higher-performance upgrade compared with lead-acid batteries for telecommunications power backup. The modularity of lithium-ion systems provides design flexibility, enabling carriers to conserve valuable space at cell-tower sites and base transceiver stations, which may be beneficial in roadside huts or other enclosures.

In addition, breakthrough lithium-ion battery technologies are coming to market that are able to operate in extremely high or extremely low temperatures without any significant drop-off in performance or life expectancy, which enhances the benefits to carriers. For instance, in Southeast Asia and other warm regions, cell sites are built with air conditioning to cool the battery backup because batteries, regardless of chemistry, typically suffer from accelerated degradation at high temperatures. The air conditioning can represent as much as 50 percent of the power consumed at a cell tower site in some cases, which increases TCO. Advances in lithium-ion battery technology are making it possible to significantly reduce or eliminate the need for cooling, which contributes to a lower overall cost to the carrier for the life of the system.

As the global demand for wireless service continues to grow, carriers face increased pressure to reduce operating cost, improve performance and deploy more environmentally conscious technologies. Thanks to advances in lithium-ion batteries, and especially leading $LiFePO_4$ technology, the telecom industry now has an economically viable alternative to lead-acid batteries for backup power that can help meet these requirements and satisfy customer demand. ■

Bill Shank is senior product manager for telecom at A123 Systems, a developer and manufacturer of advanced Nanophosphate lithium-iron phosphate batteries and energy storage systems for the telecommunications, electric grid and other commercial markets. For more information, visit *www.a123systems.com/telecom-battery.htm.*

Renewable Energy Offers Power for Backup or Year-round Use

Renewable energy serves as a backup power source during electrical service interruptions caused by disasters, and it also provides year-round benefits for wireless communications providers.

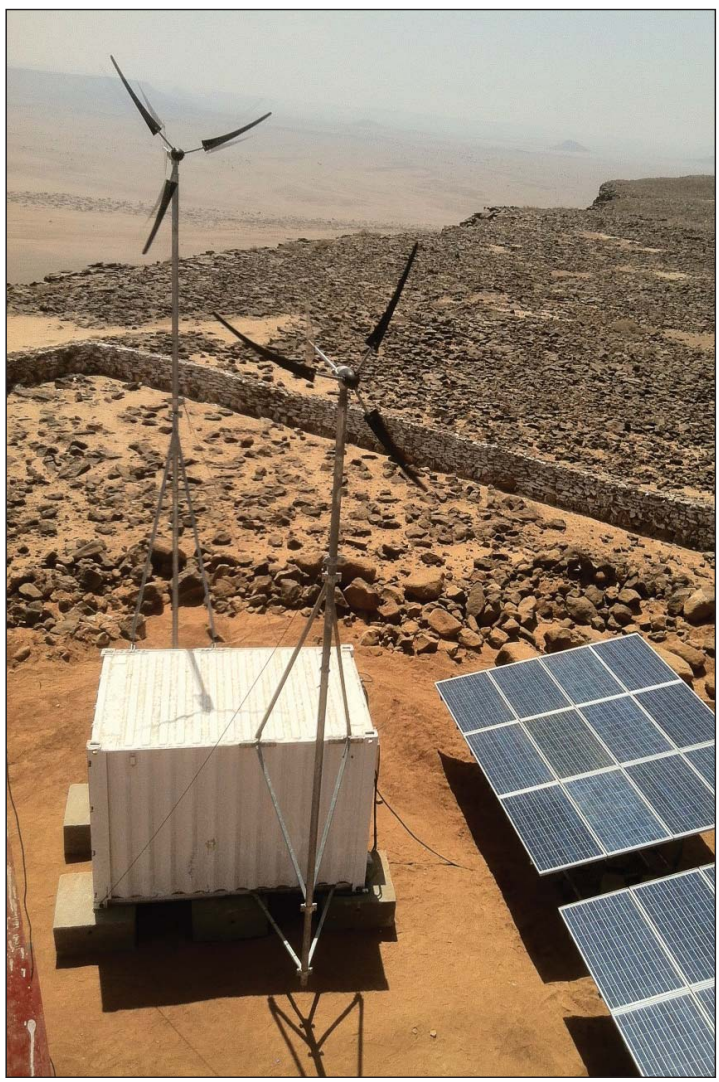
By Marie Russell

As wireless carriers work to build additional backup and redundancy into their networks, they may want to look at how renewable energy could augment existing systems, while providing financial benefits year-round. In the aftermath of Superstorm Sandy on the East Coast last fall, wireless communications companies have had time to bring their cell towers and central offices back on line and assess the damage. They may be looking for ways to avert similar future communications outages that were suffered. According to the FCC, roughly 25 percent of cell tower sites were adversely affected by the storm, leaving customers unable to call or text for help while being out of touch with family and friends, all further complicated by widespread outages of wireline services.

Although mobile telecommunications companies are not required by regulators to provide power backup at individual cell sites, in the wake of Sandy, many companies may be rethinking their strategies. As in any industry, service providers are looking to invest in areas of their businesses such as LTE that will expand their services and grow revenue, while cutting or working to contain costs without compromising service levels to customers. Therefore, each company needs to assess and balance which cell sites may be more vulnerable to power outages due to storms and the cost of ensuring that the cell sites remain up and operational.

Historically, diesel generators have been used at most cell sites for emergency backup to the electrical power grid from the local utility. Oftentimes, wireless carriers deploy cells on wheels (COWs) or cells on light trucks (COLTs) with generator backup as an added measure. However, as we saw with Sandy, with the derecho in the Washington, D.C., area in June, and with other disasters, diesel generators may fail and cannot operate when fuel distribution and supply systems are disrupted.

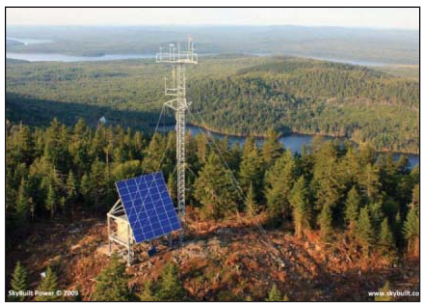
Globally, the evolving cell tower site can be powered in part or completely by a renewable energy component



A combination of wind generation and solar panels powers a cell site in the Horn of Africa, where electrical grid power is not available.

and battery storage that will augment the electrical grid tie on a daily basis. It can also serve as another level of backup in the event of a disaster. Solar arrays strategically positioned on the roof of the shelter at even the smallest cell tower site can provide additional power 365 days of the year. Wind turbines can also be used as a power source depending on the site wind resources available.

Loads can be driven by renewable energy when it is available. Excess renewable energy production is stored in a battery bank housed in the site shelter and is dispatched to the load when the renewable resource is not available. The captured solar energy reduces utility power consumption, shaving the peak of the most expensive grid power during hot summer days with rolling blackouts, thereby reducing operational costs for the site year-round. The addition of renewable energy or a hybrid solution with a cycling battery helps to extend the useful life of the diesel generator by reducing runtime, while improving operational



A solar array on a ridge powers a site in a remote location where an electrical grid tie-in is not available.

expenditures. Furthermore, renewable energy and battery storage are operational during and after the storm or disaster, thus maintaining wireless services to customers.

Similar renewable solutions lend themselves to a mobile hybrid trailer. Like the COW or COLT, a hybrid trailer can be pre-positioned before a storm for backup power or as a power station for customers during disaster recovery.

Renewable energy is especially compelling for remote locations in the mountains or desert areas where there is no grid tie to a local utility. In the United States, these off-grid sites in gap areas may be part of a wireless provider's network or are often part of a statewide network for public safety and emergency responders, homeland security and border patrol applications. By deploying a combination of solar arrays, wind generation, battery storage and a diesel generator determined by the solar insolation and wind resource attributes of a given location, an installer can have a system up and running. Such a system would require minimal maintenance. Remote monitoring and data-logging capabilities enable the service provider or tower operator to gauge system performance from the network operations center.

Overseas, with the explosion of wireless communications services in developing countries, many tower sites are positioned in remote areas with austere conditions — diesel power systems are usually the only option. No local utility or grid tie exists in most locations, and if one is available,

A solar array attached to an equipment shelter for deployment at a California site.

the power might be intermittent. It is not uncommon to have grid-connected units providing power for 10 percent or less of the time. Renewable systems fill this void by providing continuous power to support communications equipment. Moreover, renewable systems can provide power conditioning to an unstable grid source, ensuring a steady stream of power for communications. Advances in battery storage include longer life and reduced cooling requirements, which add to the economic attractiveness of renewable power.

Financially, the investment in renewable and hybrid power systems for the service provider can typically be measured in a four- to five-year payback depending on the location, the fully burdened cost of fuel and other site-specific conditions. However, when it comes to providing communications during a disaster and ensuing emergency response, the installation of renewables and hybrid systems becomes compelling, with payback seen almost immediately, helping to ensure reliable, continuous service to customers and emergency responders. ■

Marie Russell is responsible for business development at SkyBuilt Power, an engineering, design and systems integrator for rapidly deployable and fixed renewable and hybrid energy solutions installed globally for telecommunications, intelligence and military applications. Visit www.skybuilt.com. Photography by SkyBuilt Power.

Microwave Technology for Mobile Network Backhaul

A microwave technology innovation helps mobile network operators meet the backhaul capacity challenge.

By Chris York

New mobile devices and bandwidth-intensive applications, supported by 3G and 4G networks, resulted in a 2.3-times increase in mobile traffic in 2011, and demand is on pace to double once again in 2012. Given this rapid growth, the need for high-capacity backhaul has never been greater. Many operators are currently targeting 100 Mbps to 300 Mbps of capacity per cell site, a relatively modest backhaul requirement on a per-site basis. However, because backhaul networks frequently aggregate multiple sites in ring or mesh architectures, for improved economics and carrier-grade availability, operators actually need a backhaul solution that can scale to several gigabits per second of capacity (see Figure 1).

		Backhaul Link Capacity
MIMO	▪ Multiple-input multiple-output technology ▪ Potential to increase capacity well beyond 10 Gbps	10+ Gbps
Wider Channels	▪ 112 MHz channels ▪ Additional doubling of capacity	6 Gbps
Data Compression	▪ Wire-speed bulk data compression of (header + payload) for 1.5 to 2X capacity gain	3 Gbps
Multi-Carrier Radio	▪ Add second frequency for 2X capacity gain ▪ Can be done without additional hardware in some PtP products	2 Gbps
XPIC	▪ Use both polarizations for 2X capacity gain ▪ Requires a second outdoor unit	1 Gbps
Higher Order Modulations	▪ 256 QAM today → 2048 QAM future (25% capacity gain) ▪ Can be handled in software with some PtP products ▪ Must be pre-planned into the network design (link budget impacting)	500 Mbps
Baseline	▪ 256QAM Radio with 50 or 56 MHz Channel	400 Mbps

Figure 1. Capacity requirement for sample backhaul network.

In order to evolve their backhaul networks, operators are seeking technologies that can provide the right combination of scale, reliability and cost. Fiber-based networks deliver the needed capacity but are often cost-prohibitive when new builds are required. Wireless backhaul technologies can deliver the requisite performance, while offering rapid installation, flexible deployment options and much lower cost points than wired alternatives. Additionally, accelerated innovation in microwave backhaul technology is leading to much higher capacity and improved cost-per-bit economics.

The following information examines the latest innovations that are improving the capacity of microwave radios. These include higher-order modulations, advanced signal processing and compression technologies, multichannel radios and new transmission and antenna technologies.

Higher-order modulation

There is currently a lot of activity among vendors to extend the capacity and spectral efficiency of microwave systems by moving to higher-order modulations including 1024, 2048 and even 4096 QAM. A recent trial demonstrating 2048 QAM technology produced a 37 percent capacity increase over existing 256 QAM systems with no incremental hardware or spectrum allocation. As with most technology enhancements, higher modulations come with performance trade-offs in the form of reduced link budgets. This is mitigated with intelligent adaptive modulation technology that allows the system to switch to lower modulation, at a reduced throughput when fading may occur during heavy rain. Given that fading generally only affects lower-priority traffic for a few hours per year, most operators welcome the opportunity to cost-effectively add capacity to their networks.

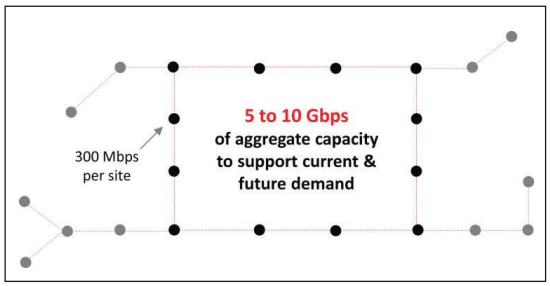


Figure 2. Microwave capacity improvements.

XPIC

Cross-polarization interference cancellation (XPIC) technology allows for vertical and horizontal transmission over the same channel, thereby doubling the link's capacity without adding new spectrum. Although XPIC requires additional hardware, it is particularly useful in regions with high spectrum costs and limited channel availability.

Multicarrier radios

Another significant development in microwave technology is the introduction of multi-carrier radios, which can transmit multiple channels from a single radio and antenna. A two-channel system can therefore carry twice the traffic without adding more hardware. This technology is most widely adopted in regions where spectrum is readily available and cost-effective.

Data optimization

Some microwave backhaul systems can employ a combination of white space suppression, wire-speed bulk compression, and header optimization technology to significantly enhance transmission efficiency. Compression algorithms used in these networks function much like those found in today's file compression tools, substituting patterns in the payload and header data with shorter symbols. Depending on the compressibility of the traffic mix, data optimization technologies typically result in a 40 percent increase in capacity with gains up to 100 percent possible under certain conditions.

Wider channels

In regions like the United States, where spectrum availability is good and new spectrum is being made available — particularly in bands above 24 GHz — operators have the opportunity to use wider channels up to 112 megahertz wide. This provides double the capacity of 56-megahertz-wide channels without the need for additional hardware investment and with no effect on the link budget. In the case of millimeter-wave technologies (60 GHz to 80 GHz), much wider channels up to 1 gigahertz wide are possible, allowing for high-capacity, albeit shorter-range, links that are well suited to fiber exten-

sion and certain small-cell backhaul applications.

