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SMALL CELLS

- Self-organizing Microwave Wireless Backhaul

June 2017 /// Volume 14 /// No. 6

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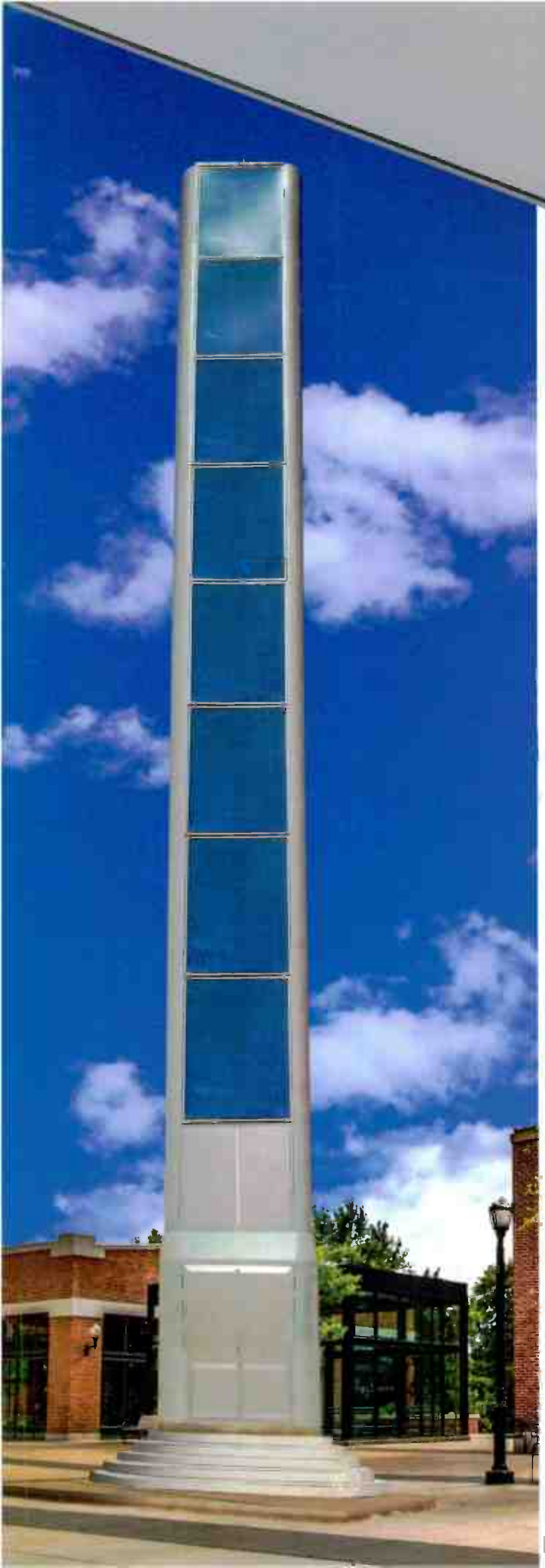

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With Towers in Mind

At the Wireless Infrastructure Show (WIS) in Orlando last month, Jonathan Adelstein said he places a high priority on fixing legislation that calls for the marking of many rural telecommunications towers as aviation hazards. Adelstein heads the Wireless Industry Association (WIA), a membership organization that owns WIS. FCC Commissioner Michael O'Rielly cited research indicating it could cost as much as $750 million to paint the many thousands of towers affected by the legislation, with repainting every seven years or so. The legislation addresses the hazard to pilots of aircraft used for crop dusting posed by temporary meteorological testing towers, but that perhaps inadvertently applies to telecom towers, too.

Although no one wants to put pilots at risk, another factor involved is the risk placed upon workers who would have to climb the towers to paint them.

O'Rielly, who spoke at WIS, said, "It is without question that there have been accidents involving crop dusters. But, it doesn't appear that communications towers are to blame one iota."

The commissioner also pointed to a possible unintended consequence that the added cost of painting towers could discourage broadband network construction in rural areas, limiting rural economic development and stymieing smart agriculture.

At the table where I sat, listening to the commissioner, two managers with one of the three public tower companies nodded their heads in agreement when O'Rielly said the escalating costs of the tribal approval process for towers represents a problem the FCC should address.

"One provider reports that, in 2011, they were paying an average of $439 in tribal review fees per site, and now they pay on average $6,754," O'Rielly said. "That's almost a 1,500 percent increase. And, more tribes have been expressing interest. For instance, 19 tribes responded to an application to add an antenna to a building in Cleveland and 39 tribes, of which 27 demanded fees, wanted to review sites in suburban Chicago. This is not economically sustainable. Further, tribes are receiving the payments, but then never respond as to whether there is actual concern, causing endless delays."

I asked the commissioner how much power the FCC has to reduce tribal approval costs. He said the FCC has some authority and has a role to play. He said the FCC also has an obligation to inform Congress of the need for changes to the statute. O'Rielly said he has testified before Congress about it.

Relief may not come soon, but we hope that one day it will come.

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Light-touch Regulation Supports Broadband Service Growth

By Ajit Pai

Broadband means economic opportunity. The internet has enabled the democratization of entrepreneurship. Today, with a powerful plan and a broadband connection, you can raise capital, start a business, immediately reach customers worldwide and disrupt entire industries. Never before in history has there been such opportunity for entrepreneurs with drive and determination to transcend their individual circumstances and transform their worlds.

There are opportunities in every city in every corner of the world, if — and this is a big if — you have high-speed access to the internet. That's why, as chairman of the FCC, I will pursue policies that promote infrastructure investment, foster innovation and expand next-generation networks across the United States.

Cusp of Advances

Within living memory, it was thought that radio-frequency spectrum above 3 GHz could not be used for mobile communications. Today, one can use millimeter-wave spectrum to produce multi-gigabit speeds. That means 5G could transform the wireless world. And when you add the potential of new satellite and fixed broadband technologies, as well as further innovation in 4G LTE, we stand on the cusp of exciting advances that will bring unparalleled choice and competition to consumers.

But it's not a forgone conclusion that we will fully realize this technological potential. After all, building, maintaining and upgrading broadband networks is expensive. And our 5G future will require a lot of infrastructure, given the densification of 5G networks. In the United States, operators will have to deploy millions of small cells, and many more miles of fiber and other connections to carry all this traffic. Doing all this will demand massive capital expenditures.

Broadband Investment

The key to realizing our 5G future is to set rules that will maximize investment in broadband. If we don't, the price could be steep. After all, networks don't have to be built. Risks don't have to be taken. Capital doesn't have to be spent in the communications sector. And the more difficult government makes the business case for deployment, the less likely it is that broadband providers big and small will invest the billions of dollars needed to connect consumers with digital opportunity.

As we move toward 5G, regulators must also recognize something many people often don't: Innovation is not limited to the so-called edge of networks. Innovation within networks is also critical, especially in the mobile space. To realize the 5G future, we need smart infrastructure, not dumb pipes. And we need to make sure our rules recognize this reality.

Investment and Innovation

We are in the process of returning to the light-touch approach to regulation that produced tremendous investment and innovation throughout our entire internet ecosystem, from the core of our networks to providers at the edge.

Let me highlight a few parts of that framework. First, during the Clinton administration in the 1990s, American policymakers forged a historic consensus across party lines that the internet should be free from heavy-handed regulation. Second, in the early 2000s, the United States rejected the notion that the broadband market was a natural monopoly. Third, we embraced a flexible-use policy for wireless spectrum, which enabled our wireless networks to evolve with technology, including the rollout of 4G LTE on a timeline that matched consumer demand. Fourth, we freed spectrum for mobile broadband, auctioning AWS-1 spectrum in 2006, 700-MHz spectrum in 2008 and 65 megahertz of mid-band spectrum in 2015. The incentive auction will reallocate 70 megahertz of spectrum from TV broadcasters to wireless providers. We also opened nearly 11 gigahertz of spectrum in the bands above 24 GHz for mobile use.

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based competition, flexible-use policy and freeing up spectrum have produced impressive results in the U.S. market. Our private sector has spent $1.5 trillion since 1996 to deploy broadband infrastructure. And consumers reaped the rewards of all this investment. On the wireless side, for example, 98 percent of Americans now have access to three or more facilities-based providers. And the United States has led the world in the deployment of 4G LTE.

Not long ago, cars, appliances and other things were analog islands unto themselves. Today, we are at the dawn of the internet of things, with 15 billion internet-connected devices and over 50 billion expected by 2020.

Likewise, a generation ago, a cellphone was a big, clunky piece of equipment that enabled scratchy voice calls, if you were lucky. Today, there are nearly 250 million smartphones in the United States alone. Consumers use them for everything from uploading live-stream videos to playing games — and even placing the occasional phone call. We would not have seen such innovation if, in the 1990s, the government had treated broadband like a railroad or water utility.

Last-century Regulation

However, two years ago, the United States deviated from its successful, light-touch approach. The FCC decided to apply last-century, utility-style regulation to today's broadband networks. Rules developed to tame a 1930s monopoly were imported into the 21st century to regulate the internet. This reversal wasn't necessary to solve any problem; we were not living in a digital dystopia. The policies of the Clinton administration, the Bush administration, and the first term of the Obama administration had produced both a free and open internet and strong incentives for private investment in broadband infrastructure.

Two years later, it has become evident that the FCC had made a mistake. The new approach injected tremendous uncertainty into the broadband market. And uncertainty is the enemy of growth: After the FCC embraced utility-style regulation, the United States experienced the first-ever decline in broadband investment outside of a recession. In fact, broadband investment remains lower today than it was when the FCC changed course in 2015. And we have seen much concern about whether the FCC would permit or ban service plans.

> *"The key to realizing our 5G future is to set rules that will maximize investment in broadband. If we don't, the price could be steep."*

New Generation

FCC leadership has now passed to a new generation, dedicated to renewal as well as change. We are confident in the decades-long, cross-party consensus on light-touch internet regulation — one that helped America's digital economy thrive. And we are on track to returning to that successful approach.

We ended the FCC's investigation into so-called zero-rating or free-data offerings. Free-data plans have proven to be popular among consumers, particularly those with low incomes, because they allow consumers to enjoy content without data limits or charges. They have also enhanced competition. Nonetheless, the FCC had put these plans under the regulatory microscope. It claimed that they were anticompetitive, would lead to the end of unlimited data plans or otherwise limit online access. But the truth is that consumers like getting something for free, and they want their providers to compete by introducing innovative offerings. Our recent decision simply respected consumers' preference.

Unlimited Data Plans

The best evidence of the wisdom of our new approach is what happened afterward. In the days following our decision, all four national wireless providers in the United States announced new unlimited data plans or expanded their existing ones. Consumers are now benefiting from these offers — offers made possible by a competitive marketplace. And remember: Preemptive government regulation did not produce that result. The free market did.

In the future, the FCC will not focus on denying Americans free data or issuing heavy-handed decrees inspired by the distant past. Instead, we will seek to advance the networks of the future and the innovative new products and services that take advantage of those networks. And as we do so, we will preserve a free and open internet. We know from two decades of experience that utility-style regulation is not necessary

to achieving that goal. As one of my predecessors, FCC Chairman Bill Kennard, put it in 1999: "The internet is really blossoming, but some policymakers and politicians want to control it and regulate access to it. We should not try to intervene in this marketplace. In this space, it's very difficult to mandate openness in a regulatory manner." In my view, Chairman Kennard was not just practical, but prescient.

Government Role

At the same time, however, we recognize that government does have a role to play when it comes to broadband. For example, a marketplace that isn't competitive doesn't serve consumers well. So our approach will not be zero regulation, but light-touch regulation — rules backed by long-standing principles of competition law.

We will also create incentives to deploy broadband in parts of our country that have not yet been reached by private investment. The FCC has announced a plan to spend $4 billion to expand mobile broadband in rural America. We will devote these funds to bringing Americans living in the analog age into the digital one. And we will do even more in the future to incentivize every sector, every company to build networks and to compete.

In short, America's approach to broadband policy will be practical, not ideological. We will embrace what works and dispense with what doesn't.

That means removing barriers to innovation and investment instead of creating new ones. That means taking targeted action to address real problems in the marketplace instead of imposing broad, preemptive regulations. And that means respecting principles of economics, physics, and law and acting with humility as we regulate one of the most dynamic marketplaces history has ever known. This vision will unleash the massive investments that will help the United States realize its 5G future. ■

Ajit Pai is chairman of the Federal Communications Commission. Edited for length and style, these are remarks he made at the Mobile World Congress in Barcelona, Spain, on Feb. 28, 2017.

End of Broadcast Incentive Auction Brings More Questions than Answers

By J. Sharpe Smith

The industry is attempting to unpack the results of the recently ended FCC broadcast incentive auction, which was highlighted by T-Mobile US spending $7.9 billion, Dish Network spending $6.2 billion and Comcast spending $1.7 billion. Who won? Who lost? Where are the opportunities?

Most of the initial work will focus on tall towers, as winning bidders hustle to clear broadcast stations from the radio-frequency spectrum in an activity known as the TV repack. Each broadcast station has unique requirements. Some stations will relinquish their TV channels. Other stations will move to different frequencies. And still other stations will move their channels in a virtual sense, but will actually start sharing other broadcast stations' towers and channels.

"The first step is to move the broadcasters off the frequencies, which will require a lot of work that is pretty specialized," said Alex Gellman, co-founder and CEO of Vertical Bridge. "There will be the need for traditional wireless services providers, including tower climbers for line, transmitter and antenna work."

Wireless companies could start building facilities to use the 600-MHz channels on a market-by-market basis, or they could wait until the last of the broadcast stations exit, thereby leaving all of the spectrum clear. That process may take as long as three years to complete, because of the deadline the FCC set for broadcast stations to vacate the frequencies.

"Normally, the tower industry sees a lot of deployment activity between 18 and 36 months after an auction," Gellman said. "This one is going to take a little longer, as far as the wireless carriers go."

Top bidder T-Mobile won 31 megahertz of spectrum nationwide, on average, or 45 percent of the spectrum auctioned, which quadrupled its low-band UHF holdings. The carrier has been preparing for the repack of the TV spectrum for some time.

"T-Mobile wants to deploy this spectrum as quickly as possible," said Gellman. "The market for broadcast tower services was a potential bottleneck that could slow down the TV repack, so the carrier has been actively growing that market."

Tower Industry Opportunities

Vertical Bridge has identified areas where it has tall radio broadcast towers that can accommodate TV station antennas. "We are reaching out to the companies that sold off their spectrum to see how we can help," Gellman said. "Broadcasters have options, and we want them to know that."

The majority of the opportunities for tower companies will have to wait until the spectrum is clear. "Secondarily, down the road, we see an opportunity related to deployment by U.S. Cellular, T-Mobile, AT&T, Comcast and Dish," Gellman said.

The major winners break down into three groups: carriers, new entrants and investors, each of which has different reasons for purchasing spectrum.

T-Mobile

T-Mobile is most likely to use the spectrum for coverage as it continues to catch up with Verizon Wireless and AT&T Mobility. It has deployed equipment to extend its network coverage using frequencies in the 700-MHz band during the last two years.

"Spectrum at 600 MHz is not great for high-density deployments which is why the final bid numbers were not as high as some people speculated they would be," Gellman said. "The final bid numbers were about half of that," Gellman said.

Comcast

In April, as a mobile virtual network operator, Comcast began reselling airtime on the Verizon Wireless network, giving Xfinity Mobile customers access to unlimited data plans and access to millions of Comcast Wi-Fi hotspots. Gellman said Comcast will use its spectrum to build out a network, which would reduce its dependence on

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Alex Gellman, co-founder and CEO, Vertical Bridge.

Cory Crenshaw, president, Crenshaw Communications Consulting.

the Verizon network and therefore also reduce its operational expenses.

"Having 600-MHz spectrum allows Comcast to provide a high and thin coverage blanket, and if the capacity gets exceeded, it can always fall back to the Verizon network," he said. "The calculus is based on the economics of providing service. The 600-MHz band is good for propagation. It is not necessary good for capacity. Initially, it may work very well for them."

Craig Moffett, a senior research analyst at MoffettNathanson, was not quite as upbeat. Comcast's 10-megahertz buy across its footprint fell well short of Moffett's expectations of a 20-megahertz buy nationwide.

