DAS Boot Camp
- Next Generation Wireless Networks -

Connectivity™:
Wireless Solutions

2018 BICSI WINTER
CONFERENCE& EXHIBITION
Orlando, FL | February 4-8

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Mark Niehus, RCDD

Mark is Director of Strategic Accounts for CWS. With more than 25 years of ICT installation, project management, and sales and marketing experience, he uses his comprehensive industry knowledge to educate clients on in-building wireless approaches and solutions.

An RCDD since 1997 and as well as a veteran presenter to the BICSI community, Mark frequently presents updates on relevant topics for customer-specific seminars and is a published author and contributor for various industry publications.

Tyler Boyd

As an RF engineer for Connectivity, Tyler applies his concentrated in-building wireless (DAS) knowledge to ensure best-in-class system design, performance and consistent RF engineering throughout the U.S.

With project experience spanning several industries—including hospitality, higher education, commercial, and sporting and entertainment—Boyd has designed, engineered, commissioned and managed some the nation's largest venues, while providing extensive customer support throughout the duration of each project.

Boyd is certified in all major DAS technologies.

Connectivity Wireless Solutions is an industry-leading technology solutions provider.

With more than 300 years of combined RF industry experience, and one of the first companies to break into the DAS industry, Connectivity has provided thousands of unique solutions to meet the wireless needs of venues and facilities throughout the U.S. since 2008.

Having integrated systems across virtually every market and industry, Connectivity takes pride in matching each customer with exactly the right technology to ensure that its wireless and IT network needs are met.

Agenda

- Public Safety Primer
- Next Gen Wireless Trends
- Next Gen Wireless Solutions
- 15-minute break
- Infrastructure Deep Dive
- Carriers and Case Studies

DAS for Public Safety

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Mandates for public safety radio service

- ICC & NFPA CODES MANDATE FIRST-RESPONDER COVERAGE
- 150+ LOCAL MUNICIPALITIES NOW MANDATE PUBLIC SAFETY COVERAGE INSIDE LARGE BUILDINGS
- INDOOR CELLULAR/PCS SERVICE REQUIRED FOR E911 LOCATION
- 700 & 800 MHZ BANDS ALLOCATED FOR FIRE AND POLICE
- 650,000+ E911 CALLS PER DAY (nena.org)
- ACCORDING THE FCC, 70% OF E911 CALLS ARE MADE FROM WIRELESS PHONES
- FIRSTNET

Public Safety DAS

NFPA GUIDELINES

- NFPA 72 2010
- Issued in April of 2009
- Only applicable if the municipality adopts this portion of the code

REQUIRE PUBLIC SAFETY COVERAGE INSIDE FACILITIES FOR FIRE, POLICE, FIRST RESPONDERS

- No building size is identified – defines coverage
- If the municipality adopts the codes - it would be enforceable for new buildings and major renovations

INCLUDES DISCUSSION ON RETRANSMISSION AGREEMENTS

- Public Safety officials want permission before rebroadcasting
- Poor designs can harm coverage

Public Safety DAS Requirements

- 99% COVERAGE IN CRITICAL AREAS INCLUDE COMMAND CENTER, ELEVATOR LOBBIES, AND EXIT STAIRS
- 90 % COVERAGE FOR REMAINING AREAS
- COMPONENT ENCLOSURES IN NEMA 4/4X TYPE ENCLOSURE
- REPEATER EQUIPMENT SHALL BE FCC APPROVED AND CERTIFICATION
- UPS REQUIREMENTS
  - Primary is dedicated branch circuit
  - Secondary is 120hour battery backup
- ANNUAL TESTING REQUIRED FOR ACTIVE COMPONENTS AND SYSTEM

Public Safety DAS Construction

- **BUILD SYSTEMS TO MEET PUBLIC SAFETY ENHANCEMENT SYSTEM CODE REQUIREMENTS**
- **CLOSE COORDINATION WITH AHJ FOR SPECIFIC BUILDING PERMIT REQUIREMENTS**
- **NEMA 4 OR 4X RATED EQUIPMENT ENCLOSURES**
- **INSTALLATION TO NEC AND BICSI STANDARDS**

SELF-DRIVING CARS PARALLEL OR COMBINED CARRIER/PUBLIC SAFETY DAS SYSTEM CONSTRUCTION CONSIDERATIONS EMPLOYED DURING DESIGN AND INSTALLATION PHASES:

- Physical separation of carrier and public safety infrastructure
- Cost effective cable routing and management
- Centralized vs. localized battery back-up

Getting AJG Approval

COORDINATION

- Radio shop UL measurements
- Fire Marshall on-site time/ walk-test
- Access to all critical areas of building
- Alarm demonstration

TEST FOR ACCEPTANCE

- Walk the floor and randomly test radio
- Witness alarm activation at fire alarm control panel
- Donor site radio noise floor monitoring

NextGen Wireless Trends

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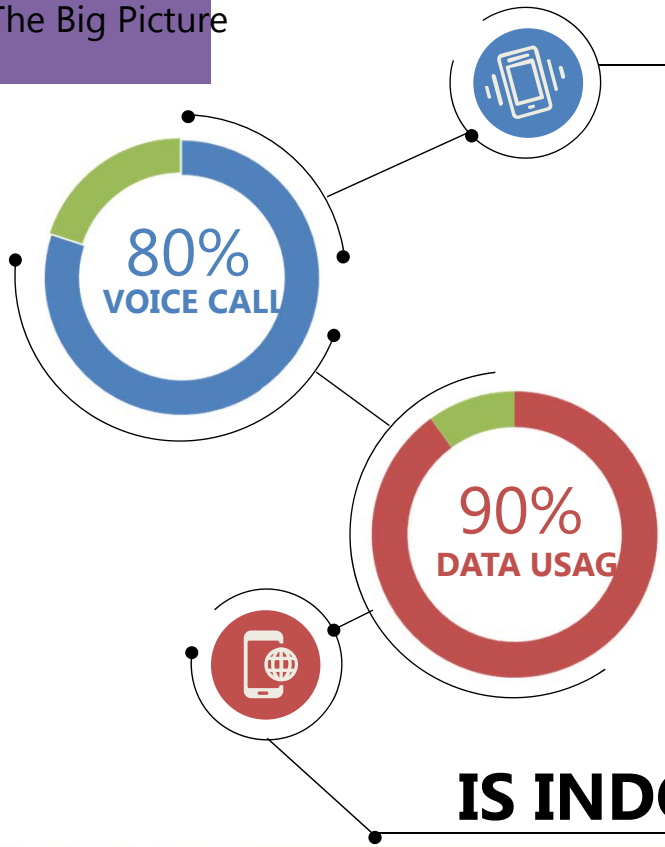
The Big Picture



IS INDOORS

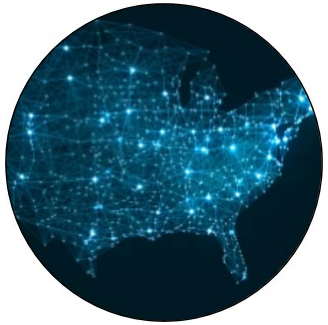
Today's **$4.83 billion** in-building wireless market is expected to top

$9 billion by 2020

North America will continue to drive the

DAS market

Future Technology Forecast



HERE TODAY

VoLTE
VoWLAN (Voice over Wireless LAN)
LTE Aggregation

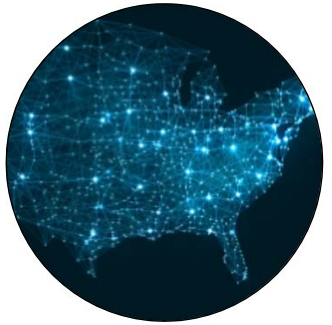
HERE TOMORROW

IOT
5G

Emphasis on increased capacity.

Bulking up bandwidth and infrastructure

Future Technology Forecast



HERE TODAY

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WERE TOMORROW

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5G

Emphasis on increased

Bulking up bandwidth and infrastructure

capacity

Internet of Things

A network of internet-connected objects ("things") able to collect and exchange data

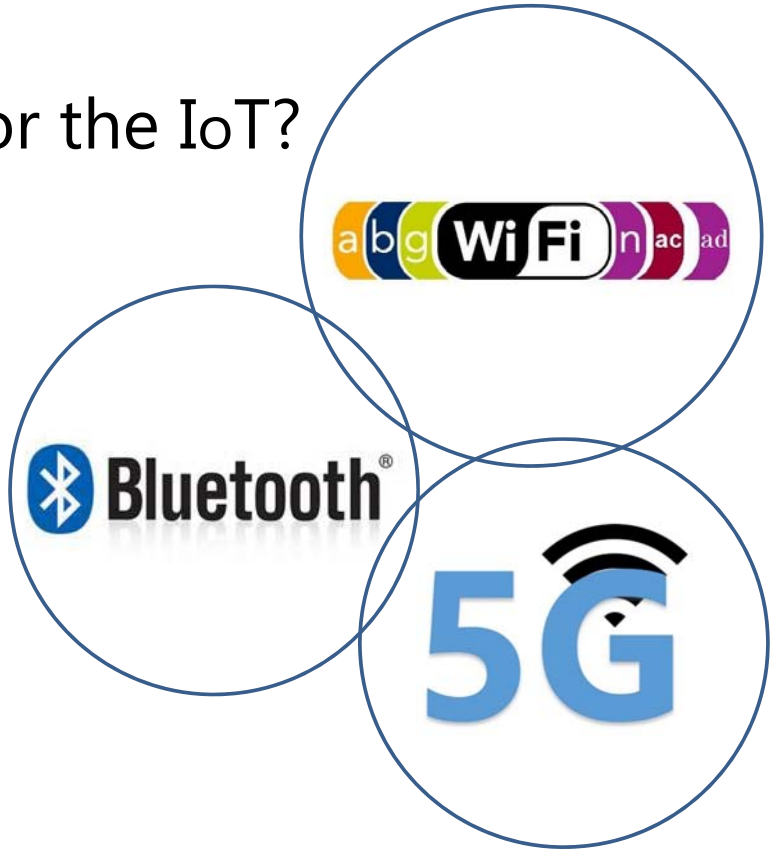
24 billion IoT devices installed by 2020 with

- **$6 trillion** invested in IoT solutions over the next 5 years

say that by 2025, IoT will have widespread and beneficial effects on the everyday lives of the public

What are the best wireless networks for the IoT?

- **LR-WPAN**
- **Wi-Fi**
- **CELLULAR**

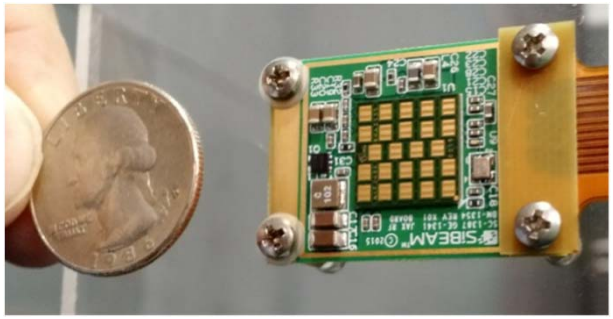


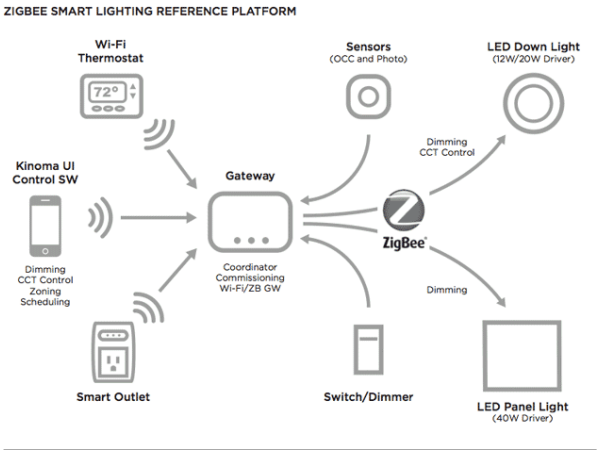
LR-WPAN (IEEE 802.15.4)

COVERAGE IN AREAS INSIDE BUILDINGS

LOW POWER, LOW SPEED, LOW COST

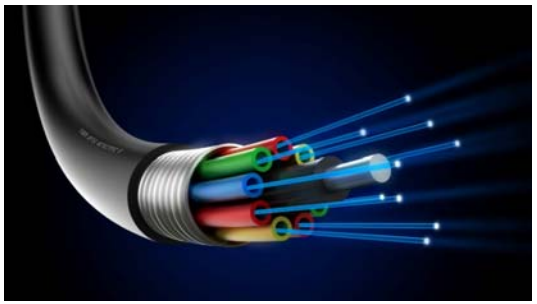
- Bluetooth
- Zigbee
- Zwave
- WiSun
- Near Field Communications (NFC)





Wi-Fi

Coverage in every building



TODAY: 802.11n and 802.11ac

TOMORROW: 802.11ad

- 57-64 GHz (V band)
- 1-7 GBps (‘fiber like’)
- 10-20 meter range

Wireless Gigabit Alliance

Cellular Coverage

Coverage wherever people are: inside and outside of buildings

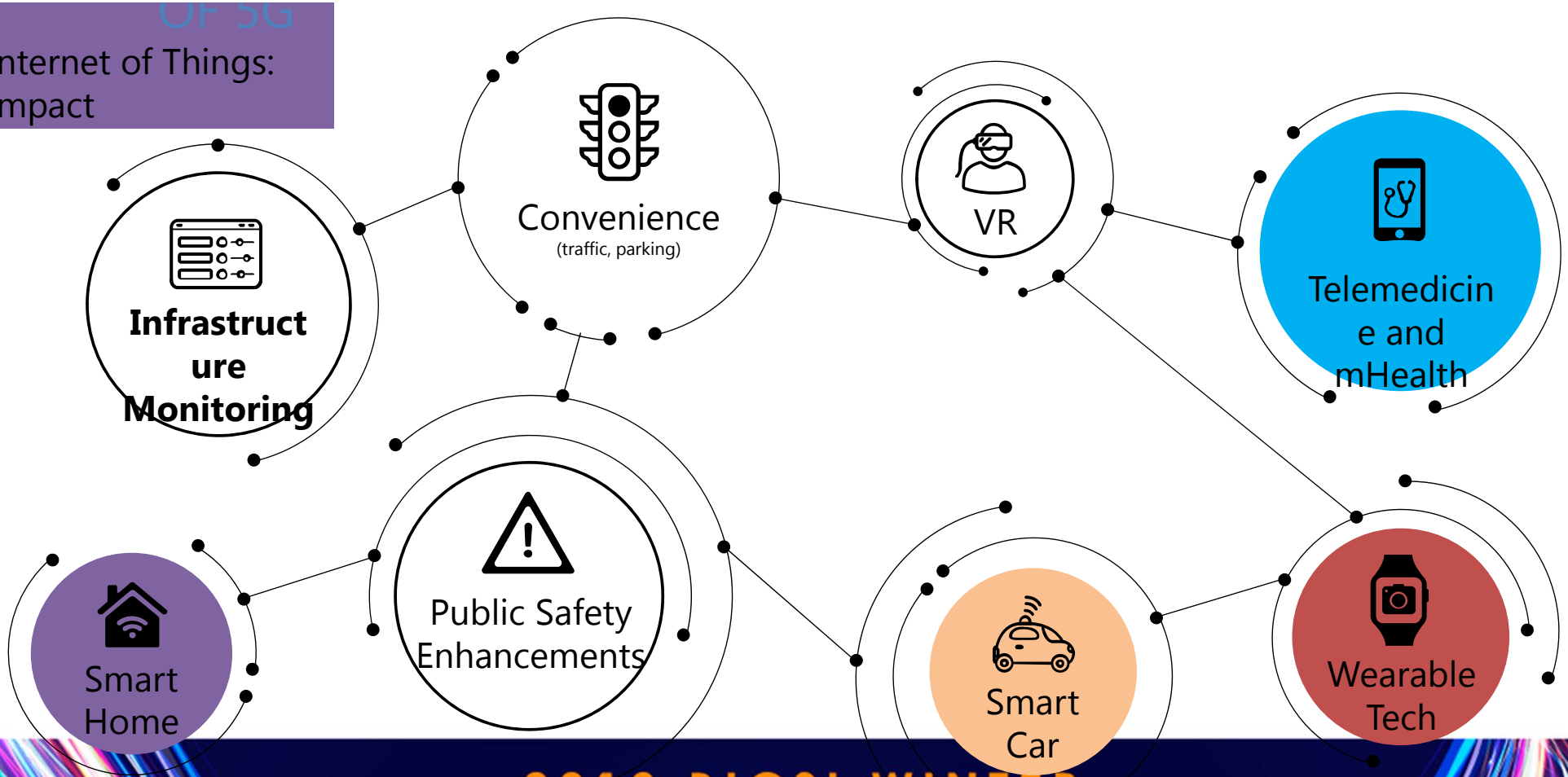
SUPERCOMPUTER IN YOUR POCKET (4.7 HOURS PER DAY)

- Real-time language translation
- Augmented virtual reality (Oculus Rift)
- The Tricorder Project

SELF-DRIVING CARS

ROBOTS AND OTHER ASSISTANT DEVICES

Internet of Things: Impact



5G

Not one specific technology,
but a standard of service

3 KEY CONSUMER BENEFITS OF 5G

1

Connect everything

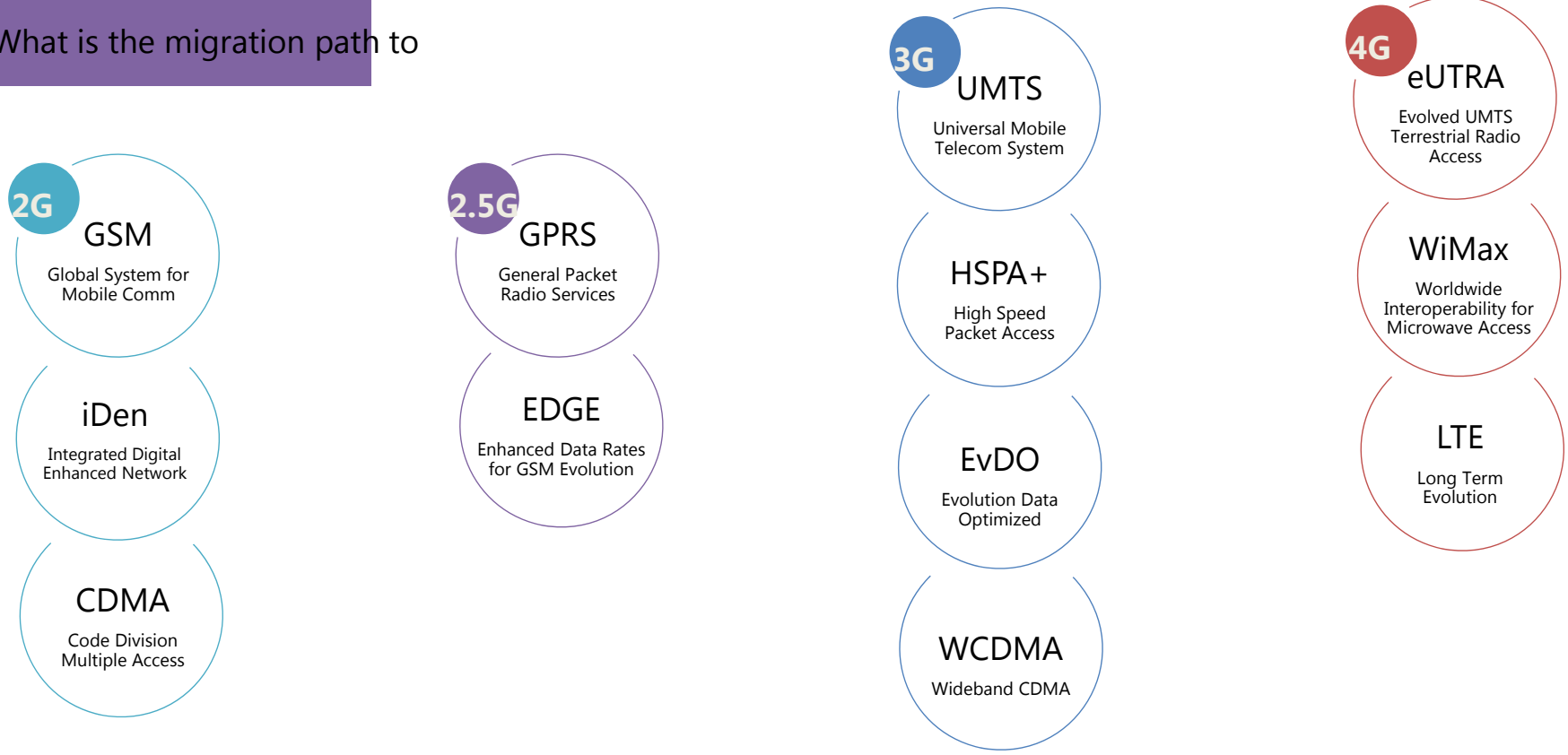
2

Responsiveness

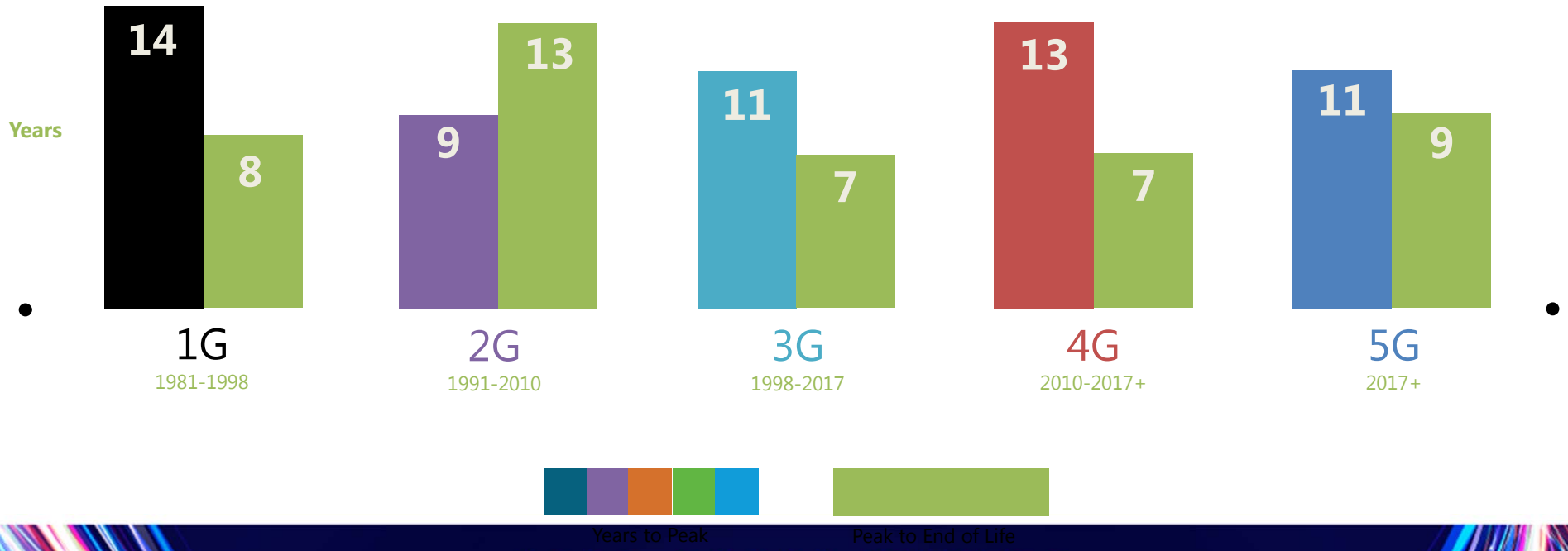
3

Speed

5G: What is the migration path to 5G?