MIMO

Multiple-input, multiple-output (MIMO) wireless communications technology, which is widely deployed in access networks, holds promise in point-to-point microwave systems. By using multiple transmitters and receivers, MIMO communications leverages multipath transmission to increase overall throughput by combining multiple signals. This is accomplished without the need for new spectrum. MIMO communications systems do, however, require an additional antenna and radio per link end and must have sufficient space diversity on the tower to achieve the desired multipath effect.

Figure 2 shows that a combination of new radio features, wider channels and higher-order modulations will be implemented to deliver backhaul capacities up to 10 Gbps and beyond, a 25-fold increase from the baseline scenario. Cisco's latest Visual Networking Index for mobile traffic has forecasted an 18-fold increase in mobile traffic over the next five years, a good indication that the technology is in fact keeping pace with end user demand.

Although spectral efficiency improvements are driving much of the capacity gains, there is also a need for increased backhaul spectrum. Therefore, frequency bands higher than 24 GHz, which tend to have greater availability, are likely to play a larger role in mobile backhaul in the future. Fortunately, the smaller antennas and shorter reach restrictions of these bands make them ideal backhaul frequencies for the small-cell networks that are expected to account for a large portion of future mobile network capacity.

Taking into account the cost and complexity of alternative backhaul solutions, it appears that microwave technology innovation, along with new backhaul spectrum being made available, should allow wireless backhaul to remain the predominant global backhaul technology for the foreseeable future. ■

Multiple-input, multiple-output (MIMO) wireless communications technology, which is widely deployed in access networks, holds promise in point-to-point microwave systems.

Chris York is director of channel sales and marketing at DragonWave. Visit www.dragonwave.com.

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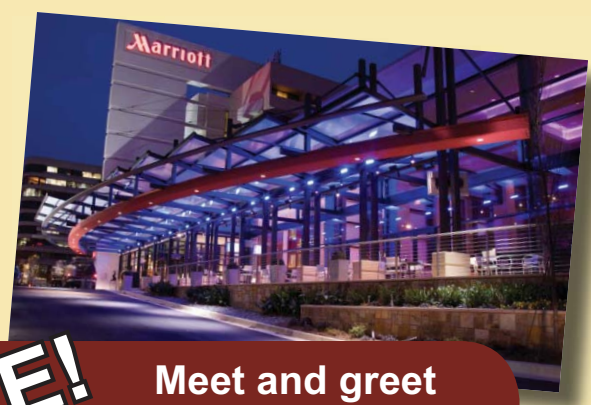

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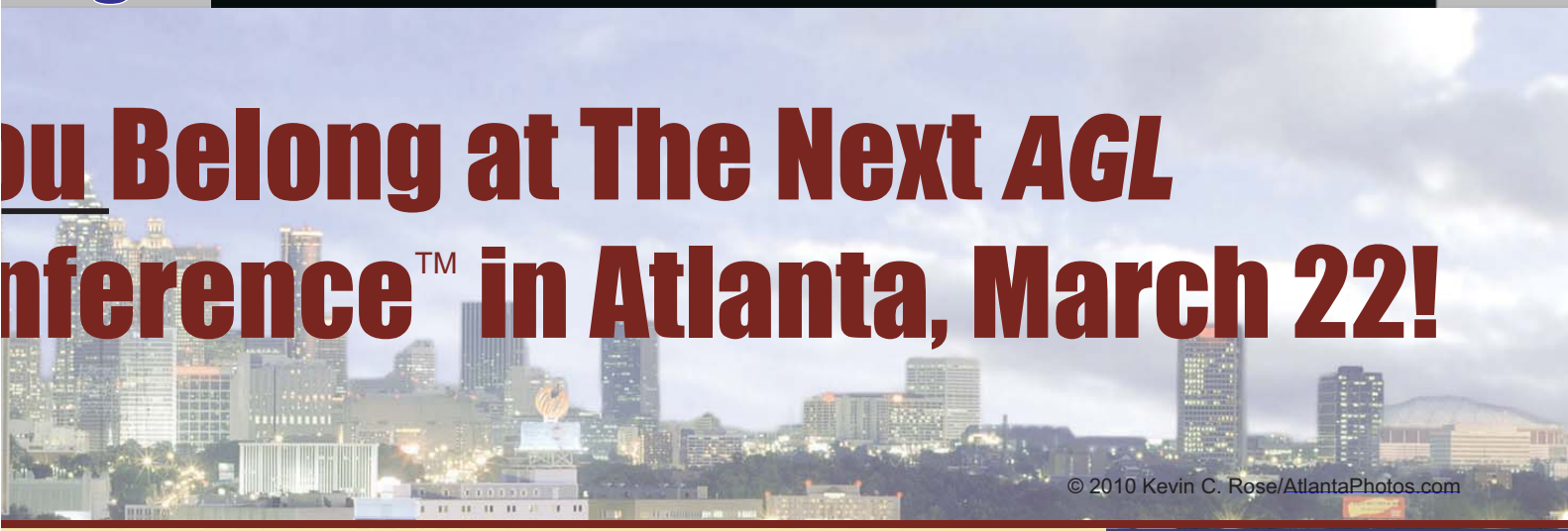

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product showcase — power and backup power systems

DC Power Systems

Integrated Circuit Technology (ICT) has launched several additional DC power products for communications site and tower managers. The 1RU ICT digital series power supply line, which features TCP/IP for remote management and battery backup with integrated LVD, is available in two power levels. All models come in 12, 24 or 48 volts DC output. The ICT site converter allows 48 or 24 volts DC to be converted to 12 volts at up to 100 amps of current. The line of ICT DC distribution panels with TCP/IP for remote monitoring and power-cycling of connected loads has been upgraded to include SNMP and five digital sensor contacts that allow built-in site monitoring of door, smoke and water. The 1RU ICT low-voltage disconnect operates in 12-, 24- or 48-volt systems at up to 200 amps and protects batteries from over-discharging.
www.ict-power.com

Battery Backup

The Durathon battery from **GE Energy Storage** is an environmentally friendly technology that uses sodium chemistry to capture excess energy from the diesel fuel generators. When the generator is off and the battery is fully charged, it feeds the stored power back to the cell tower. This hybrid, cyclical charge/discharge operation reduces fuel consumption by up to 40 percent. The technology can function in a variety of extreme conditions and store twice the energy of lead-acid batteries, while lasting up to 10 times longer, making it a viable alternative in urban and rural areas alike. Each cell is hermetically sealed within its own metal case and is strung together with other cells in a thermally insulated battery module, which ensures that the battery's external surfaces remain within 10 degrees centigrade to 15 degrees centigrade of the surrounding ambient temperature.
www.geenergystorage.com/telecom

Solar Module Monitoring

The Enlighten monitoring software from **Enphase** provides intelligence to solar power system owners and installers on the performance of each solar module. Unlike conventional monitoring systems, which only monitor the inverter, Enlighten continuously monitors the health and performance of each solar module and micro-inverter in the array. Enlighten's web-based analytics identify and alert owners and installers to any deviation in performance, allowing for quick maintenance. Enlighten can also be accessed via a web-enabled mobile device, allowing remote troubleshooting and updates.
www.enphase.com

Diesel Generator

The T-Series of diesel generator sets from **Cummins Power Generation** is a line of integrated power generation systems designed specifically for telecom cell site applications. The heavy-duty diesel engine features outputs from 8 kVA to 38 kVA, 50 or 60 Hz, and three-phase or one-phase power. An optional excitation boost system enhances motor-starting and fault-clearing short-circuit capability. Alternator sizes offer selectable motor-starting capability. The PowerCommand 1.1 control system provides generator set system integration, including automatic remote starting and stopping, alarm and status message display. Other features include an automatic transfer switch and a manual bypass switch integrated inside; a lockable 1,000-liter fuel tank; and 1,000-hour service intervals for changing fuel, oil and air filters.
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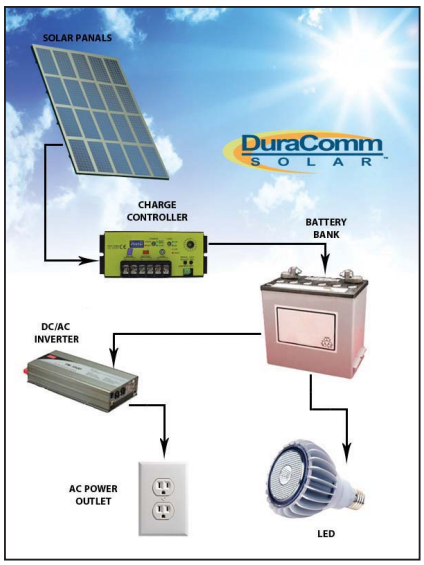
product showcase — power and backup power systems

Solar Power Solutions



DuraComm Solar has developed a line of prepackaged, solar-powered equipment kits configured specifically for telecom backup power and battery-charging needs, known as DuraSolar packs, which comprise enclosures, solar modules, charge controllers, inverters and racking. Configurations address electrical loads from 300 watts to 100 kilowatts. DC-to-DC configurations cover the range 12/24/36/48 volts DC and 10 amps up to 600 amps charging capacity for battery-charging applications. For DC-to-AC inverter applications, voltage systems are available for 208/240/277/480 volts AC services. Wind power and diesel generator integration options are available.
www.duracomm.com

Hybrid Power System Technologies

Caterpillar offers a wide range of hybrid telecom systems that provide power solutions incorporating renewable resources, including solar photovoltaics, wind turbines, batteries, diesel or gas generator sets and power electronics. By using available renewable resources and operating the generator set at peak efficiency points, hybrid power systems provide reductions in total owning and operating costs, decreasing fuel consumption and maximizing system reliability.
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www.ballard.com

Backup Batteries

Trojan Battery's industrial, flooded line of batteries for renewable energy and backup power applications is designed to support large daily loads where the batteries are cycled regularly. The industrial product family is used in large off-grid photovoltaic (PV) systems, off-grid hybrid PV systems, grid-tied PV systems with battery backup, and smart-grid peak-shifting systems. The line comprises removable 2-volt cells bundled in a secondary containment case to form single, high-capacity 4-volt and 6-volt battery solutions, assembled in a polypropylene housing.

www.trojanbattery.com

Fuel Cell

ReliOn's E-2500 fuel cell system provides reliable, scalable, environmentally benign backup power solutions for telecom applications. The E-2500 power solutions may be indoor rack-mounted or housed in a rugged, compact enclosure tested to Telcordia GR-487-CORE and CSA safety regulations. Hydrogen fueling solutions offer runtime options from hours to weeks between refueling. Remote monitoring and control software allows for off-site interaction, further reducing operation and maintenance costs.

www.relion-inc.com

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Nomination forms and seconding letters are due by Friday, March 15.

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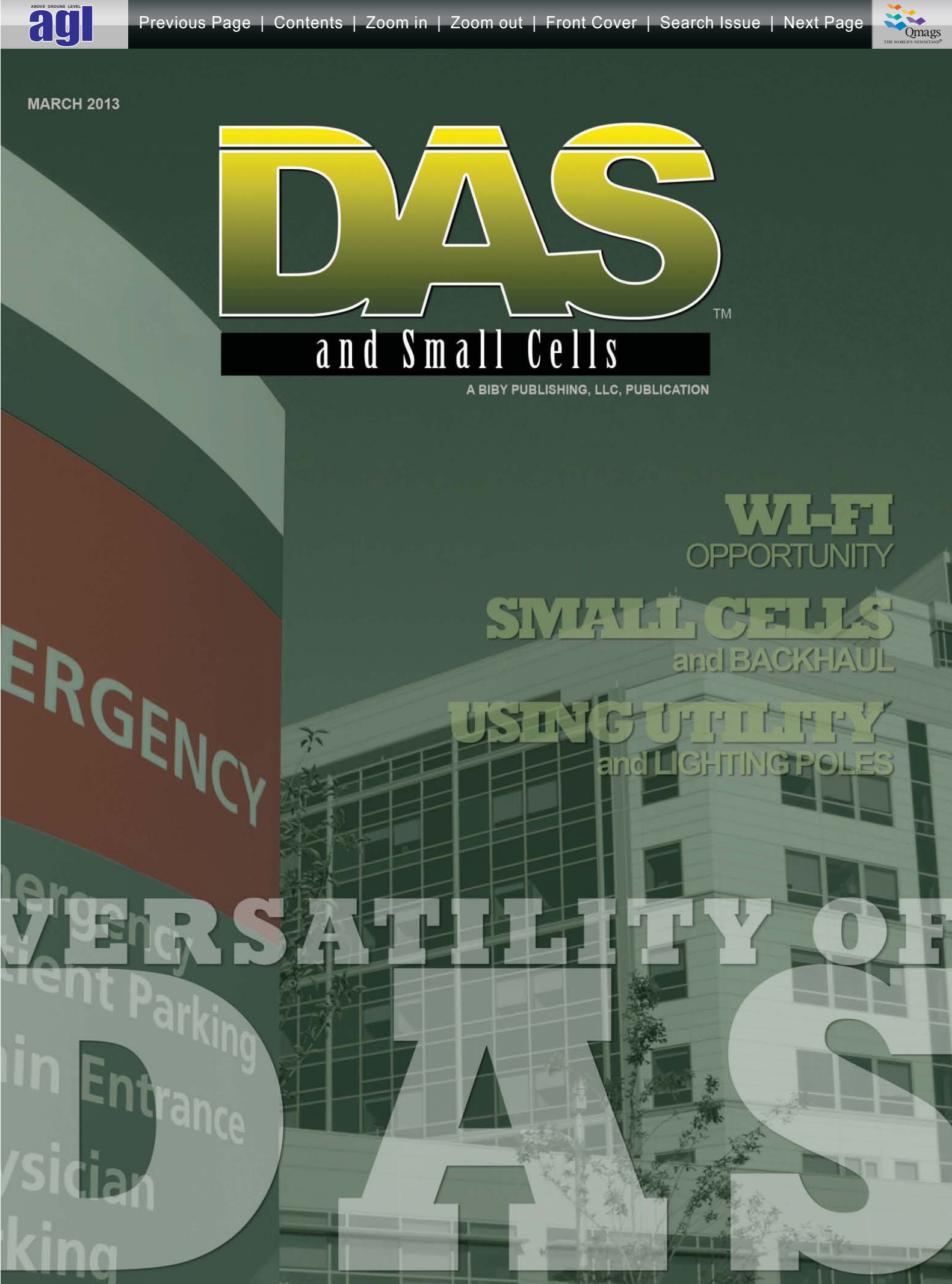

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Since the camp's inception, more than 17,000 children and families have received not only a circle of support but experiences thought to only be possible by healthy children.