"Comcast's tepid participation inevitably makes one less confident that Comcast's long-term intention is to go it alone," he wrote. "Or to put it more bluntly, the odds that they will someday buy a wireless operator — read T-Mobile or Sprint — just went up."

Of all the wild cards in this auction, Dish is arguably the wildest. It already had lots of spectrum before the auction, including 40 megahertz in the AWS-4 (2000/2200 MHz) band, 10 megahertz in the H-band and 6 megahertz at 700 MHz, as well as 25 megahertz of AWS-3 spectrum, according to Zachs Investment Research.

"With the broadcast incentive auction, Dish has invested billions of dollars in spectrum," Gellman said. "Its spectrum buy confused many analysts. Will they kick the can down the road, will they truly deploy a commercial network for broad use, or will they sell it? I don't think anyone knows yet."

Moffett was decidedly down on Dish's spectrum buy, noting that it seemed to fly in the face of industry expectations that the company would either be purchased by a wireless carrier or it would sell its spectrum to a wireless carrier.

"How can you reconcile the view that Dish Network [plans to sell its spectrum] with the fact that, by definition, they just outbid every possible buyer for precisely the same spectrum they would now hope to sell?" he wrote. If Dish is preparing for a merger, one of the possible acquirers — Verizon — didn't even bid for spectrum, Moffett added.

Regulatory Compliance

Cory Crenshaw, president of Crenshaw Communications Consulting in Texas, said that if changing the physical plant was all that broadcast stations had to do during the TV repacking period, 39 months probably would be adequate. But she said the regulatory compliance process may prove to be an obstacle that could take six to 24 months or more.

As a regulatory compliance consultant for FCC and Federal Aviation Administration matters, Crenshaw said the repack will require work on more structures than just the broadcast towers. She said there might be as many as 30 other communications structures spread out across the coverage area that feed into the network. Compliance filings may be needed for all of those structures, whether they are new towers, reinforcements, new antenna heights, lighting changes or environmental assessments.

Speaking at the NATE Unite conference on Feb. 28 in Fort Worth, Texas, and in an interview with *AGL Magazine*, Crenshaw said every one of the towers in the network may need to be touched. "Those touches will require a massive volume of filings with the FCC and the FAA for repacking," she said.

Businesses in the wireless infrastructure industry must be vigilant in making regulatory filings with the FCC and the FAA from the start of repacking

to have the best chance of completing the process before the FCC's deadline, Crenshaw said. Applications for construction permits have to be filed no more than 90 days after April 13, the date on which the FCC released the closing and reassignment public notice for the auction. Applicants have some flexibility to expand contour coverage detailed in applications filed during the initial 90-day window — with justification and appropriate showings.

For licensees that need to request the FCC to grant special temporary authority (STA) or a rule waiver to cover their wireless communications or broadcasting facilities' operations, Crenshaw said it is important to file applications during the first 90 days.

"Whenever you file an STA or a waiver on a major mandate like this, you must have a really good reason," she said. "Be sure to give them a documentation trail on why this is justified. The reality is that some tower owners won't know they need to file for a waiver on the scheduled deadline or any other waiver concern until they're in the middle of a process."

Crenshaw said she expected that during the first 30 days after the FCC issued the closing and reassignment public notice, industry experts and specialists will have been busy performing thorough assessments of the broadcasters' networks and what the infrastructure looks like. The work would be intended to answer several questions: What changes do they really need to make? Do new towers need to be built, do dishes need to be moved around, or does the backhaul need to revamped?

"Once that is done, the proper paperwork should be filed with the corresponding federal agencies or Native American tribes as soon as possible," Crenshaw said.

The FCC reported that bidding in the auction closed on March 30, 2017, repurposing 84 megahertz of spectrum — 70 megahertz for licensed use and another 14 megahertz for wireless microphones and unlicensed use. The auction yielded $19.8 billion in revenue, including $10.05 billion for winning broadcast bidders and more than $7 billion to be deposited to the U.S. Treasury for deficit reduction. ■

The World's Only Self-organizing Microwave Backhaul

For SoftBank Japan, rapid small cell deployment in the urban jungle called for fast, efficient installation of backhaul.

By David Turner

Urban small cells deployed at street level are the next logical step to meet growing data traffic demand in city centers. Practical solutions need to be quick and easy to install, adapt seamlessly with tactical evolution and be resilient during outages. SoftBank installed CCS Metnet self-organizing microwave backhaul in the challenging metropolis of Tokyo, delivering valuable insight into the behavior of 5G microwave.

Network Topology

Planning the deployment of urban small cells involves trade-offs between three key capabilities: backhaul, power and site availability.

Seven nodes were installed on existing telegraph poles, with two directly connected by gigabit fiber backhaul. The simplest links were direct line-of-sight along the street, which coped with reflections from buildings on both sides. The most remote node had three wireless links (hops) to reach fiber backhaul. The topology of the deployment shown in Photo 1 is a live screenshot from the management system. Photo 2 shows Metnet nodes installed on the streets of Tokyo.

Ultimate Flexibility

The site preferred by RF planners may not have electrical power; fiber backhaul may be unavailable or have long lead times to install; some sites may be much more costly or inaccessible than others. Flexibility is critical for success.

In the SoftBank implementation, CCS Metnet simplified the planner's dilemma by providing high-capacity, highly resilient wireless backhaul that could be quickly deployed in the rapidly changing environment of Tokyo.

Operating in the 26-GHz band where radio-wave propagation normally is constrained to a line of sight, live trials in downtown Tokyo have proven NLOS (non-line-of-sight) propagation to work as part of the mix.

Rapid Installation

No skilled tuning or calibration was required for these links. The self-organizing microwave backhaul automatically

Photo 1. The network topology as shown in a screenshot from the management system.

senses, filters and adapts to optimize performance and minimize interference. This is a continuous on-going process, adapting to environmental changes such as traffic movement, weather and foliage growth.

All nodes use identical hardware with a single radio per location. Single-RF-channel operation does not require any RF planning, making installation faster and simpler.

The node shown in Photo 3 is a typical

Photo 2. Metnet nodes installed on the streets of Tokyo (see red circles).

Photo 3. The node shown in the foreground is a typical street alley deployment. Its neighboring node is farther along the canyon.

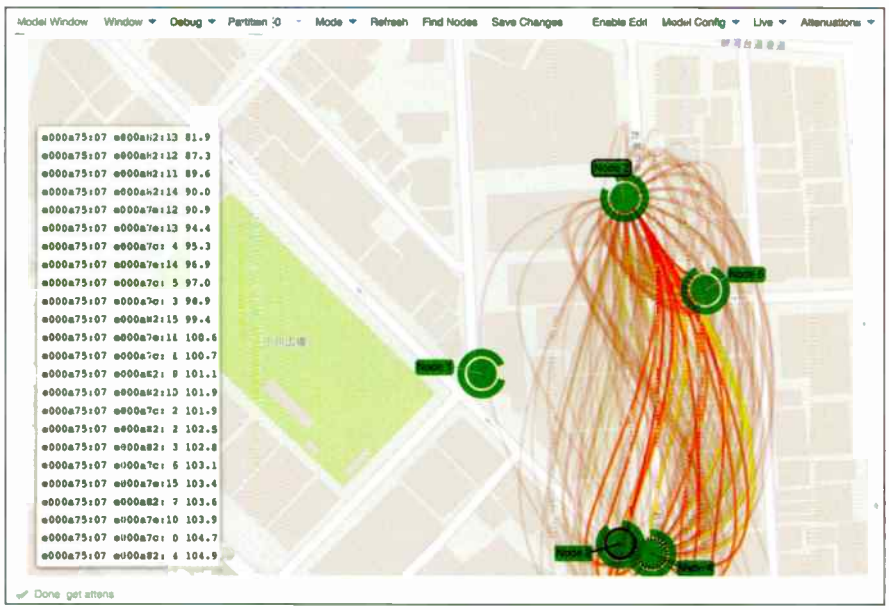


Figure 1. This diagram represents all of the potential self-organizing microwave backhaul links.

street alley deployment with its neighboring node farther along the canyon.

More unusual were NLOS links, such as one shown in Photo 2, where the self-organizing microwave backhaul resolved and adapted to multipath reflections from nearby buildings. The 270-degree, wide-angle, 16-antenna array built into each backhaul node captures a wide range of signals for extensive processing and filtering. This is much easier and more flexible than point-to-point radio links that require alignment, where instead Metnet nodes with their 270-degree antenna array automatically detect all possible LOS and NLOS links and select them accordingly.

Automatic Problem-solving

Dense environments such as this are likely to have small cells spaced closer than 50 meters apart. One link was 32 meters measured as a direct path with NLOS reflected signals traveling 49 meters. The adjacent nodes had 37 different possible RF links with varying attenuation levels for which the best options are automatically calculated and continuously reviewed. This demonstrated the high degree of multi-path reflection that occurs in a typical street-level urban canyon. All potential self-organizing microwave backhaul links are shown in Figure 1.

This link achieved an average signal-to-noise ratio/modulation of 12 dB, supporting backhaul data throughput of 135 Mbps. The link achieved 100 percent availability throughout the trial period. Round-trip latency ranged from 0.5 milliseconds (1 hop) to 0.88 milliseconds (3 hops). The latest dual-channel Metnet radios are capable of delivering 1.2 Gbps using 256 QAM in a typical 112-MHz-wide

single-channel pair.

Operating in a single channel pair without the need to radio plan, the self-organizing network algorithm selects the best possible links and topology and runs a dynamic spatial time-division, multiple-access schedule that dictates exactly which node and antenna pair can transmit and receive so as not to cause interference in the cluster. This is made possible by the thousands of measurements that are taken every second to determine the real-time state of the mesh. This cognitive approach to microwave networking provides a robust and flexible platform in the most challenging of urban environments.

Metnet addresses many of the issues of urban small cell deployment through simplified adaptation while ensuring resilient high-capacity backhaul can become available to all.

Customer Experience

"A live deployment in downtown Tokyo is the ultimate challenge for a small cell backhaul system," said Tomohiko Furutani, an engineer in Softbank's strategic technology office. "Our engineering team was impressed with Metnet's unique multipoint-to-multipoint mesh architecture and approach, and we wanted to test how this self-organizing, self-optimizing and self-healing microwave solution performed in a dense urban area.

"We designed the trial principally to assess the self-organizing microwave backhaul's automatic support for NLOS, and its ability to cope with multiple RF paths in a multipath propagation environment — all while delivering optimal performance and quality of service," Furutani said. "Metnet's capabilities fulfilled our expectations. The trial has provided a valuable insight into the behavior of microwave and millimeter-wave systems in future 5G bands, and the results of our trial demonstrate that self-organizing microwave backhaul can be well positioned to support these fifth-generation networks." ■

David Turner is head of technical sales at CCS in Cambridge, United Kingdom. CCS manufactures the Metnet self-organizing microwave backhaul. Visit www.ccsl.com.

The Advantages of Wireless Backhaul for Small Cells

Using a combination of unlicensed frequencies, phased antenna arrays for beam steering and semiconductor chips initially designed for consumer products makes the difference in providing affordable backhaul for small cells.

By Don Bishop

The cost and difficulty of providing backhaul to small cells can make the difference in whether carriers would construct the access points. In the early days of cellular network construction, carriers were reluctant to share antenna space on their towers with competing carriers. Similar reluctance to share small cell installations with other carriers either provides a competitive advantage or hampers network densification, depending on one's point of view.

Randall Schwartz, a senior analyst and consultant with Wireless 20/20, led a session about small cell connectivity at the Tower & Small Cell Summit in September 2016. He said when connecting the small cell to the wireless network costs more than the small cell itself, it drives Wireless 20/20 crazy as it develops business plans for small cell deployment. "If you can buy a small cell for $3,000, but a broadband connection with wireless is $5,000, that's an immediate red flag for us," he said.

Schwartz questioned whether wireless carriers should view small cells as dedicated resources (one carrier per small cell) versus shared resources, the way carriers share antenna space on towers.

A panelist in the session, Nitin Madan, product line manager at semiconductor manufacturer Broadcom, is responsible for his company's 60-GHz products and some of its Wi-Fi combination products for mobile phones. He said that mobile network operators pursue deployment of access points such as small cells primarily to increase capacity, sometimes referred to as network densification, and extending coverage is not a high priority for them.

"The only way we can provide gigabit speed to the next billion people on a mobile platform is with network densification," Madan said. "Although that's well understood, many underestimate the logistics. Each of these small infrastructure nodes has to be supplied with power and fiber or some other high-bandwidth backhaul. This is more expensive than what we imagine it could be if installers have to dig up the streets. The permitting process of going municipality by municipality, community by community, blows up any business case."

Nitin Madan, product line manager at Broadcom. *Photo by Don Bishop*

Three Elements

Broadcom's effort to make the process of connecting the small cells with a fiber hub over multiple hubs wirelessly as inexpensive as possible rests on three elements: its use of radio-frequency (RF) spectrum; phased antennas; and high-volume, consumer-grade silicon devices (semiconductors).

First, Broadcom tries to use unlicensed frequencies in the band from 57 GHz to 71 GHz. "There's plenty of spectrum out there, with no upfront cost to obtaining permission to use the frequencies," Madan said.

Second, the company tries to use phased antenna arrays for electronic beam-steering. "Using beam-steering allows you to be pretty sloppy in your deployment," Madan said. "You do not need two dish antennas precisely pointing at each other anymore, because of electronic beam-forming. Each node can find the next node or backup node in case the first node is blocked for some reason."

Third, as much as possible, Broad-

com uses high-volume consumer silicon that goes into the mobile cell phones so that, at the outset, the components the company uses have a certain base volume that subsidized much of the research and development. "This is important, and it's also not traditional in the infrastructure industry," Madan said. "Because we use consumer silicon, each wireless link is not five-nines reliable. But you can do mesh networking to make sure that the network, as a whole, is robust." (Five-nines reliability refers to making the connection 99.999 percent reliable, which represents a maximum of about five hours of outage in a year's time.)

High Frequencies

In the semiconductor business, cost is a function of volume, and Madan said Broadcom uses derivatives of technologies architected for consumer electronics to control the cost. He said the architected solutions tend to be modular.

Path loss at 60 GHz is extremely high. "It's a hostile frequency because of oxygen absorption and other effects that reduce range," Madan said. Engineers can increase the range by increasing the amount of power that the antenna panel can output, which Broadcom does by increasing the number of antennas. Madan said the use of 60-GHz frequencies makes it simple to increase the number of antennas because they are so small. "With the form factor of an iPhone, you can have units that can communicate 300 meters line-of-site with a good margin of signal strength at multigigabit-per-second speeds," he said.

To serve the 4G small cell market, Broadcom makes use of the technology it developed for Wi-Fi, including the intellectual property of the semiconductor chips themselves. The company also uses software it developed for Wi-Fi test infrastructure so its customers won't have so steep a learning curve — because they're familiar with products the company already makes.

Moreover, Madan said the company views the market as too new for accurate product forecasts. "I cannot tell you today what RF range the market needs to connect a small cell site to the closest fiber over wireless," he said. "That's why we've tried to make our system as flexible as possible, so that as people learn and discover the optimum configuration, it does not demand us to tape out and design new chips for each iteration."

> *"The RF side offers Broadcom flexibility, because it can arbitrarily increase the number of antennas the RF module has to support."*

The RF side offers Broadcom flexibility, because it can arbitrarily increase the number of antennas the RF module has to support. Meanwhile, on the baseband processing side, most of the timing's sense of logic is in software that the company can change with a firmware upgrade.

"But the real flexibility comes in the way we architected the RF front end," Madan said. "We're optimistic about it because, with the use of phased antenna arrays, you're not broadcasting energy in every direction. We focus a narrow beam of energy toward the receiver. This allows us to use the spectrum more wisely."

Broadcom wants to replace the fiber that comes to the small cell site. "We want to make wireless fiber on the backend." Madan said. "How the user accesses that network, I'm completely agnostic to — it could be 5G; it could be Wi-Fi. At Broadcom, we like Wi-Fi. We have a strong feeling that 80 percent of all wireless data goes over Wi-Fi, and we don't see that changing."