5G: A New Standard in Quality

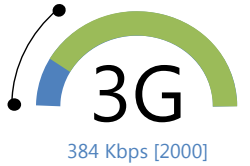


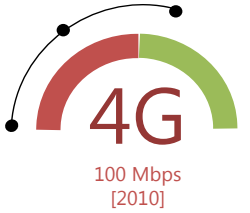
5G: A New Standard in Quality

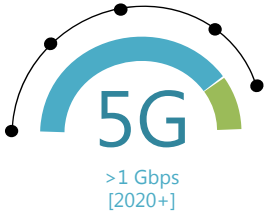
BRINGS MORE SPEED
(10 times faster)

CONNECTS MORE DEVICES
(100 times more)

ALLOWS FOR A MORE RESPONSIVE NETWORK
(5 times reduced end to end network latency)



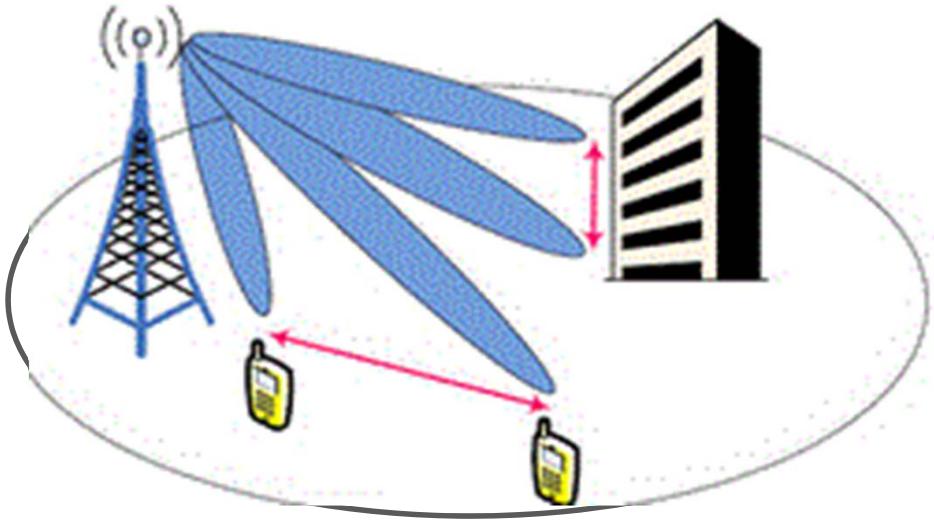




5G: What are the characteristics?

- 60 GHz and 70/80 GHz (millimeter wave)
- BEAMFORMING
  (carrier aggregation, VoLTE, RCS)
- SUBJECT TO RAIN FADE
  (Also foliage, atmosphere)
- SHORT RANGE
- HIGH DATA RATE
  (Gbps or "fiber like" speeds)
- MASSIVE MIMO

Beamforming, or spatial filtering

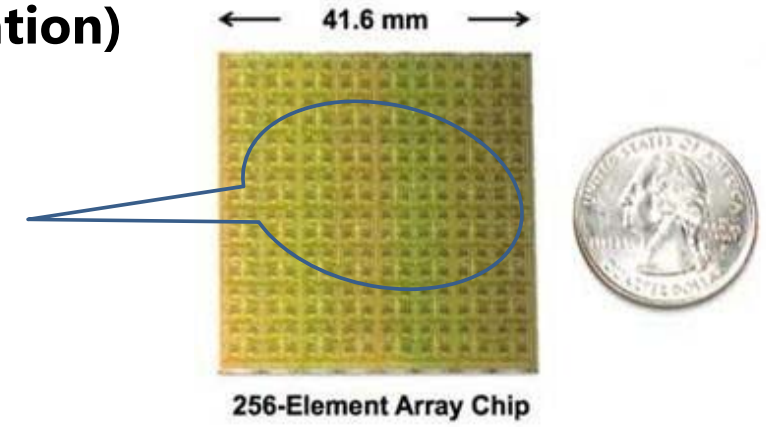


Used to improve gain over omnidirectional

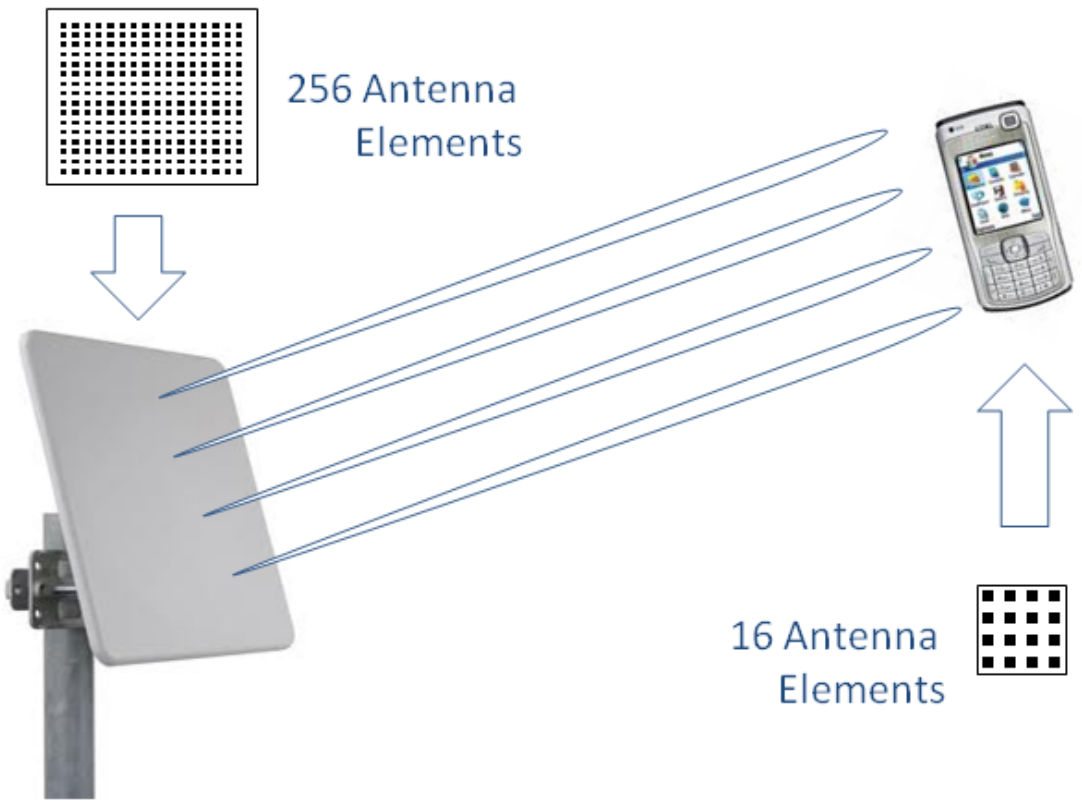
- Technique used for directional signal transmission
- Combination of elements in a phased array in such a way that signals at particular angles experience constructive interference and others experience destructive interference

Massive Mimo

- MORE ANTENNAS
  (up to hundreds of antennas at base station)
- SAMSUNG TEST PHONE WITH 32 LOW-PROFILE ANTENNA ELEMENTS
- POSSIBLY 5X THE SPECTRAL EFFICIENCY

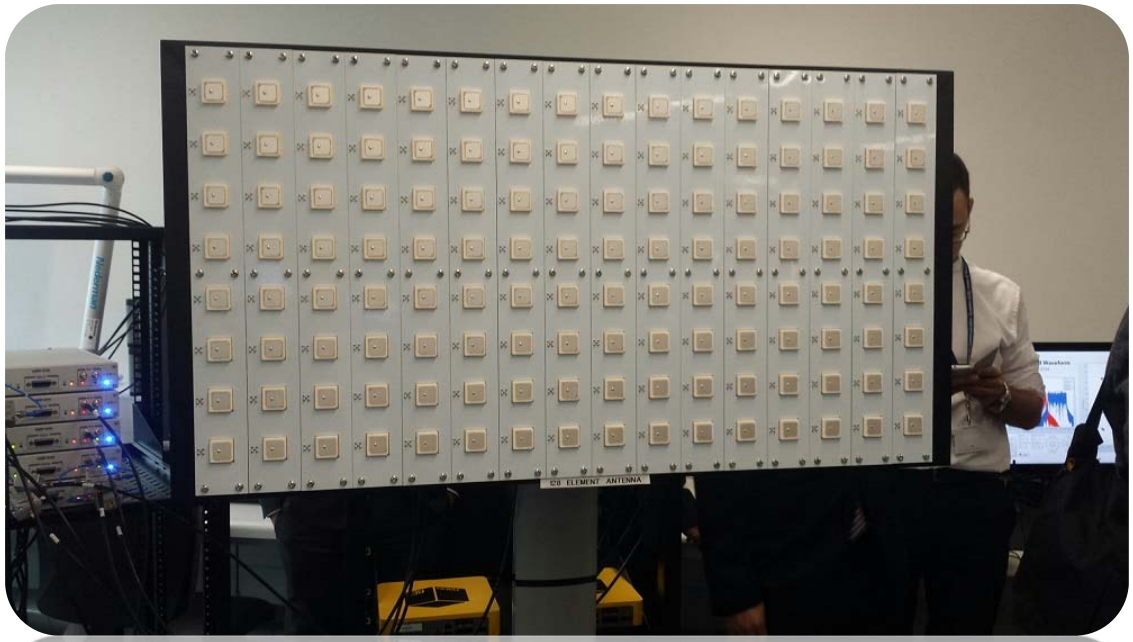


Massive Mimo



Massive Mimo

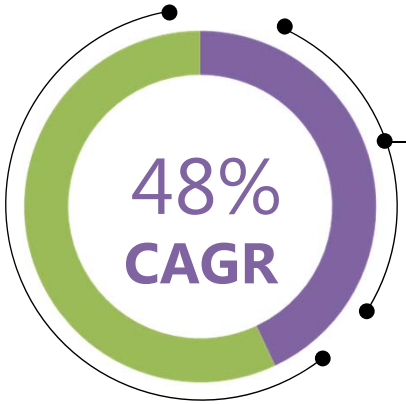
The architects are going to hate this…



5G: What Are Carries Doing?

- RESEARCHING 5G
- IMPROVING INFRASTRUCTURE
  (carrier aggregation, VoLTE,
- EXPANDING INFRASTRUCTURE
  (DAS, small cell)

Small Cells



Through 2019

$2.7 billion in

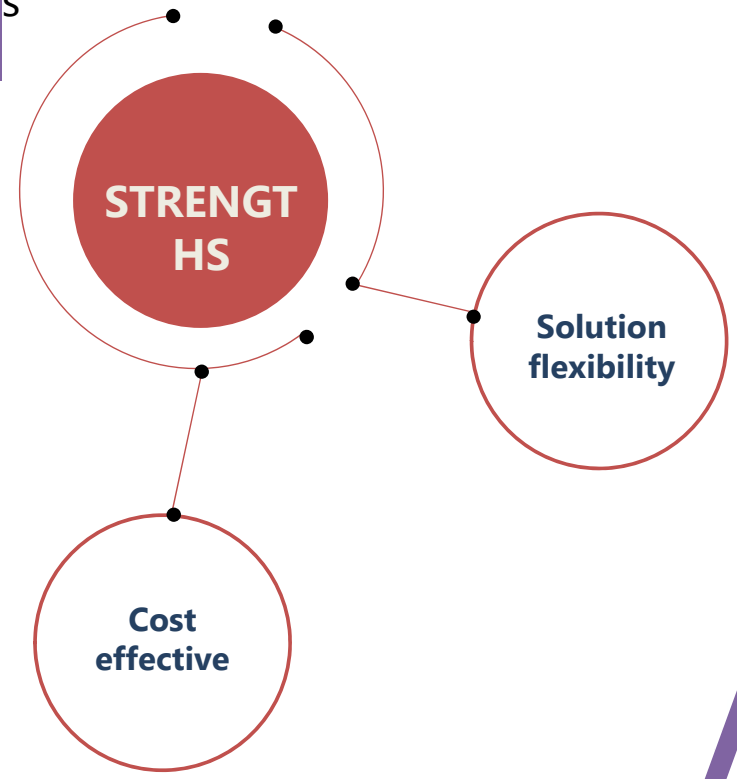
$5.98 billion by 2019

1+ million shipments in North America in 2014

Deployments expected to double in subsequent years

Small Cells: Photos

Small Cells


STRENGTHS
Solution flexibility
Cost effective


Neighbor-width population
Single-carrier solution
CHALLENGES

Virtual Reality

Changes the way we

WOR
K
PLAY

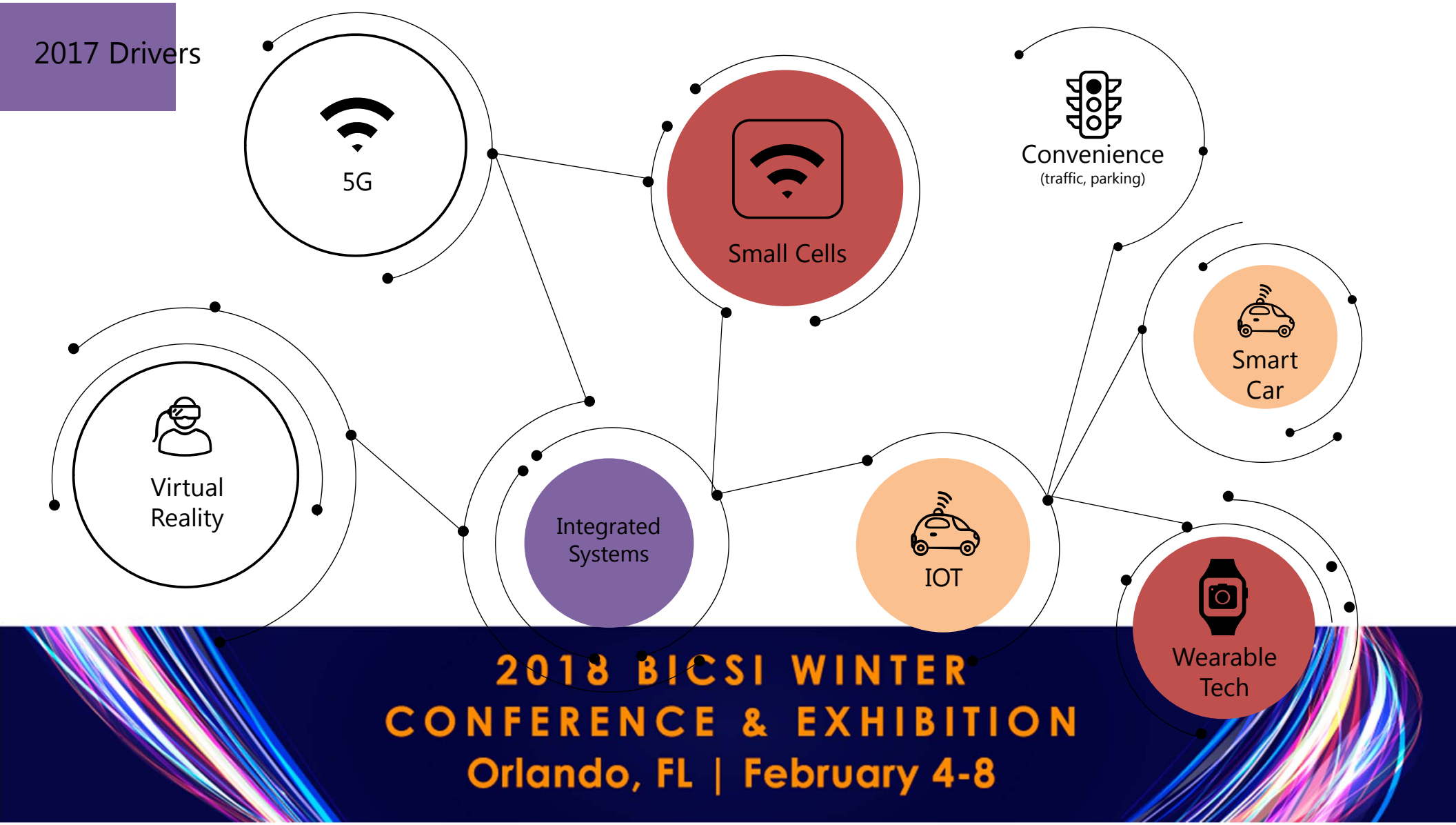
INTERAC
T

Virtual Reality: The Impact

- SOCIALIZED ONLINE WORK / TEACHING ENVIRONMENTS
- VIRTUALDATING
- CULTURAL IMERSION EXPERIENCES /TRAVEL
- TRAINING SIMULATIONS

Waaaay out there…the tactile internet

The Tactile Internet


2017 Drivers
5G
Small Cells
Convenience
(traffic, parking)
Smart
Car
Virtual
Reality
Integrated
Systems
IOT
Wearable
Tech
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The Problem

- less about COVERAGE
- more about CAPACITY

One Simple Solution

DAS

NextGen Wireless Solutions

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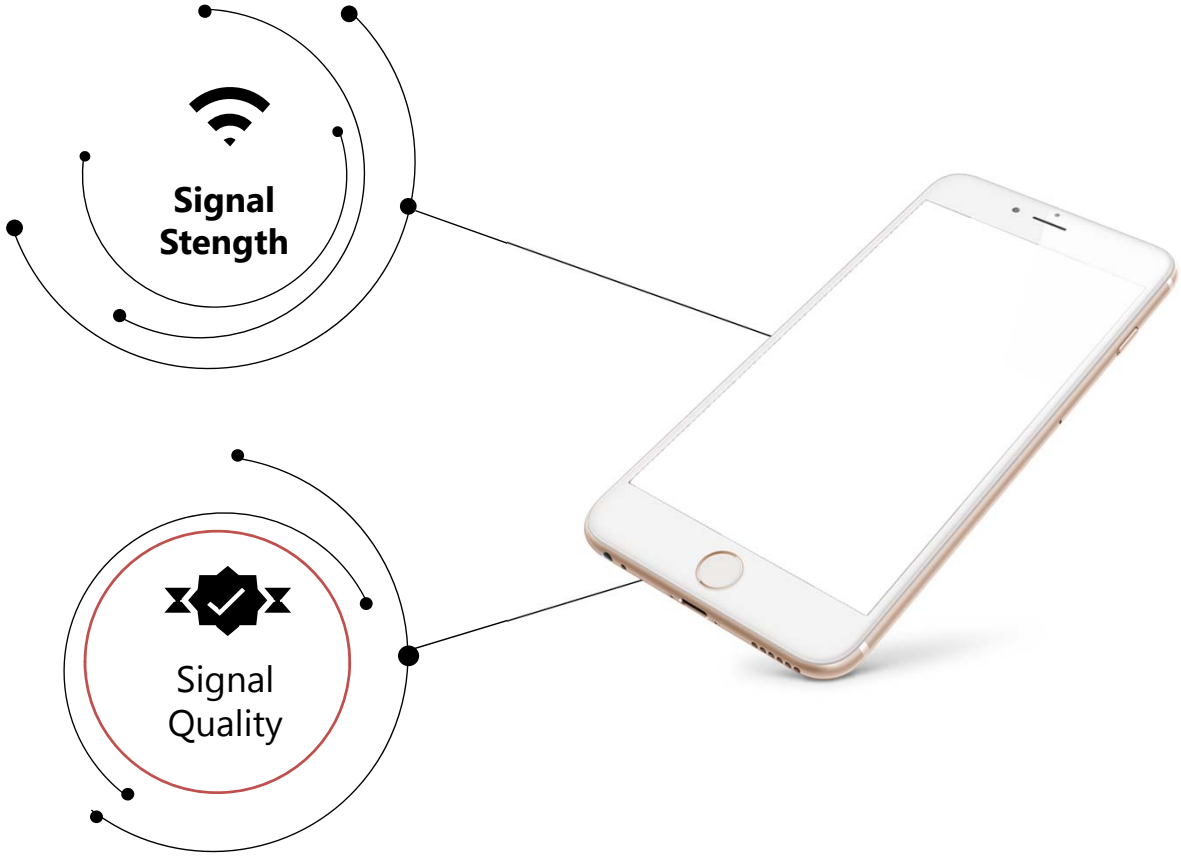
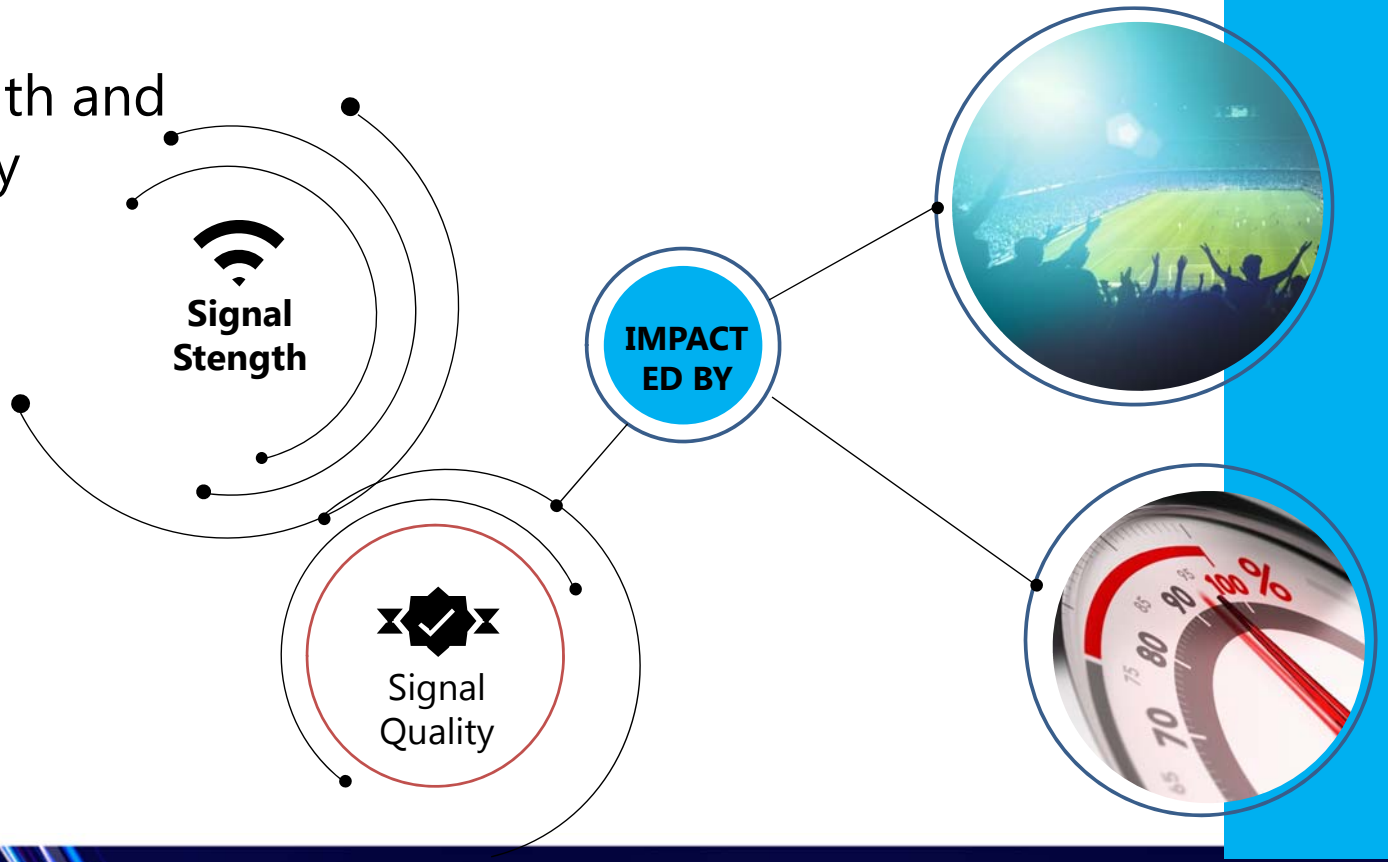
So,
why doesn't
my phone
work?