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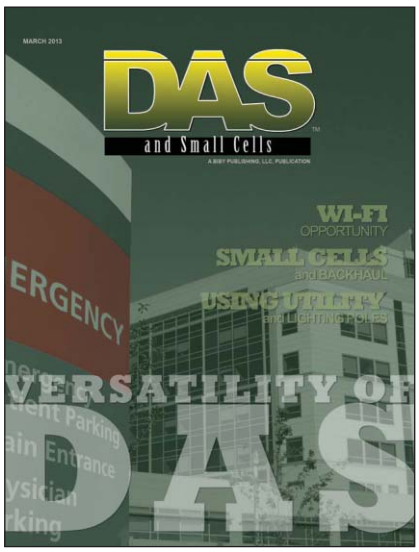
DAS and Small Cells Magazine



on the cover

Health care real estate represents opportunity for entrepreneurs and network operators to provide cellular, public safety and Wi-Fi coverage. See Jim Otte's article on page 6.

Cover design by Scott Dolash

Features

Department

DAS and Small Cells Magazine is published four times a year by Biby Publishing LLC, P.O. Box 2090, Ashburn, VA 20146-2090, and is distributed for free to qualified individuals.

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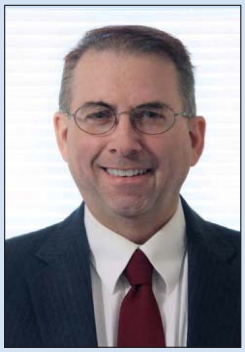

Look to *DAS and Small Cells Magazine* for a focus on information to help you select, deploy and use the technology that will serve you best as a network operator, neutral-host DAS provider, health care provider, sports venue operator, public safety services provider or commercial real estate owner.

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Purveyors of distributed antenna system (DAS) network equipment and DAS operators once justified their businesses by saying DAS was another tool in the toolbox for use by wireless carriers and by neutral-host service providers, some operating independently, and some operating as a part of telecommunications tower companies. DAS industry veterans of, oh, say, four years ago might say that there was a time when DAS was considered to be a last-resort alternative to be deployed when efforts to obtain approval for a telecommunications tower had failed.

Street furniture

It was about that time I heard Jake MacLeod, then of Bechtel, and now president of Gray Beards Consulting, speak of antennas that would use "street furniture" for places to install wireless communications system antennas and perhaps radio heads. He may not have coined the phrase street furniture, but his use of it was the first I heard.

By Don Bishop, Executive Editor
dbishop@agl-mag.com

Street furniture refers to traffic-control and light poles, bus stop shelters, kiosks and street signs strong enough to support telecommunications equipment and elevate it above pedestrians, cyclists and motorists, yet keep it low so the coverage of the radio signal remains limited. These are small cells. Well, guess what? The term "street furniture" hasn't caught on, but the term "small cells" has.

Even so, exactly what is a small cell depends on whom you ask. At *DAS and Small Cells Magazine*, we consider a wireless access point smaller than a macro telecommunications tower site to be a small cell. That means just about every antenna site that DAS uses, plus small towers, micro cells, pico cells and femto cells.

DAS is useful both outdoors and indoors. Outdoors, it continues to be called DAS, and sometimes oDAS. Yes, oDAS. I'm not sure that will catch on. Indoors, sometimes it is called in-building wireless, and sometimes iDAS. I'm guessing in-building wireless will be said more often than iDAS, but we'll see.

Fast-growing business

Whatever you call it, the business of DAS and small cells is growing fast. Defining when the turning point happened depends on whom you ask, but maybe it was about two years ago. No longer a last-resort technology nor one of many tools in the tookbox, DAS is the first-choice technology for serving up wireless communications in stadiums, hospitals and many office buildings.

The deployment of small cells within and outside of DAS networks is ever-increasing as wireless carriers hyperdensify their networks where large numbers of people live, work or visit close together. Yes, hyperdensify. I'm not sure the word hyperdensify, or hyperdensification, will catch on, either. But it's out there.

Subscribe to *DAS and Small Cells Magazine*, and you can see for yourself what catches on. ■

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DAS systems are being installed in the majority of new and existing commercial, health care and educational facilities to serve and attract clients and students. DAS installations are also becoming more common in manufacturing facilities.

Solving Communications Challenges with the Versatility of DAS

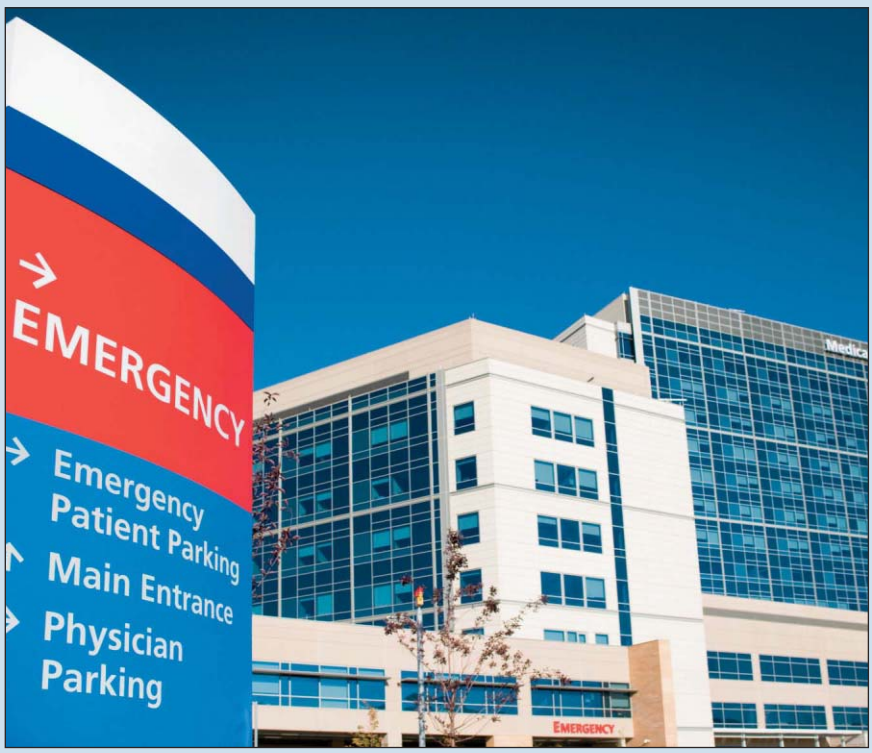
Mobile communications is reaching a new level of dependence in hospitals, higher education and manufacturing facilities. **By Jim Otte**

Why do cellular communications still exist? Many predicted that wireless networks (also called wireless Ethernet or 802.11) would replace cellular communications, as large meshed antennas were installed in cities and buildings. Many claim that cellular communications are easier to provision, control and bill, and for that reason are widely used in the deployment of Internet connectivity over smartphones. Cellular communications, however, still have distinct advantages and, for that reason, have survived the test of time. Distributed antenna system (DAS) networks have supported both cellular and 802.11 communications.

The company that sets the standards defines DAS as a network that can support data networks such as 802.11 networks, WiMAX networks, and Bluetooth networks. It further defines DAS as a network that can support telecommunications networks such as PCS, GSM, GPRS, iDEN, UMTS (3G) and others.

Facilities are installing both cellular and DAS in part to separate voice and data networks, allow for ease in mobile networking and provide a redundant means of communications. In specific facilities, cellular frequency bands offer the only means of communications due to interference factors.

A DAS can provide communications for first responders, which is a growing requirement among many municipalities as buildings become more hardened and are installed in areas without adequate cellular coverage.



Hospitals that provide open DAS platforms give visitors the ability to stay productive with reliable cell communication. DAS also improves internal staff communication and electronic asset tracking.

Many owners are not aware of what a robust, reliable, cost-effective system can do. Depending on the environment, DAS can increase profitability, provide revenue-generating user services and fulfill multiple communications functions.

The following information explains how DAS supports cellular communications strategies for leaders in three key market sectors: hospitals, education and manufacturing.

Hospitals

In hospitals, cellular phone and smartphone users include patients, family, friends and other visitors, along with first responders, clinicians and hospital staff. Because these communication devices use a signal that can handle high volume and complex applications, cellular use excels in throughput and bandwidth.

At colleges and universities, DAS creates additional revenue by allowing fee-paying athletics spectators to tie their smart devices into a DAS system to view plays, replays and stats. DAS also can be used to help find a missing person on campus.

Cellular communication is crucially important for tracking down medical personnel in a facility and is used by leading-edge institutions as an adjunct to hardwired telemetry. Nursing staff is able, for example, to keep track of a patient's vital signs as they move throughout the unit. Cellular also promises to bring added speed and flexibility in imaging and in the operating room.

Patients, families and visitors want and need reliable cell communications, both within the hospital and with the outside world, and usage volume is increasing all the time. An interesting finding is that facilities have experienced an increased positive attitude from patients and families when an easy method of connectivity is provided. Patients' families have even installed wireless video systems in family members' rooms and attached them to the in-room TV so patients can view relatives from around the country while speaking with them. Hospitals that provide open DAS platforms have reported that visitors and family members stay with the patient longer because they have the ability to stay productive, either working on business applications, downloading videos or playing interactive games with the patients. This creates a comfortable environment for all and, as a result, contributes to higher scores on internal and industry-satisfaction surveys. It is important to note that hospitals in the future will be compensated based on these scores.

To provide the connectivity to support these growing needs, in most cases, DAS is the clear winner over wireless networking (802.11) because of its transparency and the ease it provides to its users. DAS is constantly in operation and is configured for the phone, whereas wireless networking needs to be configured for each individual location. The DAS system can be used internally within the facility for staff communications and electronic asset tracking. This allows items such as pharmacy carts and code equipment, and individuals such as doctors and patients to be tracked. Eliminating the need to purchase separate asset-tracking systems reduces the overall cost of the telecommunications infrastructure.

As an added savings, health care institutions may find a cellular service carrier willing to subsidize the cost of the DAS installation in return for consideration as one of the prime carriers supported by the network.

Education

DAS is widely used to provide extended coverage within a campus. But it can also provide several additional benefits. DAS can facilitate initiatives that contribute to increased revenue. For example, colleges and universities are using DAS to enhance revenue at sports events. For a fee or as a free perk for alumni association members, colleges allow attendees to tie their smartphones into a cellular network to view plays from various camera angles, see replays and look at team and player statistics. Combining the best of both worlds, the service adds the advantages of real-time video to the live game. Venues have even added services such as providing the ability for individuals to find one another in the crowd if they are within range of a camera.

Many educational facilities are connecting the DAS system into a campus-wide mass-notification system, which will alert individuals of threats, post graphical maps of where the incidents are occurring on the campus and display photos of the suspects. The DAS system can be used to find a missing person by broadcasting a picture to all PDAs.

First responders

The Department of Homeland Security realizes that first responders need to communicate on the cellular system, but also need the ability to communicate on proprietary emergency radio frequencies. For this reason, many DAS networks are not only

repeating cellular carriers, but also providing the emergency frequencies to ensure that police and firefighters can communicate with command centers while high atop a building or deep underground. The government is considering making this a requirement of DAS for large public facilities and college campuses.

Some colleges and universities may be able to interest organizations in financing the entire upfront cost of DAS installation in return for a percentage of recurring revenue. That could result in a net zero cost to the university for DAS installation in addition to the continuing revenue stream.

Manufacturing

DAS helps manufacturers to mitigate the risks associated with just-in-time production because it enables instantaneous communication of issues and ticketing trouble. Because it is less subject to interference from welding equipment, furnaces and other factory machinery, DAS offers a viable alternative to 802.11 systems.

An all-too-frequent scenario in an automobile plant is as follows: A production supervisor for a paint line notices a problem with a paint application on a car, and he shuts down the line to determine if this is a single occurrence or part of a bigger problem because he is concerned that additional cars may be affected. As this occurs, several employees stand idle until the line restarts. In order to determine exact cause, the supervisor pages a maintenance person repeatedly, yet with no response. As it turns out, the maintenance person was in a paint booth and could not hear the page.

The alternative with a cell phone would allow the production supervisor to simply take a photo of the abnormality and send it to the maintenance person, who would look at the images and press a button, which denotes his approval to restart the line. The maintenance person would have seen that the problem was not a malfunctioning paint robot, but rather poor preparation of one car shell from an oil spot. An accurate order could then be given to check all the other shells in line and notify shell prep to make sure to wipe off all oil on the specific panel.

Many manufacturing processes are hardwired, which presents problems when equipment needs to be mobile to meet production schedules. An increasing number of production systems are moving to wireless architecture to make them truly portable. There may be significant changes in orders from month to month and associated production volumes. A company can quickly reconfigure its equipment setup when its production equipment is connected and monitored using wireless technology.

Expedited communications through DAS networks can save time, trouble and money in hospitals, in educational institutions and in manufacturing settings with the provision of reliable internal cell phone service.

Critical success factors

To optimize the benefits and minimize the cost of moving to a DAS, all three markets will require careful design and execution of their DAS strategies. A checklist should include these considerations:

- Identify which cellular carriers must be supported.
- Install a system that will support multiple carriers.
- Determine if wireless networking is needed.
- Learn whether the municipality requires interoperability and first-responder frequency-band integration.
- Ensure that colleges and universities include security from student digital intrusion.
- Ensure that health care institutions have no interference with and from sensitive electronic equipment, including imaging equipment.
- Minimize interference with and from factory machinery at manufacturing venues.

