

STADIUM

TECH REPORT

WINTER 2021



AT&T STADIUM

REWRITING THE DAS PLAYBOOK

AT&T STADIUM RETHINKS ITS CELLULAR
NETWORK WITH A 670-ZONE DEPLOYMENT

HYPERCONVERGENCE FOR VENUES

INTRODUCING THE NEW
STADIUM TECH REPORT

A photograph showing the back of a man in a dark hoodie and a young boy with blonde hair. They are both looking towards a stadium field where a game is taking place. The stadium lights are visible in the background.

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STADIUM

TECH REPORT

Welcome to the fourth issue of our SEVENTH year of STADIUM TECH REPORTS, the Winter 2021 issue!

These reports are designed to give stadium and large public venue owners and operators, and digital sports business executives a way to dig deep into the topic of stadium technology, via exclusive research and profiles of successful stadium technology deployments, as well as news and analysis of topics important to this growing market.

Our stories for this issue include an in-depth profile of the new distributed antenna system (DAS) installed this past summer and fall at AT&T Stadium, home of the Dallas Cowboys and many other events. We are also debuting some of our new, expanded areas of content coverage, with an in-depth look at how a converged compute infrastructure can help venues recover leasable space and reduce operating expenses. Also look for our inaugural "Design Vision" interview, where we talk to Chris Williams, president of WJHW, to get his insights on stadium design and on two of his company's recent projects, SoFi Stadium and Allegiant Stadium.

Also, please make sure you read my "letter from the editor" at the start of this issue, as it describes the business and strategic changes taking place here at Stadium Tech Report.

We'd like to take a quick moment to thank our sponsors, which for this issue include Corning, Boingo, MatSing, Cox Business/Hospitality Network, Comcast Business, American Tower, CommScope, AmpThink, ExteNet Systems and Ventev. Their generous sponsorship makes it possible for us to offer this content free of charge to our readers. We'd also like to welcome readers from the Inside Towers community, who may have found their way here via our ongoing partnership with the excellent publication Inside Towers.

As always, we are here to hear what you have to say: Send me an email to kaps@mobilesportsreport.com and let us know what you think of our STADIUM TECH REPORT series.

Paul Kapustka, Founder & Editor
Stadium Tech Report



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Paul Kapustka

Welcome to

STADIUM TECH REPORT!

t was 2011 and I was listening to AT&T's John Donovan give the keynote talk at CTIA in Orlando. I had gotten to know John as an analyst covering the 4G wars. During his address he shared that for the first time ever, at the recent Super Bowl (XLV at Cowboys Stadium – now AT&T Stadium) there was more commercial cellular traffic leaving the venue than coming in. That one statistic stuck in my mind.

As a former sports writer, I knew that this signaled a change in the behavior of sports fans. Cell phones were transitioning from a distraction to an enhancement of the live venue experience. Phones enabled fans to share the game with friends outside the venue in real time. As a cellular analyst, I knew that macro cell networks weren't up to the task if more people decided to try the same thing at other venues. Where sports met technology, the seed of an idea was formed.

Later that year, I launched Mobile Sports

Report to document the impact of mobile devices on sports. The general idea was to first attract an audience, and then advertisers. Early on, we covered a lot of interesting and now-dead ideas. But one topic kept popping up: Wireless network performance inside of stadiums was bad and getting worse. Fans were not being quiet about it, either – forcing venues to try to solve the problem. By covering these stories I was there, a witness to the birth of high-density ("HD"), large public venue ("LPV") networking.

OUR FOUNDATION: STADIUM SCALE NETWORKS

By 2014, the debut of Levi's Stadium established a performance benchmark. Levi's featured an HD under-seat Wi-Fi network and an extensive DAS. Wireless networks had been established as a necessary component of any venue of note – and Mobile Sports Report had its calling card. That same year, we created a quarterly report to track, analyze, and report on the progress of this nascent industry. We offered venues and venue operators insights into the progress of their peers. We offered OEMs and integrators a catalogue of their competitors' projects. And we recorded the evolution of an industry.

In addition to documenting individual stadium and arena implementations, we did surveys and compiled lists of league and school wireless deployments. We reported on network performance and implementation methods. This was the beginning of an "arms race." Our top 10 and then top 25 lists would become our most read and downloaded reports. You may hate us or love us for this, but the industry took notice!

OUR PRIORITY: IN-DEPTH REPORTING

Focusing on Wi-Fi and DAS deployments, we built a catalog of knowledge. Our publication served as a written history of the evolution of wireless technology in stadiums. Our ethos, putting objectivity and good stories first, paid off. We attracted a loyal audience that represents the vast majority of professional and collegiate venues in North America.

In spite of our success, it always felt like there was something missing, something important we weren't getting to. We tried to replicate our success in wireless networking by branching out to cover other parts of the "tech" in stadiums. But, we always found ourselves constrained by budgets, time, and the tough task of trying to balance

business operations with newsgathering and storytelling. We'd established a successful business, but one that always felt like it needed another gear.

COVID-19 – A CATALYST FOR CHANGE

For everyone, the Covid-19 pandemic has been horror beyond contemplation. We consider ourselves fortunate that we've been able to stay safe and healthy. We extend our gratitude to those who are doing the essential work that keeps us all fed, safe, and alive while we battle the unseen foe. While the stories have continued to flow, it is only because of the support of vendors, service providers, and stadium tech personnel, who all have relayed information and photos to share the places we couldn't visit.

With events canceled, no fans allowed in most stadiums, and revenue chains across the entire live-events industry greatly diminished, we contemplated scaling back our own operations. But, we believed that we had an important calling. For venues to overcome the pandemic it was going to require more technology, and more adjustments. To "return to normal," our readers would need more, not less, information.

In March we started a research partnership with our friends at AmpThink. We conducted a series of deep-dive, on- and off-the-record conversations with the best minds in our industry. We wanted to know what they thought the business of venues would look like during and in the aftermath of the pandemic.

Strangely, we came away from those talks optimistic. Our initial thinking was correct. Many of those we talked to mentioned new technologies and new ideas that would be needed to confidently bring people together again. And these ideas ventured well beyond wireless. Connectivity was part of the equation, but more an enabler than a solution.

Now more than ever, the LPV marketplace needs a voice for these ideas. We envision Stadium Tech Report as a platform to profile early adopters and groundbreakers. A place to share the seeds of the ideas that will transform venues. We've developed approaches to revamp our coverage methods, to bring more voices into the fold, and to use digital publishing to improve our story-telling capabilities. But with vision comes expense.

COMMUNITIES ARE BUILT BY PIONEERS

Stepping in as "co-producer," a change that starts with this issue, AmpThink brings a talented in-house creative team, necessary cash, and a thick Rolodex of smart people to the Stadium Tech Report family. The new Stadium Tech Report's business model will build on our cornerstone partner – AmpThink – by attracting a few more top-level partners to comprise an advisory board who will contribute their time and resources to our mission. With the support of these advisors, we will continue our tradition of providing relevant and independent news, analysis, and information. As always, we will not accept paid-for content or write stories based on sponsorship deals, but rather tell the best stories we can.

Internally we call this the "NPR model," using the well-known public radio financial model as our template. In the near term, our advisors will be our primary source of financial support. However, we will continue to offer advertising opportunities for those who want to continue to reach our audience. We also plan to open up an online shop to sell STR-branded schwag for individuals who want to offer their own support for our vision.

Over time, expect Stadium Tech Report to evolve. Building on our traditional features, we will leverage podcasts and video interviews to offer more in-depth coverage of the stadium tech world. Future topics will include compute, concessions, building automation, security, construction, ticketing,

fan experience, and oh yes – the newer, more powerful wired and wireless networks needed behind it all.