Signal Strength and Quality



Noisy Environment

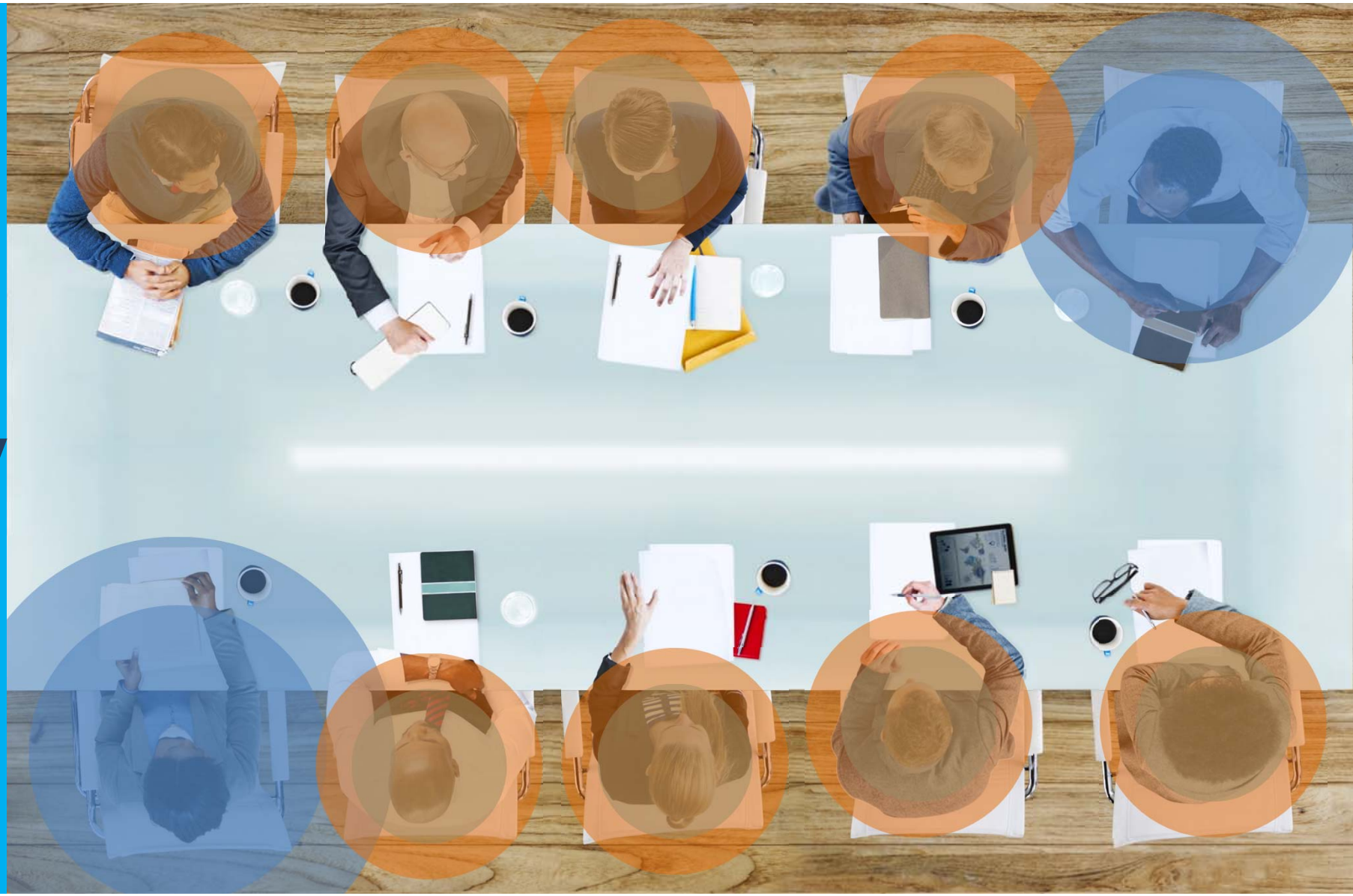
Capacity Limitations

n

Signal Quality Noise

Signal
Quality
Noise

Signal Quality Noise



Signa
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Qualit
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Noise

Signal
Quality
Capacit
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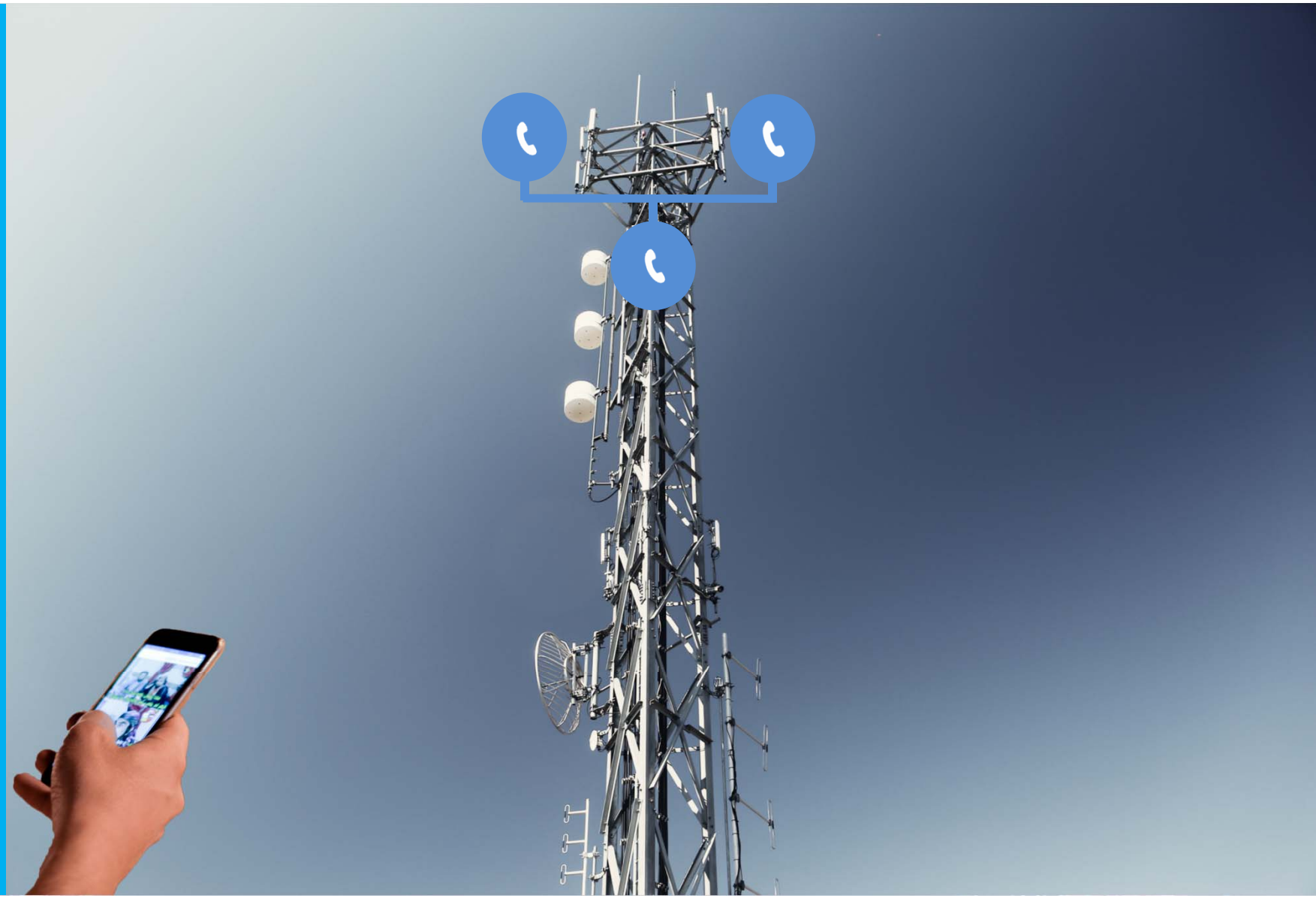

Signal
Quality
Capacit
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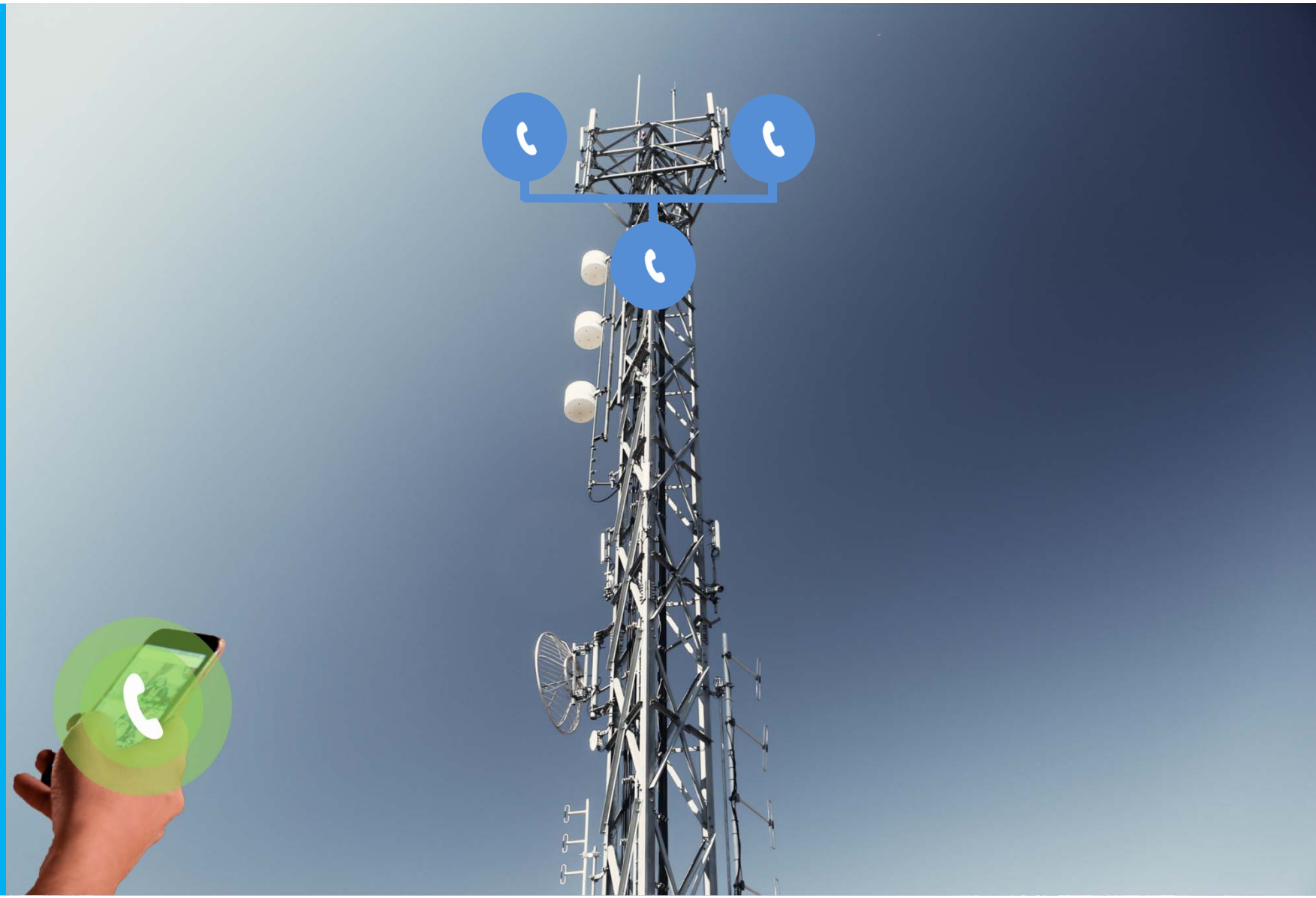

Signal
Quality
Capacit
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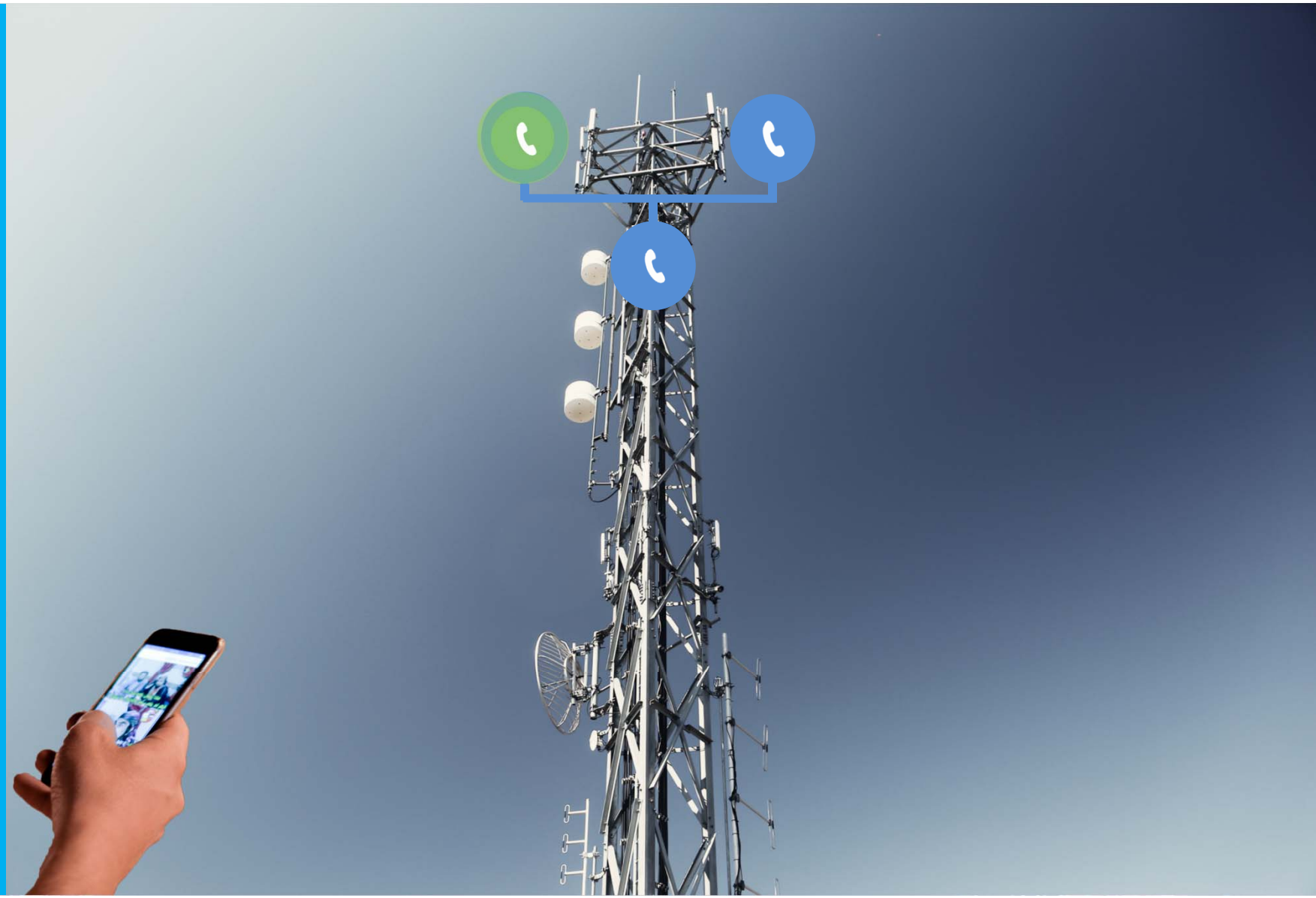


Signal Quality Capacity

Signal

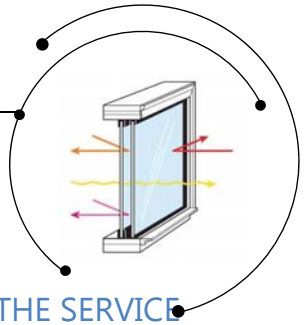
Quality

Capacit

y

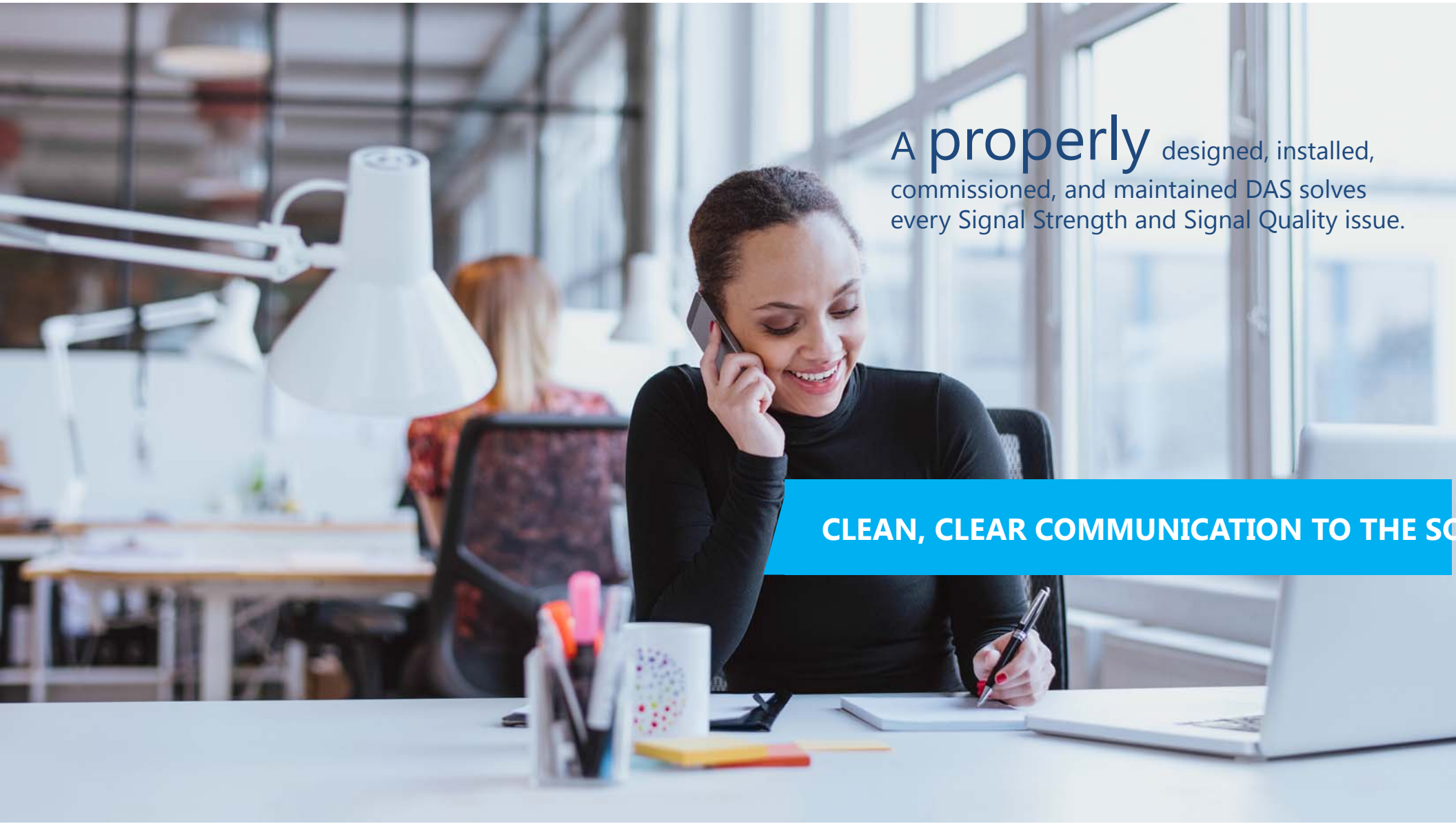
Challenges for high-rise buildings

- LOW E WINDOWS
  (great for energy, bad for RF)
- BASEMENTS, MECHANICAL AREAS, CONCRETE WALLS
- BUILDINGS IN-BETWEEN YOUR PHONE AND THE SERVICE
  (often called a line-of-sight, or los, issue)
- HIGH-RISE OFFICES OFTEN TOO FAR AWAY FROM THE TOWER TO COMMUNICATE
- TOO MANY NEARBY MACRO TOWERS WITHOUT A DOMINANT SIGNAL
- TOO MANY PEOPLE TRYING TO USE THE SAME SIGNAL
- NOISY ENVIRONMENTS
  (pim, external interference, etc.)