Finally, system designers and architects for all three industries must understand that DAS is still primarily line-of-sight communication, and walls and metal panels reduce the strength of the signal used to communicate. The design of the system must take into account the locations of building structures and equipment to avoid blocking the signal. The same is true for adequate antenna coverage, which is based on interference factors, the maximum number of cell phones that are going to be simultaneously used, the amount of bandwidth required, and the selection of the right frequencies. The solution for these issues is not the costly approach of putting more antennas in more places. In fact, using too many antennas can be detrimental to the signal. The solution is always smart design.

For that reason, owners and industry professionals need to shop for a DAS design partner with a broad range of disciplines on staff. This enables the partner to anticipate and address conflicts where multiple building codes apply and to avoid delays tied to code compliance and regulatory issues. The partner should not only have experience with DAS, but should also hold the Building Industry Consulting Service International wireless designer certification required to properly design DAS. The partner should be familiar with a broad range of building types, structures and systems — to the point of being able to design and engineer the buildings themselves with an integrated telecommunications infrastructure, using 3-D modeling tools to ensure compatibility among all design components.

Hospitals, higher education institutions and manufacturers need to consider this reliable cellular wireless broadcasting system for the simple reason that DAS is the future of internal cellular broadcasting. With insightful design and execution, DAS can solve the communication challenges of today and tomorrow. ■

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Backha

As new, small components b backhaul rema

By Andy Singer

One of the hottest phrases in the wireless communications industry is "small cells." It's not really a new concept, but rather a concept whose time may be about to come. The idea is to use micro, pico and femto cells as cell sites to bring users closer to a cell site and to provide more capacity in today's data-centric world. Cell site density will increase greatly, particularly in densely populated areas. As these new, smaller site architectures are deployed, cell site components will become increasingly distributed along the network. Although in rural and less-densely populated suburban areas, towers and traditional macro cells will continue to be used, in more densely populated areas, carriers see the use of smaller cells as the wave of the future. Backhauling communications traffic to the network core from the rising number of smaller indoor and outdoor cells that are being referred to as "small cells" will be a challenge.

The following information covers a number of potential backhaul solutions and some pros and cons. As technical development for backhaul advances, the future may bring additional ideas for new backhaul technology. Who knows, maybe we will skip a generation and move directly into the world of 802.11u, an IEEE standard that will make connecting with a Wi-Fi network seamless and faster. But for now, let's assume that the future lies with small cells.

The author, Andy Singer, with a hub antenna used for point-to-multipoint microwave links.

The small cell backhaul universe breaks down into a couple of broad cases. For indoor small cells such as femto cells, a carrier typically uses existing wired infrastructure — fiber, for sure, if you have it, and xDSL over bonded copper if you must. There are some exceptions such as a special event where a temporary system is deployed, but for permanent indoor networks, carriers will almost always use wired backhaul, and they prefer fiber. I have heard of at least one carrier looking at non-line-of-sight (NLOS) microwave links for indoor systems, but this method is not likely to be viable. The use of cable TV systems

aul for Small Cells

er site architectures are deployed and cell site ecome increasingly distributed along the network, ains a challenge that carriers need to solve.

Photo illustration by Cambridge Broadband Networks

for backhaul has some potential, more on that later. With outdoor small cell deployments, such as micro and pico cells, the situation changes completely. Some potential solutions are fiber, traditional point-to-point microwave, higher-frequency millimeter-wave such as 80 GHz, point-to-multipoint (PTMP) communications in bands such as 28, 31 and 38 GHz (yes, local multipoint distribution service [LMDS] lives on), low-frequency NLOS systems in bands such as 5 GHz, and CATV.

Fiber

Let's face it, fiber gets the job done. It's proven, and unless someone cuts it, it's highly reliable. And what's not to like about the bandwidth? Fiber is the house favorite of many a carrier. On the negative side, if fiber is not already in place, it can be costly to install and simply is not feasible to install in some situations. Because the use of small cells will be more of an urban, dense-population phenomenon, fiber is an overall excellent solution where it is available at a reasonable cost.

Traditional point-to-point microwave

Another proven, highly reliable technology is traditional point-to-point microwave. The big problem with it is that the amount of spectrum ultimately required is not available in the traditional bands such as 6, 7, 11, 13, 15, 18 and

The Cambridge Broadband Networks VectaStar Gigabit remote terminal radio with a 30-centimeter antenna for point-to-multipoint communications offers high capacity for mobile backhaul.

An 80-GHz Gigabit Ethernet medium-range wireless bridge from BridgeWave Communications extends a backhaul connection for as much as three miles.

23 GHz. In addition to the bandwidth problem, in many large urban areas, licenses for new traditional point-to-point microwave facilities are unavailable. In the short term, one could use traditional point-to-point microwave in licensed bands where licenses are available, or even in the unlicensed 5-GHz band. When using the unlicensed 5-GHz band, one has to operate the microwave system where interference is not a problem and somehow find a way to ensure that interference will not later become a problem.

It's a natural progression to consider PTMP microwave for small-cell backhaul because it has efficiency advantages that should theoretically increase as cell density increases.

Interference is one of the reasons all 5-GHz users should use high-performance antennas in lieu of standard-performance antennas. The high side-lobe suppression offered by high-performance antennas conserves spectrum and reduces mutual interference.

For backhaul from small cells, traditional microwave systems will be used, including systems in the unlicensed bands. In the end, though, for the licensed microwave bands, sufficient bandwidth is just not available to allow traditional microwave systems to serve the purpose for backhaul with a dense network of small cells.

Higher-frequency microwave

Point-to-point microwave in bands such as 60 and 80 GHz has positive traits that make it a real contender to use for backhaul with small cells. When you can get a full gigabit of backhaul that is relatively easy to deploy for $10,000, you have a viable solution that compares favorably with several others. The radios are small and light, and are well-suited for urban deployments. The challenge of aiming such high-frequency antennas accurately and finding strong, rigid locations in which to place them can be overcome. The antenna technology is challenging, but Radio Waves has mastered the art. The bandwidth available at these higher frequencies is much greater than what is available in many of the traditional bands, and many countries are setting up a "light licensing" system that makes obtaining licenses easy and quick with a reasonable cost. The short-range nature of microwave propagation in the 60- and 80-GHz bands has the additional advantage of reducing interference. BridgeWave Communications is an experienced supplier of high-capacity millimeter-wave equipment.

PTMP

Point-to-multipoint communication in the higher microwave and millimeter-wave bands is most likely a viable solution. At least two manufacturers make this type of equipment, and more are on the way. The frequency bands utilized will typically be 28, 32 and 38 GHz. Obtaining agreement from spectrum holders is required (for example, LMDS and 38-GHz licensees in the United States). One of the benefits of some of the commonly used bands for this solution is that these are often area-licensed or light-licensed bands, so licensing can be easy, assuming one has the access. There are latency problems to be resolved, according to some sources.

Current manufacturers are successfully deploying PTMP microwave in foreign markets for cell site backhaul where the density of site placement is great enough that PTMP systems serve well. It's a natural progression to consider PTMP microwave for small-cell backhaul because it has efficiency advantages that should theoretically increase as cell density increases. PTMP comes with a limitation because it is only a hub-and-spoke network topology, whereas some other solutions may provide options such as chain, ring and tree topologies. Another benefit of PTMP architecture is that, when deployed successfully, it requires fewer outdoor device units. Cambridge Broadband Networks is a supplier of PTMP microwave equipment.

Low-frequency NLOS

NLOS microwave is really a repackaged and upgraded version of the point-to-multipoint gear utilized over the years in the 2.5-, 3.5- and 5-GHz

bands, primarily by entities such as wireless Internet service providers. If you believe some of the hearsay, you would think these NLOS systems can provide extremely good broadband coverage through walls and anything else that may stand in the way. Certainly, because of the way these systems make use of scattering caused by reflections and refractions, there is a strong possibility of latency and jitter problems. NLOS systems sometimes use multiple antennas and digital signal processing to try to resolve latency and jitter, but the jury is still out. If I were a carrier, I would want to perform a trial before going down this road. Although the current technology may represent an improvement compared with previous generations, real-world performance may prove to be quite different from some of the claims for it.

One would also want to be sure that the proclaimed bandwidths are achievable in the real world. Ultimately, the spectrum limitations at these lower frequencies will limit maximum available capacity relative to higher-frequency solutions, but the lower frequencies can provide a larger coverage area. If the latency and potential interference problems can be resolved, the solution may prove useful, particularly for lower-capacity requirements where a lower quality of experience is acceptable to the end user.

CATV

Something like 30,000 cell sites in the United States are backhauled with Ethernet from CATV systems. Either there is fiber at the site, or it's built to the site, then they just drop an Ethernet line on the order of 100 Mbps. CATV backhaul can be expensive compared with microwave, but where CATV systems are in place, they offer reliable links that are easy to deploy. We will certainly see some use of Ethernet over CATV systems for a portion of small cells.

Another potential solution involves the CATV drop in a building or home. It could be used for small-cell backhaul, and the cost would be reasonable, to say the least. Although this solution comes with latency problems, undoubtedly there are people somewhere on the planet trying to resolve them. The carrier could also ask whether "five nines" of service reliability is truly needed for small-cell backhaul. If not, it makes it that much easier to consider CATV for backhaul.

A typical antenna used with 80-GHz links, the Radio Waves Discriminator.

Summary

It seems certain that any operator will use multiple solutions for small-cell backhaul, and some situations will be best served by specific solutions and technologies. So, what is the optimal solution? Any solution for outdoor small cell backhaul must meet certain basic criteria. The solution must have acceptable latency and must not suffer interference. The signal must reach the required site, and the cost must be reasonable. Installation must not be overly burdensome, and the solution must provide the required bandwidth. Bandwidth is key, or the solution does nothing to resolve the backhaul bottleneck.

Because of the variability of requirements, almost every solution described here will be used at some point, but it is clear that a couple of these solutions will dominate. Although taking out the crystal ball has proven to be dangerous at times, if I were to venture a guess, I believe that the leading solution is going to be fiber. Fiber is available in most places where carriers need it, such as densely populated urban areas, and it is the preferred solution for many of the large carriers.

Of course, there will be many situations in which, because of a lack of fiber availability or because of high cost, carriers will need to use something else. In these situations, solutions such as 80-GHz point-to-point microwave and other millimeter-wave bands will come into their own. Clearwire has certainly used 80 GHz extensively for short links, and it has superior bandwidth compared with some other solutions. Some other bands that may see use for point-to-point microwave include the 28-, 38- and 60-GHz bands.

Then, in third place, we will see point-to-multipoint solutions used where the cell density is great enough and where the carrier feels comfortable with it.

There is a wild-card technology out there, and it is CATV. Although CATV has some latency problems, if someone can resolve them, there would be a fortune to be made with gear that allows robust backhaul using CATV.

Although CATV has some latency problems, if someone can resolve them, there would be a fortune to be made with gear that allows robust backhaul using CATV.

Although it's still early in the game, backhaul for small cells will be an area of significant research and trials during 2013 and great activity over the next several years in the wireless communications industry. That's one of the great things about this industry — it's never boring! ■

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Wi-Fi Offers Opportunity for Wireless Infrastructure

The tower model of shared infrastructure applies to Wi-Fi. Tower owners have as much opportunity as anyone to build Wi-Fi networks for public and private venues to add mobile service capacity.

By the AGL Staff

Edited for length and style, here are remarks made during the session "Why-Fi? The Business Case for Wi-Fi" at the Wireless Infrastructure Show.

Pat Tant: What's Wi-Fi? What does it mean, and what does it get us today?

Ted Dolan: Wi-Fi is a wireless radio access technology that moves bits to and from the network, from an end point to an access point to the Internet. From tablets to smart phones to connected TVs, most portable and consumer electronic devices come with Wi-Fi embedded. Wi-Fi is an efficient means of accessing a network for communications, entertainment and business purposes.

Pat Tant: What is the difference between licensed and unlicensed Wi-Fi service?

Chris Wallace: Licensed frequency bands tend to be smaller, 5 megahertz to 20 megahertz wide. A license gives the operator exclusive use. Licensed macro cells allow the use of high power, tens of watts.

Unlicensed spectrum is not unregulated; it is highly regulated. All devices must be certified in each country. Frequency bands used for Wi-Fi are shared among many applications. A Wi-Fi network has to tolerate interference from Bluetooth devices and in some cases legacy uses such as air traffic control radar.

Using both licensed and unlicensed spectrum is important for telecom network operators.

Steven Glapa: The worldwide frequency band plans for LTE are highly fragmented. In comparison, shared Wi-Fi spectrum offers several hundred megahertz of spectrum, especially if you include the 5-GHz band. With the new iPhone 5 release, you saw that the 5-GHz band finally is being supported by mobile devices. The majority of popular devices are supporting 5 GHz.

By the time they finish rolling something out through the balance of 2013, operators are planning to use the entire 5-GHz band. No LTE band plan anywhere in the world comes close to that several hundred megahertz.

The majority of places where traffic causes problems for network operators are indoors. The indoor venues are public spaces or, if not, they are quasi-public spaces such as restaurants. Fifteen years in the DAS business taught us that there are two rules in those public spaces. Number one, they will put in only one wireless system because it costs them money to build, operate and maintain, and because the cosmetics are important. Number two, the wireless system has to support all of the network operators as a neutral host.