JOIN OUR FUTURE

Like AT&T Stadium – which used the Covid downtime this summer to help it build its massive new distributed antenna network in just 16 weeks – we've used 2020 to boldly transform our publication. Already, we've added stories about how things like cashless stadiums and digital ticketing have accelerated from test deployments to full operation. We've covered the convergence of wired networks. We've highlighted the evolution of new stadium construction. And we've highlighted the transformation of fan behaviors; from hesitant to download an app to demanding app-based, touchless, cashless options. What's next? Let's find out together!

A wise person once said, "Make no little plans." Following that lead, we are planning not to cut back but to expand. All are welcome aboard; advisors, partners, sponsors, readers, and skeptics. Here's to building something better for everyone.

– Paul



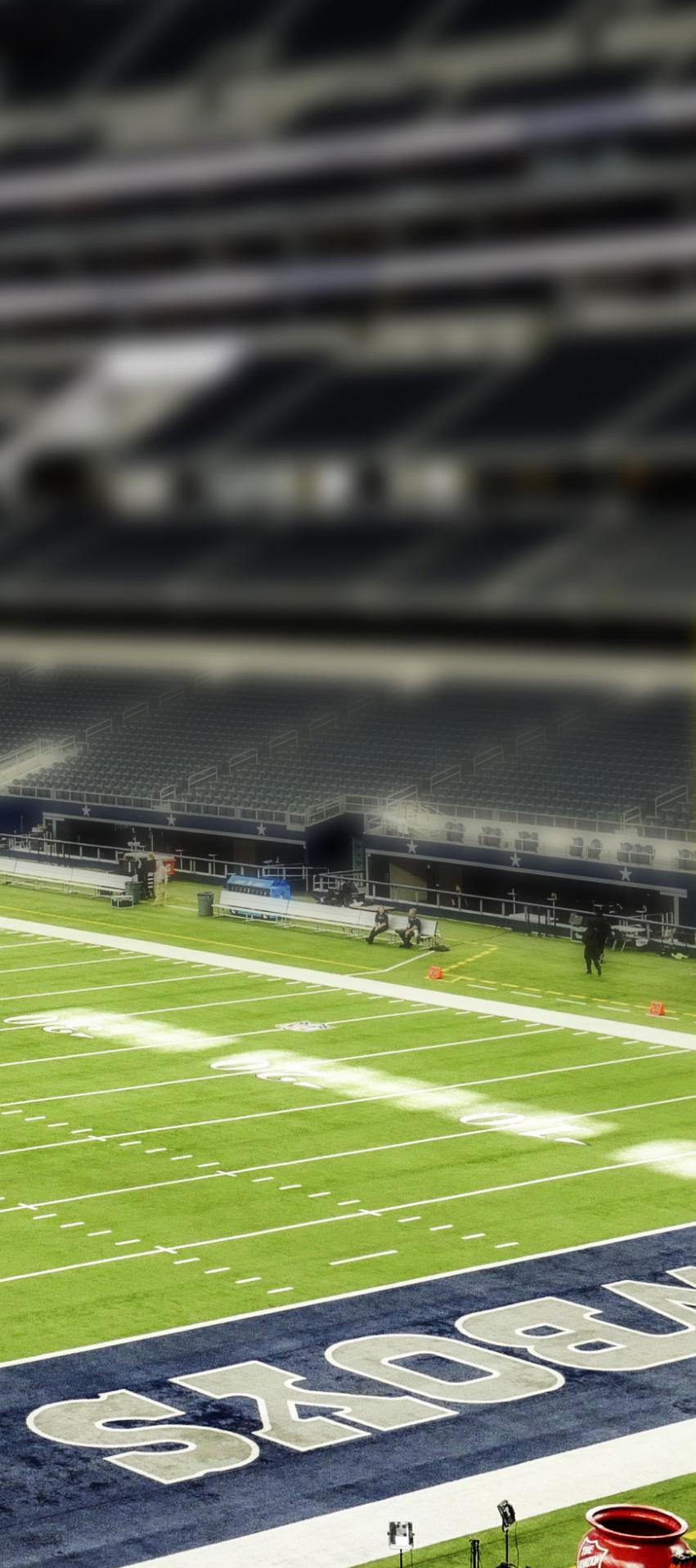
AT&T STADIUM REWRITES THE DAS PLAYBOOK FOR NEW NETWORK

ExteNet Systems' 670-sector design uses digital backbone from CommScope, MatSing Lens antennas to deliver a network for the future

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Lens Antennas | **MATSING**



\ \ BY PAUL KAPUSTKA

When the building now known as AT&T Stadium opened in 2009, it arguably changed the way the world thought about large entertainment venues. In many ways it pushed the envelope on what was possible to make the fan experience better than imagined, from the largest-at-the-time videoboard to the stunning, flexible architecture, which positioned the venue as a host to events well beyond football.

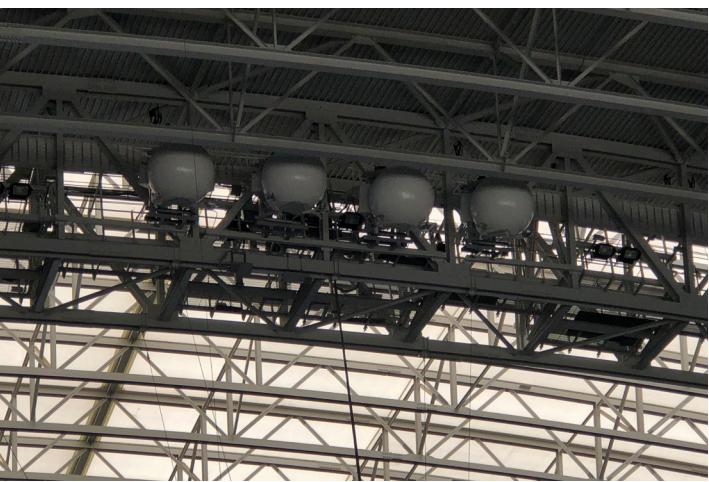
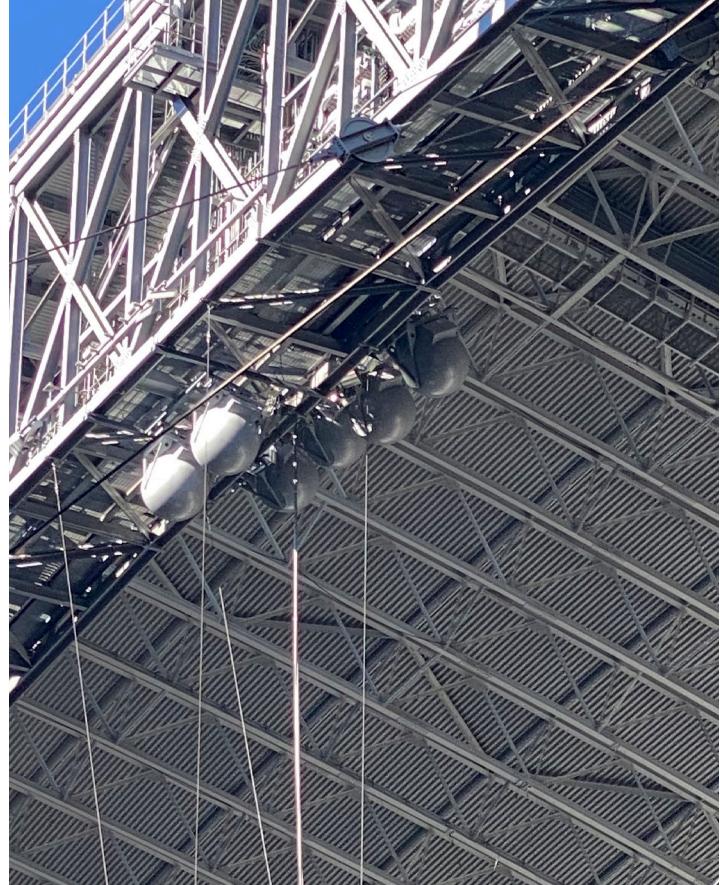
When cellular giant AT&T added its name to the venue via sponsorship in 2013, the building was already well on its way to being one of the leaders in fan-facing wireless networks, with both a cellular distributed antenna system (DAS) and a Wi-Fi network that were both expanded on in following years.