Especially for deployments that call for non-line-of-sight wireless connections, Madan said he is bullish on the Citizens Broadband Radio Service, which allows access to frequencies in the 3.5-GHz band. "Indoors, CBRS could be a big advance coupled with our technological innovations such as massive multiple-input, multiple-output communications. With line-of-sight wireless connections, millimeter-wave frequencies still have some advantages."

The CBRS and millimeter-wave frequencies would complement each other well, Madan said. He said the days in which the telecom industry operated on a cost-plus model may be behind us. "We need to find ways to cut the cost, because I don't think we can pass on the cost as price increases to the end customers anymore," he said. ■

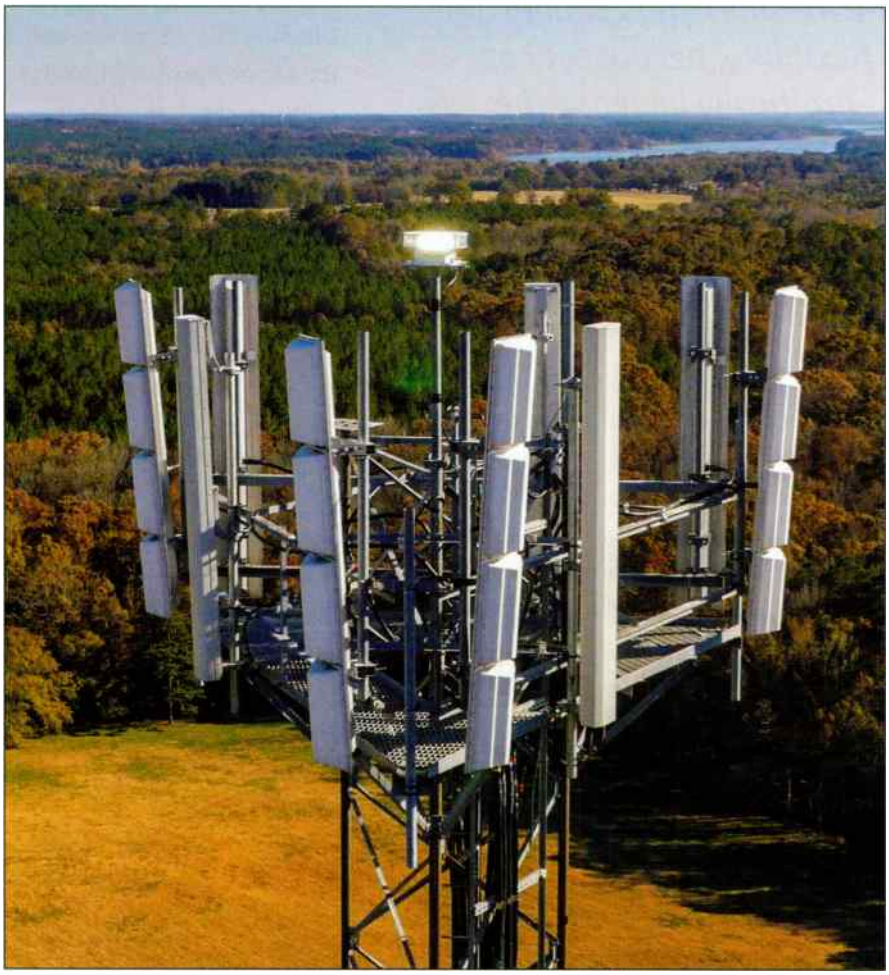
Protecting All Air Traffic, Birds Included

Changes in Federal Aviation Administration regulations give tower owners options for configuring obstruction marking to protect aviation and migratory birds while reducing operating and maintenance costs for lighting systems.

By Mark Lane

Towers of all shapes and sizes penetrate U.S. airspace to deliver various types of wireless telecommunications. The FCC's Title 14 Part 77 of the U.S. Code of Federal Regulations (14 CFR 77) establishes standards for determining obstacles to navigable airspace and how to safely mark them.

Marking towers with red and white lights, along with conspicuous paint patterns, has long been used to indicate aviation obstructions. Structures also employ different types of lighting technologies, including incandescent, halogen, neon, xenon and LED. For the last 10 years, tower lighting has been transitioning from incandescent and xenon-based systems to LED.



A Flash Technology Vanguard beacon.

Industry sources estimate that 20 to 30 percent of lit towers have converted to LED, leaving a considerable amount of incandescent and xenon lighting still in use.

For much of the last century, incandescent and xenon lighting have been dependable technologies for broadcast and telecom towers. However, they require periodic maintenance. Xenon flashtubes require replacement every few years, along with other components that ozone can damage. Nevertheless, periodic maintenance could be considered a small price to pay compared with the cost of replacing an entire system. A tower owner needs to decide at what point the frequency, power consumption and costs of maintenance outweigh a system replacement. If implemented properly with equipment selection, recent regulatory changes can actually lower maintenance costs.

FAA AC 70/7460-1L

In December 2015, the FAA released Advisory Circular 70/7460-1L, in support of 14 CFR 77. The new regulations change how towers are lit and monitored. The most noteworthy change describes an avian-friendly configuration. According to some studies, steady-burning red lights attract migratory birds. The goal of the avian configuration is to remove

lights that cause birds to fly into the tower's guy wires.

The new avian configuration consists of the following:

- Towers that are 350 feet tall or less need to flash the L-810 marker lights, referred to as L-810(F).
- Both the L-864 red beacon and the L-810(F) marker lights should flash in unison at 30 flashes per minute.
- Towers over 350 feet tall that consist of multiple tiers of beacons may remove the L-810 marker tiers.

Avian configurations were available prior to 70/7460-1L through an FAA waiver. Under 70/7460-1L however, all new tower filings and refiles of existing towers must meet the avian configuration. A tower must be refiled if the lighting type or tower height changes.

These changes do not affect towers marked with a steady-burning OL2 fixture. Towers using two L-810 marker lights on top are typically no more than 150 feet tall and do not require supportive guy wires.

Towers Over 350 feet AGL

Implementing the changes found in 70/7460-1L will have varying effects on maintenance costs, depending on the tower's height. Owners of towers over 350 feet that deploy a red or red/white lighting system can remove the L-810 marker tiers from both the tower and periodic maintenance cycle. To do so, the tower owner must refile under 70/7460-1L and set the beacons to flash at 30 flashes per minute. However, changing the flash rate of the existing lighting system may have unanticipated ramifications. Also, the manufacturer may not support the change.

Prior to the release of 70/7460-1L, the red beacon was allowed to flash between 20 and 40 flashes per minute. Most of the industry standardized on 20 flashes per minute, because it provided the longest bulb life, whether using xenon or incandescent technology. In many cases, you will not even find the option to change the flash rate with older lighting controllers. Even if workarounds allow changes to the flash rate, such as replacing the controller board with one specifically programmed for 30 flashes per minute, the outcome is most likely to be undesirable. Running at 30 flashes per minute increases the run time by 50 percent and could require more frequent bulb replacement. The difference offsets the maintenance gains of not having to service the L-810 markers.

For xenon products, the amount of ozone created also increases by 50 percent, and the ozone degrades the power supply components found in the light housing, resulting in the need to replace them more often. Using a shorter flash duration with higher energy to maintain the same light output could reduce ozone creation. But increased run times negatively affect the wear on the xenon electrodes. In addition, this approach may not be approved by the OEM or might not be tested and found to meet the FAA photometry requirements.

In summary, modifying existing lighting systems on towers over 350 feet may not only fail to lower maintenance costs, but also could cause the system to fall out of compliance. Check with the original equipment manufacturer to see what options are supported by its product. The safest way to remove the markers from the tower is to upgrade to a lighting system that can accommodate the changes.

Towers Under 350 feet AGL

For towers 350 feet tall and shorter, the avian configuration has no maintenance benefit. As a matter of fact, not only do the L-810 markers have to stay on the tower, but they must also flash at the new higher rate of 30 flashes per minute, making the failure of one an event worthy of a NOTAM (Notice to Airmen).

The tower owner or its agent must open a NOTAM ticket with the FAA within 30 minutes of a detected failure of a tower's flashing lights. Advisory Circular 150/5345-43H, which brings further definition to 70/7460-1L, states in Section 3.3.5.2.2 Monitoring that:

1. Each separate L-864 light unit and each tier of the L-810 light units must be monitored for FLASH/FAIL status.
2. FAIL is defined as outage of any lamp in an L-864 light unit, outage of any lamp in a tier of L-810 light units, or failure of a flasher (steady on and/or total) for an L-864 or L-810(F) light unit.

Before 70/7460-1L, when a marker failed, the FAA did not require the tower owner or its agent to open a NOTAM. A technician simply addressed the failure during the next scheduled site visit. Now, if a tower is filed under 70/7460-1L, the tower owner or its agent must treat a marker failure the same as if a flashing beacon failed.

Although it doesn't make sense to deploy these changes for the purpose

of lowering maintenance costs, a refile could be unavoidable. If the owner wishes to install a dual system in order to stop having to paint the tower, a refile is required. Structural changes, such as an increase in height, also require a refile. Retaining the existing lighting system when refiling the tower may present another set of challenges.

First, the beacon needs to flash at 30 flashes per minute, presenting the same life expectancy considerations previously mentioned. Second, flashing the L-810 markers may not be an option for the existing lighting controllers in the field. Controllers use a mechanical relay to switch the markers on at night and then off during the day. A mechanical relay is not made to cycle 30 times per minute and will fail before a solid-state beacon relay would. Any changes made to the lighting system to make the markers flash need to account for this. Finally, given that the flashing markers are now NOTAM-worthy if they fail, accurate monitoring of a flashing power load is more important. If these concerns cannot be adequately addressed, a new lighting system may be required to safely accommodate the changes.

Upgrading to LED Lighting

When it's time to invest in a new lighting system, migrate to LED technology for a longer service life and lower power consumption. The system should support synchronized flashing of both the beacon and markers at 30 flashes per minute using solid-state relays. It should also be able to accurately monitor a failure of either one.

Not only do the beacon and markers have to flash in unison, but they also must have the same flash duration. Advisory Circular 150/5345-43H states in section 3.4.3.1 Simultaneous Flashing Systems: "All obstruction lights in systems composed of either L-810(F), L-864, L-856 or L-865 light units must flash within 1/60 of a second of each other." Older controllers in the field flashing at 20 flashes per minute typically will have a flash duration of 1,500 milliseconds. The flash duration can now be as short as 100 milliseconds, something many manufacturers have taken advantage of in order to lower power consumption.

With LED lighting, the steady power consumption of an L-810 marker has decreased from 116 watts to as low as 2 watts. The same technology used to monitor steady-burning incandescent markers on older controllers will have difficulty accurately monitoring a 100-millisecond flash on a fixture drawing 98 percent less power.

Flash Technology addresses accurate monitoring of low-power LEDs in the Vanguard series of lighting controllers. The new FTS 371 red-light controller uses a patent-pending technology to monitor the loss of a single flashing L-810 marker. The FTS 370 dual-light controller uses separate channel monitoring for each marker. Both systems can flash at 30 flashes per minute in either legacy flash mode (1,500 milliseconds) or an efficiency flash mode (200 milliseconds). The Vanguard series is fully capable of meeting the requirements of 70/7460-1L and keeping all air traffic safe, including birds. ■

Mark Lane is director of product management and marketing at Flash Technology. Visit www.flashtechnology.com.

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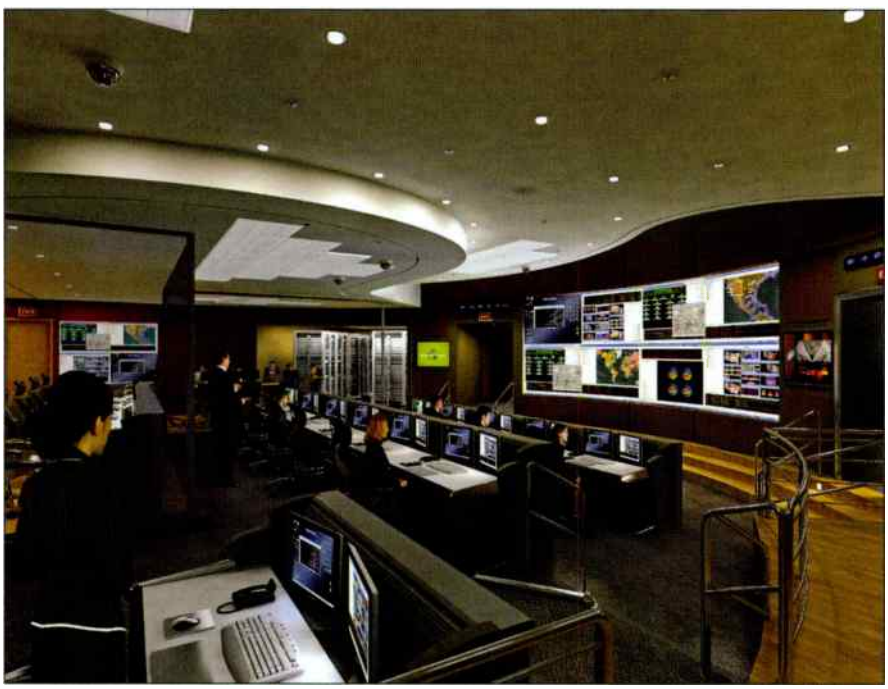
NOC, NOC. Who's There?

The network operation center (NOC) business needs to move data among the service provider, the NOC, the FAA, the FCC and the tower owner. Developing and implementing field service data system integration standards would improve the national telecommunications infrastructure, support airspace safety by closing out NOTAMs faster and reduce costs.

By Rob Sobol

No one; all our operators are busy; please hold for the next available operator. So, for the customer trying to locate information on recent site repairs using NOC records, the field service technician trying to close out a service call or the manager attempting to estimate service costs for multiple towers as a line item in next year's budget, it feels like no one is there. Today's network operation center (NOC) data systems for tower site management function for the NOC, but they offer marginal value to customers. The NOCs collect their monthly fee and, in the better examples, give internet access to a limited set of site information and a list of open NOTAMs or site issues. (A NOTAM is a Notice to Airmen, which is filed with an aviation authority to alert aircraft pilots of potential hazards, such as communications tower obstruction light outages.)

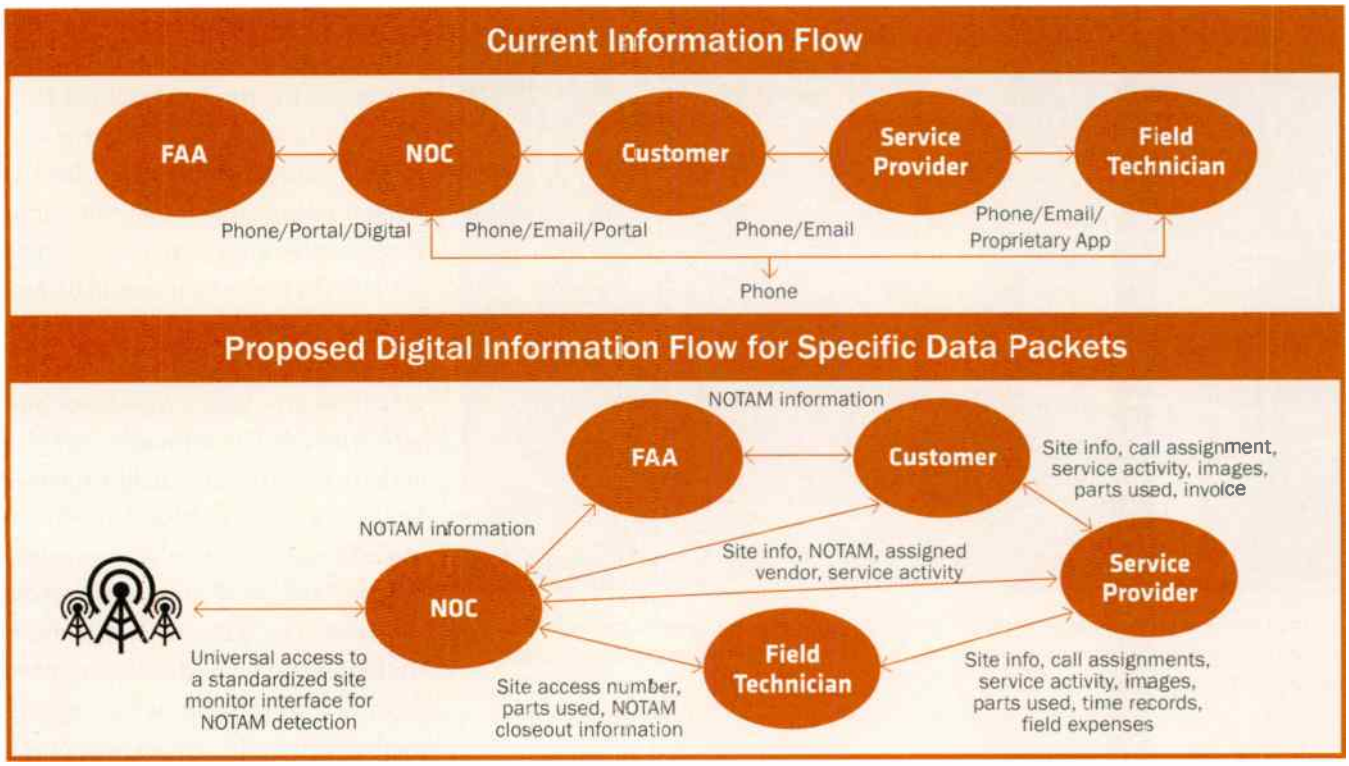
Are NOCs necessary? Of course they are. NOCs are continuously manned to monitor and report situations ranging from the trivial to the critical at telecommunications structures. Yet, NOCs could achieve more efficiency, reduce costs and provide improved services through the use of standardized data management techniques.