If you think about moving from a DAS with a coverage objective, which only re-

Pat Tant
President and CEO
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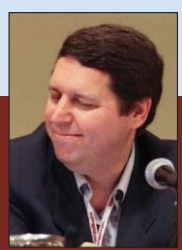
Chris Wallace
Wi-Fi Strategic Product Manager
ERICSSON



Ted Dolan
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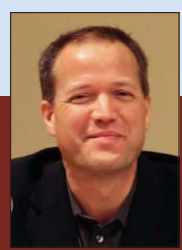

Steven Glapa
Senior Director of Marketing
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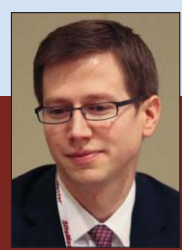


Corey Wagner
National Manager, Wi-Fi Business Development
AT&T ANTENNA SOLUTIONS GROUP

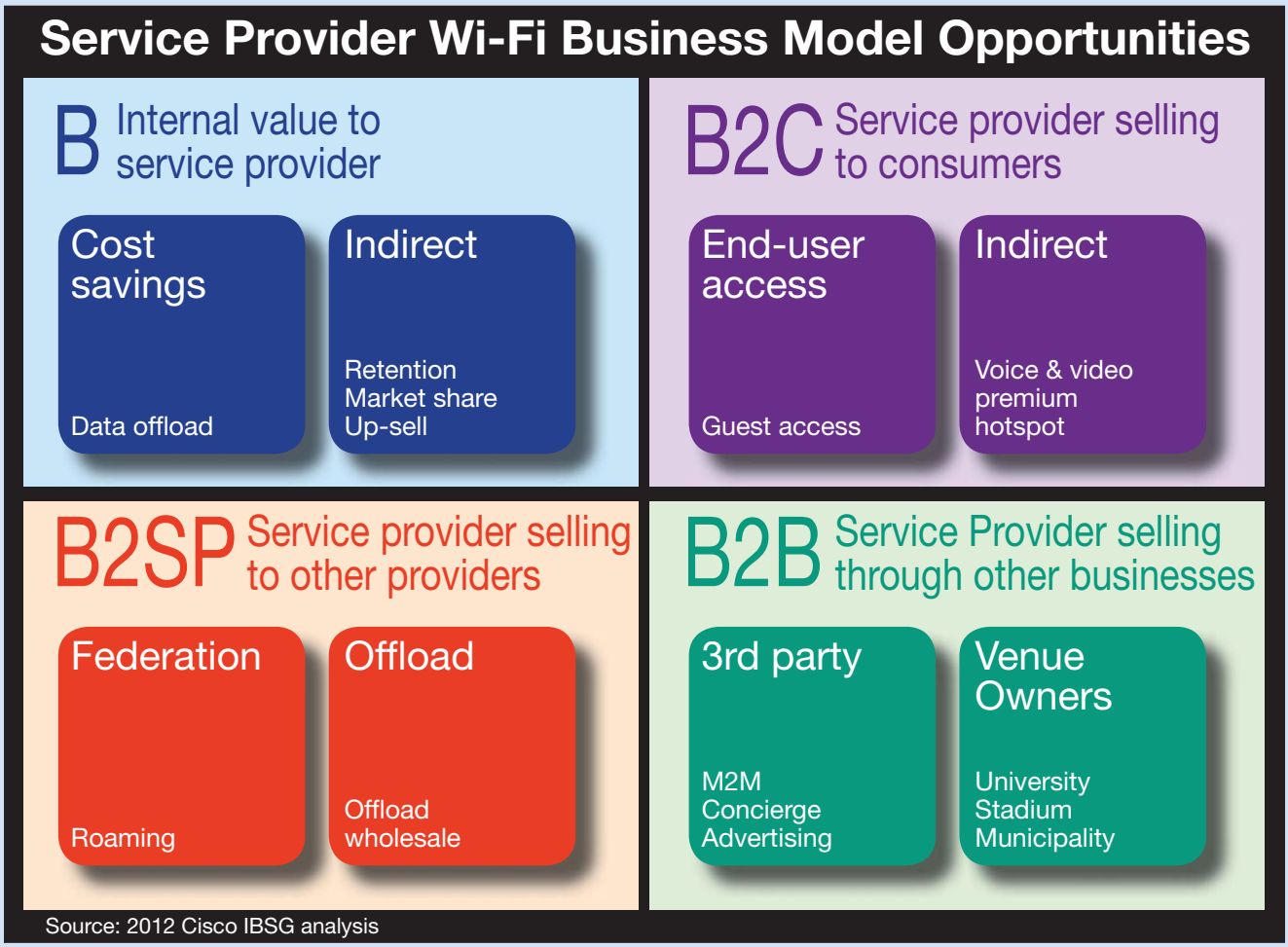


Figure 1. As Wi-Fi becomes more pervasive, network operators may be able to create services to sell to consumers.

quires one demarcation point to the network operators, and look at that from a capacity perspective where instead of one active node you need to have hundreds, neutral-host wireless service becomes complicated in the licensed frequency band.

With Wi-Fi, where you have several hundred megahertz to work with, neutral-host wireless service is easy because you just share service set identifiers (SSIDs) or Hotspot 2.0, and then you don't even have to have multiple SSIDs.

Chris Wallace: Another advantage of the unlicensed frequency bands that Wi-Fi uses, besides the sheer volume of spectrum available, is global applicability. You would hope that things would be getting better with the fragmented band plans, but with LTE, it is only getting worse. You have paired and unpaired spectrum for frequency-division duplexing and time-division duplexing LTE. You still have the plethora of regional divisions. It hurts the ecosystem. It makes it more difficult for the macro equipment vendors.

As we build small cells in licensed bands, you have the same problem of strict prioritization that makes it difficult to deliver in the critical bands that operators are going to need.

Wi-Fi, on the other hand, has global adoption of the same frequency bands. This is evidenced by how fast Wi-Fi has taken off. Every device has Wi-Fi because the economy of scale is there. They can produce Wi-Fi devices for that much cheaper.

Pat Tant: For carriers, what is offload and how does AT&T look at it?

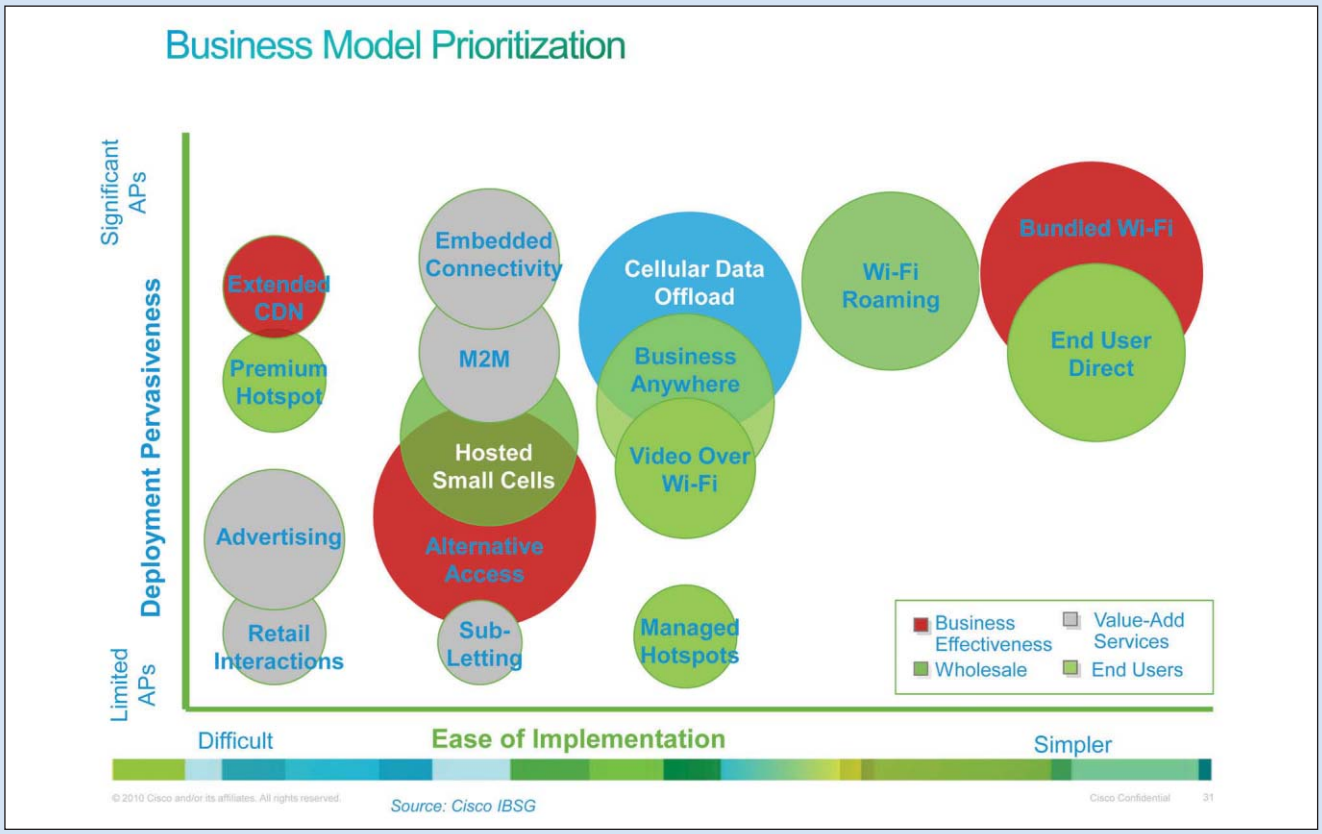
Corey Wagner: Offloading refers to moving traffic from the macro network to another network, DAS or Wi-Fi. The idea is to use the wireless spectrum as efficiently as possible to serve customer demand. We have about 30,000 Wi-Fi hotspots in the United States, focused on areas where people congregate.

Pat Tant: How do you describe the business case? How do you evaluate the opportunity?

Chris Wallace: Wireless traffic peaks in stadiums, train stations and busy urban areas as people get more devices, the devices become more data-hungry and applications use more data. Solving capacity problems now and gaining a good understanding and experience deploying Wi-Fi in conjunction with cellular systems is important for preparing for a future where the need for higher capacity will spread to wider areas.

Wireless network densification will require in-fill with various types of small cells in heterogeneous networks. Making use of unlicensed spectrum and small in-fill devices for cellular bands and for Wi-Fi access takes advantage of opportunities to increase network capacity.

For offload, it is not simply about diverting as much traffic as possible off of the cellular bands because we will be in-filling



A Cisco Systems In-building Systems Group analysis conducted in 2012 found that among the business models available to Wi-Fi network operators, retail interactions were the most difficult to implement and had the fewest applications, and bundled Wi-Fi was among the easiest to implement and had a significant number of applications. Other business models fell in a range in between.

with cellular small cells, too. It is about engineering the traffic onto the right access network for the user's application and what service level agreement he may have with the carrier. It involves partners with which the operator may have to share network access. It's about being able to engineer customer access to Wi-Fi and the cellular bands in the most efficient way to help the user experience.

Pat Tant: How is the network operator going to make money off of Wi-Fi?

Ted Dolan: Offloading is an internal business model for mobile network operators to manage the capacity of their licensed spectrum. With a Wi-Fi network that is pervasive enough, they can offload traffic and manage network expenses to improve operational efficiency and capacity for licensed spectrum.

As Wi-Fi becomes more pervasive, network operators may be able to create services to sell to consumers. (See Figure 1.)

Where a service provider establishes a Wi-Fi network, it could sell access to other service providers. For example, Cablevision installed a pervasive Wi-Fi network in Manhattan and Long Island, N.Y., and it made access available to their customers as a retention tool. Cablevision entered into discussions with Comcast and Time Warner to federate the model and allow those companies' customers — who are contiguous with Cablevision customers — to allow them to roam onto the network as part of the Xfinity package for Comcast or the Roadrunner package for Time Warner.

Another example could be where the service provider sells a Wi-Fi access point network or Wi-Fi mesh network into a stadium, mall or convention center and the venue makes it into a value-add for its customers, whether it is monetized the way a hotel or convention center might, or whether it is in a stadium where it offers fan access and supports stadium operations.

Steven Glapa: We see operators deploying indoor Wi-Fi with the thought in mind that, just for the sake of argument, if you have a $10 billion capex number to get your network from where it is today to where it needs to be in 10 years to support the traffic, you can cut that number in half by looking at a pervasive Wi-Fi deployment.

Corey Wagner: Once you have the Wi-Fi in place, allowing the venue to monetize the design turns the Wi-Fi into a platform they can customize to the venue with a splash or landing page that a user will see, and a platform with custom applications and localized services that they can use in the application. Wi-Fi gives them the ability to touch people individually who enter the venue. It also gives them reporting capability and continuous support mechanisms through call centers and network operating centers. That makes Wi-Fi an end-to-end solution.

In many venues, for monetization, you get another screen. A stadium for example, has a scoreboard and several hundred TVs throughout the venue. Now, with Wi-Fi and the smart phones people bring with them, it has several thousand new screens. Those become sponsorship assets or a

merchandise or concession sales platforms. It gives the venue a new avenue to impact the bottom line.

Pat Tant: That leads into one of the more critical things. Corey, from a carrier — AT&T's — perspective, how critical is the design stage?

Corey Wagner: Determining the number of people who will be in the area is the most critical portion of the design process. We have hotspots that range from one access point to several hundred.

Pat Tant: What's the end user going to do with this? What's in it for them?

Ted Dolan: Young people are used to having Wi-Fi access everywhere. Wi-Fi is the enabler of the value proposition of the nScreen computer and widescreen LCD integration where I can use any device to reach the network at any time in any place I want.

Cisco conducts primary research in the consumer broadband business. About six months ago, in Cisco's mobility and Wi-Fi study, we found that consumers are accessing Wi-Fi and mobility 80 percent of the time from a fixed location. Fifty percent of that is from their homes. Five percent of that 80 percent is from their offices. The remainder is from another fixed location.

Consumers use nomadic Wi-Fi access, not mobile or on-the-go access, even though we have mobile phones, smart phones and tablets.

Pat Tant: How do you determine the cost?

Chris Wallace: Steve pointed out it's half the cost for Wi-Fi to provide capacity compared with the licensed bands. That jibes with some of the work we have done. Small-cell Wi-Fi is almost an order of magnitude cheaper than trying to in-fill with more macro cells. Even in the licensed bands, small cells aren't the whole answer, because even if you had the licensed spectrum, which in many cases you don't, you still need equipment priced at a point that allows you to deploy the access points you need to provide the coverage and capacity.