But sometimes, like a star player whose talents are fading, networks reach the end of their useful life, and it's time for a replacement. Such was the case with AT&T Stadium's DAS network the past few years, as older equipment in an older design just couldn't keep up with the growing demands of a mobile-device-centric fan base.

"Our DAS was really at the end of its life," said Matt Messick, chief information officer for the Dallas Cowboys. The past couple seasons, Messick said, "I was receiving instant feedback about when it was not performing. And last year was especially rough. At every Cowboys game, we were hitting the limits."

"I was receiving instant feedback about when it was not performing. And last year was especially rough. At every Cowboys game, we were hitting the limits."

But like a good front office that is constantly seeking to improve its talent, Messick and the team's networking partners had been busy forming a new plan – one more than two years in the making – that threw out



Clockwise from top left: A look inside the cavernous arena; scissor lifts help with installation; MatSing antennas painted to blend in. Credits: Top left, Todd Bergman, STR; other photos: ExteNet Systems.

all the old DAS playbooks and instead built something completely new. The end result included: An incredibly dense network design, with 670 network zones, approximately a 10x increase from the previous DAS; an all-digital infrastructure that allows for more optical fiber, reducing the amount of telecom gear needed on premise, resulting in huge power and space savings; And cutting-edge MatSing Lens antennas to provide precise coverage to the seating bowl, with the ability to cover previous problem areas, like lower-bowl seating and on-field configurations, for concerts and other events. The DAS will also be able to support lower-band 5G communications when carriers deploy services in that spectrum.

Taking advantage of the break in event hosting brought on by the Covid-19 pandemic this summer, the Cowboys and networking partners ExteNet Systems,



Above: MatSing Lens antennas point down from the rafters; below: Tech crews built the new network in 16 weeks. Credits: Top: Todd Bergman, STR; below: ExteNet Systems

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CommScope, MatSing and lead cellular provider AT&T were able to install the new network in just 16 weeks, having it ready to go before the Cowboys' 2020 NFL season began. And while the limited number of fans in attendance at home games this year probably had more bandwidth than they could handle, Messick is looking forward to a future of full houses, because he's confident that the new DAS will be able to support all the demands the crowds request, for now and into the foreseeable future.

TAKING A LARGE LEAP INTO THE FUTURE

While any stadium's operators and network crews may feel pressure if their wireless isn't performing well, consider the extra impetus on making sure mobile devices work well inside a building that has the name of one of the nation's top cellular providers across its facade.

"The AT&T name on our building is just one of the main driving factors behind this, and why we needed to take a large leap into the future," Messick noted.

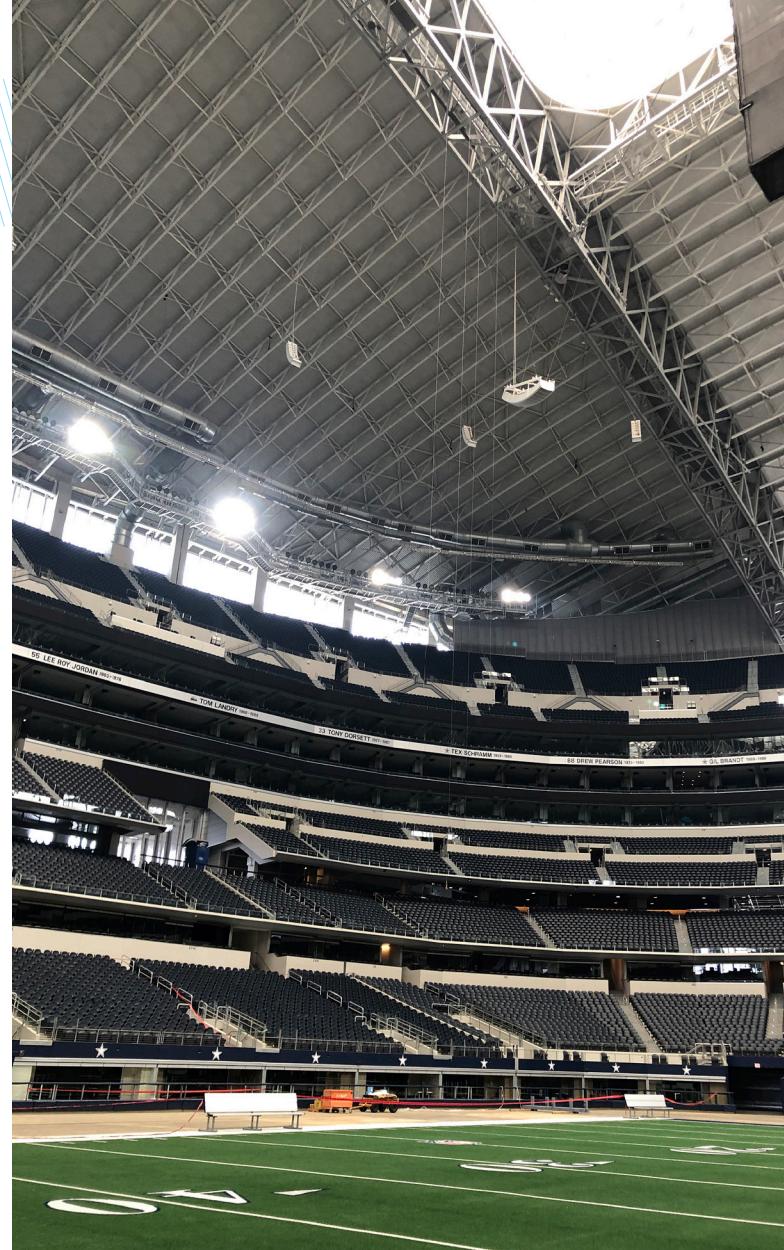
Ian Sinclair, AT&T's director of RAN engineering for north Texas, agreed.

"For AT&T, this is one place we wanted to be loud and proud," Sinclair said.

But if there was agreement on the end goal — to build the biggest and best DAS ever — it was the devil of the details of how to get there that caused the most consternation. Jeff Alexander, senior vice president for ExteNet Systems, the network operator at AT&T Stadium, said the process started with the understanding that the new system would be much more detailed than just a simple upgrade.

With traditional top-down cellular DAS systems under strain in stadiums everywhere, the partners picking the new network for AT&T Stadium knew they couldn't rely on prior designs to be their guide.

"This had to be nothing like the past — the past designs could only get us so far, and we knew we needed something more, something different," Alexander said.



AT&T Stadium's roof structure provided a perfect place for the MatSing antennas. Credit: ExteNet Systems

"This had to be nothing like the past — the past designs could only get us so far, and we knew we needed something more, something different."

In search of a combination of technology and deployment strategy, the team of partners left no stone unturned in their search for the pieces needed to solve the puzzle.

"If I said we looked at every available option, that's an understatement," said Alexander, who ran off a long list of different vendor equipment and deployment

methods considered, like under-seat, behind-the-seat, and small-cell architectures, among others.

With stringent requirements for architectural aesthetics and structural engineering concerns as well as overall performance, Alexander said that all of the early ideas failed in one way or another.

"For some reason, we disqualified everything we came up with," Alexander said.