Network Improvements: What Are Carries Doing About It?

- CARRIERS IMPROVE THEIR MACRO INFRASTRUCTURE AND FOOTPRINT
- CARRIERS CAN BETTER UTILIZE THE INFRASTRUCTURE THEY ALREADY OWN


A properly designed, installed,
commissioned, and maintained DAS solves
every Signal Strength and Signal Quality issue.
CLEAN, CLEAR COMMUNICATION TO THE SC

Infrastructure Deep Dive

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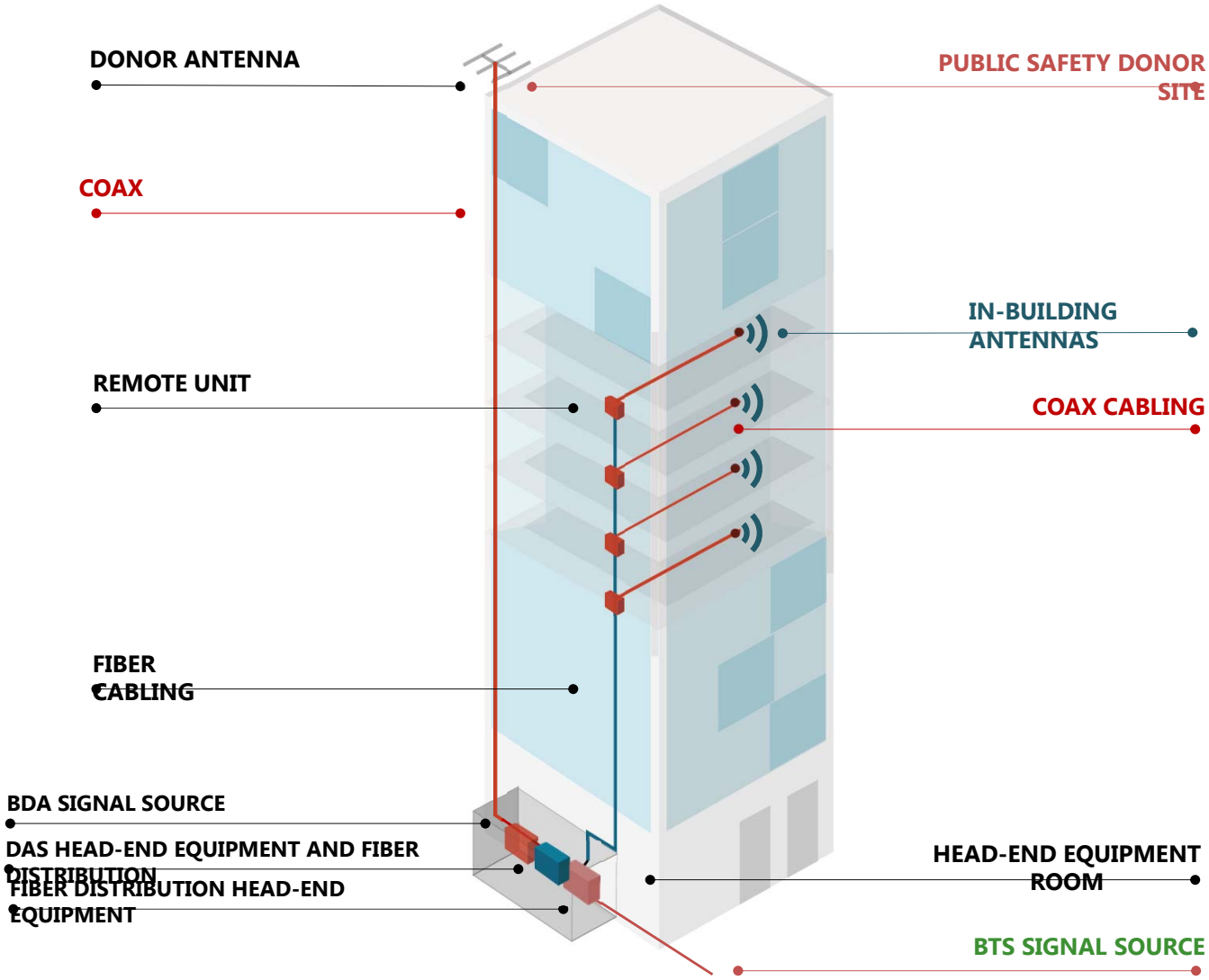
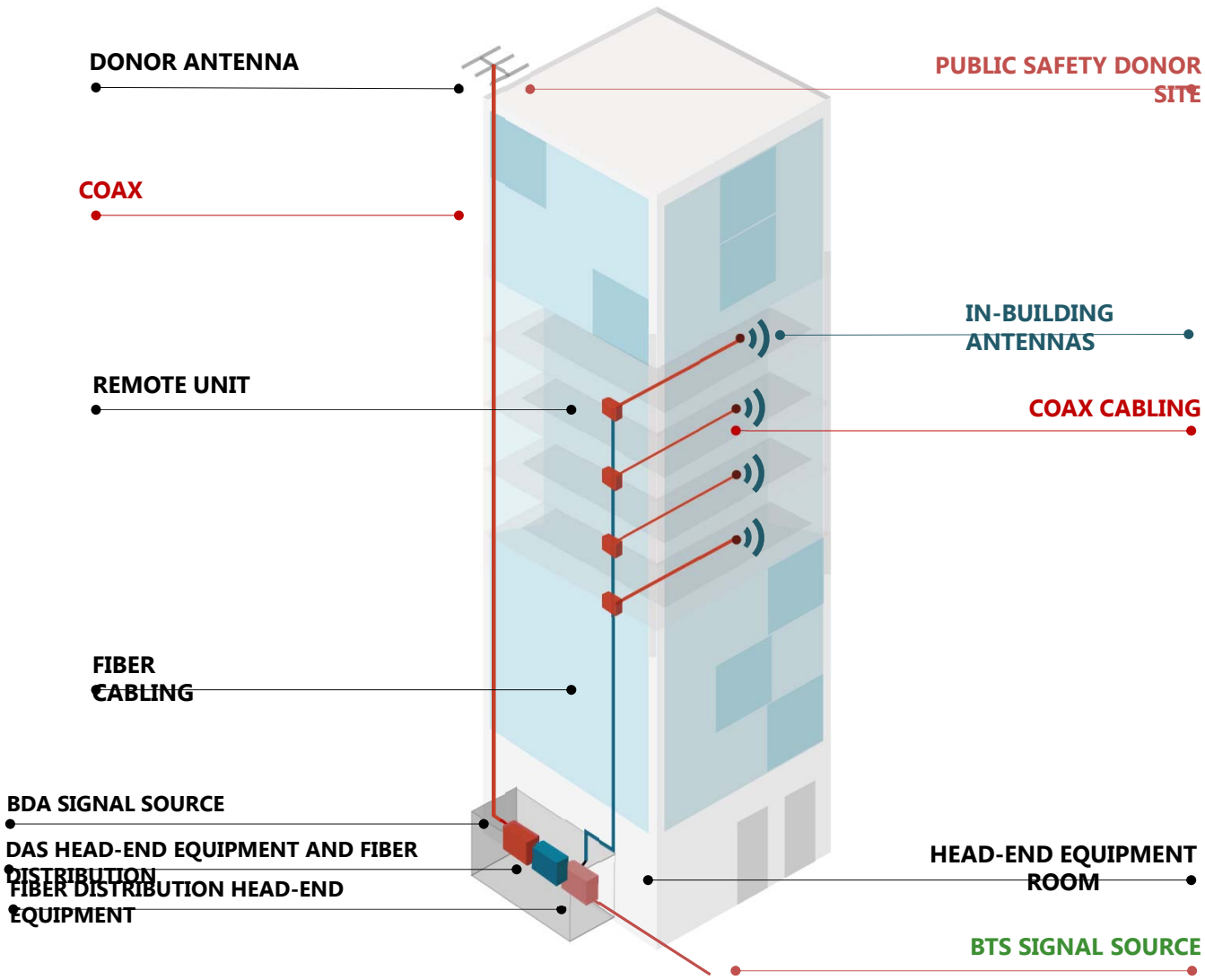
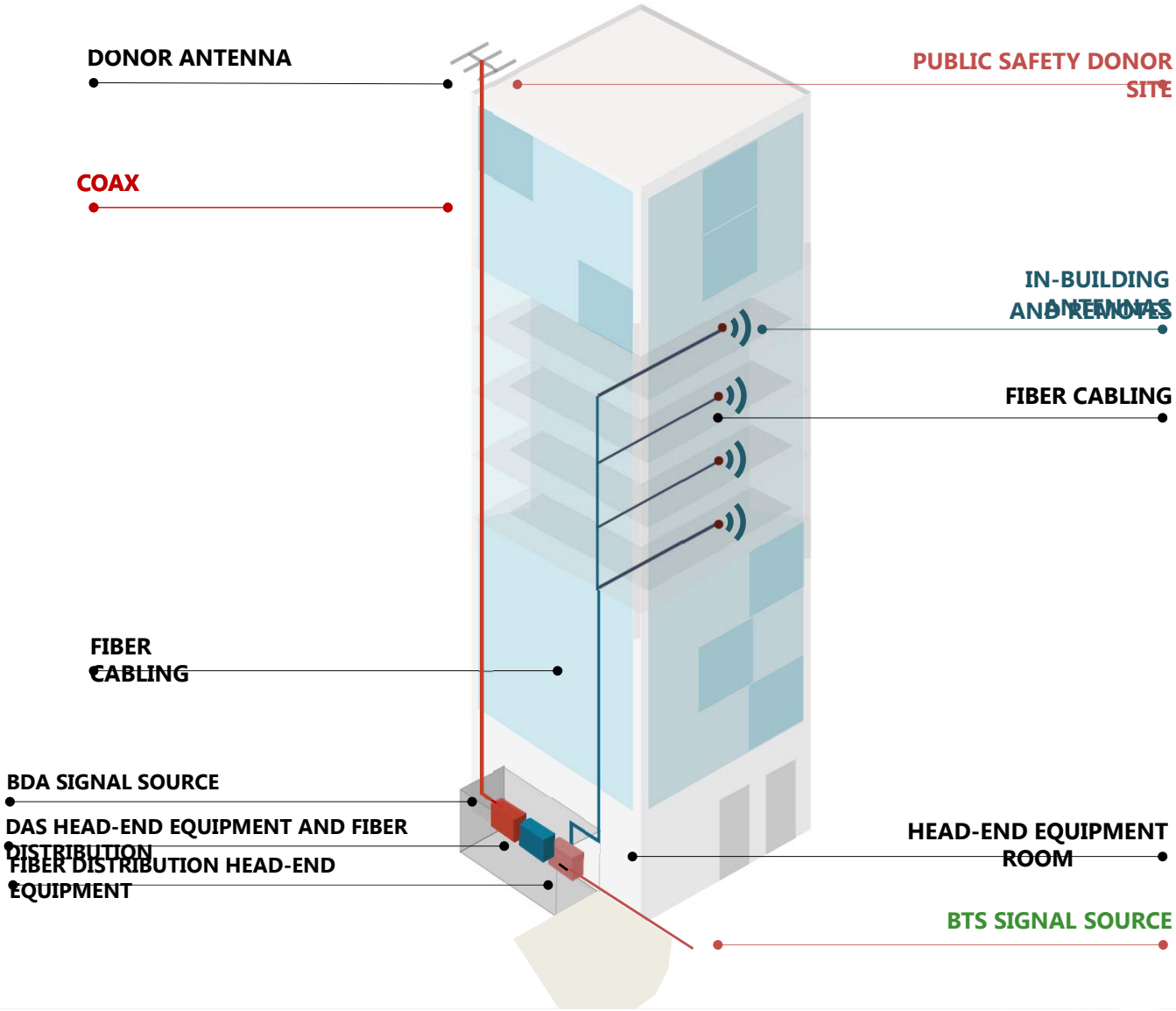
DAS Architecture Ove



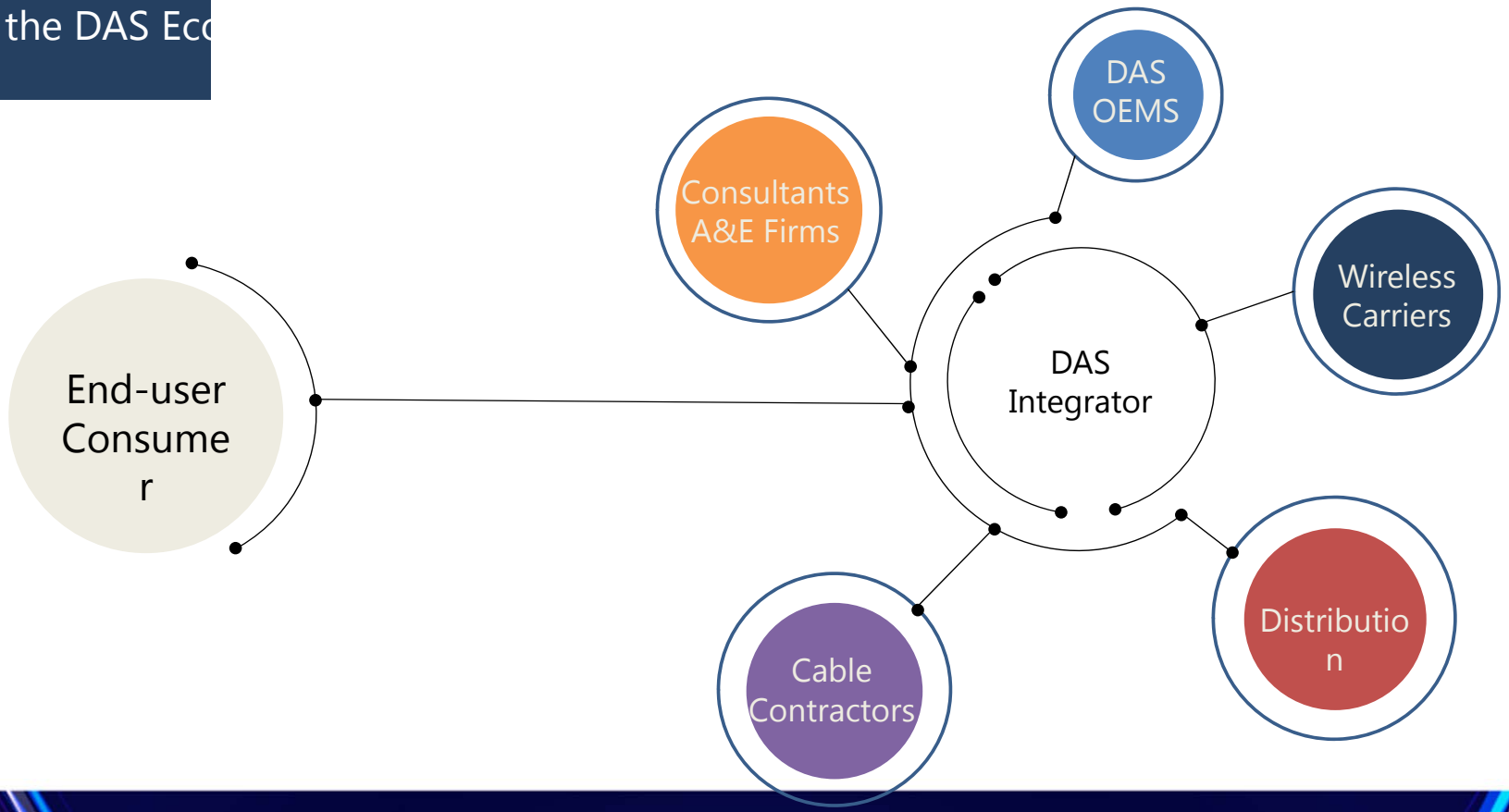
Traditional DAS Archit



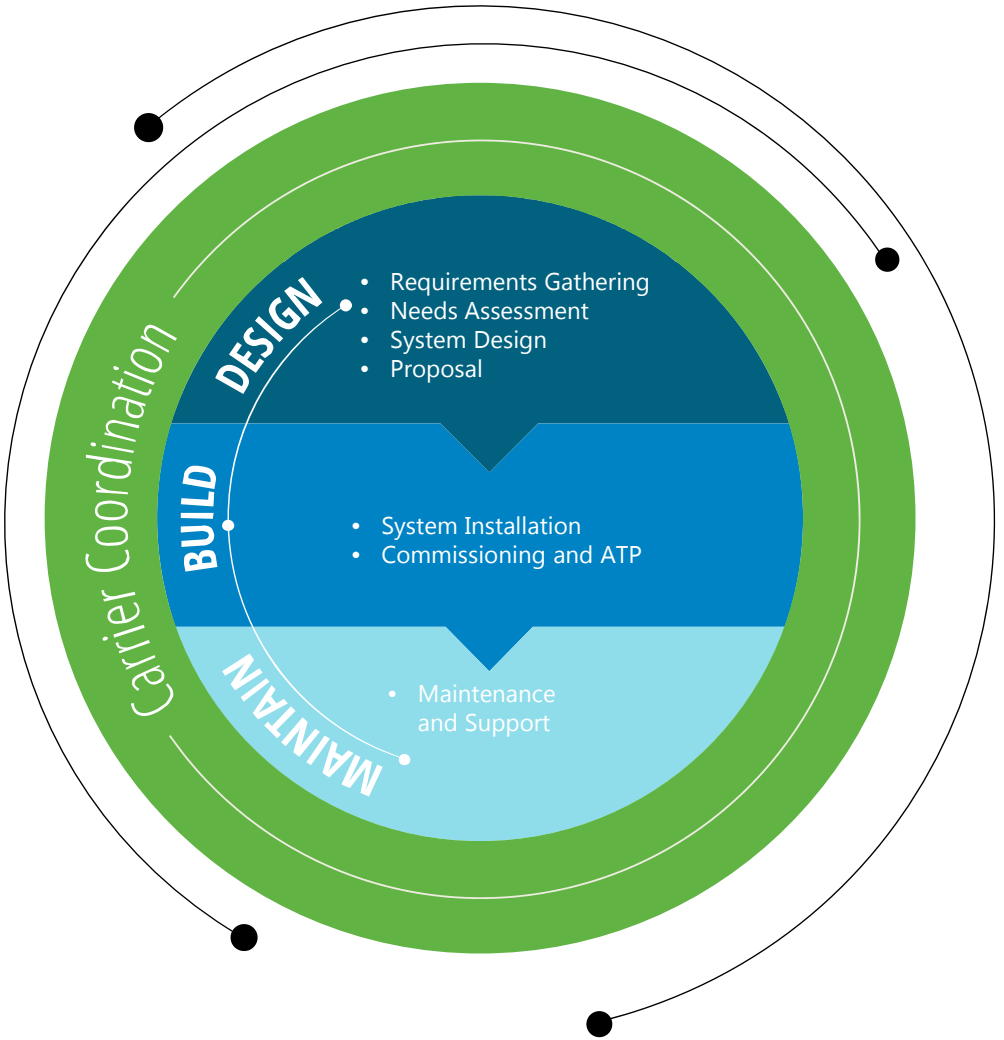
Fiber to the Edge Arch



Players in the DAS Ecc



DAS Lifecycl



Benchmark Data Colle

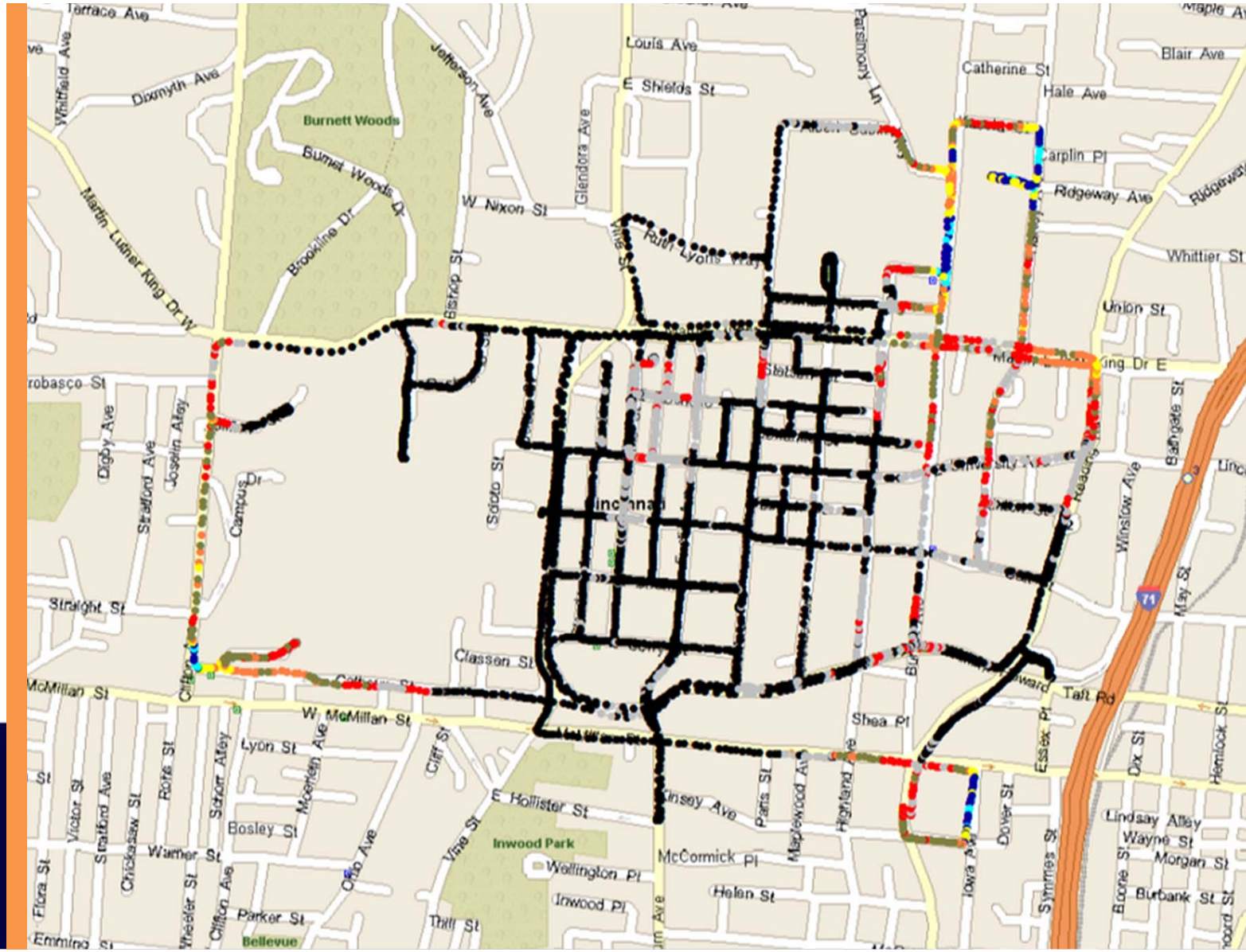
Collecting and recording carrier data helps with