Steven Glapa: There is a 10:1 difference if you look at just the basic equipment cost of Wi-Fi versus an LTE small cell. But the social cost to the operator gives an opportunity to those in the infrastructure business. In general, wireless network operators have fewer people in their operations organization today than they had 10 years ago. And these people are responsible for building, operating and maintaining 2G and 3G, neither of which are going away, and now they have added an LTE network. When solving network capacity problems, they don't want vendors to bring them more work to do.

One of the biggest components to the total end-to-end cost of building a high-density network is just the hassle of getting the thing built and operated, and working with these venues to solve the neutral-host problem. Anyone familiar with the DAS business knows that the number of entities that care about what is going on is large, and some of them compete with each other. Thus, the social mechanics of putting a system into a venue such as a hotel or stadium are not trivial. Thus, to the extent that the wireless infrastructure providers can work as an abstraction layer above all of that

Starbucks Coffee and McDonald's Restaurant locations are well known for offering Wi-Fi access — provided by AT&T.

operational complexity and present a united front to the mobile network operators and give them one relationship that they can manage and make these small cells happen, that's going to be immensely valuable.

There is a lot of money to be made in the extension of the tower model to the small cell, and especially Wi-Fi deployments indoors.

Another unique aspect in the wireless telecom carrier business is the thriving enterprise business portion. Enterprises are getting wise to a couple of things. One is the fact that they own a lot of real estate that the mobile operators would like to get into. It's like it was 15 years ago when they realized they could rent tower space and make some money from the operators. A second point is that they are not looking at the mobile network only as connectivity, but as a way to differentiate their venue. Shopping mall owners, in particular, are aggressively going after applications on top of the Wi-Fi.

All of these things are beginning to make it feel like there is a new service provider layer that can work with the enterprise.

Pat Tant: Do you think the network cost is being viewed as finishing the 3G/4G build out?

Corey Wagner: It can be. At AT&T we are growing the capacity to the scale that we have to meet. We have to use all of our available options, whether that's macro, DAS or Wi-Fi. Whichever option is the most cost-effective or a combination of the three, in many cases, is where we have to take it.

Pat Tant: The underlying factor is data growth, which has to solidify the business case. How do you determine the data growth? When does the business case make sense?

Corey Wagner: Wi-Fi has exploded, just as mobility has. In 2008, across all of our hotspots, it used to take us a full year to hit 20 million connections. We do 20 million connections every four days, now. The growth has been exponential, the adoption of Wi-Fi, and the proliferation of devices is behind it.

At AT&T Park, where the San Francisco Giants play, Wi-Fi has been installed for six years. We have over 300 access points deployed, and over a three-year period, we saw 625 percent growth in traffic. In 2010, on the mobility side, we increased the capacity by four times. The consumption of data in the venue has continued to skyrocket. The Giants have been a good partner in pushing it. The club's view on technology is that it is about the fan, and enabling them to do whatever they want.

In one of the World Series games in 2010, we saw over 20 gigabytes of data downloaded just from the first pitch to the end of the game, and the fans uploaded even more. Uploading video and pictures to Facebook and Twitter, telling their friends what they are doing, has become a critical component of delivering the service.

The Giants' CIO, Bill Schlough, has been on the forefront of pushing technology. He said, "We have made a concerted effort to invest in both Wi-Fi and 3G here at the ballpark. My vision is that every fan in every seat throughout the park can call, text and surf the web and watch video replays throughout the entire game."

That means offering a service to 45,000 fans, give or take, and allowing them to use their devices for whatever they want.

Pat Tant: What about operations, Ted?

Ted Dolan: Operating the Wi-Fi network once it is up and running is a big task that cannot be dismissed. The best operational approach is to integrate the operational folks into the planning process upfront. Start to record and learn as Wi-Fi hotspots or access mesh networks are deployed. Record everything that happens during the site survey and the installation. Create a constant feedback loop to get to standardized approaches and processes that will make operating the network much more efficient once the deployment is up.

Interviews with eight global service providers indicated that once they started those practices, they were able to drive 20 to 30 percent of the follow-up operational expenses after the deployments were made.

Pat Tant: Chris, Ericsson's proper integration has to be critical as well.

Chris Wallace: One thing we haven't talked too much about yet is integration of traffic from Wi-Fi networks as another access network into an Evolved Packet Core architecture along with the LTE traffic. As Steve says, there is operational overhead for operators running another Wi-Fi network when they have 2G, 3G and 4G networks out there.

Evolving standards push for more integration of the Wi-Fi traffic so operators can have one-stop policy control that is distributed and enforced on the Wi-Fi networks. Access and policy control are the sorts of things that an operator manages holistically in one place, rather than having to do separate provisioning of Wi-Fi access control, LTE access control policy enforcement, throughput, traffic steering and packet inspection. You can simplify the operational expense by consolidating that and by taking advantage of the new standards that are coming out.

Additional locations with Wi-Fi access that are perhaps not as well known for having Wi-Fi as Starbucks and McDonald's are FedEx, the Hilton Garden Inn and Home Depot.

Pat Tant: It involves customer retention, too, wouldn't you say?

Chris Wallace: Everyone just expects Wi-Fi to be there. From an operator's point of view, your competition is not just other mobile operators. When you're talking about 3G and LTE, your competition may be other mobile operators, but other players are getting into the Wi-Fi game. You may wind up having to pay them to provide Wi-Fi access to your customers versus them paying you to provide access on your Wi-Fi network.

For venues and cable operators, the business case opportunity is there to build a Wi-Fi network that will provide the capacity. You can call it offload or you can call it an additional access network that's going to provide the capacity, but there are revenue-making opportunities, going to venues, adding applications these sports teams want to have, such as richer content being provided in the stadiums, advertising, that sort of thing. Tapping into that revenue stream is a good opportunity for operators.

Corey Wagner: "The benefit to the end user is when they can hop on a Wi-Fi network, they are not using their data plan. They have unlimited service. They can do a lot with the services that otherwise would chew up their data minutes. They're going to be able to do it for free."

Pat Tant: Steven, operational comments?

Steven Glapa: You don't just set a Wi-Fi network and forget it. The exponential rise in demand for mobile Internet traffic is a curve that everybody knows, but when you look at a little slice of that, that means next week it is going to be different from last week. It's difficult in some of these high-density venues to know what people are going to be doing.

We had a deployment with an operator in Amsterdam in the Ziggo Dome, a 20,000-seat concert stadium. This is not for symphonies. This is for acts such as Lady Gaga and Madonna. For a Madonna concert, the downlink-to-uplink ratio was about the same during the entire time. But when Lady Gaga showed up two weeks later, the ratio was about the same while the warm-up bands were playing, and then the minute she hit the stage, every kid in the whole place was videotaping it and then sending it up to Facebook to say, "Ha ha, I'm at the Lady Gaga concert, and you're not." It was a 10:1 ratio, uplink versus downlink. Who knew?

During the Democratic National Convention, which we supported, the downlink-to-uplink ratio was consistent. Nonetheless, we did about a terabyte worth of traffic in a couple of days, for a 20,000-seat venue.

What's happening in these places is supercrazy and highly variable, so the instrumentation of your network, the management system that you have to do, watching your network and tuning it up over time, is a critical piece.

Chris Wallace: Being able to gather those kinds of statistics from your Wi-Fi network, as well as your 3G and LTE networks, gives you a much better view to be able to plan where the capacity holes are and anticipate where you need to add capacity and on which networks. The closer you can integrate the operation of the Wi-Fi network into the cellular network, the bigger the advantage.

Steve Glappo: When you put up hundreds of nodes in a true carrier network, you have to treat it just like it's the licensed band and monitor it.

Pat Tant: With Wi-Fi, who wins?

Corey Wagner: The goal is, everybody — end users, venue owners and network operators.

You're going to have a customer or a venue that you're delivering service to. We have our customers, our end users, who are holding a mobile device, and we as a carrier want to get that benefit from a network as well. The benefit to the end user is when they can hop on a Wi-Fi network, they are not using their data plan. They have unlimited service. They can do a lot with the services that otherwise would chew up their data minutes. They're going to be able to do it for free.

The venue owner has the ability to customize the venue, deriving a benefit in differentiating it from competing venues, offering a localized, custom experience and even enhancing their products and services. Hopefully, that will increase their sales.

For the carrier, offload is a benefit.

Those are the reasons we look to deploy the hotspots — the spectrum utilization, effectively using all of the wireless technology available to make sure we have the capacity to meet customers' demands. And Wi-Fi typically costs less to traverse data than it does over macro networks, so there is a potential cost saving as well.

Pat Tant: What will Wi-Fi look like in 2013, and what will it look like in five years?

Steven Glapa: In 2013, what you're going to see are many carrier networks built out to the scale of tens of thousands if not hundreds of thousands of access points. In the longer term, it looks like a lot more density. More and more markets

will be built out. We're working with one of the U.S. carriers on plans for a 90-market rollout of Wi-Fi. That's the scale at which people are thinking.

The technology is going to advance. Everyone is talking about 802.11ac as a great thing. The next version of it is not super-helpful because aggregating more channels in the 5-GHz band actually runs counter to spectral efficiency in high-density venues. But, 802.11ac Version 2 with multi-user MIMO communications is going to essentially double the capacity of Wi-Fi in another three or four years.

In some high-density situations, the 60-GHz band might come in handy. The kind of Wi-Fi that the Giants' CIO wants to have for all 45,000 people in the stadium is difficult to achieve by hanging antennas in the rafters because in the AT&T Center and similar stadiums, you don't have the ceiling to work with and you can't put access points close enough. An advantage of 60 GHz is that it doesn't go very far. You can begin to envision places where you have essentially a personal cell by your seat for maybe you and your two neighbors. I think you'll see that in another 10 years.

Chris Wallace: You'll see the scale of Wi-Fi networks increasing as more and more operators, MSOs, venues, and independent companies are building out Wi-Fi networks. In three, four or five years, you'll see it's just easier for users to use Wi-Fi as a network service than it is today. No hunting for SSIDs and no "who's mine," and "I'm in a busy place and I have 50 to choose from." You'll see automatic network selection.

You'll have Wi-Fi as part of your operator package. That will include international Wi-Fi roaming so you'll roam seamlessly on foreign carriers' Wi-Fi networks, just as you would roam seamlessly on a Wi-Fi network here. That's one of the biggest changes we see. It takes the user manual configuration and automates that and allows the operator to control access to all of those different technologies.

Ted Dolan: Maybe we should stop using the word offload and anticipate that in two years' time, more MSOs, more mobile network providers and more traditional fixed providers will have embraced Wi-Fi to the point where it becomes integrated into the network fabric, for both your mobility and for your broadband access.

Chris spent a lot of time talking about small cells. That's where I think this will be in two to three years' time.

Corey Wagner: Technology certainly will continue to advance. We're trying to make it easier for the end user. For example, we have an auto-authentication tool on our devices that allows them to automatically connect with any AT&T network without the end user having to do anything. That's where I see it heading — more tools like that for the end user. It doesn't necessarily change behavior. It just makes it easier and simpler. ■

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Photography by Don Bishop.

Demystifying the Challenge of Small-cell Backhaul

Solutions for next-generation networks may rely on non-line-of-sight (NLOS) backhaul to fit the deployment model and end goal of small cells. It provides the right cost structure to scale small-cell deployments.

By Frank Rayal

There's a consensus in the wireless industry that the ultimate success of small cells is affected and sometimes restricted by the need to maintain a low total cost of ownership for the entire small-cell deployment, of which the cost of backhaul is a major component. Hence, the small-cell wireless backhaul problem is primarily one of cost. Fortunately, the solution to this problem is not far from hand.

There are many solutions for small-cell backhaul, ranging from fiber, which provides the ultimate in capacity, to a number of wireless backhaul technologies that shorten the deployment cycle compared with fiber. The wireless technologies include line-of-sight (LOS) solutions. Examples include point-to-point (PTP) microwave and millimeter-wave solutions, point-to-multipoint (PTMP) microwave solutions and non-line-of-sight (NLOS) solutions. Except for NLOS backhaul, all other solutions have been used extensively and successfully in macrocell backhaul. However, when it comes to small-cell base stations, which are outdoor, below-roofline base stations, the story is different. Traditional LOS backhaul solutions are challenged for scale, meaning that they don't offer the lowest cost for large deployments. In contrast, NLOS backhaul is highly scalable for mass deployments. The following information explains how NLOS backhaul scales to reduce the total cost of ownership of small-cell base station backhaul.

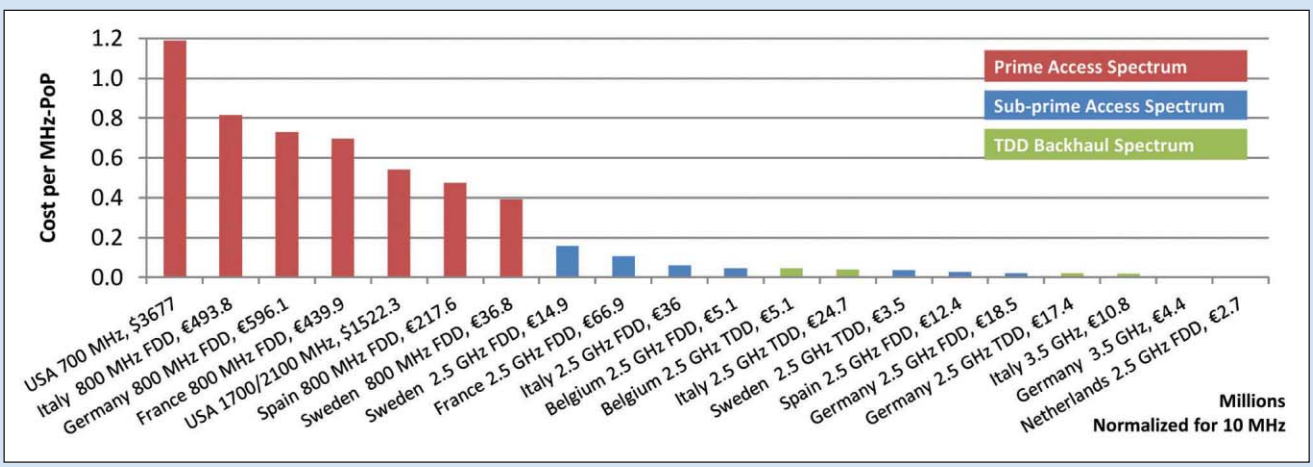

Figure 1. Comparative spectrum pricing.