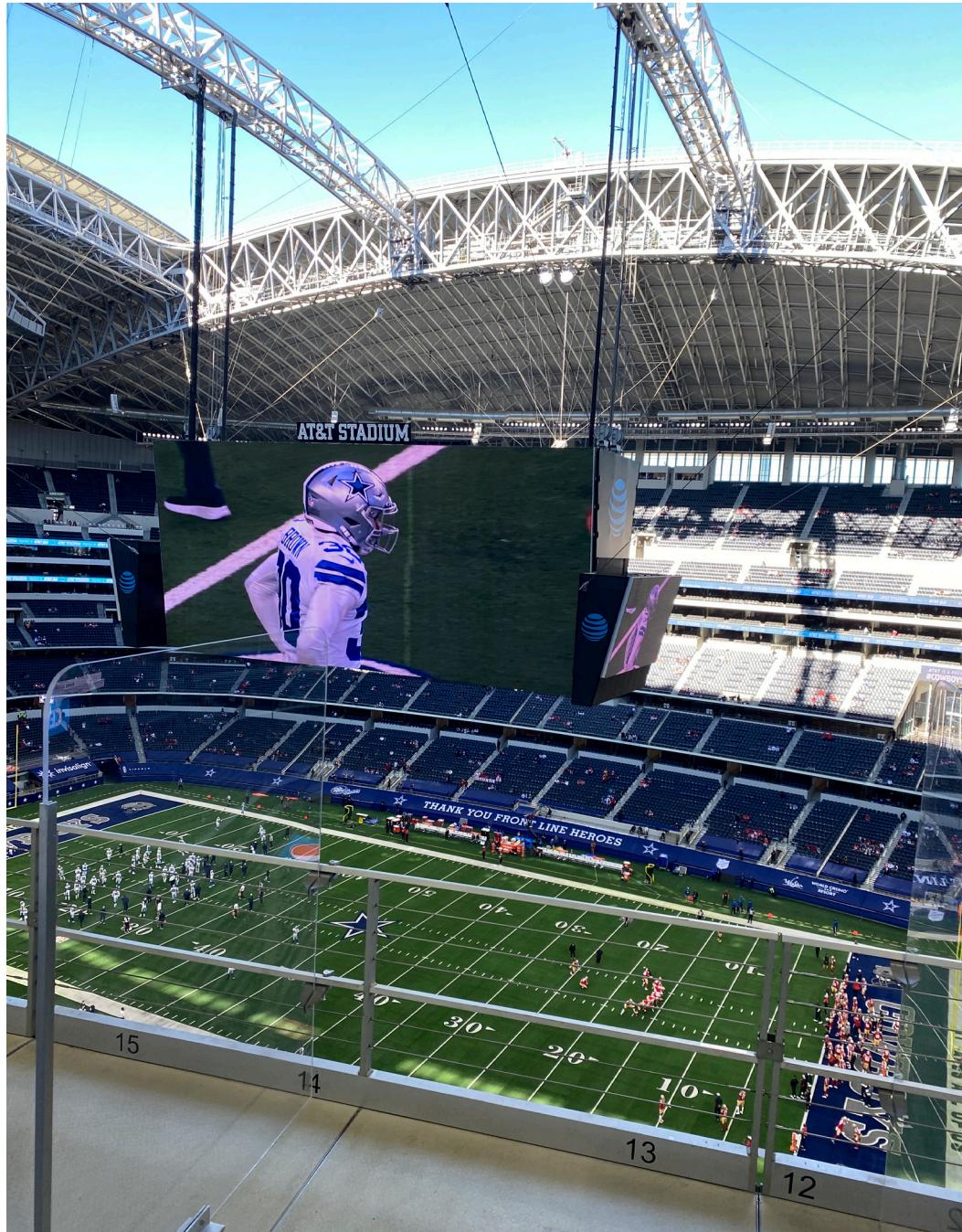
But then, Alexander said a key question was asked: "We wondered – if we used MatSing antennas, what would it do for us?"

MATsing ANTENNAS A 'GAME CHANGER'

Both AT&T and ExteNet had some recent experience with the unique, ball-shaped antennas from MatSing, which offer multiple radio antennas with the capability to allow for incredibly precise beams of coverage. AT&T, which installed a DAS based on 52 MatSing antennas at Amalie Arena in Tampa a couple years ago, saw good initial performance from that network at the NCAA Women's Final Four in 2019. ExteNet, which used some MatSing antennas in its DAS design at the Milwaukee Bucks' new Fiserv Forum, said it was pleased with the performance of the MatSing devices there.

Since the MatSing antennas can broadcast a signal much farther than conventional antennas, the latest design twist with MatSings is to put them in the rafters of an arena, a placing that gives them

clear line of sight to seats while also keeping them hidden from fans' eyes. With its extensive overhead structure, AT&T Stadium had more than enough places to mount the MatSing antennas, which were six feet in diameter, to point down at the seating bowl.



A bird's-eye view of the huge videoboard. Credit: Todd Bergman, STR



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With each antenna able to accept 48 remotes, MatSings give venues a different way to deliver dense coverage from a single installation spot – and one that is much simpler to tune, since the line-of-sight coverage areas are calibrated with a laser beam instead of the extensive RF balancing required with traditional DAS systems. The Las Vegas Raiders are just one of the recent converts to the school of MatSing, using 30 antennas to supplement the DAS at their new home, Allegiant Stadium.