- CARRIER NEGOTIATIONS
- PROPER DESIGN

Benchmark Data Colle

RSRP (dBm)

- < -95 (3336 - 62.96%)
- -95 to -90 (892 - 16.83%)
- -90 to -85 (411 - 7.76%)
- -85 to -80 (256 - 4.83%)
- -80 to -75 (170 - 3.21%)
- -75 to -70 (117 - 2.21%)
- -70 to -65 (93 - 1.76%)
- -65 to -60 (24 - 0.45%)
- -60 to -55 (0 - 0.00%)
- -55 to -50 (0 - 0.00%)
- > -50 (0 - 0.00%)



Benchmark Data Colle

Floor 24	Quality					
	Signal Level					
Floor 23	Quality					
	Signal Level					
Floor 22	Quality					
	Signal Level					
Floor 21	Quality					
	Signal Level					
		LTE 700	LTE 1900	LTE 2100	UMTS 850	UMTS 1900
		4G			3G	

	Signal Level	Signal Quality
Good	Majority of Coverage Area -85dBm or better	-10dB or better
Marginal	Majority of Coverage Area between -85dBm and -95dBm	Between -10dB and -14dB
Poor	Majority of Coverage Area -95dBm or less	-14dB or less

Connectivity™
Wireless Solutions

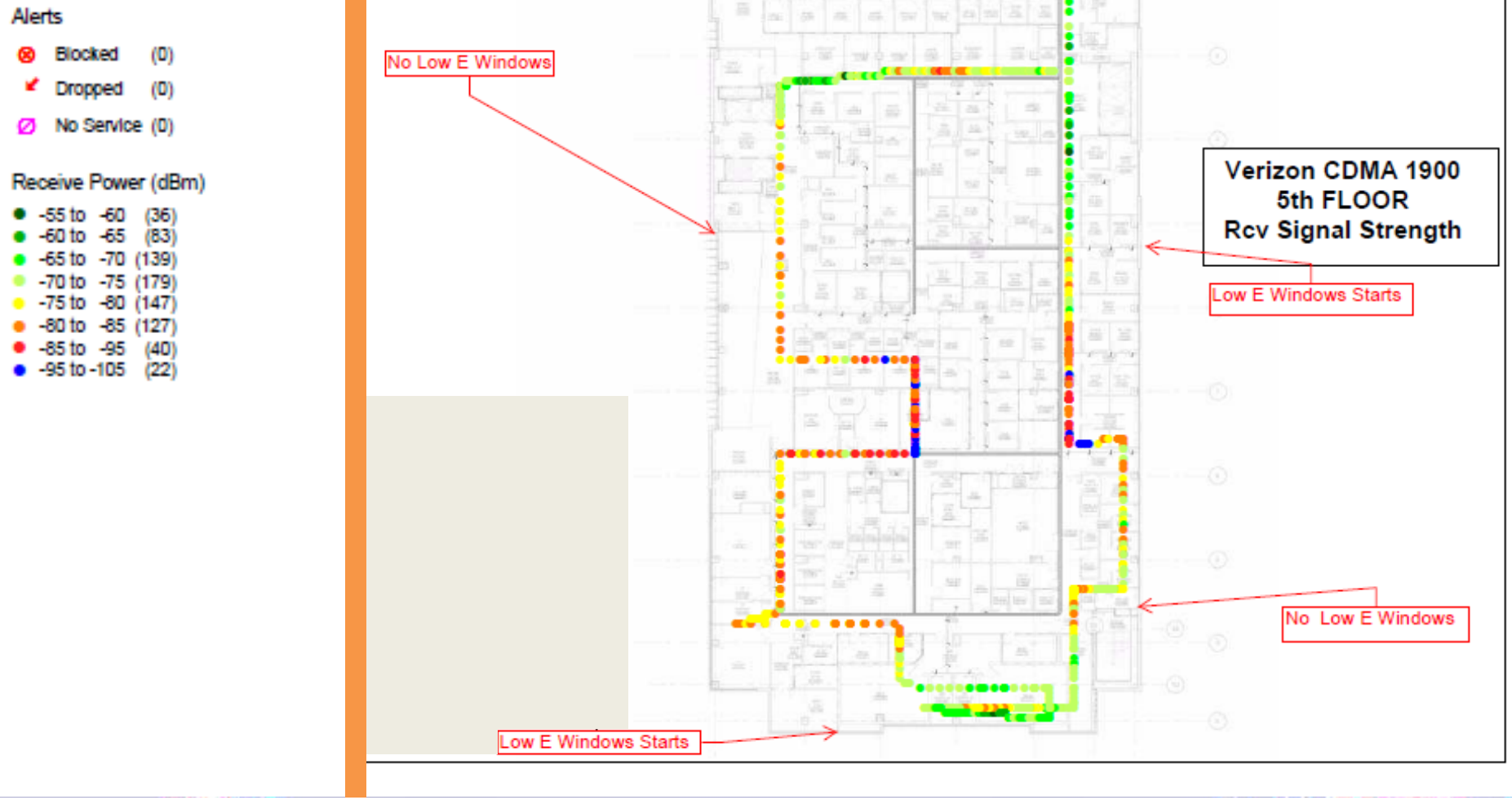
CW Testin

Collecting and recording the characteristics of the facility helps with

PROPER DESIGN

facility helps with

Data Collection Example



Carrier Coordina

Site Survey

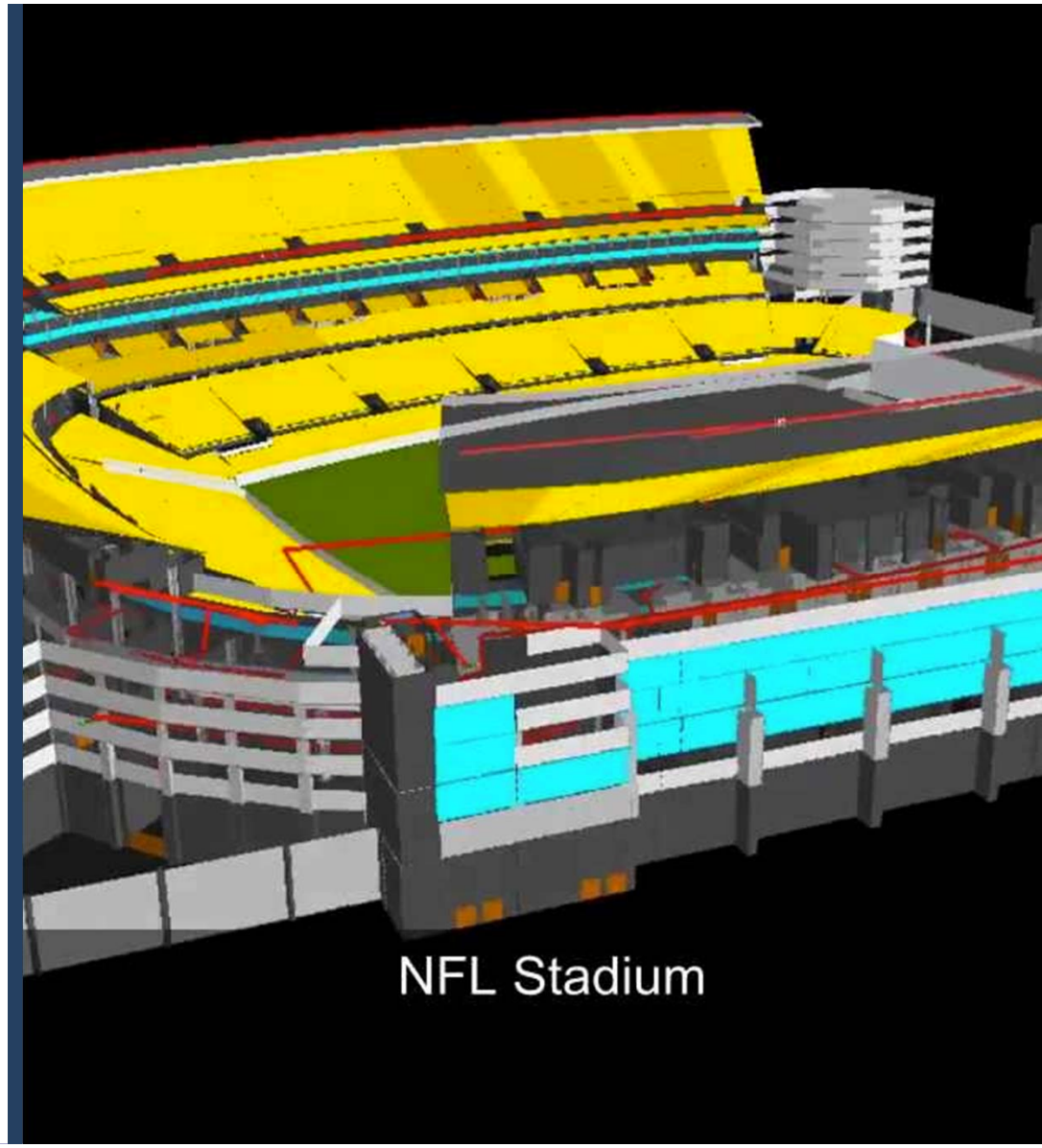
OBJECTIVE

To ensure that the system can be constructed per the specifications of the design and to help determine additional value engineering specifics.

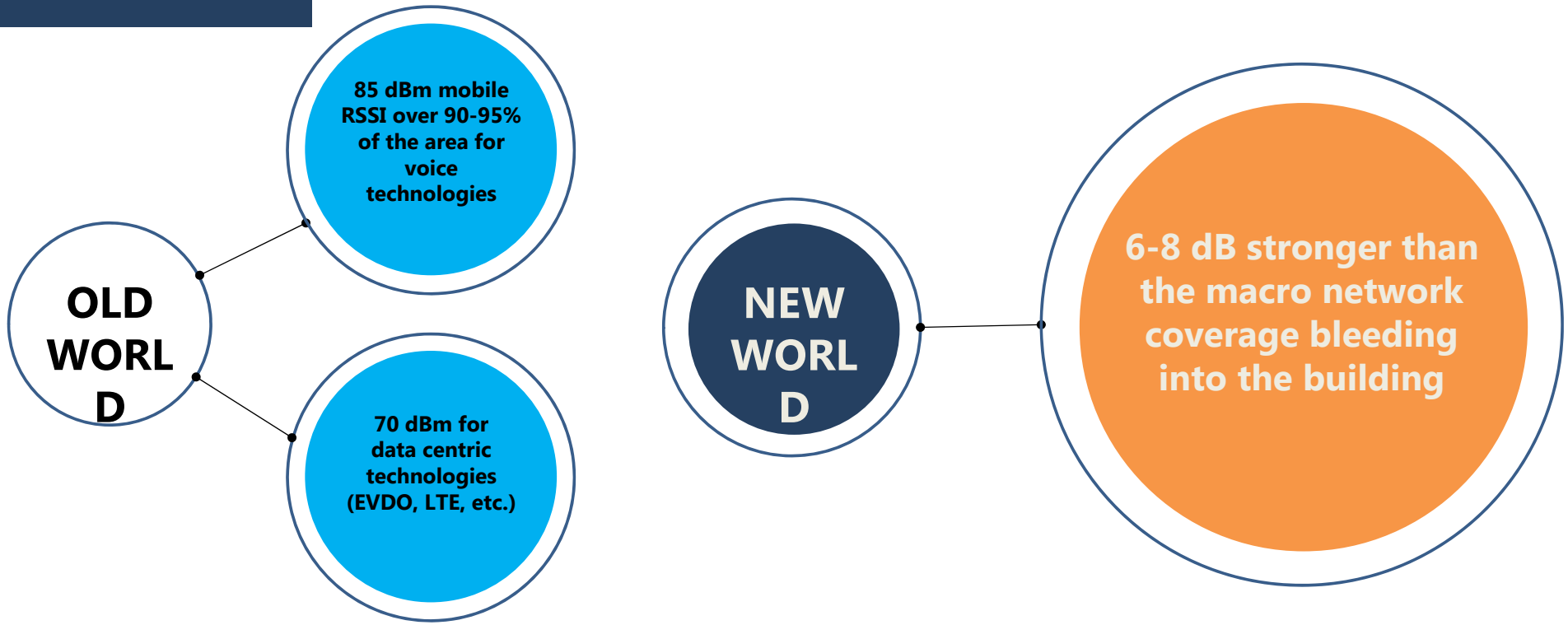
- RF OBSTACLES
- INTERIOR WALL MATERIALS
- CEILING HEIGHTS AND TYPES
- PURPOSE OF BUILDING
- VERTICAL CHASES

Design

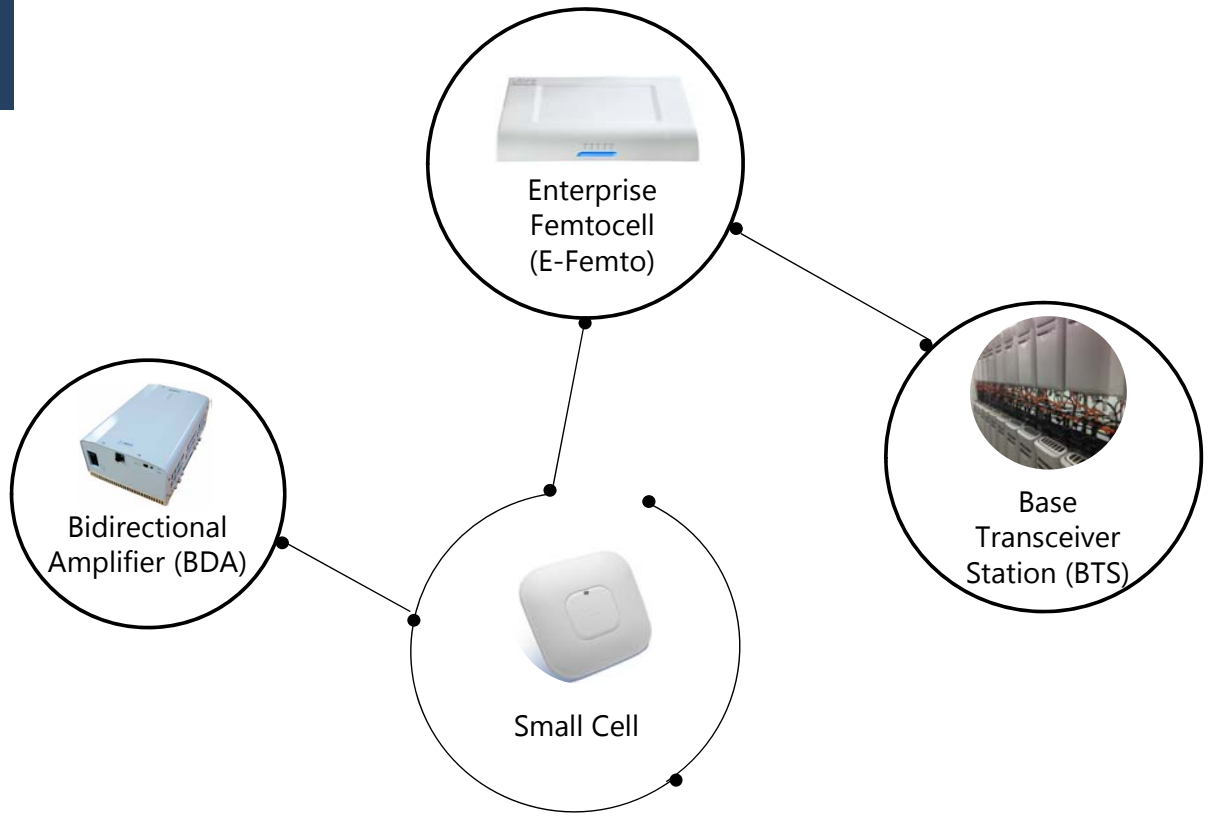
iBwave



Wireless Design Thres

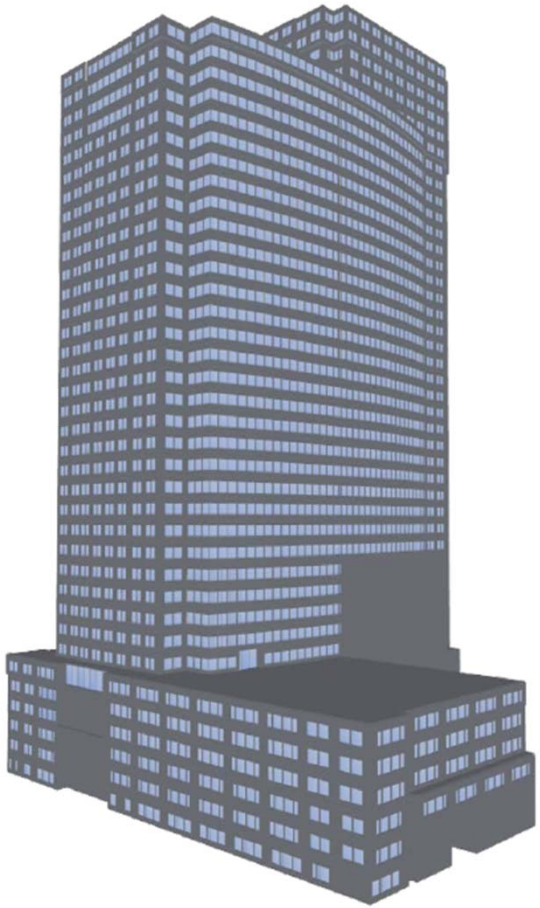


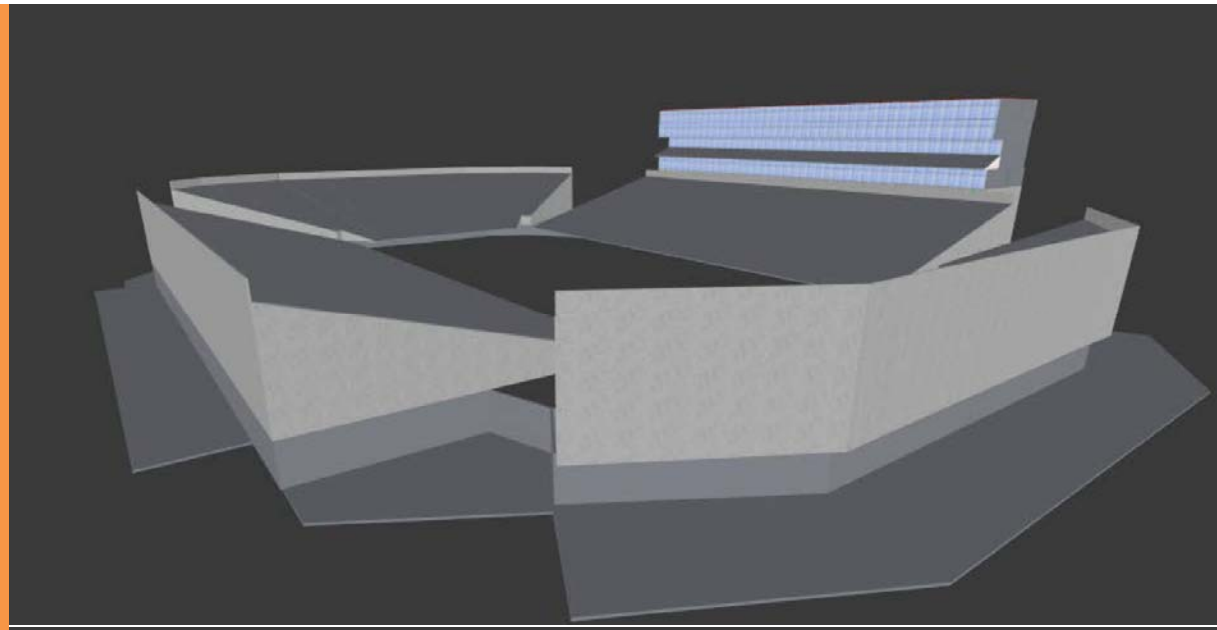
DAS

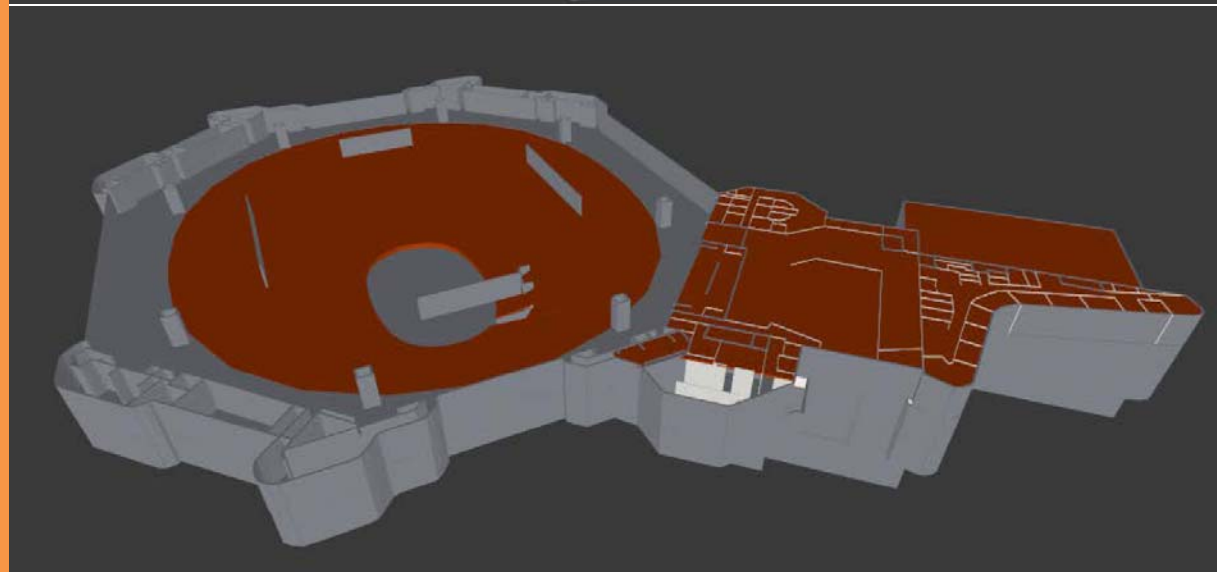


RF Sources – What am I going to connect to the DAS?