To achieve a low total cost of ownership, one has to derive efficiencies from every aspect of the small-cell backhaul deployment. In addition to the cost of equipment, this includes the cost of spectrum, the cost of planning and deployment, attachment fees such as antenna and equipment space lease fees, and support and maintenance. So how does NLOS reduce the total cost of ownership? Let's look at each element of cost independently.

Cost of equipment: NLOS systems leverage the ecosystem of broadband wireless, which is a high-volume market. Semiconductor technologies used in the 2-GHz and 3-GHz bands provide for high-yield, low-cost RF components. There's also a high degree of integration in silicon, born of demand for low-cost broadband access products that result in further cost reductions. For these reasons, NLOS systems typically cost less than systems operating in frequency bands between 10 GHz and 90 GHz.

Cost of spectrum: NLOS uses sub-6-GHz bands, primarily the 2-GHz and 3-GHz bands. For broadband services in many regions of the world, large swaths of frequencies within these bands became available during the past 10 years. Although this spectrum has been significantly discounted for use in mobile access networks because of its poor wall and in-building penetration properties (see Figure 1), it is prime spectrum for NLOS wireless backhaul because limited propagation characteristics reduce interference and result in higher capacity and reliability of backhaul links. In the United States, the 2.3-GHz band, including the WCS band, is a strong candidate for mobile broadband services. In Europe and the rest of the world, the 2.6-GHz band is a strong candidate. Meanwhile, there are chunks of frequencies, such as 2.57 GHz to 2.62 GHz, the 3GPP Band 38, where deployment of NLOS backhaul is planned. On the other hand, particularly in Europe and much of the rest of the world, including Canada, the 3.5-GHz band is available for NLOS backhaul deployments. In the United States, the FCC is considering a spectrum-sharing regime for the 3.5-GHz to 3.65-GHz band that will open a new market for wireless technologies. The band lies in between incumbent federal government and commercial users.

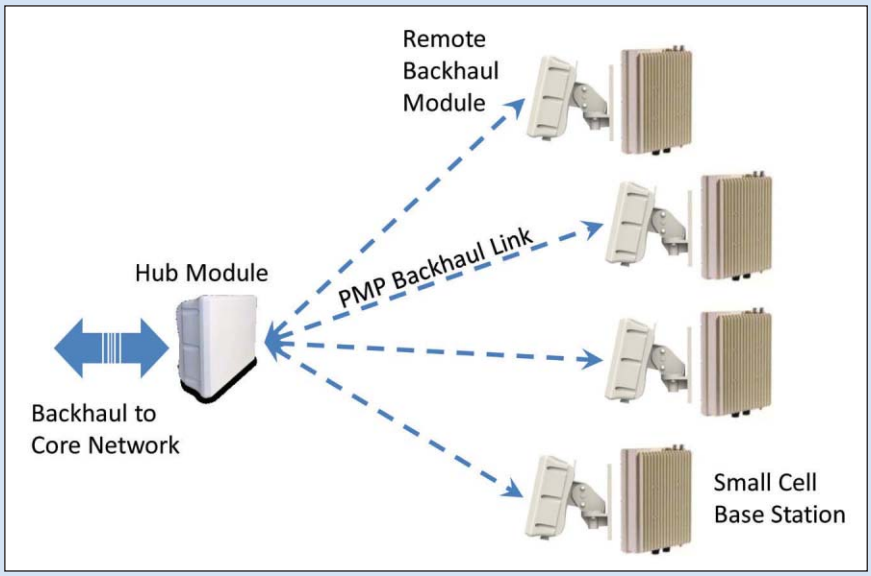

Figure 2. Point-to-multipoint configuration for small-cell NLOS backhaul.

In the meantime, the nonexclusive licensed 3.65-GHz to 3.70-GHz band is available for NLOS backhaul services. It offers the unique advantage of virtually eliminating spectrum expenses while significantly reducing the potential of interference. To operate in this band, licensees are also required to obtain from the FCC a license that can easily be obtained through its website at a nominal fee, and to register every station in the Universal Licensing Service (ULS) database. Licensees are required to coordinate with one another to resolve interference issues. This makes the 3.65-GHz band a much cleaner alternative to unlicensed bands such as 5.8 GHz, where the proliferation of wireless systems contributes to reducing the reliability of backhaul. The wireless systems include consumer products such as cordless phones and tablets.

The licensing scheme for sub-6-GHz bands is typically handled on a block-and-area basis for a period of 12 to 20 years. The operator is free to deploy as many links in an area as needed, without the need for extensive registration or frequency coordination with other operators. Although this presents an initial economic hurdle because spectrum expense is a capital expenditure, it provides much more flexibility in a number of ways that affect the business case in a positive manner versus LOS wireless backhaul solutions. For example:

- It eliminates the relatively long lead-time associated with microwave licensing.
- It eliminates the need for frequency coordination between different microwave licensees.
- It allows amortization of spectrum over an increasing number of small cells, which results in diminishing marginal cost; hence, it allows scalability of small-cell backhaul networks.

Deployment configuration: The architecture of the backhaul network is another cost-driver. NLOS technology is well-suited for PMP operation, which saves capital expenditures because a single hub module (HM) connected to the core network serves multiple remote backhaul modules (RBMs) connected to small cell base stations. The expense is reduced by 38 percent for four links. But perhaps more importantly, aggregating traffic from multiple small cells at the hub reduces the cost of backhaul to the core network. Given that a large number of small cells are forecasted in urban centers, the PMP configuration

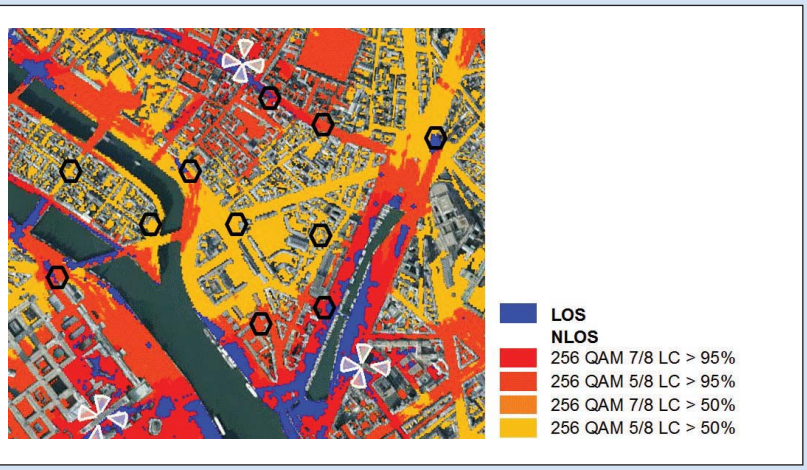

Figure 3. Service availability for a small-cell base station at 5 meters above ground level.

may be the *only* solution because it saves space on building rooftops where the hub module is placed (see Figure 2).

Cost of planning and deployment: NLOS systems are designed to operate despite obstructions between the transmitter and receiver by relying on a physical layer hardened against multipath fading, which is a characteristic of a propagation channel with obstructions. Multiple antenna systems that leverage multipath are used to increase the reliability and capacity of the backhaul link. Thus, NLOS systems can be deployed anywhere. This is important because small cells will be located in traffic hotspots that generally cover a small area. This is because NLOS allows the operator to drop a small-cell base station exactly where it is needed and bring backhaul to the small cell, as opposed to deploying the base station where backhaul is available, as is often done with macro cells.

Figure 3 shows backhaul service availability for a base station mounted 5 meters above ground. The area covered in blue is for LOS technologies and is highly limited, while service is available in the entire area for NLOS technology. For this reason, bringing LOS service to a small cell may require more than a single hop, which drives the total cost of ownership higher. From an installation perspective, NLOS technology requires only a single installer to point the remote backhaul module in the direction of best received signal, whereas two installers would be needed in LOS technologies to ensure accurate alignment between the transmitter and receiver, which in itself is a time-consuming process.

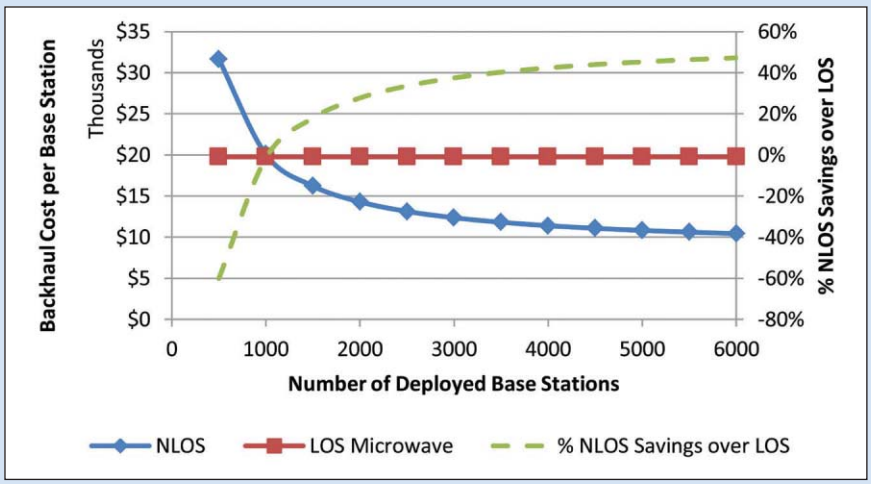

Figure 4. Backhaul cost per small-cell base station for NLOS wireless and LOS microwave solutions.

But before deployment, the operator needs to plan the backhaul link. This is yet another area in which NLOS cuts costs. There is no need for the expensive path profile surveys associated with LOS technologies. This reduces the effort and time required to get a small cell up on the air. Furthermore, the NLOS deployment is quick because frequency licensing and coordination with other operators is not required. The operator is able to realize immediate improvements in wireless network performance.

Attachment cost: The cost paid to mount equipment on poles is a key factor in determining how successful small cells will be. Put simply, these costs alone can make or break the business case. One way to reduce attachment cost is to integrate the small-cell base station with the backhaul module. Integration can be achieved at different levels, ranging from simple mechanical integration of two modules, the small cell base station and the backhaul module, in a single mounting contraption, to a possible full integration onto a single board and enclosure. In either case, NLOS backhaul is amenable to integration because, for example, the shape and function of the antenna and the air interface technology are similar to 4G/LTE access systems. Integration can result in a 30 percent savings in capital expenditure on equipment and up to a 50 percent savings in recurring attachment fees that count toward the operational expenditure.

Multiple antenna systems that leverage multipath are used to increase the reliability and capacity of the backhaul link.

Ongoing maintenance: System failures and service interruptions translate directly to lost revenue, frustrated customers and a damaged brand. Because small cells are deployed at relatively

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low elevations, typically 3 to 5 meters, their performance is more susceptible to changes in the surrounding environment. A new building or simply a sign may block the path of an LOS system, resulting in an extended outage. Not so with NLOS systems, which are robust to such changes in the surroundings. This translates directly to lower support and maintenance cost over the lifetime of a small-cell deployment, which typically is five to 10 years.

The business case: Keeping in mind the qualitative outline of costs as described, let's look at a quantitative example for the 10-year cost to backhaul a single small-cell base station using NLOS versus LOS microwave solutions. Assume that 40 megahertz of spectrum is required with a 1:3 PMP ratio for NLOS backhaul at $0.007 per megahertz per capita. For microwave spectrum, assume a $1,200 one-time setup fee. The deployment occurs during the first two-year period of the financial model. Figure 4 shows that it only takes about 1,000 base stations for NLOS to become the preferred solution.

Financial models of different backhaul solutions show that NLOS backhaul provides the lowest total cost of ownership when the plan calls for deploying a high volume of small cells, such as 1,000 units or more.

In other words, if an operator is deploying more than 1,000 small cells, it makes economic sense to deploy NLOS backhaul. The marginal cost of NLOS links continues to decrease as the number of deployed links increases, whereas the cost for LOS systems remains constant. In an efficient LOS deployment, it costs the same amount per link to deploy one unit or 1,000 units. This is not the case in NLOS, mainly because the spectrum-licensing regime results in diminishing marginal cost, leading to a lower total cost of ownership once a certain threshold for number of deployed small cells is surpassed.

Although we used licensed LOS microwave for the comparison, the use of unlicensed band millimeter-wave solutions gives similar results. This is because today millimeter-wave solutions are priced higher than microwave solutions in many instances, and the cost of millimeter-wave solutions exceeds the combined cost of microwave solutions and the license fee.

Financial models of different backhaul solutions show that NLOS backhaul provides the lowest total cost of ownership when the plan calls for deploying a high volume of small cells, such as 1,000 units or more. NLOS wireless backhaul is uniquely positioned to deliver a scalable backhaul solution for small-cell deployments. Although there is an upfront capital expenditure for spectrum, unless unlicensed spectrum or the nonexclusive licensed band is used, the cost for spectrum can be reduced significantly if a third party provides backhaul as a service to mobile operators. This service then quickly translates into a profitable venture because there are several mobile operators to serve the market. In addition, a significant cost reduction can be achieved by acquiring the skillset and efficiency required for deploying small-cell base stations and backhaul systems on poles, sidewalls and other structures.

Strategic solution

In the near future, mobile operators will be hard pressed to cap their infrastructure expenditure, given that the average revenue per user is flat or declining in most markets. Small-cell deployments will only take off when the entire cost structure is palatable. To this end, NLOS backhaul is a strategic solution that fits well with the deployment model and end goal of small cells. It provides the right cost structure to scale small cell deployments that is unmatched by competing technologies. ■

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Using Utility and Lighting Poles for Microwave-based Small-cell Backhaul Systems

There is more leeway under prevailing twist-and-sway standards than you might think, and carriers should consider using utility and light poles for microwave backhaul deployment.