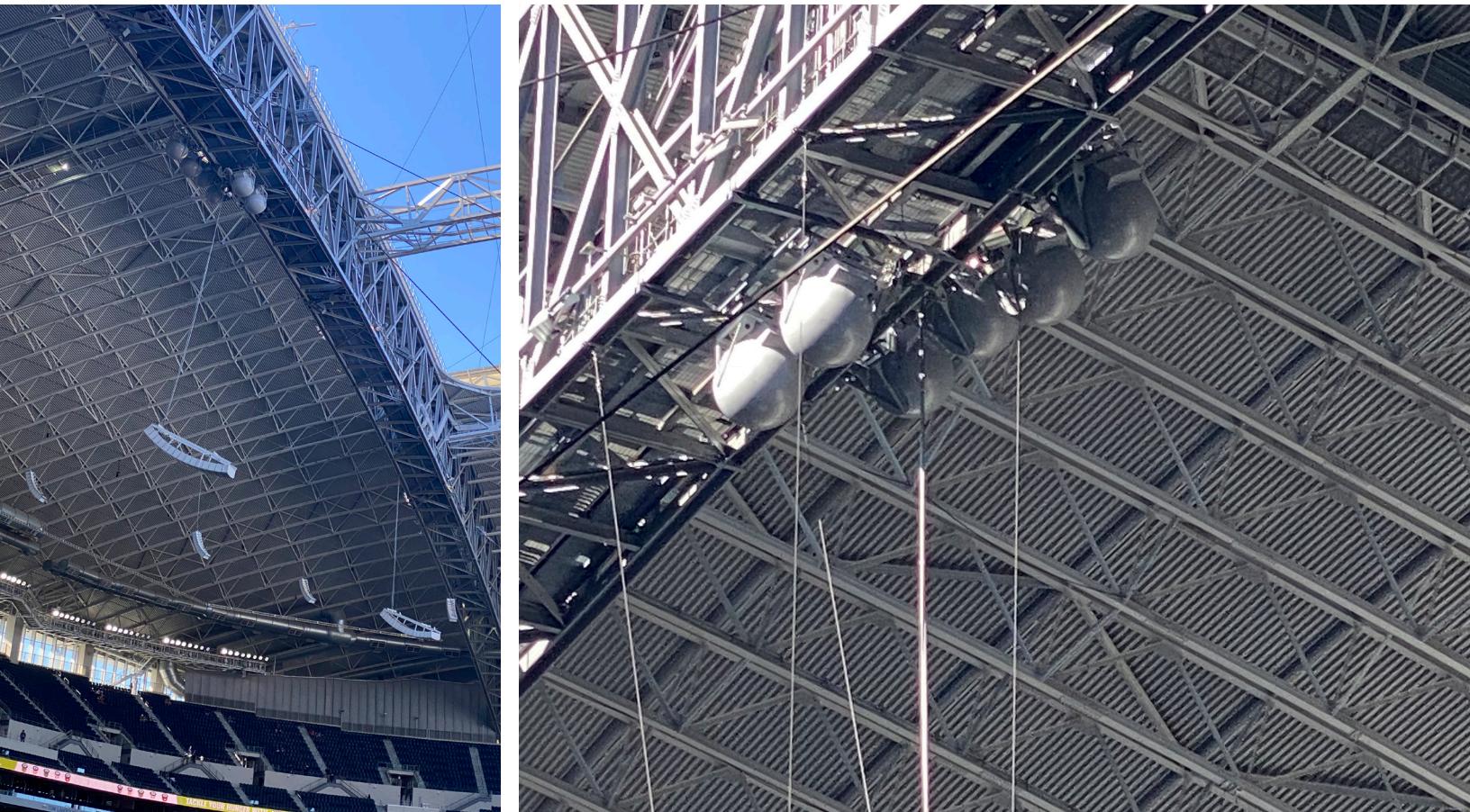
GETTING IN THE ZONE: MORE DAS DENSITY THAN EVER BEFORE

With the MatSing antennas' ability to precisely split the seating area coverage, the team of network partners had the key element to support their idea that what was really needed was a radical increase in the "zones,"

or separate areas of antenna coverage, inside the stadium.

Increasing network density with smaller zones is the design goal of several new DAS deployment methods, including under-seat antenna designs, which mimic the low-power, many-antenna designs familiar to under-seat Wi-Fi deployments. But with the MatSing antennas, ExteNet's Alexander said the network team was able to support "extremely precise" zones without having to worry about the costs of drilling under-seat, or having to do network testing for interference between nearby devices as would have to be done with an under-seat design.

"MatSing was just a huge game-changer for us," the Cowboys' Messick said.



Far-away and close-up views of the MatSing antennas. Credit: Todd Bergman, STR

From there, other design elements and strategic decisions emerged. One was to make every one of the stadium's 380 suites its own DAS zone. Another was to exclude the use of lower-band spectrum, primarily those bands under 1000 MHz, because signals in that range are actually "too good" at covering a wide area — a feature great for outdoor macro networks but not so fantastic when you are trying to deploy low-band cellular inside a close space. According to Alexander, the new DAS will only support licensed cellular spectrum from 1700 MHz and above.

"Lower bands are just not controllable," said Alexander. Leaving them out, he said, "was a key to the design."

DIGITAL DAS BACKBONE PRODUCES SPACE AND COST SAVINGS

To support a DAS design with 2,345 remotes, the AT&T Stadium team turned to longtime partner CommScope, which had been the backbone infrastructure and cabling partner for the original DAS deployment.

"When we did the first one, the DAS had 21 zones and we thought we overbuilt it," said CommScope director of business operations Sean White. Now, there are 238 zones just for the seating bowl.

For the new DAS CommScope



It takes a lot of wires to make a wireless network happen. Credit, top photo: ExteNet Systems; bottom photos: CommScope

brought its all-digital ERA digital distributed antenna system, which uses a Common Public Radio Interface (CPRI) to link the Era C-RAN system to Nokia baseband equipment. According to White, the system allowed the elimination of the traditional DAS analog conversion stage, keeping the entire system digital. The amount of power-hungry, bulky telco gear is substantially reduced, producing a low power consumption and huge reduction in head-end room geographical space. According to White and AT&T, the carrier's internal equipment gear footprint is about four or five racks, down from 30-40 racks needed in a traditional DAS deployment.

"When you eliminate the need for the power and A/C, it's a tremendous amount of savings for operators," White said.

"It's an incredible opportunity to have the DAS be very efficient on power, space and cooling," said AT&T's Sinclair, whose company is the first carrier on the new DAS. "It's an amazing shift in technology, it's very expandable, very neat," Sinclair said.

5G AND THE FUTURE: BUILDING A DAS TO STAND THE TEST OF TIME

On top of the new DAS the stadium also has an AT&T millimeter wave 5G overlay installation, which according to Messick is already producing "ridiculous" speed tests in the gigabit-per-second range. All



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Clockwise from top: A MatSing antenna is lifted into place; DAS gear under the seating areas; looking down from a MatSing's location.

Credit: ExteNet Systems

of the capacity is necessary, he said, especially in an era when teams are already seeing an acceleration of internal technology-related business plans due to the concerns raised by the pandemic.

"We had planned a slow roll for things like digital ticketing, because many people, including suite holders, still wanted paper tickets," said Messick of plans made before Covid-19. But with social distancing concerns, the Cowboys (like many stadiums that were open to fans this fall) went immediately to all-digital ticketing, and also made the leap to cashless concessions and parking operations.

"We had planned a slow roll for things like digital ticketing, because many people, including suite holders, still wanted paper tickets."

"But to do all that you have to have rock-solid connectivity," Messick said. "The timing is right to make a lot of digital transformations. And now we have the DAS to support it."

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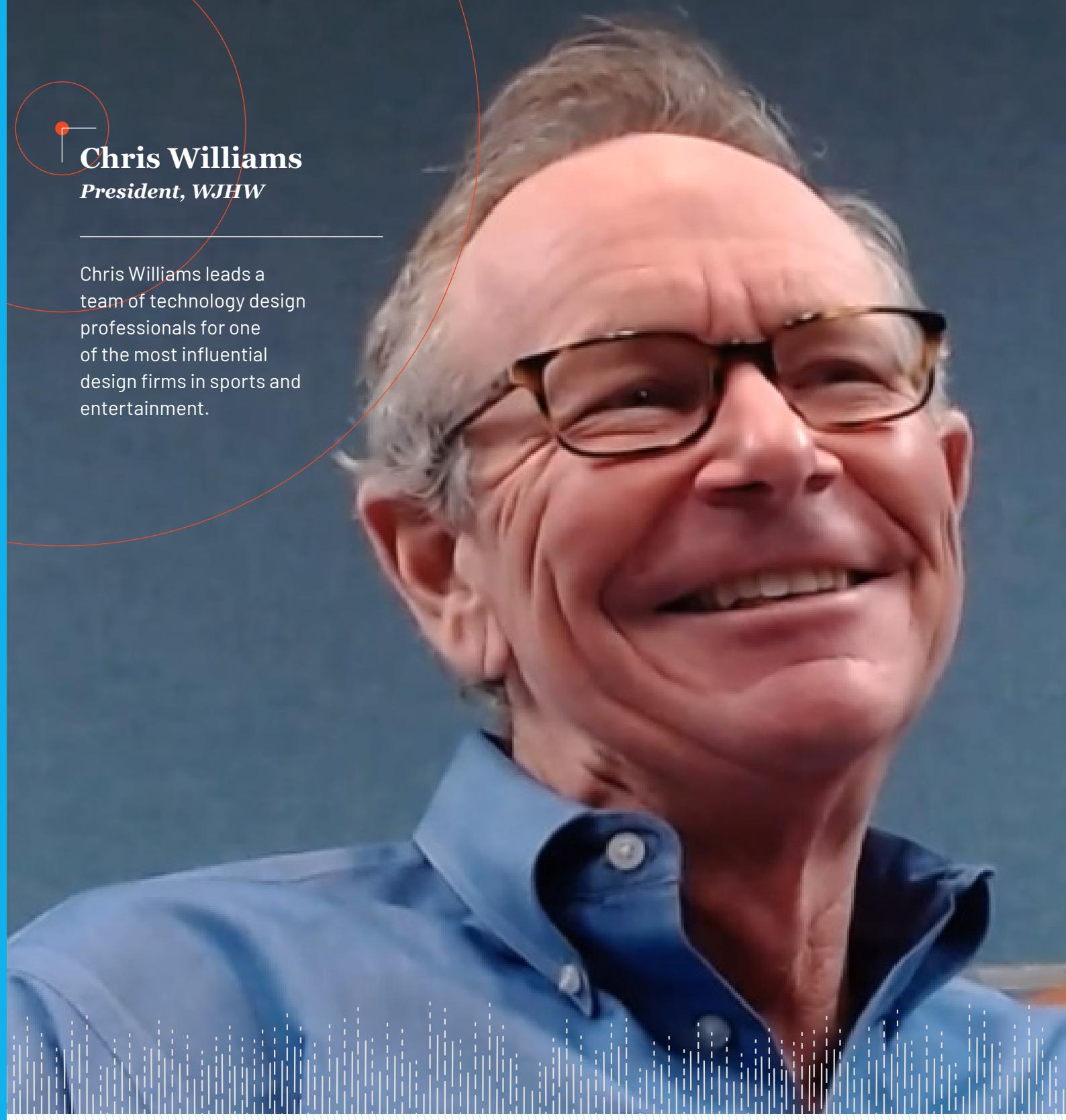
Join experts from Ventev and Velaspan, an industry-leading network design company, on February 24, 2021, at 2:00 p.m. ET for a live webinar discussing the changes and technological advances seen in the past year in network design for stadiums, arenas, and other high-density venues.