In response to a communication from a network operation center (NOC), a service vendor may dispatch technicians to a telecommunications site.

The NOCs' shortfalls cost everyone. In a typical field service cycle, the NOC senses a site problem and contacts the customer. The customer's site representative evaluates the situation and contacts a repair vendor. The customer and the NOC wait for a service technician to call the NOC for an access ticket number, to request a quarterly light inspection or to submit NOTAM closeout information. During the repair cycle, the NOC usually does not learn which vendor the customer assigned to the open ticket. One can only hope the customer keeps track of that information. Sometimes, customers maintain regional open-ticket spreadsheets or track in a centralized purchase order system. Upon completing the site work, the technician calls the NOC to close out the NOTAM; the customer's home office receives an invoice; and everyone is happy for a while.

Then, someone opens another NOTAM for the site, perhaps within a week. The problems begin. The customer asks the NOC, "What is wrong now?" The NOC, lacking a detailed problem description, cannot answer



Today's typical information flow (top) versus a recommended information flow among all the parties involved in using standardized data packets.

completely. The customer's site representative asks the vendor to send a technician back to the site. Depending on the historical data the vendor keeps, the service technician may or may not have detailed records of the previous problem: What was worked on, what corrective action was taken and what replacement parts were installed. Upon arriving at the site, the technician evaluates the situation and determines that Tier One Beacon Two is not lit and needs repair. He repairs the light by installing new bulbs and calls the NOC to close the NOTAM. A couple of weeks later, the customer's home office receives an invoice, pays for the service, and everyone is happy again.

So what is the problem? Suppose the issue was faulty bulbs, and Tier One Beacon Two was just repaired a second time within week. Because the customer doesn't track or otherwise doesn't have access to detailed repair records, it could be paying for a service that is covered under warranty. We can assume the technician has to document and communicate his work hours and the parts used to his home office. So, the data is recorded somewhere, somehow, by someone. Thus, the service provider stores the information most important for the customer, but it may or may not be available in detail or in electronic form.

Imagine being a regional communications manager, responsible for 500 towers across multiple states. You have the task of developing an expense and capital expenditure budget for the coming year, together with supporting documentation. In an effort to reduce mobilization costs, you have been using regional vendors for air conditioning, diesel generators, lawn maintenance, fence maintenance and obstruction lighting, and you cannot put your fingers on critical site management information. At best, you have to search through invoices and handwritten field service notes. You have to request reports from your vendors, search your emails or whatever information you have and piece together an audit trail of what happened during the past 12 months at sites spread across five states.

Better Data Management

The solution is to have a data management system that efficiently collects service information and provides access to the appropriate data to the customer, the NOC and the service technician. In today's marketplace, the technician records his activity and

Without an optimum exchange of information among the network operation center, customers and service vendors, technicians may be called upon to fix the same faults repeatedly when the cause goes undetermined.

parts consumed in some fashion. But how he records it, to whom he communicates it and what level of detail he provides remain as wide open as the Wild West. Reporting requirements for service technicians before the site visit and after repairs vary from site to site. Some customers require notice 48 hours before site access. Some allow access at any time. Some customers require detailed repair information, and others only want to know that the NOTAM was closed. The NOC is in a prime position to manage, host and communicate a large portion of field activity information, but not all of it. Although it may be appropriate for the NOC to collect service notes and information about parts used and pass those details along to the site owner, details about field expenses (such as mileage, per diem, material and hotel costs) are proprietary to the service company.

Hardware vendors developed and run some of today's NOCs with an underlying objective of keeping their feet in the door with the customer. They offer enhanced monitoring for sites equipped with the hardware they sell, and they offer adequate monitoring for sites with hardware from other vendors. As lighting systems age out, hardware vendors seek to replace them with their proprietary solutions. This marketing strategy appeals to lighting company management, but it doesn't function for tower portfolio owners. The tower portfolio manager has a responsibility for hundreds of towers with various technologies (obstruction lighting, HVAC, etc.), manufacturers, models, monitors, multiple NOCs and service vendors. Many times, they don't own the assets long enough for the systems to age out, and they usually find it less expensive to patch and sell than to upgrade and standardize.

This is where applying some technology and keeping an open mind will serve everyone well. The NOC needs to expand the data maintained for a site to include details such as the customer's contact information for the person responsible for the site, unit to be serviced and the vendor assigned the job. The technician should be provided a modern digital tool — a phone app or laptop application that provides pre-site visit procedures and efficiently collects images, service activity descriptions, field expenses and parts used. Service data should include specifically which unit was serviced and what components were replaced. The data, collected once, could then be filtered and formatted according to the end user's requirements and transmitted where it's needed. The NOC, the FAA and the FCC would receive NOTAM closeout information, and the technician's home office could receive field data properly formatted for integration into applications such as QuickBooks. The customer could receive field service reports via email to a predetermined distribution list, with data formatted to the customer's specification (XML, CSV or spreadsheet) and merged into its corporate data system.

The Key to Improvement

Data exchange standards are key to improving field services while reducing costs. Necessity is the mother of invention, and competition adds fuel to the fire. Having each NOC venture off and create its version of the perfect customer portal typifies the free enterprise system. Field service companies expect laptop and phone application developers to create the ultimate data collection program.

Field data collection applications already exist, but interface with proprietary service tracking applications. Establishing an open data standard in a competitive software development market will yield low-cost, feature-rich field service data collection applications. The NOC field service business model is screaming for a standardized format for data transmission to move the information among the parties involved.

Imagine a standard data package that encompasses photographs, site activity verbiage, employee hours, parts used, mileage records and field expense information collected and transmitted by the field technician. The application could help guide the field technician to complete the data collection to the level of detail required by the field technician's home office and the specific customer. The process could be flexible and configurable to enable appropriate data to be transmitted from the technician directly to the home office, the NOC, the customer or any combination of recipients.

Who Benefits?

Let's list the advantages of a standard data package.

1. By using one, flexible application to record all field service activity, the service companies benefit from reduced costs. The standard field activity data package, FactPack, could be merged into the recipient's data system. The process eliminates duplicate data entry and errors introduced while entering information communicated by phone or handwritten notes.
2. Data recipients benefit from not having to re-enter the data, resulting in a significant human resource cost reduction at the NOC, reducing end-user costs.
3. Faster data access benefits everyone — whether it results in faster service-call dispatching, expedites NOTAM closeout, reduces the cycle time to create an invoice or expedites post-incident investigation for the FAA.
4. The entire industry benefits because inventory systems can be updated based on real-time use and parts availability improves. Having the right parts in the right place at the right time reduces maintenance costs by increasing the percentage of field problems that can be solved during the first site visit.
5. Customers benefit from improved service information flow. If a customer transfers site monitoring to a different NOC, there is a seamless transition, similar to changing cell phone carriers. You keep the same phone number; the data just gets routed through a different network, or in this case, to a different NOC. Although changing from one cell carrier to another typically requires changing cell phones, site monitors should provide universal access to a standardized interface to eliminate the time and expense required to replace the site monitor.
6. Customers and management benefit from more transparent reporting. Regardless of the service provider, the customer receives standardized field activity reports in a text version or, optionally, a preferred data format (CSV, XML or spreadsheet).
7. NOC personnel, management and owners benefit as they are enabled to more efficiently manage site problems and collect service data from multiple service providers for various equipment.
8. Tower owners reduce liability exposure during post incident investigation when accurate, verifiable and timely maintenance records can be produced.

The NOC field service business model is screaming for a standard for data transmission to move information among the parties involved.

The development of field service data system standards is an opportunity to improve the national telecommunications infrastructure by closing out NOTAMs faster while providing accurate post-accident obstruction lighting maintenance data and reducing costs.

The monitoring industry is at a unique stage of development. The NOC has the opportunity to increase market share by expanding services to market segments outside of its current niche. The benefits and potential for growth using an open system approach far outweigh the potential of growth by controlling a smaller market segment through proprietary solutions. Adherence to a data standard would be a selling feature of a NOC, in much the same way a manufacturer promotes its compliance with OSHA requirements and ISO standards.

Standard data formats form the backbone of large data systems. You probably pay your personal bills via online banking. How do you suppose your bank sends funds to the bank of your electric company or cell phone carrier? It communicates electronically using data standards. Why do we give our employer our bank account and routing number for direct deposit? The payroll company communicates with the banking system via data standards. How do large retailers send purchase orders to their suppliers? They transmit electronic orders via electronic data interchange standards and require their suppliers to adhere to the standard. So why do we not communicate our service information using standards?

Maintenance of our telecommunications infrastructure, whether we are referring to cell towers, broadcast towers, satellite dishes, AC units, diesel generators, obstruction lighting , lawn maintenance, access road maintenance or site access security systems, consumes a significant amount of the expense budget. The amount is large enough to justify detailed management at the income-and-expense sheet level. If you do not have access to the detailed data, you cannot manage it.

We also can apply the value of data standards to the corporate balance sheet. The value associated with an asset can be substantiated when accurate service records are provided. It adds value to an automobile when an owner provides service records that prove proper maintenance and that document the cost of ownership. Taking the concept of a data standard a step further, the historical maintenance records could be transferred from NOC to NOC, or NOC to customer, and the integrity of the maintenance records would be maintained. If accurate service records are provided for all significant site equipment, then a more realistic purchase price can be determined if the tower were to be sold. This could help to avoid possible post-sale litigation and balance sheet losses.

The development of field service data system standards is an opportunity to improve the national telecommunications infrastructure by closing out NOTAMs faster while providing accurate post-accident obstruction lighting maintenance data and reducing costs. The FAA and the FCC should participate in developing a standard data interchange format; tower owners should encourage it; service providers should welcome it; and the NOCs and software development teams should race to implement it. ■

Rob Sobol is general manager at Hilights. Visit www.hilightsinc.com.

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Photography by Don Bishop

Six-point Plan for Lightning Protection and a Grounding System at a Telecom Facility

From capturing the lightning strike to protecting low-voltage data and telecommunications circuits and everything in between, a combination of devices and methods proves successful in protecting telecommunications facilities.

By Rohit Narayan

A six-point protection plan will protect any facility from the damaging effects of lightning, transient voltages, noise and other disturbances.

1. Capture the lightning strike — On a telecommunications tower as high as 140 feet, a simple rod of the Franklin air terminal type adequately captures lightning. When users install electronic equipment, such as remote radio heads, on top of the tower, they may find some merit in using an isolated Franklin rod air terminal to facilitate the use of isolated down conductors. To achieve the isolation, some install an air terminal on a 6-foot fiberglass mast. Other mission-critical telecommunications facilities, such as central offices, data centers and major repeater sites, also may need lightning protection.

Lightning protection systems for buildings include conventional lightning protection installed to the NFPA 780 standard using a smooth-weave cable system, an early streamer emission system and proprietary systems, such as the Erico Dynasphere air terminal.

The Six-point Plan of Protection from Erico

1. Capture the lightning strike.
2. Convey lightning energy to ground.
3. Dissipate energy into a low-impedance grounding system.
4. Bond all ground points together. Bond all ground points to eliminate ground loops and create an equipotential plane.
5. Protect incoming AC and DC power feeders. Protect equipment from surges and transients on incoming power lines to prevent equipment damage and costly operational downtime.
6. Protect low-voltage data and telecommunications circuits. Protect equipment from surges and transients on incoming telecommunications and signal lines to prevent equipment damage.

2. Convey the energy to ground — Lightning protection specialists use two ways of mitigating side-flashing and flash-over risk: bonding and isolation. With isolation difficult to achieve, designers more commonly use bonding.

Where communications systems use remote radio heads or where cable or feeder trays have been installed close to one tower leg, isolated systems have advantages. An isolated system can be used to bypass lightning energy and dissipate it into the tower leg at a distance below remote radio heads. Neither bonding nor isolation can mitigate all risks associated with lighting. Also, secondary effects, such as magnetic coupling, still will occur.

An essential part of any telecommunications facility, including outdoor cabinets and outside plant, the outdoor grounding electrode is the part of the system that dissipates excess lightning energy into ground.

3. Dissipate the energy into a low-impedance grounding system — The ITU K56 Recommendation, "Protection of Radio Base Stations Against Lightning Discharges," provides an excellent depiction of the grounding system with ground rings around the building, around the masts and in the perimeter of the compound.

The Telcordia Technologies Generic

Requirements GR-3171-Core, "Generic Requirements for Network Elements Used in Wireless Networks," makes extensive recommendations on the use of ring ground electrodes. This document states that the use of ground rings is a method to "minimize the differential potentials and induced current flow across the facility." As does ITU K56, the Telcordia GR-3171 promotes the use of ground rings around buildings and towers.

Where space constraints do not allow placing a ring that encircles the entire structure, alternative arrangements can be used. To ensure that the rings produce low earth potential rise (EPR) during lightning current flow, designers must pay attention and keep the ring installations as symmetrical as possible (see Figure 1.)

Resistance to Remote Earth

It is widely accepted in the industry that 5 ohms of resistance to a remote ground is the highest allowable value for any telecommunications facility. Sometimes resistance this low isn't achieved in areas with high soil resistivity or on sites with limited space for installing an earth grid (i.e., at roadside cabinets and in built-up areas). More complex sites, such as central offices, mobile switching centers, larger repeater sites and satellite stations, require lower ground resistances between 0.5 ohms and 2 ohms. Telecommunications operators themselves define the ground resistance values in internal standards and guidelines.

Using predetermined design often achieves proper levels of ground resistance. Tower owners who want to have consistent designs at multiple sites often use predetermined designs. Sometimes the approach produces varying results because of differences in soil resistivity among sites.