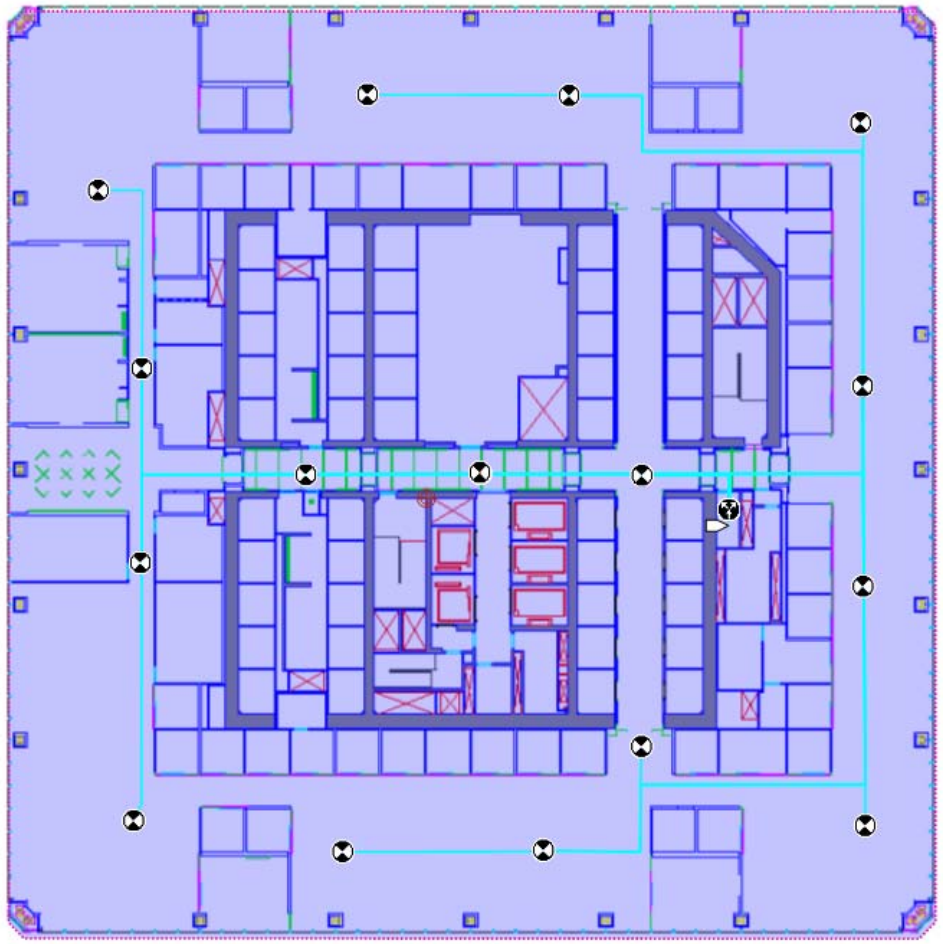
Design: 3D Modeling



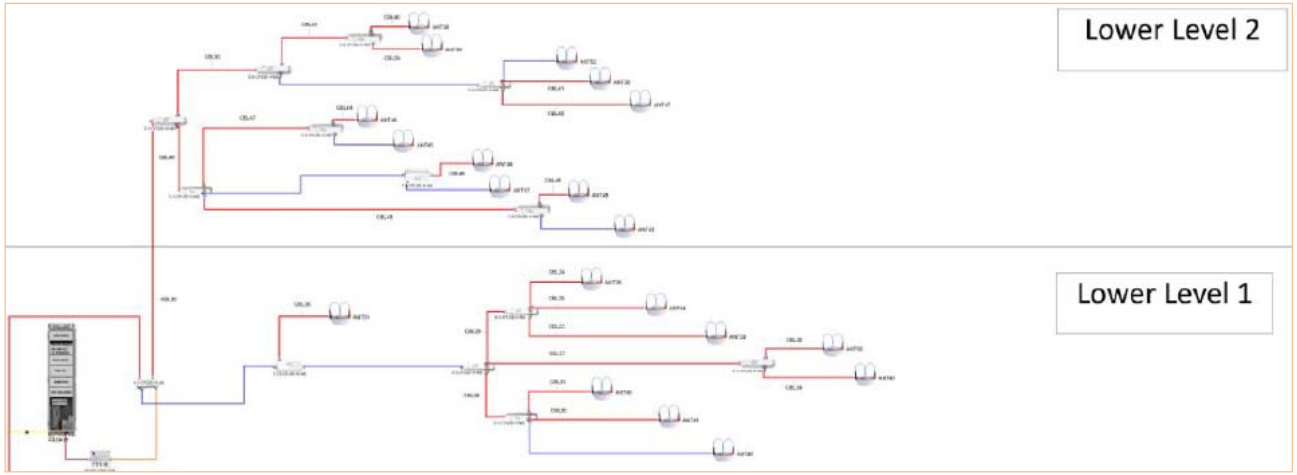


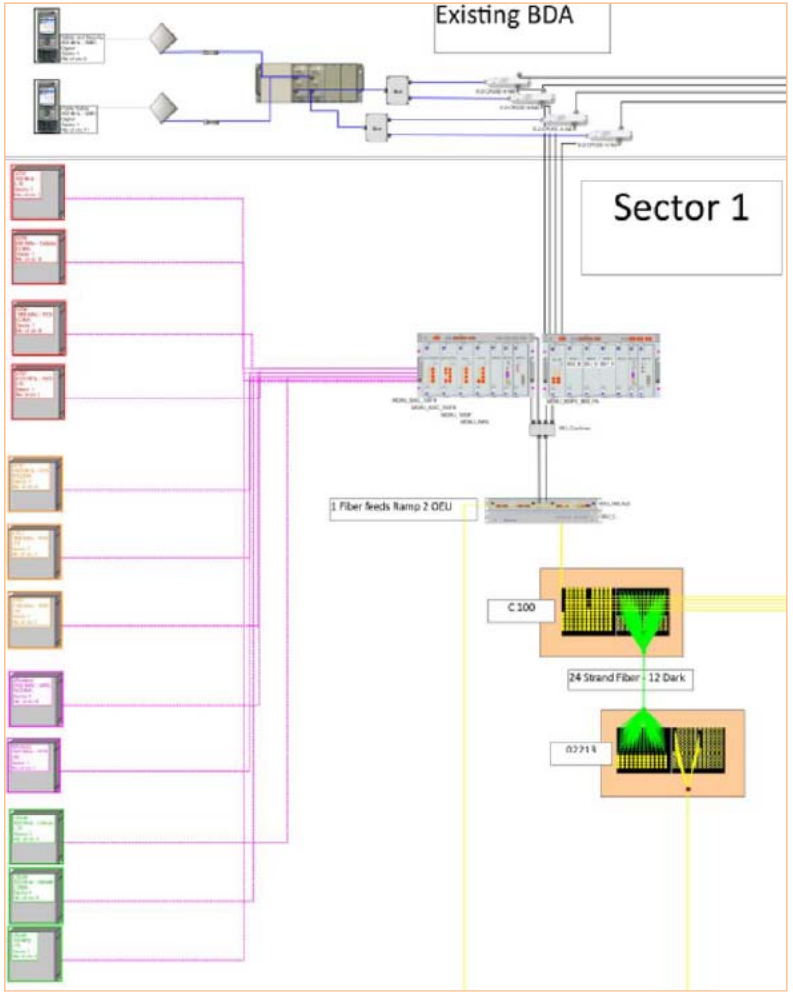


Design: Antenna Layouts



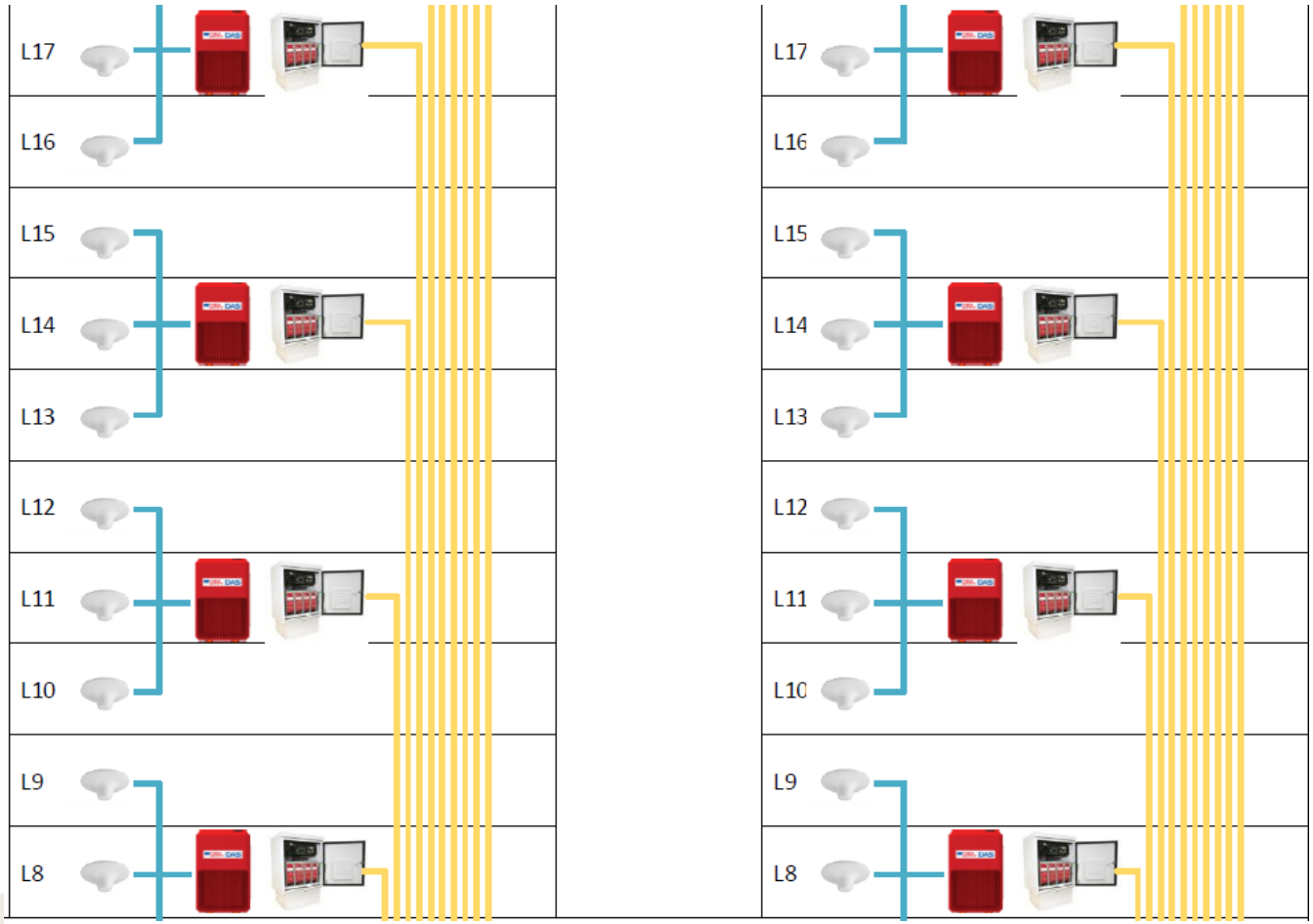
Design: Riser Diagrams



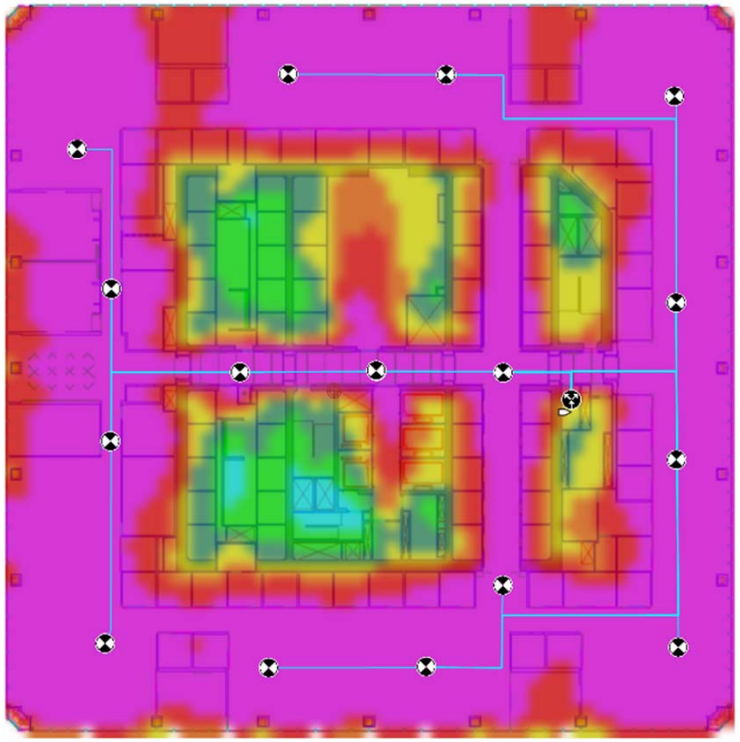


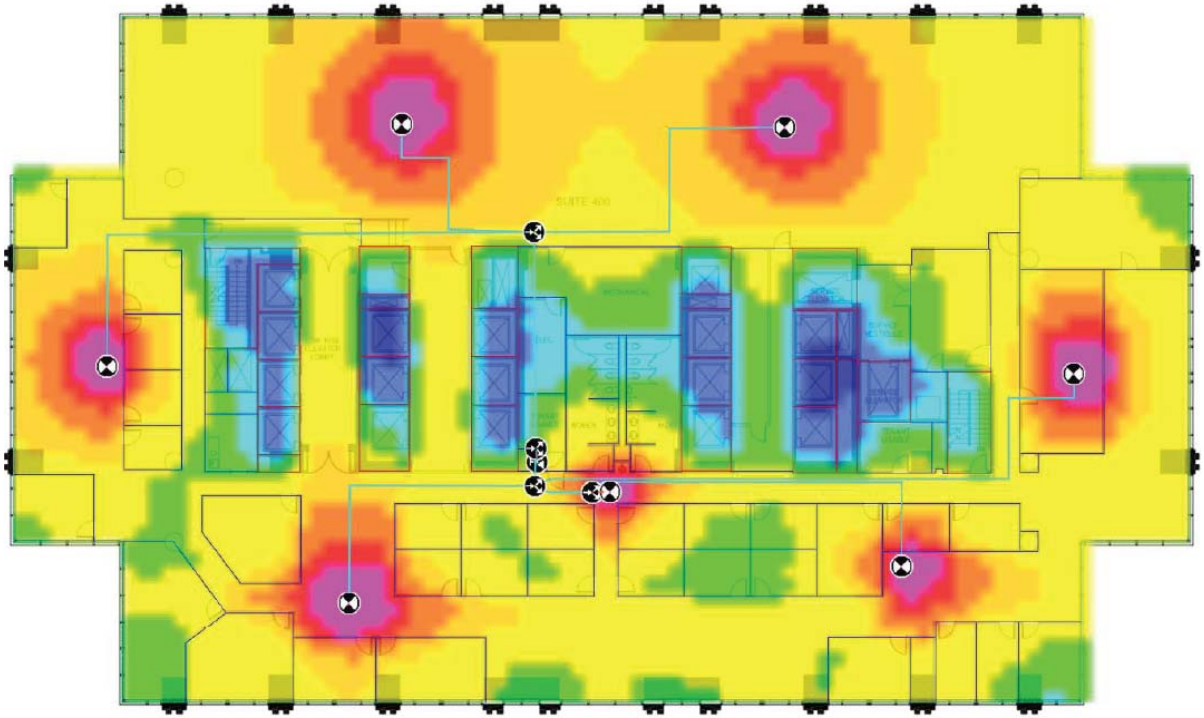
Design: Riser Diagrams

Tower	IDF's	Fiber Strands	Notes
1	16	32	Includes IDF in the Podium and 49th Floor for BDA
2	10	20	No IDF in the Podium
3	12	24	Includes IDF in Podium
Total	38	76	