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Chris Williams
President, WJHW

Chris Williams leads a team of technology design professionals for one of the most influential design firms in sports and entertainment.



DESIGN VISION

Before the holidays we had the opportunity to sit down with Chris Williams, President of WJHW. WJHW has been involved in the design of hundreds of stadiums. He was personally involved in recent projects featured in STR including Allegiant Stadium and SoFi Stadium.

INSIGHTS

EXPERTISE: Display technology and broadcast production

EDUCATION: Electrical engineering degree from UT Arlington "which I promptly threw away" to work in video production

WHAT YOU MIGHT KNOW: Likes to swim, likes to ski

WHAT YOU DON'T KNOW: Is an Eagle Scout, enjoys cooking

MAC OR PC: Apple to the core. On his iPhone all day long, though he runs some Windows apps in a VM

FAVORITE APPS: WAZE, IMDB, and BIM 360

SPORTS MEMORY: The day before his wedding, attended Nolan Ryan's seventh no-hitter

VENUE HE LIKES BUT DIDN'T DESIGN: Baylor's McLane Stadium – "it looks great on TV"

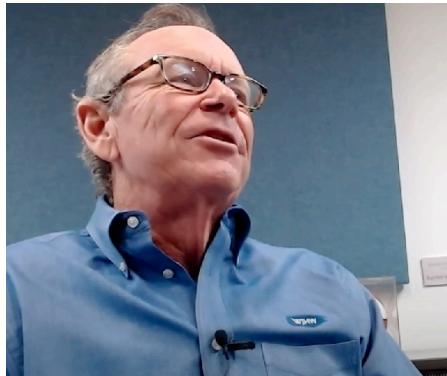
WORK PHILOSOPHY: "A top-notch designer is always obsessed with the technology that they're working on deploying."

Continue reading...

Welcome to Design Vision, our new feature that puts the spotlight on stadium design and build professionals with one-on-one interviews. In our first interview, AmpThink president Bill Anderson talks to Chris Williams, the president of WJHW.

During our almost hour long interview – available as a podcast in the near future – Chris talked about getting started with audio/video technology at his church as a teenager, a brief stint working as a systems integrator, and eventual career as a consultant resulting in the formation of WJHW in 1990 with Jack Wrightson, Jim Johnson, and Bill Haddon.

With 30 years of experience designing stadium technology, it was interesting to learn what keeps Chris going. While he and his firm may be best known for their work in sports and entertainment, WJHW devotes much of their practice to K-12 AV projects which offer more volume and a counter point to the complexities of an NFL stadium. When pressed to explain the success Chris has had with his career, he focused on being obsessed with the technology being deployed. That obsession is the key to being more than a journeyman. Longevity has provided Chris with the opportunity to see shifts in technology in real time. In 2004



WJHW designed several standard definition video production facilities while they opened high definition ("HD") facilities for the Atlanta Braves and the Toronto Blue Jays. In 2020, Chris led the implementation of the first pure SMPTE 2110 video production environment in a stadium or arena. Each of these projects ushered in new technology that had or will have profound consequences for teams and venue operators. Another shift Chris witnessed firsthand was the transition to massive and complex video boards; first with the largest video board at the time – Jacksonville Jaguars at TIAA Bank Field – then the "Halo Board" in Atlanta, and now the "Oculus" at SoFi Stadium in Los Angeles.

A large body of work has afforded perspective. While WJHW's work on new buildings make headlines, Chris sees renovation projects as being the bigger challenge. While new construction has its challenges, renovations are often constrained by existing conditions. What is possible is limited by what is. Or as one of Chris's clients summed it up, "You know I'm going from the stone age to the space age."

Leading WJHW requires that Chris needs to drive innovation to keep WJHW relevant to the industry and their customers. What levers is he pulling? On the design front, Chris is evangelizing the use of modeling tools – both visual and auditory. Chris sees "an absolute explosion of opportunities of advancement in technology from computer-aided design or building information modeling".



Chris sees “an absolute explosion of opportunities of advancement in technology from computer-aided design or building information modeling.”

And as one of the largest licensees of Ease (audio modeling software),



WJHW’s “Ease Jockeys” are relying on audio modeling to design systems before a single shovel hits the dirt.

When it comes to recommending technology to their clients, what informs the team at WJHW? Technology should drive a financial or operational advantage. One example has been Chris’s advocacy for using 4K cameras capable of virtual pan, tilt, and zooming. Implementing these systems provided WJHW’s NFL customers with a competitive advantage on the field with many spending as much as a half a million dollars to gain the advantage.

What advice does Chris have for venue operators? “Visit other venues and talk to other users. I think that really facilitates the

educational process. We can see teams that are divisional rivals – say, the Ravens and the Steelers – and they’re willing, very willing, to share back-office type things and technology things that don’t impact their playing on the field.”



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of the shrinking data center.*



\ \ BY BILL ANDERSON

Today, venue owners can leverage hyperconvergence to reduce the costs of the technology deployed in their buildings.

Starting in the late 1990s, enterprise customers seeking to address the rising costs of server infrastructure began seeking ways to load more applications onto individual servers to reduce the space, power, and cooling expenses related to increasing demand for information technology systems. Building on increasingly powerful processors and time-sharing concepts implemented on mainframes by providers such as IBM, enterprise customers began to employ virtualization to run multiple workloads in parallel on a single server. Pioneers in the space included VMWare and Microsoft, two players who dominate the virtualization space today. Virtualization is the foundation of cloud computing and has been enabling efficient scaling of IT Operations for the last 20 years.

In parallel with the development of virtualization, storage area networks ("SANs") emerged as a way for a collection of servers (a "server farm") to share disk space on a network

attached appliance. The benefit of shared storage was the consolidation of unused space across servers, reducing the total amount of disk space required in the data center. As virtualization technology matured, physical storage devices were virtualized allowing applications on one server to access storage on one or more disconnected servers ("virtual SANs" or "VSANs").

The combination of virtualized applications and virtualized storage together created the possibility for any application to flexibly use resources of any connected server; memory, processor, and/or storage. In fact, with all applications executing on top of a common virtualization platform (the "hypervisor") it became possible to optimize performance by eliminating the duplication of common application components and dynamically allocating the use of all connected resources.

The resulting "hyperconverged systems" where applications ("workloads" in hyperconverged speak) run on commodity servers provide a compact, energy efficient platform for today's enterprise compute requirements.