A more scientific approach to designing the ground electrode includes a soil resistivity test prior to starting the installation. Computer software or empirical formulas can use the results to predict the number and dimensions of

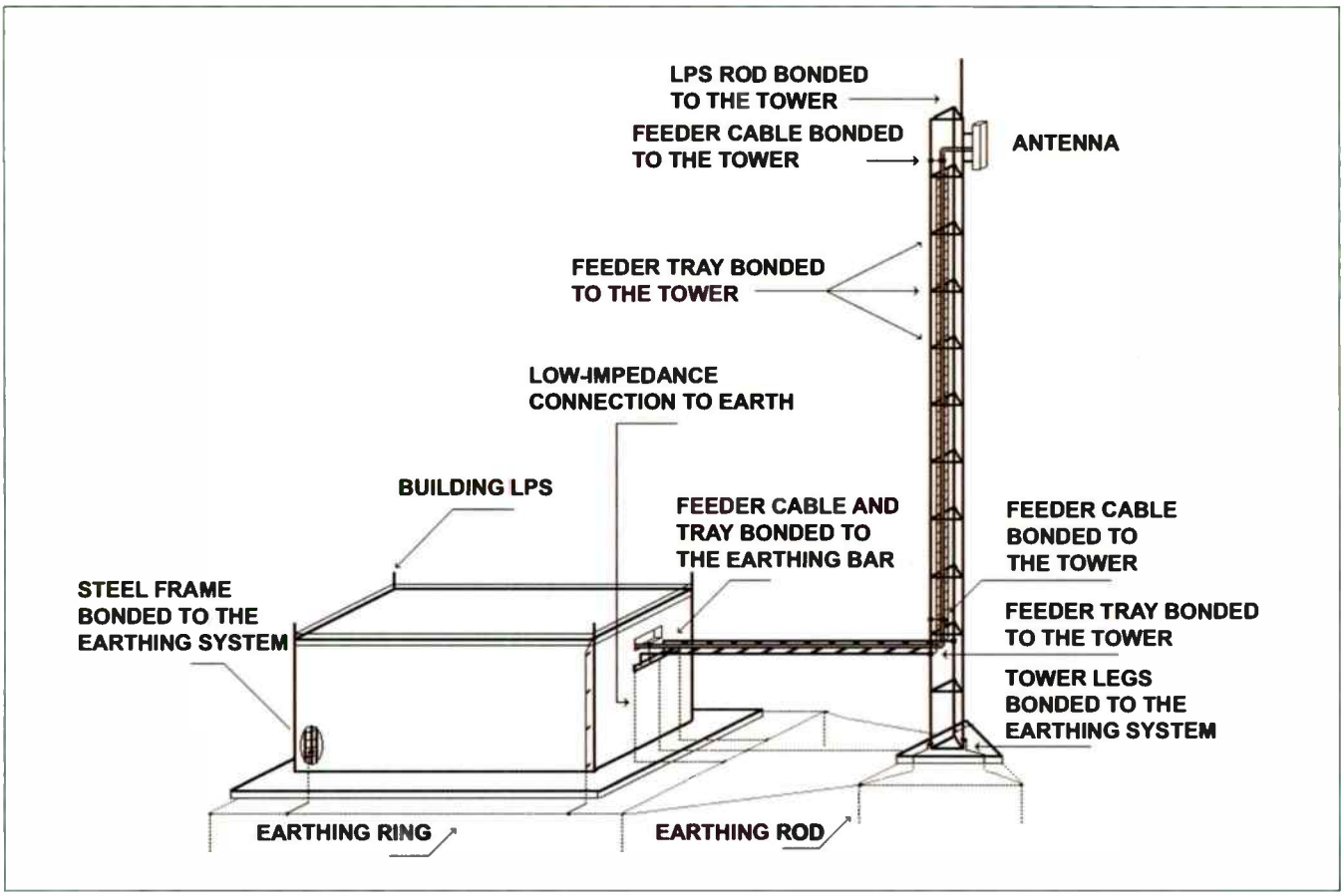
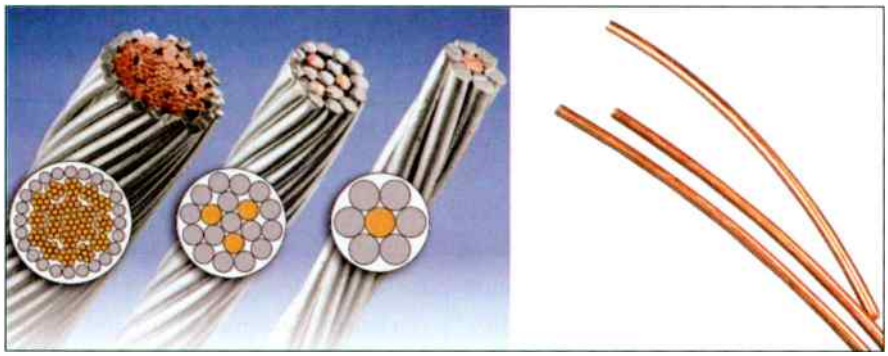


Figure 1. A general view of earthing and bonding procedures external to a shelter, as shown in ITU K56 recommendations. To ensure that the rings produce low earth potential rise (EPR) during lightning current flow, designers must pay attention and keep the ring installations as symmetrical as possible.



Photos 1A and 1B. CU bond composite and CU bond solid conductors. Using modern conductors such as these helps to reduce copper theft at telecommunications sites. These conductors also cost less and last longer.

Photo 2. Copper-bonded ground rods with couplers provide the best long-term corrosion resistance relative to their cost.

ground electrodes required to meet the target ground resistance. Lightning protection equipment manufacturers recommend the scientific approach for larger sites where resistance values lower than 5 ohms are desired or where soil resistivity is high. Many use the Wenner method and measure soil resistivity at various depths at four points.

Choice of Grounding Materials

Conductor — Grounding systems most commonly use copper wire for horizontal connections in the ground. Copper has excellent electrical conductivity, and it offers good resistance from corrosion in a wide range of soil conditions. These characteristics make it an ideal conductor. However, copper is relatively expensive, and it often tempts thieves when used in exposed locations. U.S. standards recommend using copper conductors equivalent to AWG #2.

With an adequate coating, copper-bonded steel conductors have a long service life similar to copper and the lower cost of steel, compared with copper. Steel makes the conductors rugged and more difficult to handle. They come in solid and stranded sizes equivalent to AWG #2.

Reasons behind the need for modern conductors include increasing incidences of copper theft at telecommunication sites, a desire for long grounding system service life and a desire to keep the cost of conductors

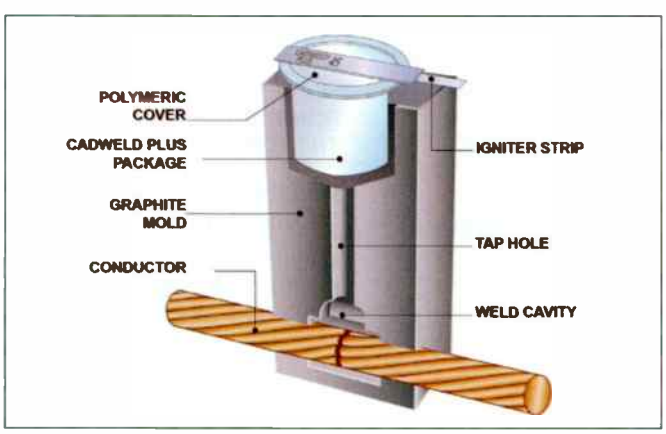


Figure 2. A Cadweld exothermic weld has high reliability, long life, a low corrosion rate and a low relative cost. Commonly used for grounding system connections, exothermic welds even work with tape conductors and vertical surfaces.

Photo 3. A cross section of an exothermic weld shows how it combines metal between a stranded conductor and a solid conductor. These welds work with a wide range of materials and shapes of conductors.

from increasing, in comparison with alternatives (see Photos 1A and 1B).

Ground electrodes — The three most common types of ground electrodes use copper-bonded steel. Copper-bonded ground rods provide the best long-term corrosion resistance relative to their cost (see Photo 2).

Grounding connectors — In telecommunications, the most common grounding system connections use exothermic welds, bolted connectors and crimped connectors. Among exothermic welds, Cadweld connections are the most common type used with copper-based grounding system in large parts of the world. Some reasons for their popularity include high reliability, long life, a low corrosion rate and a low relative cost. Exothermic welds can be used on a wide range of materials and shapes of conductors, including tape conductors and vertical surfaces (see Figure 2 and Photo 3).

Ground bars — Tinned and bare copper has been the material of choice for telecommunications ground bars for many decades. Increasingly common copper theft at telecommunications facilities has led to carriers and tower companies to look for suitable alternatives for copper for use as ground bars. These include tinned aluminum and galvanized steel with a suitable amount of zinc coating (see Photo 4).

Photo 4. A galvanized ground bar with a pigtail.

4. Bond all grounding points together — In the opinion of the author, the indoor grounding arrangement is the most important aspect of the grounding system design. This aspect of grounding also is more likely to contribute to equipment faults, in comparison with the four other points. Among the six points of the plan for lightning protection, bonding all the grounding points together generally is the step with the lowest relative cost. Not surprisingly, it is sometimes given the least importance.

ITU-K27 describes the two methods for bonding all the grounding points together commonly used in telecommunications facilities around the world: the Star-IBN and the Mesh-IBN (IBN stands for isolated bonding network).

In the Star-IBN system, the indoor grounding system connects via a

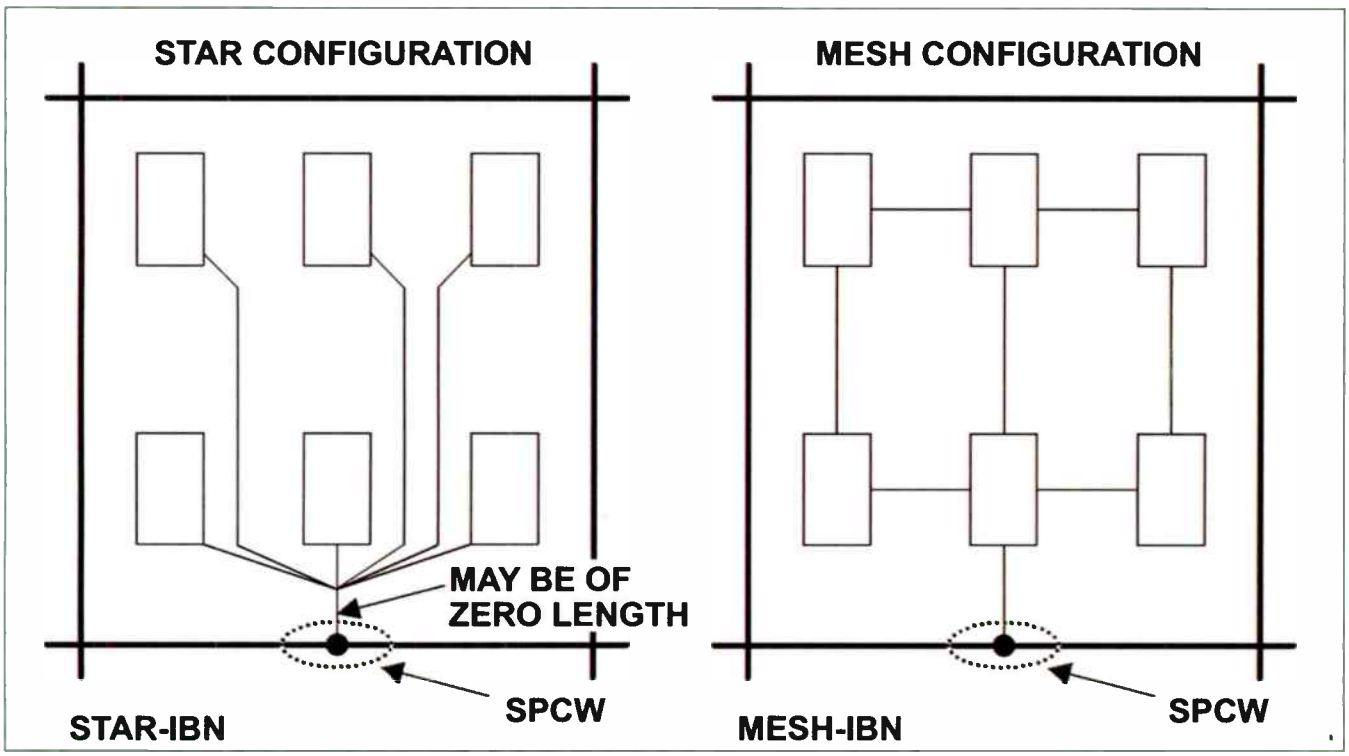


Figure 3. On the left, a Star-IBN, and on the right, a Mesh-IBN, with single-point connection windows (SPCWs). These isolated bonding networks are found in telecommunications facilities around the world.

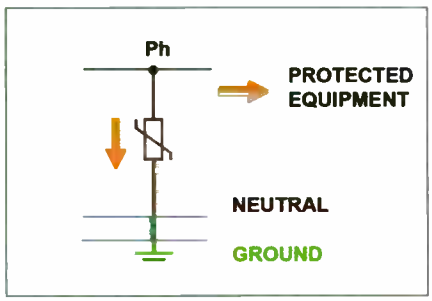


Figure 4. Controlling energy that confronts a telecommunications facility from outside the facility requires the proper installation of surge protection devices.

Photos 5A and 5B. Erico models TDX100M and SES40P surge protection devices. The devices must switch on quickly and handle large amounts of energy in a short time.

single-point connection window (SPCW) to the ground electrode system. The SPCW usually takes the form of a ground bar, but it also can be a ground ring inside the telecommunications facility (see Figure 3).

In the Mesh-IBN system, components inside the telecommunications facility (e.g., equipment frames) are interconnected to form a mesh-like structure. This may, for example, be achieved with multiple interconnections between cabinet rows or by connecting all equipment frames to a metallic-grid bonding mat or signal reference grid extending beneath the equipment. The bonding mat is insulated from the common bonding network (CBN) of the adjacent room or building. Although there are multiple connection paths within the equipment room, there is only one single point via which the Mesh-IBN connects to the external ground electrode system (see Figure 3).

The comprehensive Telcordia GR-295 document "Mesh and Isolated Bonding Networks: Definition and Application to Telephone Central Offices" details how to construct Star-IBN, Mesh-IBN and Mesh-BN systems. There is consistency in methodologies recommended in ITU-K27 and Telcordia GR-295.

5. Protect incoming AC and DC power feeders — The installation of the indoor and the outdoor grounding system addresses the safety, electromagnetic compatibility, lightning energy dissipation and noise control system at a telecommunications facility. Grounding alone does not fully control what happens outside of the facility that could transfer a transient or a surge to the facility. Obtaining this level of control requires proper installation of surge protection devices (SPDs) (see Figure 4).

AC surge protection — Lightning strikes near power lines or other power system disturbances, such as switching, can couple voltage transients or surges onto power lines. Lightning can couple onto power lines via a direct strike to the power line or via capacitive and magnetic coupling when lightning strikes nearby.

The IEC 61643 suite of standards and the Institute of Electrical and Electronics Engineers (IEEE) trilogy of standards documents (C62.4.1, C62.4.2 and C62.45) cover SPDs for AC application in detail. The IEEE has published additional standards for testing and using SPDs. UL 1449 4th Edition defines the requirements for SPDs designed for repeated limiting of transient voltage surges and is arguably the most onerous standard for safety testing of SPDs.

The most common topology for an SPD is the shunt connection. Various types of SPDs include metal oxide varistors (MOVs), silicone avalanche diodes (SADs), gas arrestors, spark gaps and triggered spark gaps. No one device type is superior to other device types. Instead, each has advantages and disadvantages, and they need to be chosen correctly for the application.

In a shunt application, a user installs a surge diverter between the phase and the neutral lines and between the neutral line and earth ground. SPDs are normally open-circuit, but turn on when a higher voltage appears across its terminals during a transient voltage or a surge current. They momentarily create a short circuit to ground to allow the surge energy to divert to the ground instead of going to the load. Lightning surges and other power system transients are quite fast (durations of a few tens of microseconds) and can have extremely high amplitudes (many thousands of volts). Therefore, to be effective, SPDs must switch on quickly and handle large amounts of energy in a short time. Normally, upstream circuit breakers or fuses do not have time to trip when the surge diverter activates because the reaction time of circuit breakers and fuses is much slower (see Photos 5A and 5B).

DC surge protection — Modern cellular and microwave equipment uses a remote radio unit (RRU) or a remote radio head (RRH) fed from the base station via optical fiber. This method eliminates feeder loss and allows transmission to occur at much higher frequencies with wider bandwidth.

Power cannot be transferred from the base station to the RRU or the RRH via optical fiber. Thus, the power supply feeds power to the remote units separately as DC on copper cables. The copper cables are either separate from the fiber or are part of a composite fiber-copper cable.

The DC feed acts as a source of lightning surges back into the equipment room. In the traditional radio settings of the past, damage normally would have been limited to the radio equipment. In modern installations, damage can occur to the rectifiers or the entire DC power system, which then would jeopardize other equipment installed at the site. This development has heightened the need for DC surge protection.

6. Protect low-voltage data and telecommunications circuits — Surges and transients caused by lightning can couple to telephone lines and RF feeders via magnetic or capacitive coupling. Where telephone lines run parallel to power lines for longer distances, the surges and transients can also couple to the lines through electrical induction. Leaving these communication lines unprotected may still leave the facility open to potential damage, even if other elements of this plan are implemented.