By Eduardo Sanchez

Traditional towers may not be available for mounting microwave equipment for small-cell backhaul, so carriers are looking at utility and light poles as potential mounting sites. However, operators are concerned that these smaller poles will sway too much in the wind to support effective microwave communications. The following information explains standards and requirements for pole sway in nontower deployments.

Twist-and-sway requirements for towers and poles that support backhaul microwave hops are more stringent than for other RF equipment. This is especially true for deployments in frequency bands above 18 GHz, where the antenna beam width is typically narrower. Standards such as Telecommunications Industry Association TIA-222-G set a minimum sway and twist that a structure should endure for a microwave installation.

The subject causes concerns among network operators interested in deploying microwave for small-cell backhaul on structures such as utility, lighting and traffic poles that are not designed to meet the TIA standards. Although the use of a sturdy structure is always recommended, a close look at lighting, traffic and utility poles suggests that under certain circumstances, these structures can be an option for deploying microwave backhaul for small cells.

Different types of poles are governed by different standards, and the usefulness of a particular pole for mounting a microwave backhaul system depends on environmental conditions and how they affect the standards.

Utility poles

Utility poles are primarily designed to support distribution lines and structures such as electric power, cable television and fiber-optic cables. For details, refer to "Special Research Topic Report on Current Practice in Utility Distribution Poles and Light Poles" by Adam Crosby, published in 2011. A copy is available at *www.kornegayengineering.com/wp-content/uploads/2011/05/structural-utility-distribution-light-poles-whitepaper-acrosby.pdf*. Wooden poles that support distribution lines are built to meet the National Electric Safety Code (NESC) and the American National Standards Institute 0.5.1 (ANSI 0.5.1) standards. Horizontal and vertical loading creates sway. The NESC sets horizontal and vertical loading standards from various combinations of wind loading and ice on poles.

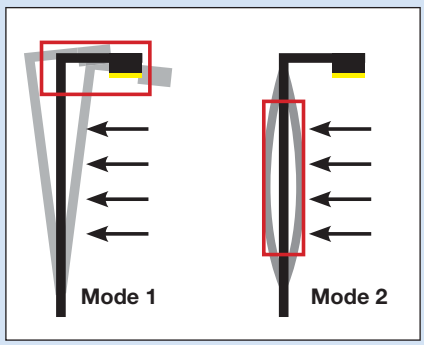

Figure 1. Pole vibration types.

Wood poles are governed by ANSI 0.5.1, which classifies poles based on top circumference. Different tables are generated based on wood type and specify the stresses the pole can resist. These stresses are calculated

by applying a horizontal tip load to simulate the horizontal forces transferred from the wires to the pole due to wind load. The common practice is not to design each pole based on standards but for experienced personnel to select the pole from manufacturers' handbooks — or in more complicated cases use specialized software — to estimate the effect of wind and ice on the pole. Although wood poles are also subject to warping and tilting, this occurs at such a slow rate that periodic realignments of the antenna may be required. Other materials also used for utility poles include steel and concrete.

Light poles

Light poles have a great variety of uses that include street, road or area lighting, and traffic signs. The standards that govern light poles include:

- **AASHTO:** The American Association of State Highway and Transportation Officials standard specifies the general requirements, materials, design specifications, wind and weight loads under different environmental conditions.
- **State-specific:** Each state can decide what standard to use, but in most cases states use a specific version of the AASHTO.
- **Commercial criteria:** If the pole is not going to be used by the department of transportation, in most cases the manufacturer will use its own criteria instead of the AASHTO standard. Commercial criteria are not as stringent as standards-based criteria because in many cases cost is a definitive factor.

Vibrations in light poles

Because many pole deployments are based on commercial criteria instead of standards like ANSI or AASHTO, there is a greater possibility that light poles will vibrate under steady winds below 45 mph. These vibrations not only can create sway for microwave deployments but also can lead to mechanical failure of the pole. Field data suggests that poles over 35 feet that have a square cross section and effective projected area (EPA — the projected area combined with the appropriate drag coefficient) of less than 2 feet squared ($2ft^2$) are more likely to vibrate.

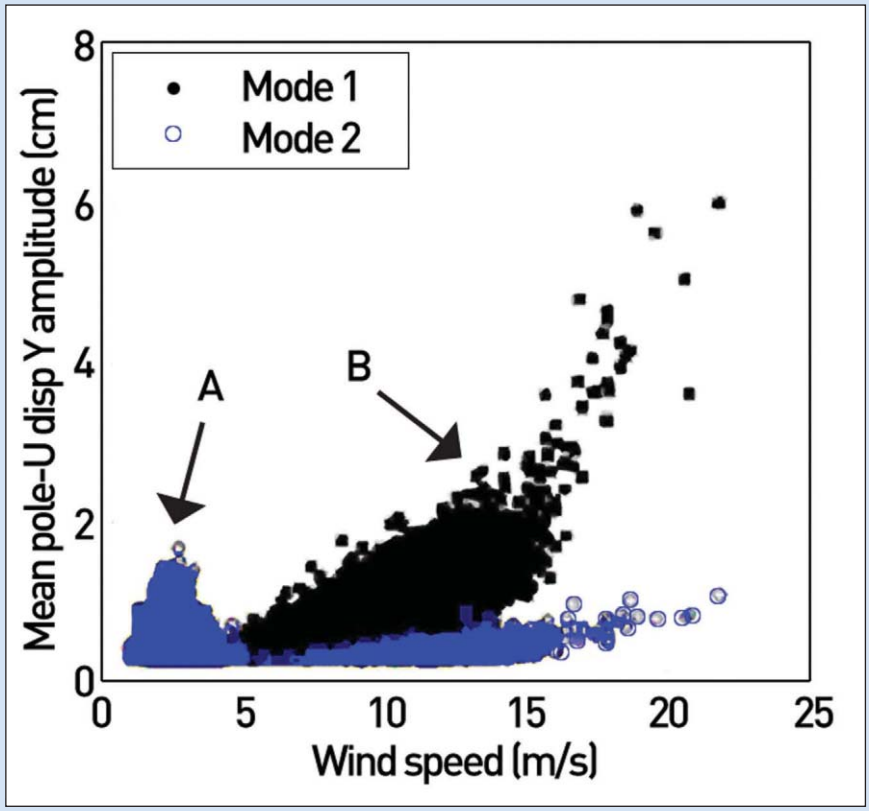

Figure 2. Vibration data for light poles.

The two main vibration types for light poles are shown in Figure 1.

Both of these vibration types will create sway that might affect the link performance. Mode 1 vibration is movement of a pole pushed by high winds. Mode 2 vibration is movement based on the resonance of the pole in high winds.

Figure 2 is from a Texas Tech University study that shows the measured vibration results for a typical light pole. The study, "Field Observations of Wind-induced Mast-arm Lighting Pole Vibration," was written by Delong Zuo of Texas Tech and Chris Letchford of the School of Engineering, University of Tasmania. Basic conclusions are:

- For wind speeds below 5 meters per second (11 miles per hour), pole vibration is primarily Mode 2, with a maximum displacement of 2 centimeters as measured at the top of the pole. This type of vibration depends on the direction of the wind, with measured directions close to 90° and 270°.
- For wind speeds above 5 meters per second, Mode 1 and Mode 2 both contribute to pole displacement as much as 6 centimeters. Mode 1 vibration is the larger contributor. The pole vibration contributions from Mode 1 and 2 are additive and can be translated to degrees to obtain the total sway of the pole.

The case for a typical light pole

In order to evaluate the effect of sway and twist in possible backhaul deployments, Table 1 shows the results of the comparison of field measurements from a light pole to the calculated maximum sway and twist according to Annex D of the TIA-222-G standard for the bands of 18, 23, 70 and 80 GHz. The calculated maximum sway from TIA-222-G can

Frequency band (GHz)	18	23	70/80
Antenna gain (dBi)	33.5	30.5	45
Antenna 3dB beamwidth	2.2°	3.3°	0.8°
Antenna size	1 ft./0.3m	1 ft./0.3m	1 ft./0.3m
TIA-222-G Standard (10 dB loss)	3°	2.3°	0.8°/0.7°
Maximum wind speed	Pole sway (degrees)		
5 m/s (11 MPH)	0.1°	0.1°	0.1°
10 m/s (22 MPH)	0.22°	0.22°	0.22°
15 m/s (34 MPH)	0.26°	0.26°	0.26°
20 m/s (45 MPH)	0.64°	0.64°	0.64°

Table 1. Pole sway and microwave small-cell deployments.

be used as a reference to gauge the maximum allowable sway and twist for a standard telecommunications structure against the sway experienced by a typical light pole.

The table shows sway criteria for a link that runs between a building with no sway and a light pole. For example, at 80 GHz, the maximum allowable sway under TIA-222-G is 0.7 degrees, while under a 45-mile-per-hour wind, a pole will sway only 0.64 degrees. If we assume the deployment scenario is from a building to a pole with the measured data, it is clear that for all deployment cases, the pole sway (highlighted in green) is less than the allowable sway on a comparable standards-compliant telecommunications tower.

Recommendations

As utility poles (ANSI O.5.1 and NESC) and light poles designed under the AASHTO guidelines usually have higher robustness than light poles designed using commercial criteria, we can infer that vibrations due to steady winds less than 45 miles per hour will be less likely to occur in standards-compliant poles.

However, even for poles designed using commercial criteria like the light pole shown as an example in Table 1, vibrations that create sway can be in a range tolerable for link deployment. The installation of any structure on existing poles, including small-cell and backhaul radios and antennas, will necessarily change the weight and wind loading characteristics of the deployment pole. This will require a structural analysis to verify if the existing poll still meets the standards or the commercial criteria set by the pole manufacturer.

In summary, carriers considering light and utility poles for microwave backhaul deployment have more leeway under prevailing twist-and-sway standards than they might think, and they should consider these types of deployments for small-cell backhaul. ■

Eduardo Sanchez is technical marketing engineer at Aviat Networks.

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New Jersey Wireless Association donates fundraising proceeds to the Wounded Warrior Project

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.

NEW JERSEY WIRELESS ASSOCIATION

Activities

March 14
Quarterly Educational Luncheon

June 18
7th Annual Charity Golf Outing
Forsgate Country Club, Monroe Township

Important Contribution

The New Jersey Wireless Association was instrumental in the enactment of New Jersey collocation legislation.

Award

The New Jersey Wireless Association received the Gold Medal in the 2012 State Wireless Association Program Olympic Games, a program created to encourage participation, communication and unity among state wireless associations.

A public service ad from *AGL*

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NEW JERSEY WIRELESS ASSOCIATION

newjerseywireless.org

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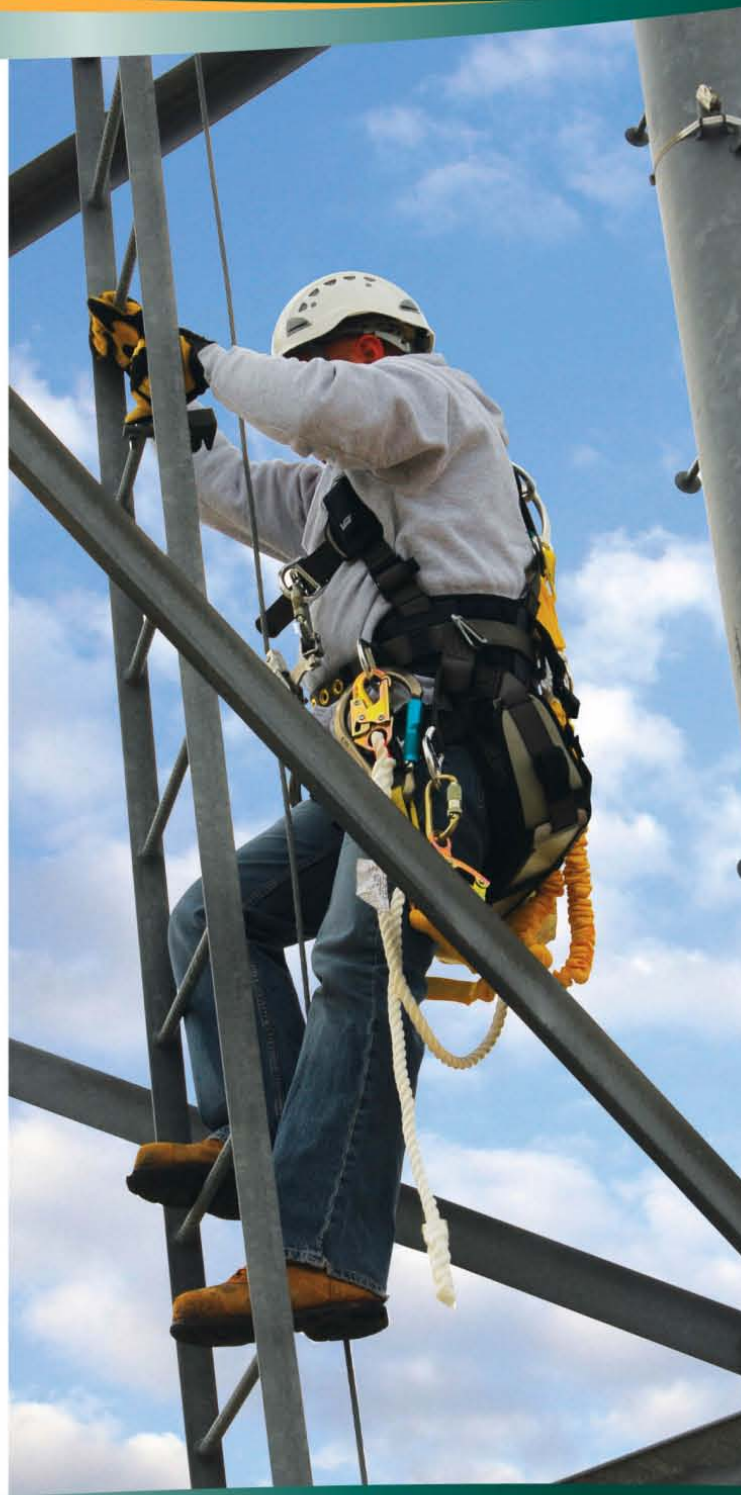

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