VENUE OPERATIONS: THE RISE OF TECHNOLOGY

Like data centers, public venues have evolved dramatically over the past 20 years. Venue operations have become increasingly dependent on technology with main telecommunications rooms growing into mini data centers connected to a network of smaller telecommunications closets throughout a building. Legacy systems which ran without any attached communications infrastructure became connected. Telephone systems which ran on large proprietary PBXs were rendered onto commodity servers. Facility managers implemented applications to manage their building systems (building management systems or "BMS") developing centralized control of systems including HVAC, lighting, and electrical. Venue security migrated from coaxial connected cameras storing images on tape to network connected surveillance and access control systems relying on servers with large attached storage arrays. Concessionaires migrated away from proprietary point of sale ("POS") terminals to PC and tablet-based devices connected to server-based concessions management software. Tickets migrated from paper to digital. And venue sales organizations implemented customer relationship management ("CRM") software to improve sales outcomes with some CRM solutions layered on top of a data warehouse. Today, every aspect of venue operation relies on servers running in the building or on the cloud. These systems are further dependent on large networks

which have compute and storage requirements of their own, demanding more servers.

MANAGING INFRASTRUCTURE: THE IT PROFESSIONAL'S DILEMMA

When Stadium Tech Report reached out to some of our contacts in the venue space to discuss this article, we heard the same message from many venue IT professionals. Managing a hodge-podge of servers collected over time was a burden. They faced a heterogenous mix of computers dependent on disparate management tools, tied to different security update regimes, and covered by a patchwork of support agreements. Keeping these servers current and secure placed significant demands on their time and budgets.

While some IT managers were resigned that this was just their reality, a few had established plans for consolidating their systems. One operator with experience operating multiple venues who preferred to remain anonymous stated it plainly:

"When I take over a building, I spend the next five years trying to consolidate systems onto a single platform with a comprehensive support plan." The business case for consolidation was simple; consolidation would decrease operating expense. However, the ability to move forward quickly is constrained by capital budgeting requiring that installed equipment reach full depreciation before replacement was palatable.

If the business case for consolidating servers exists, how did venues end up with a collection of disparate platforms? In most cases, system procurement was

"When I take over a building, I spend the next five years trying to consolidate systems onto a single platform with a comprehensive support plan."

CREATING A TOUCHLESS FAN EXPERIENCE WITH BOINGO WIRELESS

There is no question that live sports and entertainment are changing as a result of the COVID-19 pandemic. With neutral host 5G and Wi-Fi 6 networks from Boingo, stadiums and arenas can meet new health and safety protocols, while delivering the immersive mobile experience fans expect.



The Path Forward

Boingo has identified key use cases to rebuild fan confidence and foster a safe environment. World-class stadiums partner with Boingo to design, build and manage converged wireless networks that move contactless experiences from concept to reality.

USE CASE	CHALLENGE	COMPONENTS	CONNECTIVITY SOLUTION
Social distancing	+	Cameras; sensors	Wi-Fi, Wired Internet, Private LTE
Security measurement and monitoring	Monitoring	Cameras; sensors	Wi-Fi, Wired Internet, Private LTE
Personal identification checkpoints (e.g. ticketing)	Health, Monitoring, Communication	Touchless, self-service facial/biometrics recognition devices and kiosks	Wi-Fi, Wired Internet, Private LTE
Concessions and point of sale	Health, Monitoring, Communication	Touchless, self-service payment; direct-to-consumer delivery and pickup; dispersed concession areas and mobile kiosks	Wi-Fi, Wired Internet, 4G or 5G DAS, Private LTE
Guest communications	Monitoring, Communication	Digital signage; Wi-Fi connection portal; push notifications	Wi-Fi, Wired Internet, 4G or 5G DAS
Staff and first responder communication	Monitoring, Communication	Push-to-talk devices	4G or 5G DAS, Private LTE
Cleaning and maintenance tracking	Health, Monitoring	Robotics; cameras; sensors	Wi-Fi, Wired Internet, Private LTE
Health check screening	Health, Monitoring	Infrared scanners; sensors	Wi-Fi

= Health

= Monitoring

= Communication

= Wi-Fi

= Wired Internet

= 4G or 5G DAS

= Private LTE

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Contact Us – We're in This Together

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For 20 years, Boingo has helped the world's leading venues navigate a complex technological landscape with state-of-the-art cellular DAS, Wi-Fi, CBRS and 5G networks. As stadiums and arenas prepare for a new age of live entertainment and sports, Boingo is here to help with technology to facilitate the new touchless venue – and beyond.

INTERESTED IN HYPERCONVERGED INFRASTRUCTURE?

Below we've included links to the manufacturer websites describing three hyperconverged platforms being used in venues today.

Cisco HyperFlex

Cisco Hyperflex: <https://www.cisco.com/c/en/us/products/hyperconverged-infrastructure/index.html>

VXRAIL

Dell VxRails: <https://www.delltechnologies.com/en-us/converged-infrastructure/vxrail/index.htm>

Hewlett Packard Enterprise

Hewlett Packard Enterprise (HPE) dHCI: <https://www.hpe.com/us/en/storage/nimble-storage-dhci.html>

decentralized and the various operating units within the venue rarely or peripherally included the IT organization in the procurement process. The expectation was that system vendors would determine what servers were needed, from what vendor they would be sourced, and what type of support agreement would be attached. What followed vendor selection was a request for rack space and requirements for power and connectivity.

THE PATH FORWARD: OPERATIONAL EFFICIENCIES

For new venues, the business case is clear. By establishing a compute strategy early in the design phase and enforcing compliance with that strategy across project scopes, the project can achieve project savings and lower Day 2 operating costs. Stadium Tech report partner AmpThink shared that in the last 18 months, they've incorporated hyperconverged platforms from Cisco, Dell, and Hewlett Packard Enterprise in four of their projects with platforms delivering between 22 and 95 virtual machines. AmpThink Solution's Architect Robare Pruyn noted that "While supporting our recent venue projects, hyperconvergence allowed us to quickly spin up and support applications, meeting project schedules without the

cost of additional hardware or the complexity of integrating new servers into the data center and/or network." AmpThink's Adam Haskin shared that at So-Fi Stadium, "the Hyperconverged platform which currently supports 95 virtual machines replaced dozens of physical servers with all but the physical security applications running on a platform that lives in two data racks."

For existing venues, hyperconvergence offers the opportunity to reduce the number of servers under management and the resulting operational costs. Physical consolidation reduces space requirements, energy consumption, simplifies securing your server infrastructure, and reduces the number of support contracts. But achieving convergence may require time. Establishing a platform and organizational standards for systems requiring compute resources is the foundation of future efforts. Building the business case for hyperconvergence will require a detailed analysis of your current operating environment and planned system purchases across business disciplines.

Looking to understand what a typical hyperconverged implementations looks like? Below, we've shared the planning template that Stadium Tech Report partner AmpThink uses as the baseline for developing a hyperconverged solution for an arena. The presented sizing is based on previous hyperconvergence projects and provided here for illustration purposes only. Prior to proceeding with your own convergence project requirements should be reviewed with a person/consultant familiar with virtualization and a technical representative of each of the systems proposed for convergence. Not all applications are candidates for convergence and some system providers limit support for systems operating in a converged/virtualized environment.