Telephone and data lines — Twisted pair (ordinary copper wire) transports the telecoms services subject to this discussion. The services may be telephone lines or services such as Category 5 (Cat 5) and Category 6 (Cat 6) cable. Each service has two wires, or lines, sometimes called the a and b wires.

With telephone and data lines, surges can occur from each line to ground, known as L-G or common mode, or can occur across the lines, known as L-L or differential mode. Protection against these surges requires the use of appropriately designed surge protective devices.

Coaxial feeders — The magnitude of surges that can be coupled onto the signal in a coaxial feeder is relatively small in comparison with total lightning energy. This is because the telecommunications tower and the cable ladders provide significant shielding to the feeder. Furthermore, the construction of the coaxial cable provides excellent shielding to the inner conductor. Differential mode transients are not possible because there is one signal line and the other is the feeder screen, which is directly grounded at several locations. Furthermore, there is some level of sharing of the induced and coupled currents among multiple parallel runs of feeders.

Despite this level of shielding and sharing, it remains possible to have several thousands of amps at a fast rise-time coupled or induced onto coaxial feeders.

As a minimum, the coaxial feeders should be grounded at the top of the telecom tower, at the point where they bend close to the ground and at the point of entry to the equipment room or cabinet. The feeder tray should be kept continuous in its trajectory along the tower. The feeder tray should be continuous when it leaves the tower and extends toward the equipment room or cabinet, preferably using a curved section at bends.

Where additional precaution is needed, coaxial surge protectors with appropriate connector type, bandwidth and surge ratings can be installed at the point of entry to the equipment building or the cabinet. ■

Rohit Narayan has 27 years of experience as an electrical and telecommunications engineer and has a passion for telecommunications power systems and grounding. He has helped develop grounding standards, drawings and specifications for various telecommunications carriers. He is global sales director for telecom at Erico. Visit www.erico.com.

Using Drones for Tower Inspections

Selecting the right drone operator and the right data analysis platform pays dividends when it comes to conducting inspections safely and obtaining useful reports with exacting detail in a timely manner.

By Larry Shaefer

Using unmanned aircraft systems (UAS) technology to inspect and evaluate telecommunications towers involves more than simply selecting an aircraft and beginning to operate. Productive UAS operators analyze individual data requirements for specific companies and apply a proven systems integration approach. UAS include unmanned aerial vehicles (drones), ground-based controllers and a method of communication between them.

Vetting drone contractors takes time and care, but pays off with increased safety in conducting inspections, more data, and better and more timely reporting.

In many parts of the United States, telecommunications towers are sited where weather conditions range from hurricane winds to hail storms to tornadoes. Maintenance workers and contractors risk their personal safety and even their lives to document tower conditions, locate defects and repair damage. Some may sustain life-altering injuries while inspecting the towers.

Inspection is only the first step in what can be a lengthy process. It may take weeks for some inspectors to write the field reports, identify and purchase the necessary materials and schedule repair appointments. Meanwhile, the tower's structural integrity hangs in the balance. With UAS technology and data analysis, this time-consuming process can be shortened to a few days.

The author engaged the services of a UAS operator and a data analysis platform company to inspect his 263-foot tower in Willis, Texas. The horn antennas on top reveal the tower's origin as part of AT&T's Long Lines microwave network.

The Vetting Process

When T-Mobile US requested to make updates to its equipment in space rented on my 263-foot tower that AT&T built in 1967, I wondered whether using a drone could help to answer questions about hanging cables and about parts that had fallen off the tower. I wondered if a drone could verify whether a neighbor had ceased shooting at the tower strobe lights.

So I set about conducting interviews and watching demonstrations of UAS equipment at work. I found significant differences among companies and individuals who use UAS to evaluate towers. One company used a drone to take 200 photographs, only to accidentally erase all but 49 of them. Their process also required the purchase of a specialized computer program for $69 in order to clearly view the ones that were left.

Safe drone operation near telecommunications towers requires drones

to keep their distance to avoid colliding with the tower, which could happen if the drone were too close when the wind shifts. A collision also could happen if a drone were too close when the pilot makes an error or if the drone malfunctions. Yet, drones need to be near enough to capture images for satisfactory analysis. Some UAS operators use high-resolution photography to allow drones to take photographs from a safe distance of at least 15 to 30 feet from a tower, yet still provide images that can be magnified sufficiently to reveal details.

For my tower, a cooperative effort between a data analysis company, Panton, and a UAS operator, Aviation Unmanned, produced the best photographs, data archive and inspection reports. Their photographs had such high resolution that I was able to enlarge the image of a 1-inch bolt to nearly full-screen size and count its threads. The photographs allowed me to evaluate a clear fall zone area and any problems within a 263-foot radius of the tower. The drone took the photographs from 15 to 30 feet away from the tower.

High-resolution photographs taken from a safe distance of 15 to 30 feet from the Willis tower allow examination of hanging cables and tower bolts.

It helps when the tower owner can be present during the drone flight, as I was. Being on site allowed me to ask

Rise of the Drones: Managing the Unique Risks Associated with Unmanned Aircraft Systems

Managing risks associated with drone operation involves both the owner and/or operator as well as the manufacturer. It also requires those who hire a drone or related service provider to follow certain guidelines.

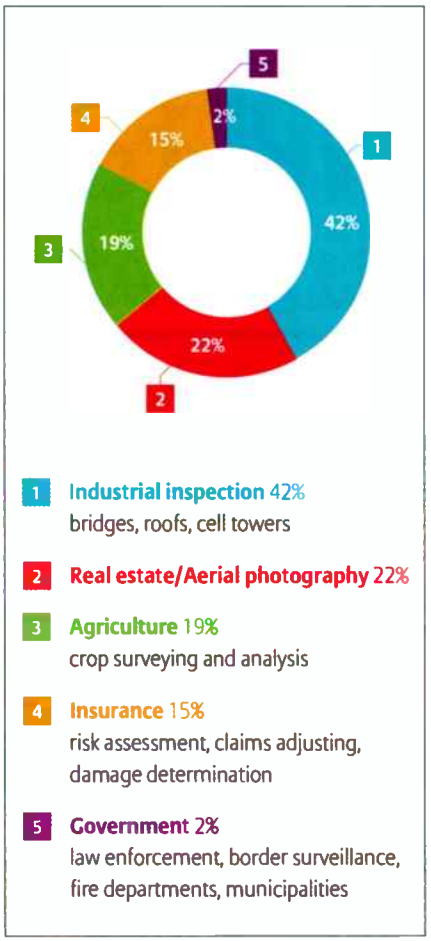
By James Van Meter

Drones or unmanned aircraft systems (UAS) used to be primarily associated with military operations. Today, compact versions are increasingly operating in everyday life and the UAS industry is fast becoming a multibillion-dollar business, as the benefits to be gained from using such innovative technology become increasingly apparent.

The following information examines the key issues and trends underpinning rapid growth in the use of UAS and provides insight into the potential risk exposures related to their deployment in the private, public and commercial realms.

UAS have the potential to both solve problems and save costs in a number of industries throughout the developing world and in disaster relief scenarios. Growth projections for the sector are significant as UAS become cheaper to purchase, smaller in size and easier to operate. In fact, the UAS industry is regarded by many as the most dynamic growth sector of the global aerospace industry.

However, as civilian and commercial use of UAS rapidly increases and continues to evolve, the potential for misuse of this technology needs to be considered. Advances in technology are inevitably accompanied by a host of new and little-understood risks. There have already been enough incidents and near-misses to date involving UAS to generate concern that the likelihood of collisions and other loss events will grow as UAS numbers multiply.



The use of drones for industrial inspection, which includes cell towers, represents 42 percent in a breakdown by industry. *Source: FAA Aerospace Forecast FY2016-2036*

UAS consist of unmanned aerial vehicles (UAVs, or drones), ground-based controllers and a means of communication between them. The use of drones in the public airspace is increasing dramatically. In the United States, the Federal Aviation Administration (FAA) projected that by the end of 2016, more than 600,000 UAS would be deployed for commercial use — three times the amount of manned general aviation aircraft. In addition, 1.9 million UAS are expected to be for recreational purposes. The number of UAS is set to triple by 2020, according to the FAA Aerospace Forecast for the fiscal years 2016–2036.

The Research and Markets report, "Unmanned Aerial Vehicles Market, By Value and Volume Analysis and Forecast 2015-2020," predicts the global UAS market volume to reach 4.7 million units by 2020. Other estimates are even higher. The market for commercial application of UAS technology is estimated to soar from $2 billion to $127 billion by 2020, according to PwC. Expectations that UAS will become cheaper, smaller and easier to use support such projections, as does the expectation for regulatory progress.

Uses and Benefits

Piloted remotely on the ground via control stations, UAS are increasingly

A realistic UAS loss scenario

Source: Allianz Global Corporate & Specialty

The incident

A building surveyor uses a UAS for a façade inspection in a town center in Europe. During the inspection the pilot loses control of the UAS. The UAS crashes into the windshield of a truck, which crashes into a coffee shop with 14 people in it. All suffer injuries – three of them fatal. The shop interior, including all merchandise, as well as the truck and its payload are destroyed.

Liability Claim: Who claims for what?

Fatal injuries
All dependants of the fatally injured are entitled to indemnification arising from the loss of income

3 fatalities

Bodily injuries
All dependants of the bodily injured are entitled to indemnification arising from the temporary loss of their provider's income. Health care provider's claim for subrogation of medical expenses

4 seriously injured
7 minor injuries

Shop owner
Costs for rebuilding the shop interior and costs for replacement of the merchandise and potential business interruption

Shop interior destroyed

Trucking company
Costs for truck replacement

Owner of the cargo
Costs for the replacement of the goods

Truck and cargo destroyed

Incident used as example only

Estimated total indemnity: $7.5m (€6.75m)

used for both menial and dangerous tasks, potentially solving problems and overcoming challenges across numerous countries and industries, improving the safety of thousands of workers every year, and significantly reducing costs.

UAS are commercially used in a variety of situations, the most popular of which are industrial inspections, aerial photography, agriculture (surveying crops) and law enforcement. As UAS technology penetrates further, a decline in workers compensation losses can be anticipated, particularly related to building inspections. Insurers are also increasingly using UAS to survey loss damage from floods and other catastrophic events, and to help alleviate distress and damage to victims and property more quickly.

Emerging UAS use includes delivering blood and vaccines to remote locations in Africa, as monitoring tools to prevent the exploitation of slave labor in Brazil, fighting grass fires, and even delivering pizza and coffee. Subsidiary UAS industries are also being created, such as the emergence of third-party drone-for-service vendors who rent UAS to commercial operators.

The Risk Landscape

As recreational and commercial UAS use increases, new risk exposures are emerging. More incidents are likely to occur once regulations are finalized that encourage more widespread use. Such incidents could result in multi-million-dollar claims against businesses, operators and manufacturers.

Hobbyists account for the majority of UAS owners, yet they remain largely unregulated in many countries, raising safety concerns because many can be untrained and inexperienced. Insurers have already seen loss activity resulting from novice control of UAS. Regardless of technological sophistication or operator skill, however, accidents happen.

UAS raise two priority safety concerns: mid-air collisions and the loss of control. A collision can occur if the pilot cannot see and avoid manned aircraft in time. Most at risk are manned aircraft that fly below 500 feet, such as helicopters, agricultural planes, and aircraft landing or departing from airports.

Loss of control can result from system failure or flying beyond signal range, a major risk that has already caused incidents involving injuries. A scenario involving a pilot losing control of a UAS during a building inspection could result

Risk Management Checklist

Owner/operator of UAS

- ☐ Does the owner/operator have approval to operate? Have they completed factory training from the UAS manufacturer? Do they use and apply checklists and standard operating procedures?
- ☐ If you are the owner/operator, insurance needs to be bought from a knowledgeable provider. Aviation-specific UAS coverage with hull and liability coverage is recommended for the vehicle and/or general liability coverage. Purchase adequate limits for the exposure and the type of operation.

UAS manufacturer

- ☐ Does the manufacturer have approval for testing the vehicle and for demonstrating its capabilities at point of sale? Does it adopt high quality manufacturing standards?
- ☐ Manufacturers should require all suppliers to indemnify, include a "hold harmless" clause under which one or both parties agree not to hold the other party responsible for any loss, damage, or legal liability, and carry adequate coverage for their operation. The manufacturer should include thorough user warnings on all products in order to successfully mitigate a failure. Manufacturers should require purchasers to complete training prior to operation of the vehicle.
- ☐ Manufacturers should consider aviation-specific products liability insurance and specialty UAS coverage with no aviation exclusions. The manufacturer should encourage all purchasers to carry liability coverage, shielding the manufacturer from potential lawsuits.

Hiring a UAS operator or service provider

- ☐ A third party operator or service provider should be required to show a copy of their approval documents and answer questions about their safety record. Additionally, they should have experienced pilots. The hiring agent should complete due diligence before hiring services.
- ☐ Require the UAS operator or service provider to carry insurance from a reputable carrier. Require high limits of liability that match the exposure ($5m to $100m) depending on the exposure.
- ☐ Purchase non-owned UAS coverage that provides coverage in excess of the operator's or provider's coverage.
- ☐ The UAS operator should recognize the hiring agent as an additional insured under their aviation insurance policy.

Source: Allianz Global Corporate & Specialty

in a loss easily in excess of $5 million. Damage from foreign objects, such as bird strikes for example, is already a problem for the aviation sector, and it is the fifth-largest generator of insurance claims, according to a global claims review by Allianz Global Corporate & Specialty. A collision involving a UAS striking the engine of an airliner could cause $10 million in physical damage alone.

As with manned aircraft, there are concerns UAS may be used for malicious acts. An emerging peril is the potential threat from UAS being used to target critical infrastructure. There have been a number of incidents of drone overflights at power stations. There are also concerns that UAS could be used to attack sports stadiums or other events where large crowds gather.

Other risk scenarios include the prospect of hackers spoofing a UAS radio signal and potentially leading to a crash, the potential loss or theft of valuable recorded data when the device is transmitting information to the control station, or after the flight by a cyber-attack when the data has been stored. In addition to data protection, there are also many public concerns about such matters as privacy, trespass and nuisance.

The increasing use of UAS is also altering the risk profile of many industries. For example, a real estate agent has little bodily injury exposure, but this changes if an agent engages UAS to take aerial photographs.

Regulation

Regulations have been a significant barrier to more widespread use of UAS. Standards differ remarkably around the world, as evidenced by the hundreds of working groups trying to harmonize rules. Another challenge is posed by the fact that regulations cannot keep pace with technological advancement.

In most cases, the designation between commercial and recreational UAS use is the starting point. Other common standards exist such as visual line of sight

(VLOS) requirements for pilots, size restrictions (usually less than 55 pounds), and restrictions against operating UAS near airports or outdoor venues.

New rules for commercial use in the United States that became effective in August 2016 represent a milestone because they lower the barrier to entry for new commercial users and are expected to significantly increase the number of units in operation. These new regulations are likely to influence other countries to adopt similar laws. The European Union is also working toward issuing UAS rules.

Insurance and Risk Mitigation

As UAS ownership grows, so will expectations for safety education. Operators should make this a top priority and obtain the necessary training and experience to competently pilot their UAS.

Training is crucial to reducing the number of incidents, and operators should focus on flight time calculation, meteorology, security checks for aircraft navigation systems, emergency instructions and air traffic law. For businesses, additional training should include onboard camera image use, flight communications and planning, system maintenance, and a host of other technological issues. Even basic safety checklists can help.

In many countries, UAS registration is not required, causing problems for insurers and claimants. Identification of both UAS and operators will be essential for maintaining proper liability in the future. Introduction of car registration-style methods will help.

Insurance can protect both operators and the public from risk of mid-air collision, as well as physical or property damage or injury to others. Manufacturers, owners and operators of UAS are exposed to a number of risks, as are businesses that sell and service UAS.

If growth projections for the commercial UAS industry in the United States materialize, the drone insurance market has the potential to be worth more than $500 million by the end of 2020. Globally, its value could be approaching $1 billion, according to Allianz Global Corporate & Specialty. ■

James Van Meter is the aviation practice leader at Allianz Global Corporate & Specialty, the Allianz center of expertise for large corporate, specialty and industrial insurance.