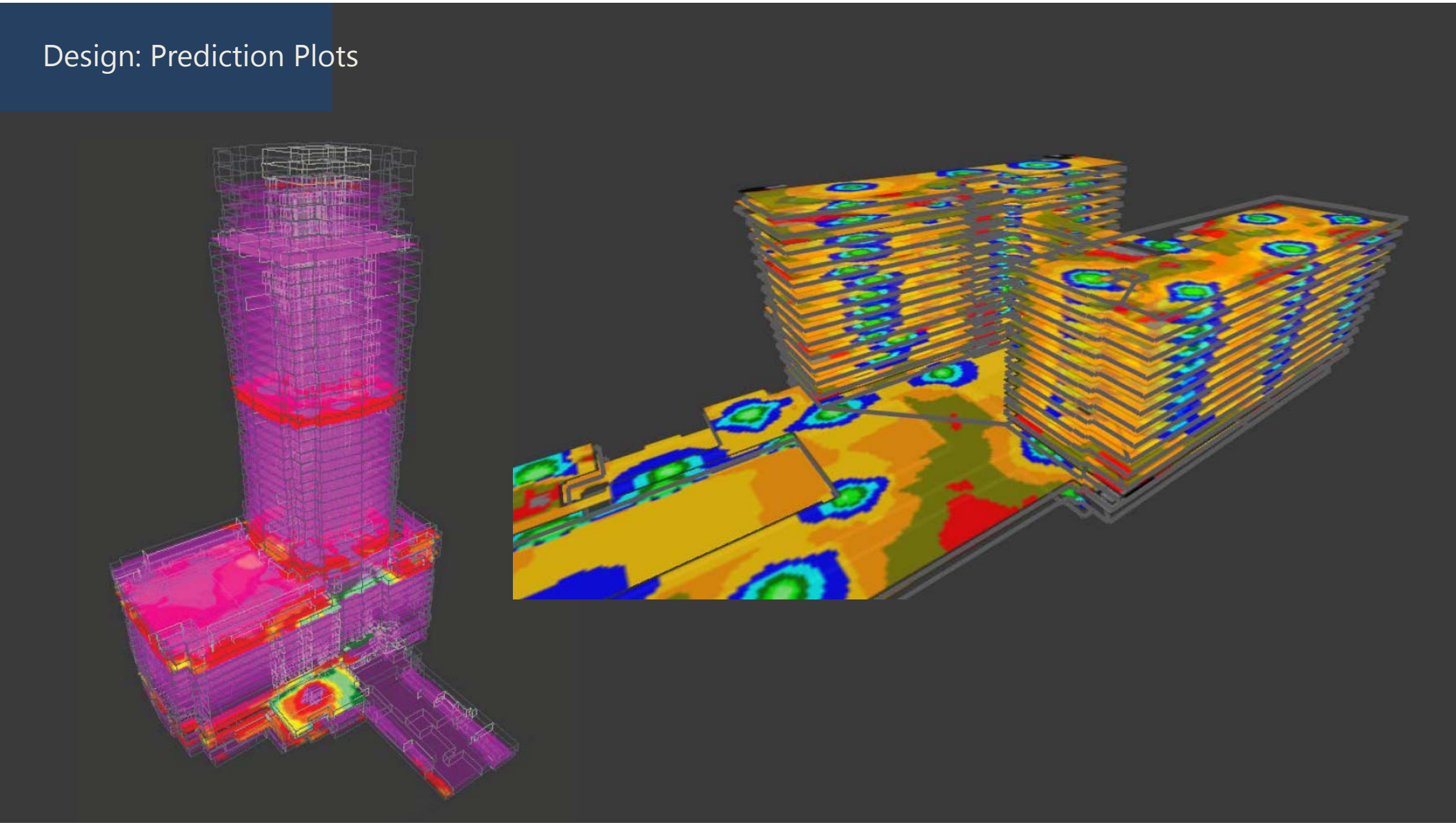


Design: Prediction Plots

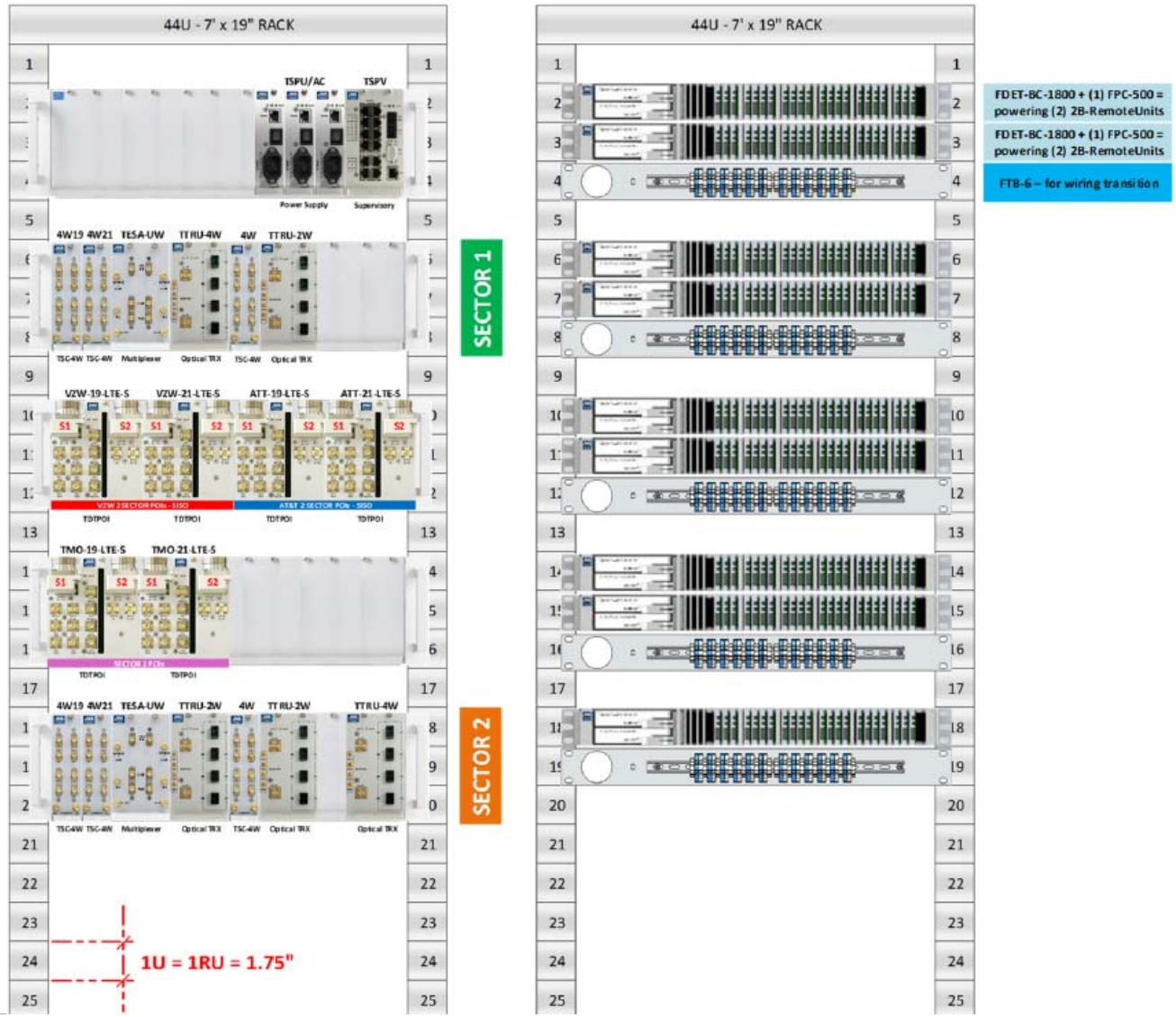




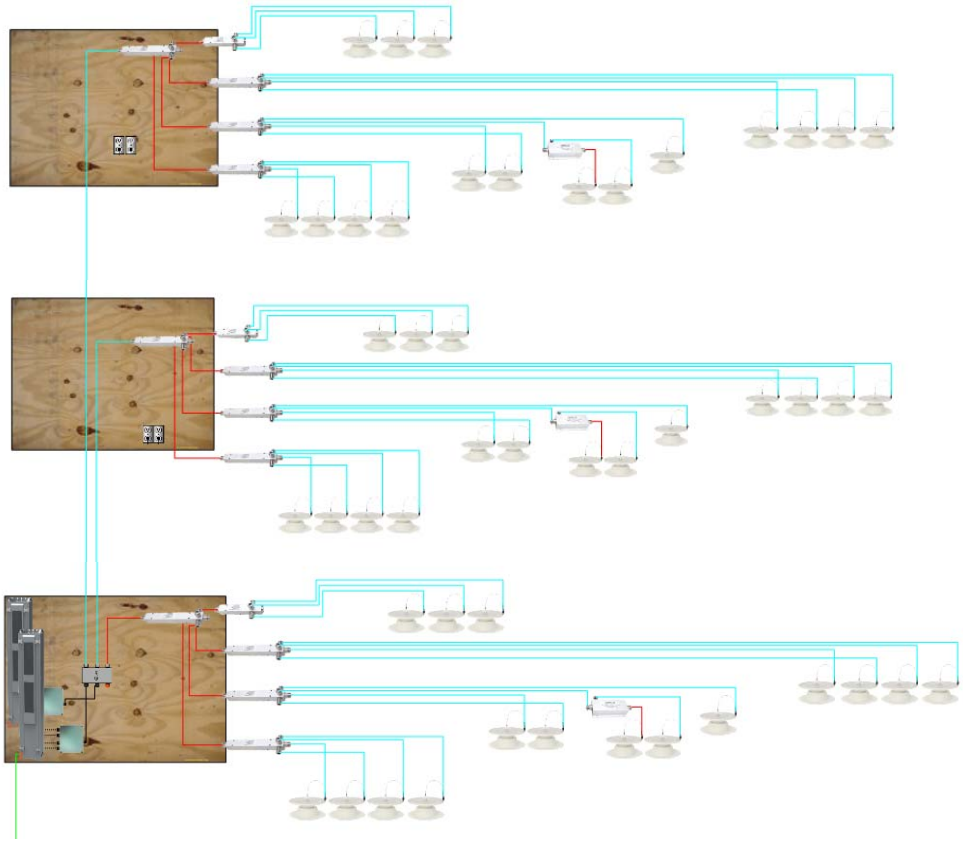
Design: Prediction Plots

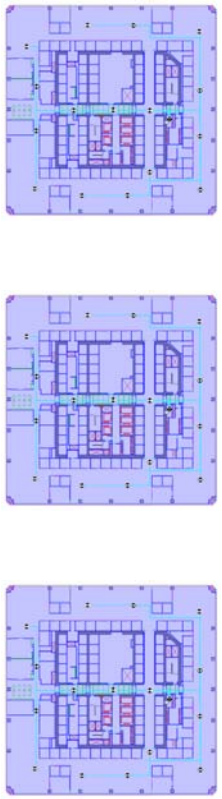


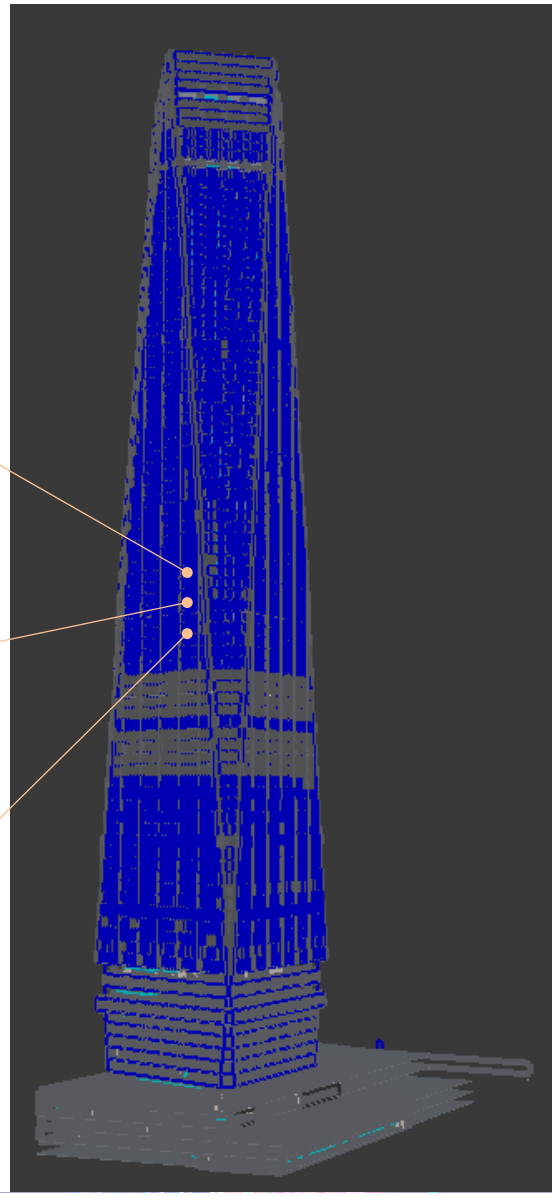
Design: Prediction Plots



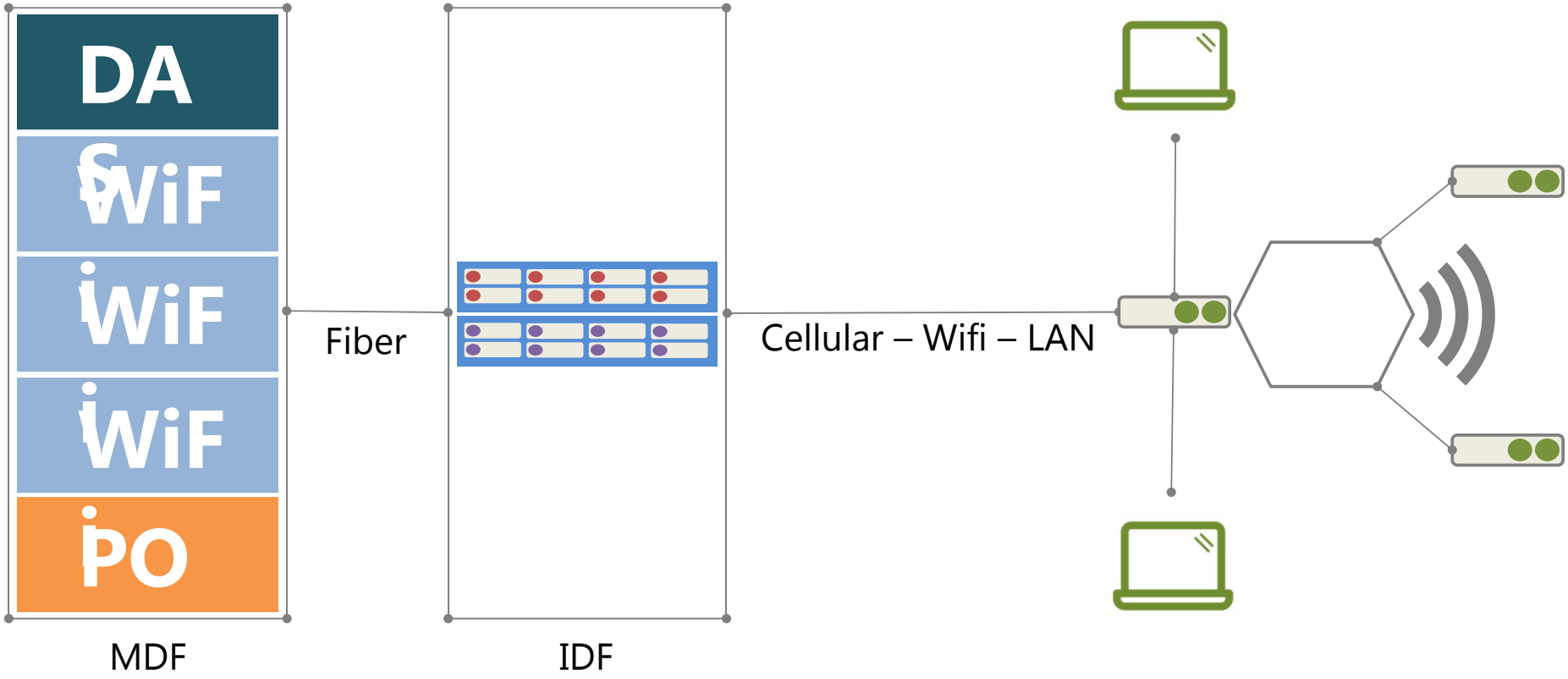
Design: Piecing It All Toge







Design: Converged Netwo



Design: The Value of Conver

NETWORK

PACKET VOICE

RF

PON

ONE DAS

APPLICATIONS

POINT OF SALE

SECURITY SUREILLANCE

VoIP PHONE

RF VIDEO AND IP VIDEO

WIFI ACCESS POINT

SMARTPHONE & TABLETS

BUILDING AUTOMATION

VALUE

Neutral-host DAS = Venue controls, manages, and operates its own network

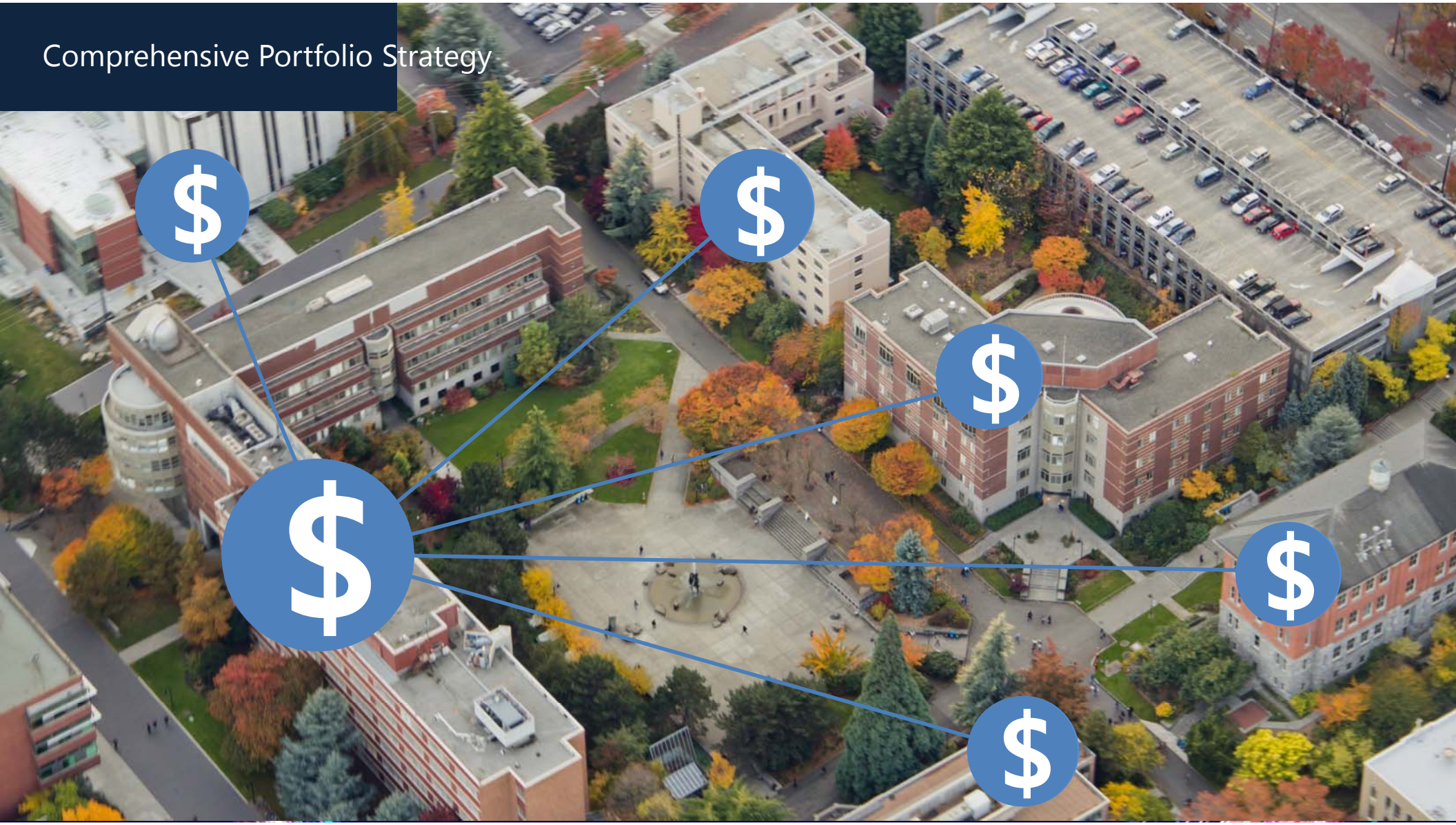
Seamless connectivity on any network with any device = Enhanced customer experience

Combined fiber management, powering and power backup = Reduced CAPEX and OPEX

Traditional Implementation Strategy

Comprehensive **Portfolio Strategy**

Comprehensive Portfolio Strategy



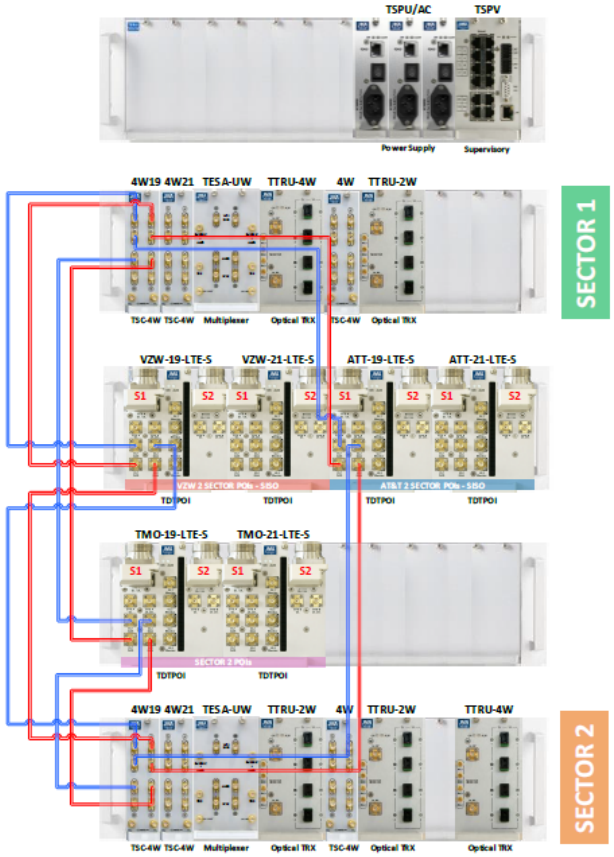
Best Practices

DAS Installation

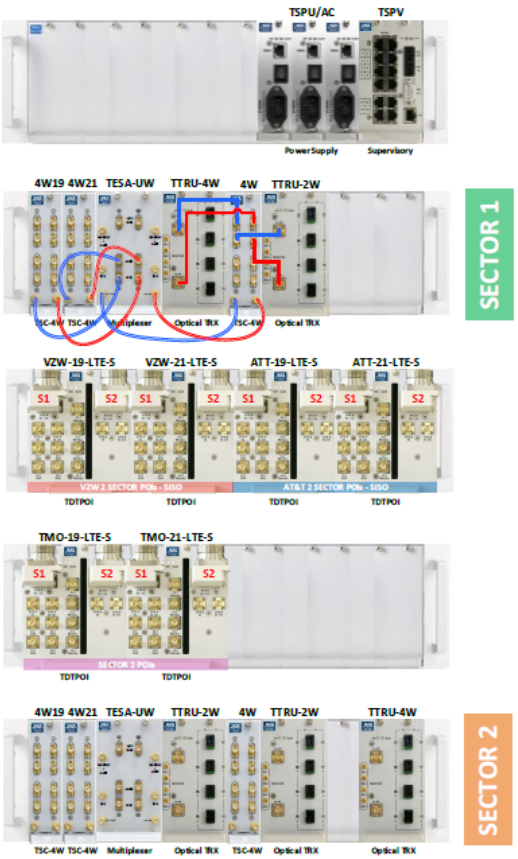
- IN-HOUSE TEAM OR DIRECT MANAGEMENT
- ON-SITE CONSTRUCTION MANAGEMENT
- PROFESSIONALISM
- DETAILED DOCUMENTATION FOR EACH PROJECT
- STRATEGIC INSTALLATION APPROACH
- SWEEP, PIM AND OTDR STANDARDS

Installation Document

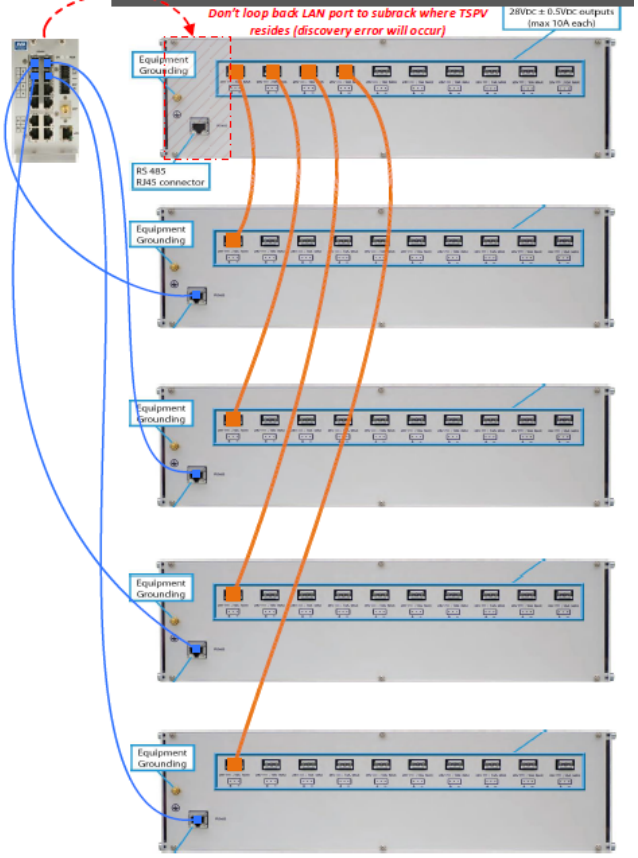
A) Sample Connection from 1900 POI (S1 and S2) to Respective Sector 1900 TSC-4W Combiners (Repeat Same Procedure For AWS)