Count	Description/Provisioned System	vCPUs	RAM (Gb)	Storage 1(Gb)
1	DNS/DHCP 1	8	16	250
2	DNS/DHCP 2	8	16	250
3	TFTP/NTP/Syslog	2	4	200
4	Domain Controller 1	4	12	200
5	Domain Controller 2	4	12	200
6	Certificate Authority	1	2	30
7	Remote Access Services 1	1	2	30
8	Remote Access Services 2	1	2	30
9	Network Policy Services 1	1	2	30
10	Network Policy Services 2	1	2	30
11	SQL Server	2	8	300
12	Suite Control Server 1	1	2	30
13	Suite Control Server 2	1	2	30
14	IPTV Primary	24	32	900
15	IPTV Secondary	24	32	900
16	IPTV Applications	2	8	100
17	Phone Primary	2	8	110
18	Phone Secondary	2	8	110
19	Phone App Server	2	8	110
20	Voicemail Primary	2	8	160
21	Voicemail Secondary	2	8	160
22	Contact Center Publisher	2	10	146
23	Contact Center Subscriber	2	10	146
24	Emergency Responder Publisher	2	8	110
25	Emergency Responder Subscriber	2	8	110
26	IM & Presence Publisher	2	8	110
27	IM & Presence Subscriber	2	8	110
28	VMWare vCenter Appliance	4	16	320
28	VMWare vCenter Appliance	4	16	320
29	Building Management 1	2	32	4800
30	Building Management 2	2	32	4800
31	Power Monitoring and Control	2	32	1600
32	AAA Primary	12	16	200
33	AAA Secondary	12	16	200
34	Network Management Primary	16	16	300
35	Network Management Secondary	16	16	300
36	Vertical Transport	2	32	200
37	Lighting Control	2	32	300
38	Plumbing/Irrigation Monitoring	2	32	300

Corning is a leading provider of wireless infrastructure

solutions, offering flexible architectures in the rapidly growing wireless market. With a portfolio of products ranging from converged cellular and Wi-Fi solutions for enterprises, to distributed antenna systems for wireless operators, Corning offers in-building infrastructure solutions that cover the needs of venues of all types and sizes. www.corning.com

CORNING

Boingo Wireless (NASDAQ: WIFI) is a leading provider of cellular and Wi-Fi networks at stadiums and arenas, universities, airports, military bases, convention centers, multifamily communities and commercial properties. You'll find Boingo connecting people at sports and entertainment venues across the NFL, NBA, MLS, NCAA and more. These venues include Soldier Field, Vivint Arena, State Farm Arena, University of Arizona's Arizona Stadium, University of Nebraska's Pinnacle Bank Arena and more. Boingo's industry-leading Distributed Antenna System (DAS) networks leverage state-of-the-art design to deliver comprehensive stadium coverage and maximize carrier participation to ensure more fan access and meet the demands of the 5G era. As a global leader in managed Wi-Fi services, the company maximizes access to networks through global roaming agreements via carrier offload and major brand sponsorships through the Boingo Media Platform. For more information, visit www.boingo.com.



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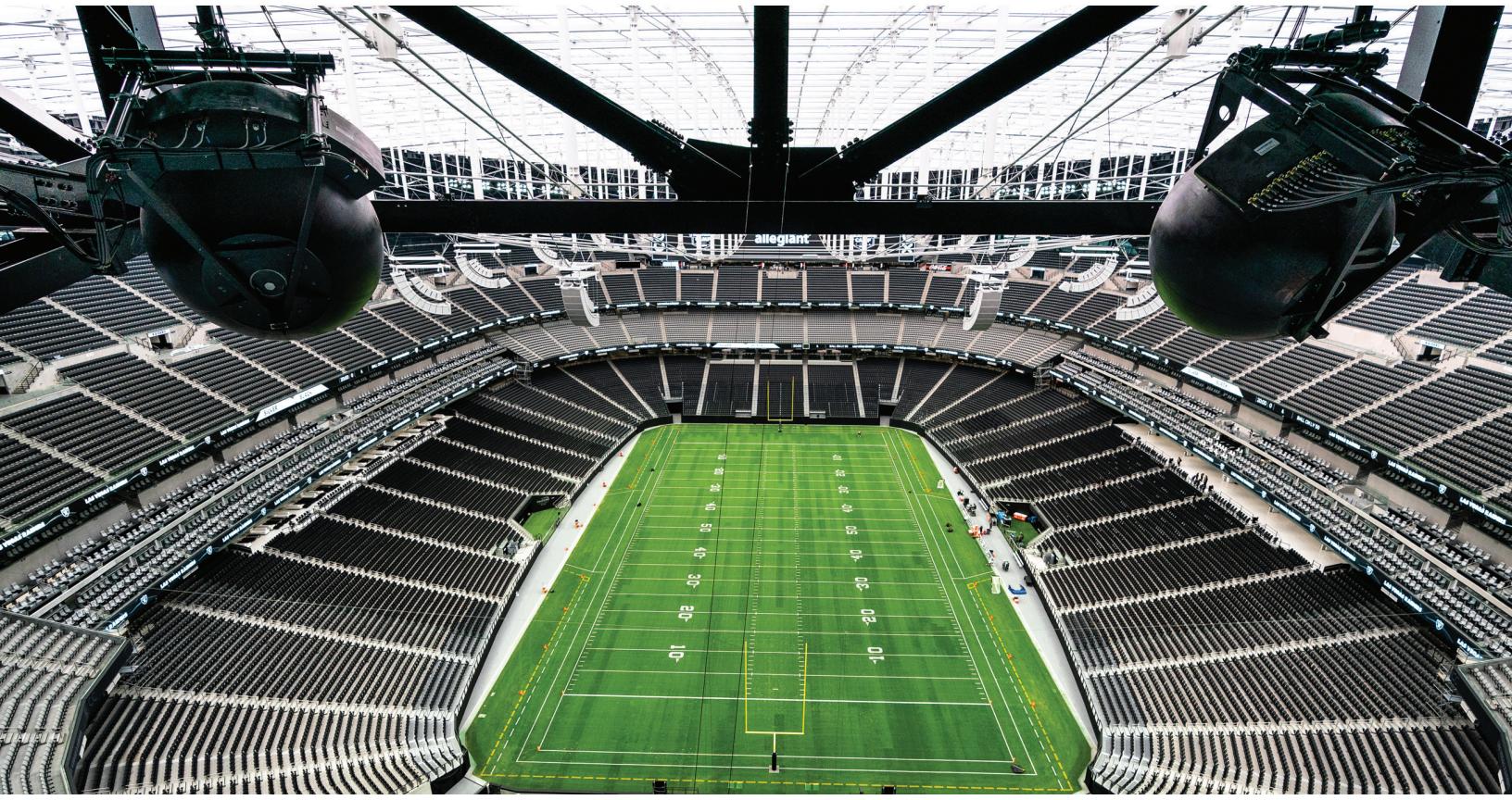
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Creating a great customer experience **COMCAST BUSINESS | BEYOND FAST** requires data, speed and security, and that requires a great network solution. Imagine your venue with a secure, high-performance, scalable network solution, designed for heavy data processing loads, enhanced application performance, and secure access to cloud or data center resources. Advanced network solutions help to create those memorable experiences. Beyond our advanced network, Comcast Business also offers voice and mobile options for a unified communications approach that helps improve communication and collaboration for a mobile workforce, HD entertainment options to help keep your customers informed and entertained, advanced Wi-Fi for customers and staff, and Managed Services for technology supported by a team of service professionals. Advanced network solutions help create memorable experiences, enhance customer satisfaction and boost employee productivity. Our connectivity can power the fan experience beyond the game Learn more at business.comcast.com/stadiums

ExteNet Systems, Inc. is a leading provider of converged communications infrastructure and services addressing outdoor and in-building wireless, fiber and other advanced connectivity needs of its customers. Our customers include mobile network operators (MNOs), real estate owners, property managers, wholesale carriers, enterprises, municipalities and rural carriers. ExteNet's outdoor networks are deployed in a variety of urban, suburban and rural environments while indoor networks are typically deployed in property verticals like commercial office buildings, sports and entertainment venues, hotels and convention centers, healthcare facilities and transit systems. For more information, please visit <https://extenetsystems.com>.



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