Using a Drone as an Emergency Cell Site

Airborne cell site equipment helps emergency workers save lives and property in the aftermath of severe weather and other occurrences that interrupt traditional communications services.

By Don Bishop

On April 5, Verizon conducted engineering flight tests to determine how large an area of wireless coverage can be created aerially using a flying cell site aboard a long-endurance unmanned aerial vehicle (drone) piloted by American Aerospace Technologies. The test of airborne LTE took place at Woodbine Municipal Airport in Woodbine, New Jersey, and was designed to simulate an environment in which commercial power is knocked out indefinitely by severe weather or other occurrences that interrupt traditional communications services.

Verizon conducted the test under a Certificate of Waiver or Authorization (COA) issued by the FAA to Cape May County in preparation for an emergency preparedness exercise involving county, state and federal emergency responders. Christopher Desmond of Verizon Network said the test built upon test flights Verizon conducted in October 2016 to demonstrate aerial coverage.

In October, Verizon used an unmanned aircraft system (UAS) at Cape May Airport in New Jersey to test delivering 4G LTE network coverage from the drone itself, as essentially a small cell site in the sky. A UAS consists of an unmanned aerial vehicle and ground-based controller apparatus. This was the first test with Verizon's Airborne LTE Operations (ALO) during an emergency management and disaster recovery exercise. The test proved that 4G LTE coverage can be provided from an aircraft to first-responders in the event no traditional service is available.

Verizon has a long history of being about to get out in the wake of a disaster, according to Dave McCarley, a Verizon Network Technology Fellow. "We consider ourselves to be leaders in this area, not just in thought leadership, the leaders in action," McCarley said. "Instead of the cell site being planted on the ground, we lifted that equipment up into the belly of a small aircraft to provide coverage where it otherwise might not be."

The test used a 17-foot-wingspan RS-20 drone, owned and operated by AATI. The FAA authorized the drone to fly as high as 7,500 feet, but it was tested with Verizon's network at 3,000 feet and below. The aircraft is capable of flying as high as 22,000 feet. It can fly 12 to 16 hours at a time. With a weight of 165 pounds, the drone can fly in windy weather. The drone streams imagery of the ground to emergency personnel in real time.

The drone connects with Verizon's network, not for piloting, but for providing a 4G LTE signal to emergency personnel through the aircraft.

Verizon conducted the technical trial under authority of a COA issued by the FAA to the New Jersey Institute of Technology (NJIT). The NJIT approved the operation and participated in the research conducted by Verizon and AATI. Data on the flight activity was shared with the FAA in order to advance its goal of safely integrating UAS into the National Airspace.

Shown as it was being launched, the RS-20 drone used in the test of airborne LTE conducted in Woodbine, New Jersey, carried equipment to connect it wirelessly with the Verizon network core. The 165-pound drone has a 17-foot wingspan.

Small unmanned aircraft systems (sUAS) were used to conduct cell site inspections in the Carolinas in the wake of Hurricane Matthew. The aerial footage allowed rapid assessment of any damage to cell sites that were inaccessible by land due to the flood waters.

Verizon conducted its first drone venue inspection at the Circuit of the America's (COTA) racetrack in Austin, Texas, to measure network coverage. The drone carried two smartphones to test the 4G LTE network and record data. The drones were able to fly easily over a large concert area, rows of bleachers and spectator areas still under construction. The drone-based system performance testing took half the time it would take to walk the venue.

Measure, a company that uses different types of drones based on flight needs, used quadcopter drones for both inspections. Small drones weigh 55 pounds or less.

Both drones capture HD video images and can be equipped to capture network performance data.

Measure operates under FAA authorization with a two-person crew that includes a ground pilot and visual observer for safe, legal and insured operations.

Rep. Frank LoBiondo (R-NJ), chairman of the House Aviation Subcommittee, said it comes down to what really matters: saving lives and property. "In terms of emergency preparedness, this is the future," he said. ■

This article was compiled from press releases and video from Verizon.

Verizon Acquires Skyward for Drone Expertise

To spur innovation and adoption of internet-of-things (IoT) services in high-growth markets, Verizon purchased Skyward, an unmanned aerial system company in Portland, Oregon. Verizon wanted Skyward's expertise to use in simplifying unmanned aerial vehicle (drone) operations and management. In 2016, Verizon received $1 billion in IoT-related revenue.

Information released by Verizon said that internationally, companies rely on Skyward for managing operations, improving safety and lowering operating costs. With the acquisition, Verizon intends for businesses small and large to have a single source for integrating, managing and wirelessly connecting their drone operations, linking people, projects and equipment into one clear and efficient workflow.

"We announced our strategy to drive innovation and widespread adoption for in-flight wireless connectivity through our Airborne LTE Operations (ALO) initiative, a new service to simplify certification and connectivity of wireless drones," said Mike Lanman, senior vice president of enterprise products and IoT at Verizon. He said the acquisition helps Verizon focus on operating in innovative, high-growth markets. He also said it helps the company use its network, scale, fleet management, device management, data analytics and security enablement capabilities and services to simplify the drone industry and help support the adoption of IoT.

Skyward's founder and CEO is Jonathan Evans. "Drones are becoming an essential tool for improving business processes at large companies, but scalability has been a challenge," Evans said. "Skyward's drone operations management platform combined with Verizon's network, reliability, scale and expertise in delivering enterprise solutions will allow organizations to efficiently and safely scale drones across multiple divisions and hundreds of use cases."

With Skyward's technology, Verizon will streamline the management of drone operations through one platform designed to handle end-to-end activities such as mission planning, complex workflow, FAA compliance support, supplying information about restricted airspace and pilot credentialing, drone registration and provisioning rate plans for drones on Verizon's network. All of this is designed to help developers and businesses create and manage a wide-range of services backed by Verizon's mobile private network, secure cloud interconnect and data analytics capabilities.

Enhancing Property Values Through In-building Wireless Connectivity

Is vertical integration right for your company? Although it can be a fast path to transformation, it takes time, money and resources. It can require an enormous amount of preparation to manage integrating services from end to end.

By Vince Varga

Property managers, owners and builders are missing an opportunity to increase profits through attracting modern, mobility-favoring tenants. The easiest way for a property to miss out on revenue is to lose tenants to turnover, or worse, not to get them in the first place. To get them in the door, your property must be well-maintained in your tenants' eyes, and your operations staff must be able to work efficiently throughout your property to make this happen. These needs hinge on mobile connectivity, an area in which many properties are lacking. You already provide utilities (water, energy) and amenities (parking, workout facilities), but you may not be aware of in-building wireless, a compelling way to attract and retain tenants in our technology-centric era.

The Opportunity

In-building wireless — which is only present in 2 percent of commercial real estate space — can be a massive untapped opportunity for property owners and managers to increase the loyalty of their tenants and even their property values. For tenants, good mobile connectivity means increased productivity. So much so, that 66 percent of enterprise tenants rated indoor wireless connectivity as essential for employees, as reported by CommScope in its 2015 article, "Wireless in Buildings: Overcoming The Barriers to Wireless Connectivity." When these tenants feel more productive, they are more likely to renew their lease (see Figure 1).

Figure 1. Benefits of an in-building wireless system, CommScope (2015).

With the direct effects of tenant turnover on property cash flow, increasing tenant satisfaction is an important concern. In order to keep tenants renewing, it is imperative that the property is comfortable and well-maintained with competitive features. In a world where more things, both business- and leisure-related, are web-based, improved mobile connectivity is a strategic way to increase tenant happiness and, in turn, property renewals. Research around the issue of managing the high costs of turnover reveals that the best solution is to "never let it get to that point: encouraging renewals is always preferable to turning units over," and enhancing mobile connectivity is a tactical way to keep tenants renewing — as Linsey Isaacs and Derek Mearns put it in their Multifamily Executive article, "Keeping Turnover Costs Low."

For building management and operations, mobile connectivity is important for staff in the performance of duties around the property. As reported by Pete Swaby in his article "Mobility,

Performance, and Engagement," published by *The Economist* in 2016, half of respondents in a survey of property operations staff said that the ability to work from any location at any time has the greatest effect on their productivity. In "Transforming Real Estate Operations with Technology, Automation and Innovation" published in 2014 by Realcomm, Jim Young wrote that mobile devices are also seen by experts as the largest component in the daily operations of a property. Therefore, any gaps in wireless coverage within a property translate into lost efficiency. Seamless connectivity indoors and out is a reality property owners can create to benefit both tenants and staff.

The Problem

Wireless communications are a crucial part of our modern day-to-day lives, but can be frustrating when connectivity is unavailable or unreliable; anyone who has ever dropped or missed a call because of poor cellular coverage knows this. In a 2013 survey of business tenants conducted by AT&T and reported in "AT&T Small Business Wireless Rules," two-thirds claimed it would be a major challenge to survive without wireless connectivity. If a business is lacking coverage and can't survive in its current workspace, it has two options: find a new space to lease or pressure the owner to fix the problem.

Market studies have exposed a driving need for improving in-building wireless communications, noting that:

- Mobile traffic has increased massively and will continue to grow (reported in 2014 by Adam Lella and Andrew Lipsman in "The U.S. Mobile App Report" published by comScore
- Eighty percent of all data funneled to mobile devices is being consumed indoors (Pete Swabey)
- More than half of large U.S. offices have noticeably poor indoor cellular reception (as reported in 2014 in Jeffrey Spivak's *Urban Land Magazine* article, "Raising the (Phone Coverage) Bars in Commercial Buildings."

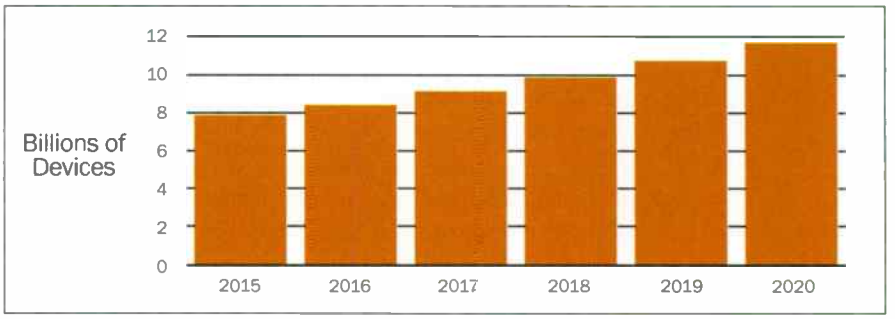


Figure 2. Cisco Visual Network Index Mobile (2016).

Most properties are not exempt from the problem of poor in-building wireless coverage. A 2015 CommScope article, "Wireless at the Office: Are You Meeting Subscriber Demand?" says that three out of four enterprise tenants reported that employees had to move around the building or go outside to find good reception. Not only is poor connectivity inconvenient for tenants, but it can be extremely inefficient for building operations staff when they need to work in traditionally poor coverage spaces, such as a basement, stairwell, or interior room (see Figure 2).

Who is Responsible?

Unfortunately, it is often unclear who exactly is responsible for improving indoor connectivity. According to "Wireless in Buildings: Overcoming The Barriers to Wireless Connectivity" by Commscope, most building professionals place the responsibility on the mobile network operators to solve the problem, but in most cases, it is the property owner's responsibility to deal with this issue. The company pointed out that for property owners, there are several common roadblocks to implementing an IBW system: the cost of the network, the complexity of the technology and a lack of skilled workers to manage the system.

Technology Options

As a solution, in-building wireless comes in a few different flavors, but the goal remains the same: wirelessly connect tenants, guests, and other building occupants to the network services and software applications that they want and need. Whether it's in an apartment building, commercial office building, hotel, healthcare facility, school, mall or public building, everyone now depends on reliable mobile connectivity where they work, live, learn, shop and play.

With an in-building wireless system, your tenants can be more productive (voice calls and email), more engaged (video collaboration and instant messaging), more efficient (building automation), more entertained (Netflix and Facebook), and safer (911 and public safety).

To create a mobile-friendly property, three main technology options are available: a distributed antenna system, small cells/femtocells and

	DAS: Distributed Antenna System	Small Cell + Femtocell	Wi-Fi (WLAN)
Description	Wireless voice and data network via coaxial and fiber-optic cabling to extend one or more mobile network operator's (MNO's) services. These services can come over the air via rooftop antennas or dedicated, MNO-certified base station equipment.	Wireless voice and data network via Ethernet cabling network and access points to extend one mobile network operator's services. MNO services come from shared or dedicated internet connections.	Wireless data network or internet connectivity via Ethernet network. Wireless access points (WAPs) connect to the Ethernet network and then to the internet.
Capabilities	Provides wireless device connectivity for voice and cloud-based software application.		Provides connectivity for any cloud or local software application.
MNO Involvement	Licensed RF spectrum used; carrier will attach based on local market approvals and retransmission agreements.		Unlicensed RF spectrum used. Property owner can deploy at will with off-the-shelf hardware.
Stakeholders	Your IT and facilities personnel, MNO(s), internet service provider, finance.		Your IT personnel, tenants' IT personnel, internet service provider, finance.
Major Considerations	Virtually unlimited in coverage area. Space and power requirements for DAS components. Dedicated internet circuit may be required; may be supplied by MNO.	Limited coverage (5-15,000 square feet) per cell. Dedicated internet circuit may be required; generally supplied by property owner.	Easy to install but can be poor performing if not planned correctly. Internet circuit may be required; supplied by property owner. For shared multitenant Wi-Fi, segregation/security methods likely required.
Costs*	About $1 to $2 per square foot.	About $1 to $2 per square foot; monthly recurring charges involved for ongoing service.	
Timeline	Varies by size: weeks to months; large sites may take a year.	Varies by size; several weeks to months for large facilities.	

*Costs provided are rough estimates; each in-building wireless system has a unique set of cost influences.

Table 1. In-building wireless technology options.

Wi-Fi. The benefits and tradeoffs of each are detailed in Table 1.

Wireless Considerations

Mobile network operators, also known as wireless carriers (think Verizon Wireless, AT&T Mobility, Sprint and T-Mobile USA) have all paid substantial FCC license fees for exclusive access to and control of specific radio spectrum in a given geography. Because of this ownership, carriers require any in-building wireless system to be approved and retransmission of their spectrum authorized prior to connection with their mobile network.

Obtaining this approval involves knowing the right carrier personnel and processes; therefore, when pursuing the implementation of a carrier-involved in-building wireless system, it's best to engage an experienced supplier with established mobile network operator relationships.

Historically, in-building wireless systems at large-scale public venues like convention centers and sports stadiums have been funded with the mobile network operators' capital budgets. At private facilities needing improved mobile network connectivity, in-building wireless may be partially funded by the carriers, but only if they have a compelling financial incentive. To determine if there is value in it for them, carriers look at the number of corporate subscribers, the contract term commitment and the risk of losing those subscribers.

With the increased adoption of BYOD (Bring Your Own Device: the practice in which enterprises allow use of personal mobile network subscriptions and devices [smartphones, tablets and laptops] for work purposes), mobile network operator-funded in-building wireless is becoming less feasible. Because an enterprise loses its buying leverage with any given carrier, the case for mobile network operators to invest in the in-building wireless system is largely reduced.

Another funding option is the solicitation of a third-party operator to fund, design and deploy the IBW system. In this arrangement, third-party operators typically require more than a 10-year commitment from the building owner. Although the financing looks attractive, there are risks to the building owner in that any changes or upgrades to the in-building wireless systems are under the control of the third-party operator.

Another up-and-coming funding option that several in-building wireless integrators have been offering is an operating expense (opex) funding model. This method effectively functions like a lease, reducing the need for large capital expenditure while keeping control of the system within the property owner's hands.

Property owners can implement a technology fee (if correctly crafted) to offset the capital expense (capex) and opex of in-building wireless systems.

In-building Wireless Coverage

It's important to understand where connectivity is needed within a property, because the entire building may not require coverage from all carriers. A simple assessment survey performed by a reputable integrator can give an idea of the current baseline coverage a property receives from surrounding outdoor cell sites and what it would take to fill in any holes in coverage.

For Wi-Fi services, installation of equipment is relatively simple because the building owner has complete control of the system, meaning no outside approvals are necessary. However, complexity enters the equation when each tenant provides its own Wi-Fi coverage — bringing poor signal quality due to RF interference, or when the property owner installs one shared Wi-Fi system — bringing complexity in creating secure, segmented and controlled connections for each tenant.

Care and Feeding

Ongoing in-building wireless network monitoring and management can come from several sources. For large organizations, a dedicated, internal technical staff should be able to diagnose problems and make changes to the in-building wireless system, although some problems may require outside technical support. For other organizations, external support personnel may make more sense. Monitoring and maintenance service contracts of various scale and scope are available on the market.

Centerline Solutions

Modern tenants and guests have an insatiable thirst for ubiquitous mobile data and voice connectivity. Matthew Barksdale's *EngageMobile* article, "New Mobile Survey: Where Mobile is Driving the Most Value for Organizations," says that improved wireless services in a property can raise tenant satisfaction and productivity, improve field service operations, increase sales and revenue, and help property owners gain a competitive advantage.

At Centerline Solutions, our in-building wireless design and build services lead the industry with simple sales and design guidance without the technical intimidation; reliable, comprehensive pricing with funding options to simplify your financial decision; and seasoned technical expertise and established industry relationships that simplify in-building wireless deployment, monitoring and maintenance.

Unlike other network integrators, Centerline Solutions balances the technical and business aspects of any in-building commercial wireless, public safety or Wi-Fi project. Wireless connectivity has evolved into the hub of modern life, and tenants and staff need and expect seamless mobile coverage anywhere and everywhere. Centerline Solutions' in-building wireless services were developed to bring any location up to this expectation. ■

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Quick-Guide to RF Compliance, Monitoring and Management Companies

As a supplement to *AGL Magazine's* January Buyers Guide, a list of RF compliance, monitoring and management companies offers more detail to help you choose a vendor for your next project.

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info@3ztelecom.com
www.3ztelecom.com
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flashsales@spx.com
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See ad on Page 39.

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oblighting@hugheyandphillips.com
www.hugheyandphillips.com
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Product Showcase
Tower Lighting

Combo White Strobe/Red Beacon

The all-LED BKON medium-intensity white strobe and red beacon from **Fuellgraf Chimney & Tower** is designed for the lighting of communications towers and other obstructions to aerial navigation, as specified by the FAA and FCC. The dual L-864/L-865 uses LED technology for light output from both the red beacon and white strobe. Unlike conventional Xenon flashtube technology, little or no maintenance is required during its lifetime. Working voltages of less than 48–200 VDC are significantly less than the 1,000 + VDC of Xenon flashtube designs; therefore, this system represents an advance in safety. The BKON dual L-864/L-865 LED beacon operates from a 120/240 VAC or 48 VDC supply. The power supply/control box can be located up to 550 feet away from the light engine using 18 AWG cable, such as at the base of the tower.

www.chimneytower.com

LED Obstruction Lighting System

The Vanguard Red FTS 371 from **Flash Technology** is an FAA L-864 medium-intensity LED obstruction lighting system. Designed for red-only telecom, utility and MET tower lighting, the lighting system features flexibility for avian and non-avian programming and a variety of monitoring options. The lighting system, which comes with a five-year warranty, meets requirements for structures under 350 feet AGL (FAA A0 and A1 tower types) and complies with FAA AC 70/7460-1L and 1K as well as Transport Canada, ICAO 6th edition and DGAC regulations.

www.flashtechnology.com

Light Pole Power Extender

Ventev's multiport power extender enables continuous operation of access points, surveillance cameras and other PoE+ (power over Ethernet) devices that are installed on light poles with intermittent AC power. Designed for light poles controlled by timers or photocells, the extender powers devices for as long as 18 hours during daylight hours and recharges batteries within six hours at night when AC power is available. The extender provides PoE+ for wireless access points and an additional 35 watts of PoE power for one to two other devices.

www.ventev.com

Lighting Controller

The **Slatercom** WCD FAA E-2 medium-intensity lighting controller incorporates all three Dialight D1RW lighting controllers required for an E-2 system in a single NEMA enclosure. All interconnections for system sync, power and photocell wiring are complete, leaving only flashhead, a single AC power connection and photocell wiring to be completed. The completed system is then completely tested and adjusted as necessary. Systems can be supplied with flashing, steady on, or no marker lights to comply with the latest FAA A/C. Various monitoring systems are available, integrated into the same enclosure (Sensaphone WEB600 monitoring shown).

www.slatercom.com

Medium-intensity LED Tower Light

Hughey & Phillips' Horizon LED medium-intensity dual (red/white) lighting system combines a daytime white LED light and a nighttime red LED light into a single flashhead. The system is self-contained and has a 20-foot pigtail to simplify wiring and installation. With its available GPS or photocell option, the system allows the flashhead to be used at any site. Advanced features include replaceable LED modules, cutting edge optics, individual LED monitoring and bypass and active lightning protection (patent pending). An internal dry contact alarm point allows remote monitoring directly at the flashhead, if a controller is not used. The flashhead's compact, lightweight design allows for easy installation at new or retrofit projects and is covered by a five-year warranty.

www.hugheyandphillips.com

NVG Lighting Modification System

Hughey & Phillip's Halo infrared modification system provides an infrared visual indicator for structures lit with LED technology so anti-collision beacons can be seen with night-vision googles (NVGs). Current LED technology in FAA L-864 and L-865 lighting fixtures may not be visible during NVG operations. The Halo system can be added to any manufacturer's installed medium-intensity LED lighting fixture. The infrared modification system will automatically flash in sync with the lighting fixture during night operation via a patent-pending optical interface. The system will also mimic the flash duration of the installed fixture. The infrared modification system is self-monitored with a dry-contact alarm providing the tower owner verification of operation because it is not visible to the naked eye. The system can also be easily upgraded to future infrared specifications without the need to replace the existing medium-intensity LED flashhead. Mounting of the system is done quickly and easily by simply loosening the four mounting bolts, sliding the bracket under any flashhead and tightening the bolts. Wiring is done with #18-6C cable that will interconnect at supplied terminal boxes on the bracket and in the shelter.

www.hugheyandphillips.com

Obstruction Lighting Monitoring System

The Unimon IOT monitoring solution from **Unimar** offers remote monitoring and control for obstruction lighting, generators and other equipment. It features security and safety in an easy-to-use, economical package. It is designed to provide industrial system status and error

indication along with the best troubleshooting, diagnostics and remote control, all of which are easily accessible through virtually any web browser anywhere in the world. A field technician or engineer can access a system on a smartphone, tablet, laptop or desktop to display system status, view data logs, perform remote test and diagnostics, and control the system. The user can also remotely override the system and perform advanced test and diagnostics. In the event of a status change or alarm condition, alerts can be sent immediately through a variety of user configurable methods.
www.unimar.com

Obstruction Lamps

The Task-Master obstruction lamps from **H&H Industries** are independently tested to meet or exceed all FAA regulations. The 116-watt lamps feature strong C-9 filament construction to burn brightly and dependably through shock and vibration for 8,000 maintenance-free hours. The nickel-plated brass base cannot corrode or freeze in the socket. The lamps come with a one-year free-replacement warranty.
www.lightsbyhh.com

Medium-Intensity LED Obstruction Lighting

TWR Lighting's L550-D series (white) and L550-E (dual red and white) are FAA L-864/865 medium-intensity LED aviation obstruction lighting systems designed for reliable day and nighttime marking of structures between 200 feet and 700 feet AGL (above ground level) that represent a hazard to aviation. The systems meet the FAA AC70/7460-1L specifications and comply with multiple international standards, including ICAO Annex 14, CAR 621 (Canada) and DGAC (Mexico). The L550 D&E systems feature a single combined power and alarm connection cable for easy installation, a modular designed controller, wireless or TCP/IP monitoring options for monitoring beacon failure, heartbeat (active confirmation), power and photocell functionality, as well as custom NOC software and service options.
www.twrlighting.com

Lighting Controllers

Farlight's advanced NV-Series LED obstruction light controllers allow site operators to reliably monitor the latest low-power LED beacons and marker lights. Farlight manufactures alarmed controllers that operate from 100 volts to 277 volts AC, as well as 12 volts to 48 volts DC. Models are available to match all common tower configurations; they feature surge protection on all outputs and inputs, plus an array of alarm contacts to report on all aspects of system health. The controllers are compatible with all Farlight LED obstruction lights, as well as most other LED obstruction lights.
www.farlight.com

Dual LED Beacon

Farlight's NV-L864-865LED beacon incorporates the latest in LED technology. Robust surge protection and a ground-based power supply make the system highly reliable and easy to maintain. The flashhead is compact, lightweight and easy to install. Farlight's night-vision goggle-friendly obstruction light technology is included as a standard feature on every beacon.
www.farlight.com

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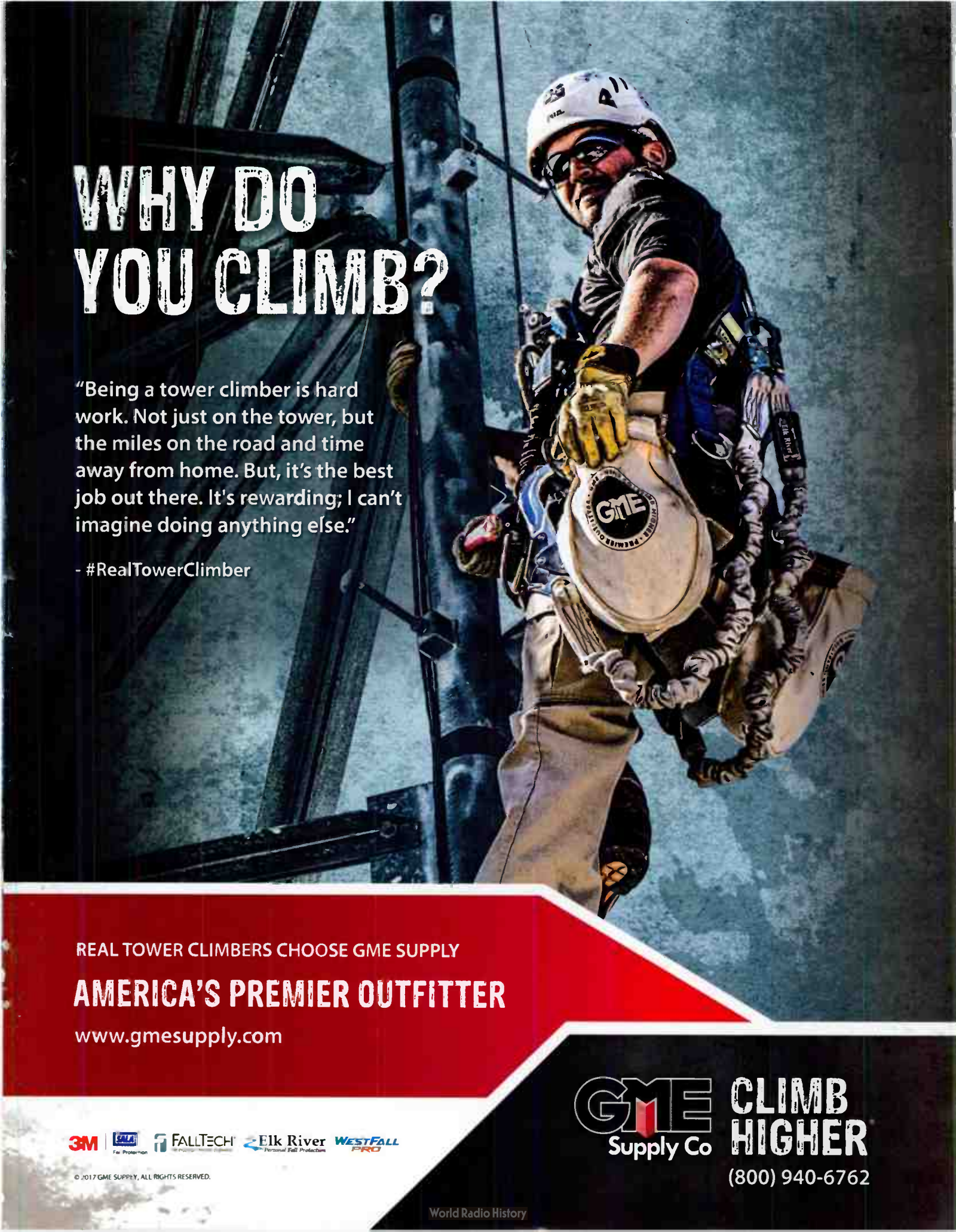

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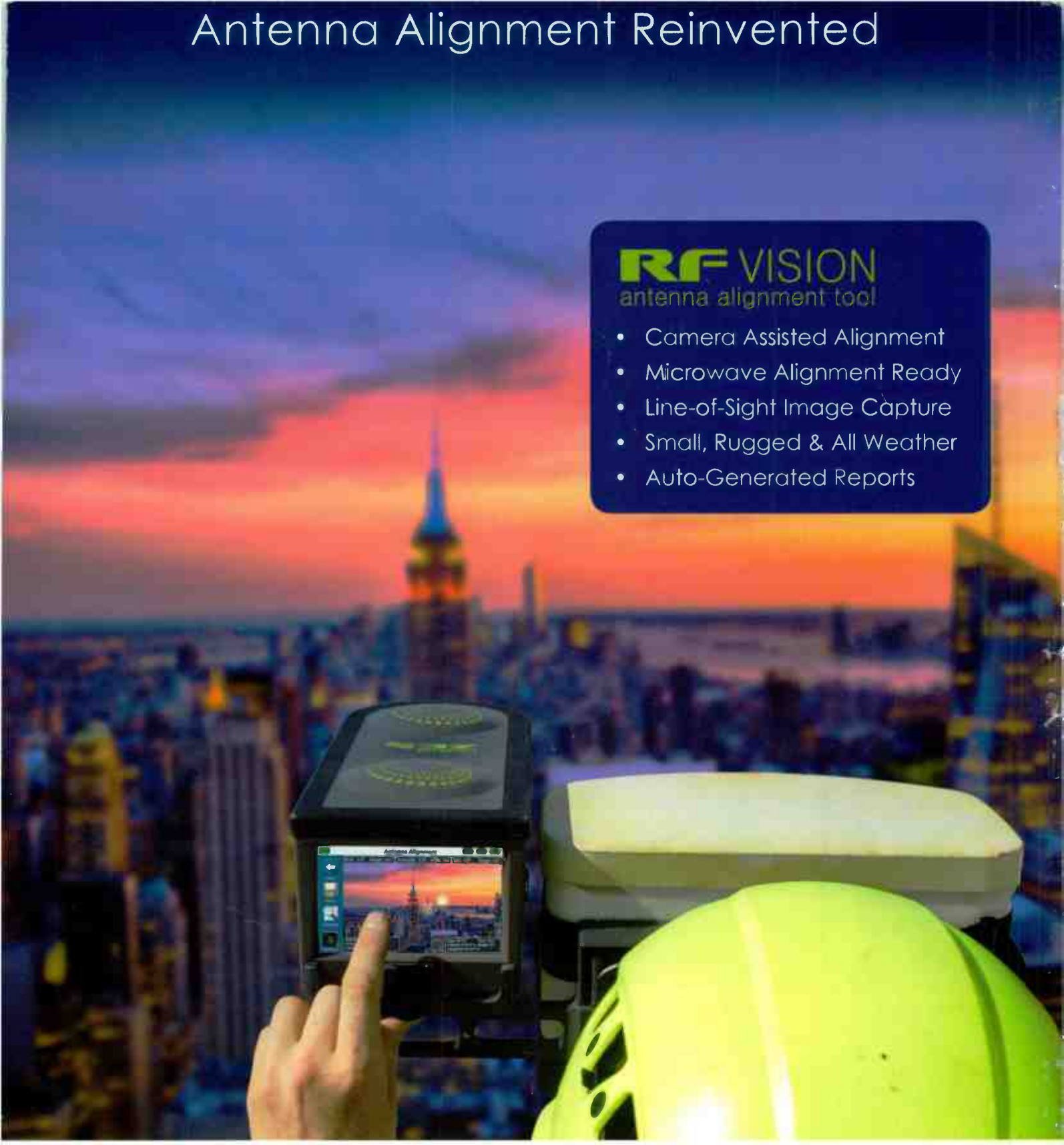

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