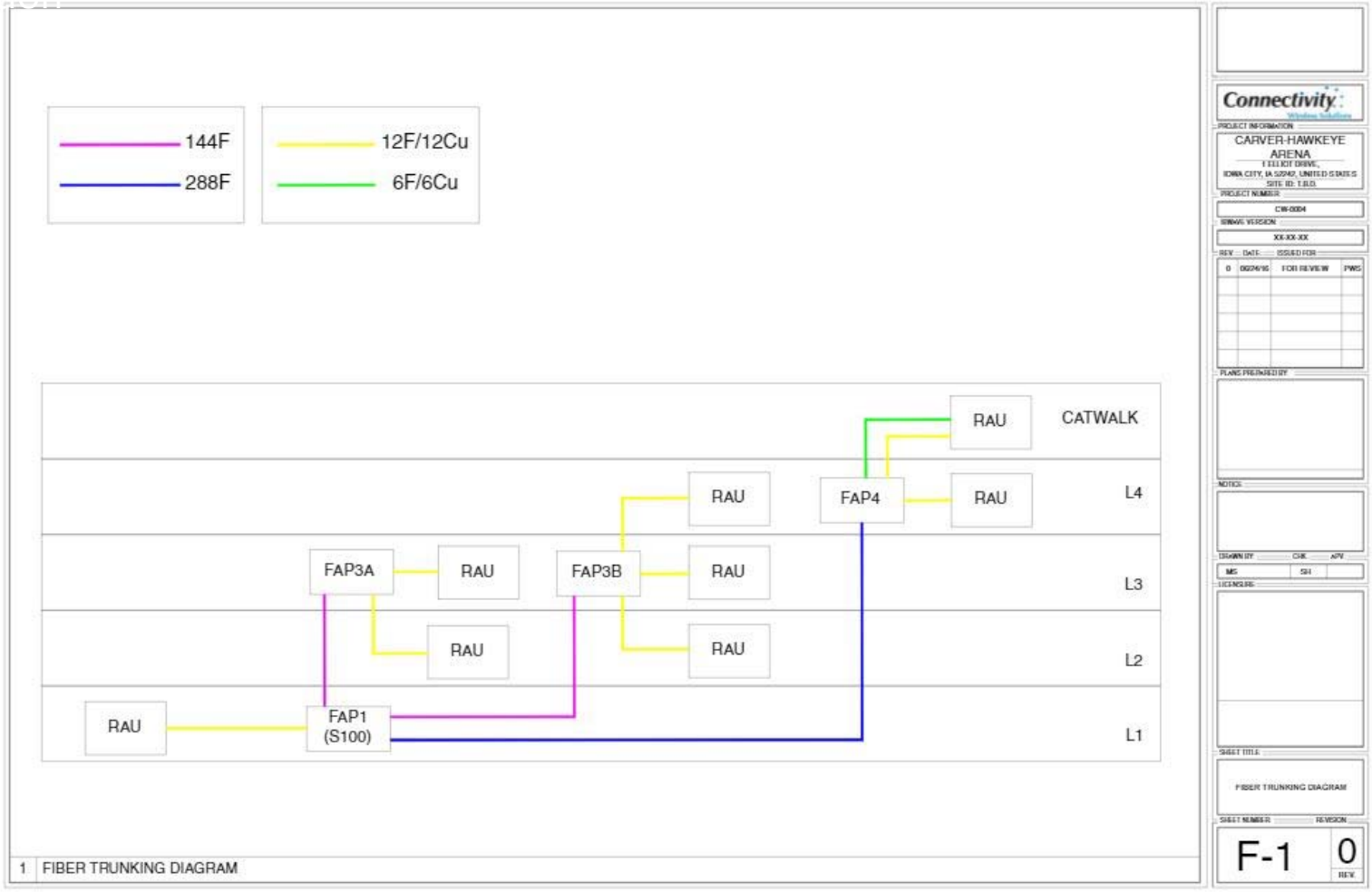
B) Interconnection from TSC-4W >> TESA-UW >> TSC-4W (Post TESA) >> TTRU/OTRX



C) Power and Monitoring Connections (back of subrack)



Installation Document



Installation Compo

BASE STATIONS

Head-end radio equipment, provided by the wireless carriers, that provides the RF signal source to drive the DAS

FIBER HEAD-END

Converts the RF signal to RF-over-fiber (RFoF), then transmits the signal via single-mode fiber-optic cable to the fiber remote unit

MULTI-BAND REMOTE UNIT

Converts the RFoF transmission back to an RF signal, which is then transmitted down coax cable to the coverage antenna

FIBER OPTIC CABLE

Transports the converted RF signals from the head-end equipment to the remote units

PLENUM CABLE

Transports the RF signals from the fiber remote unit—to the coverage antenna

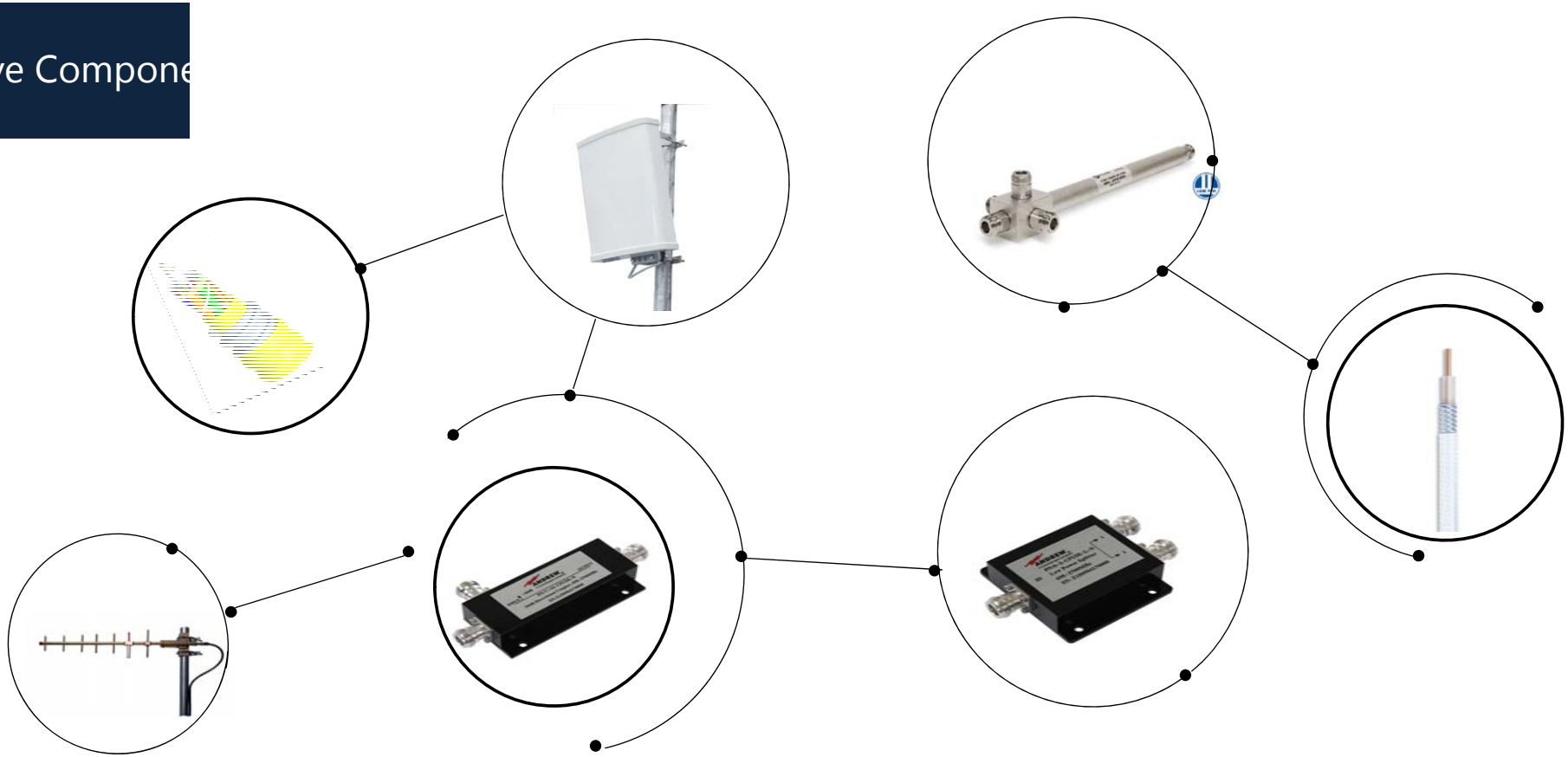
SPLITTER

Splits the RF signals, which is then delivered to multiple inputs/elements

COVERAGE ANTENNAS

emits multi-band RF signals to the coverage area

Passive Compone



Active Components

Sample Remote Photos

Sample Remote Photos

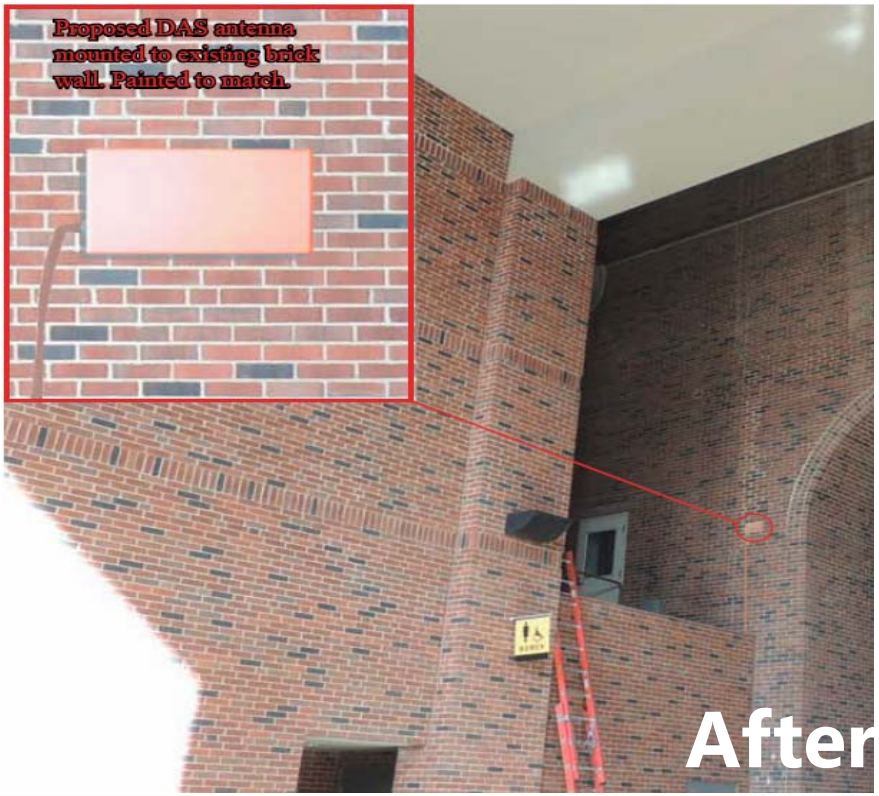
Sample Antenna Photos

Sample Antenna Photos

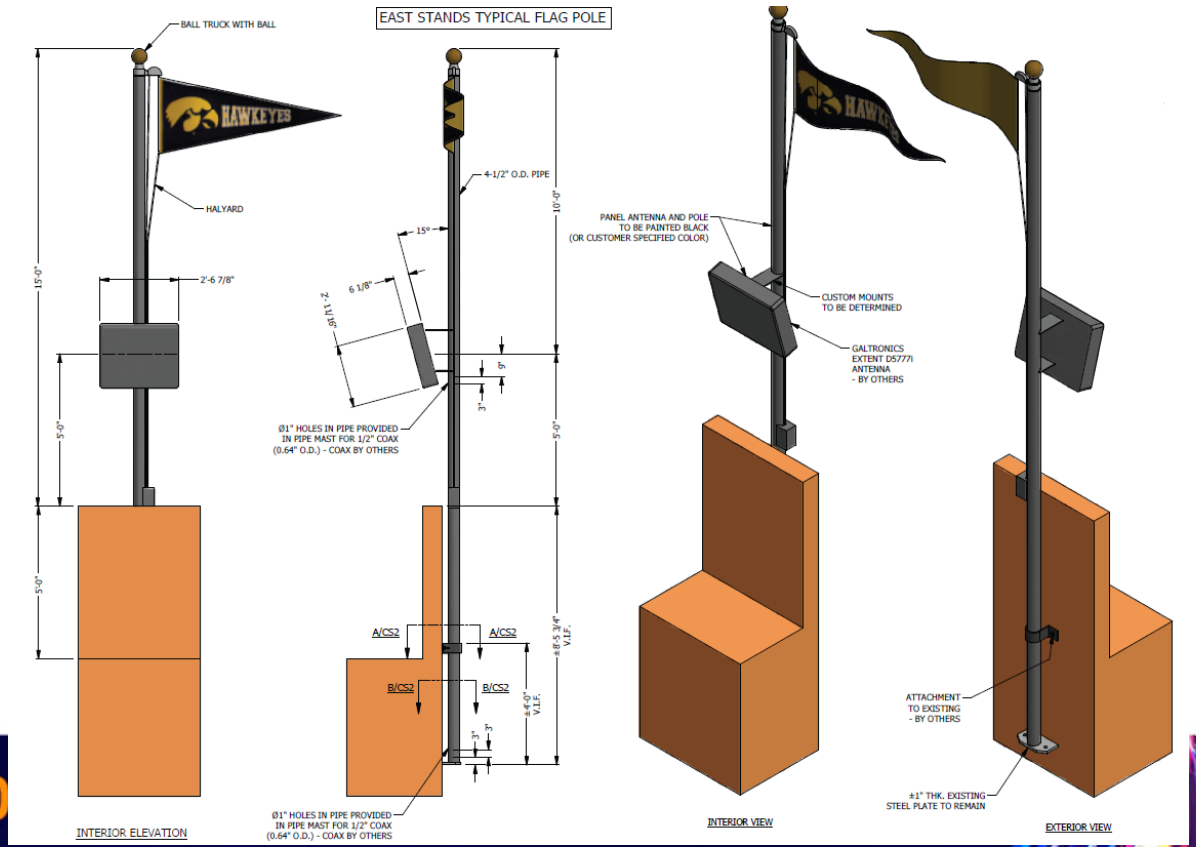
Sample Antenna Photos

Aesthetics


Before


Proposed DAS antenna mounted to existing brick wall. Painted to match.
After

Aesthetics

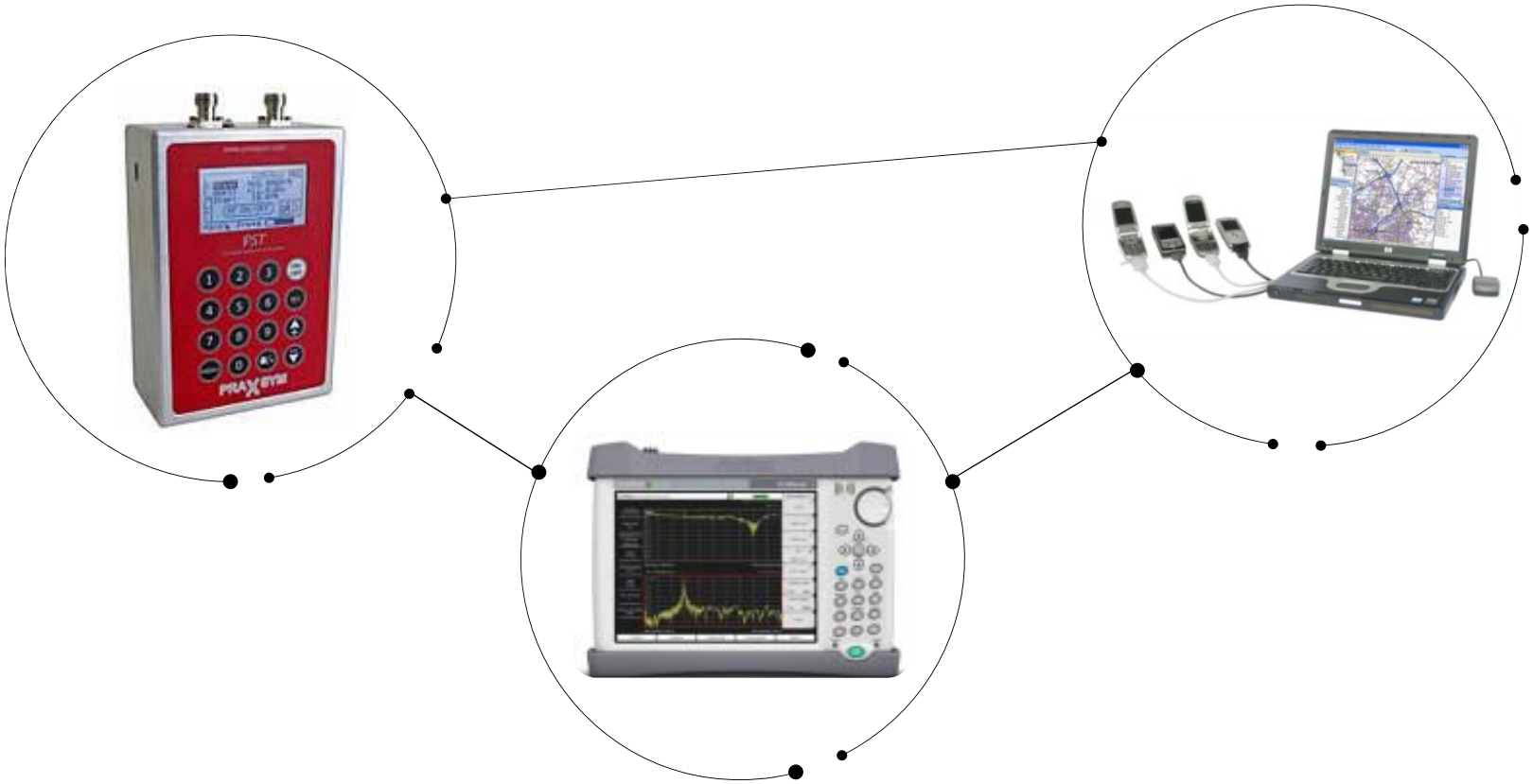


Commissionin

Commissioning is generally defined as the industry approved process and methodology of systematically verifying that the:

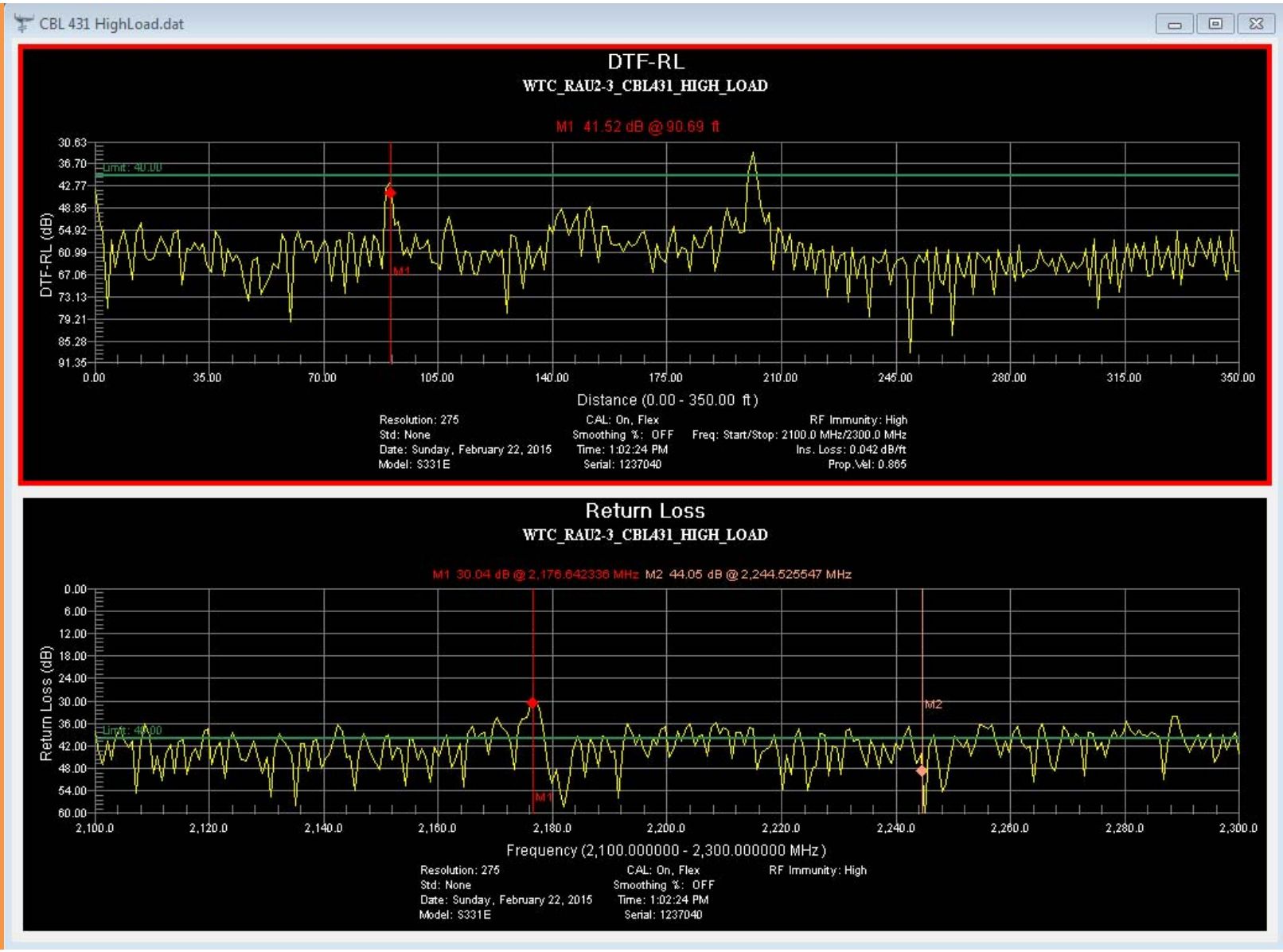
- System was installed correctly according to the design
- Active and passive components are functioning according to factory specification
- Link budget and associated DAS power metric performance matches the design specifications
- Intended carrier signals are integrated onto the DAS according to design and are done so within optimum equipment parameters
- Intended carrier signals are optimized to the systems optimum performance metrics, as determined by the design

Tools for Succ



Data Processir

- SWEEPS – RL/DTF
- PIM
- FIBER

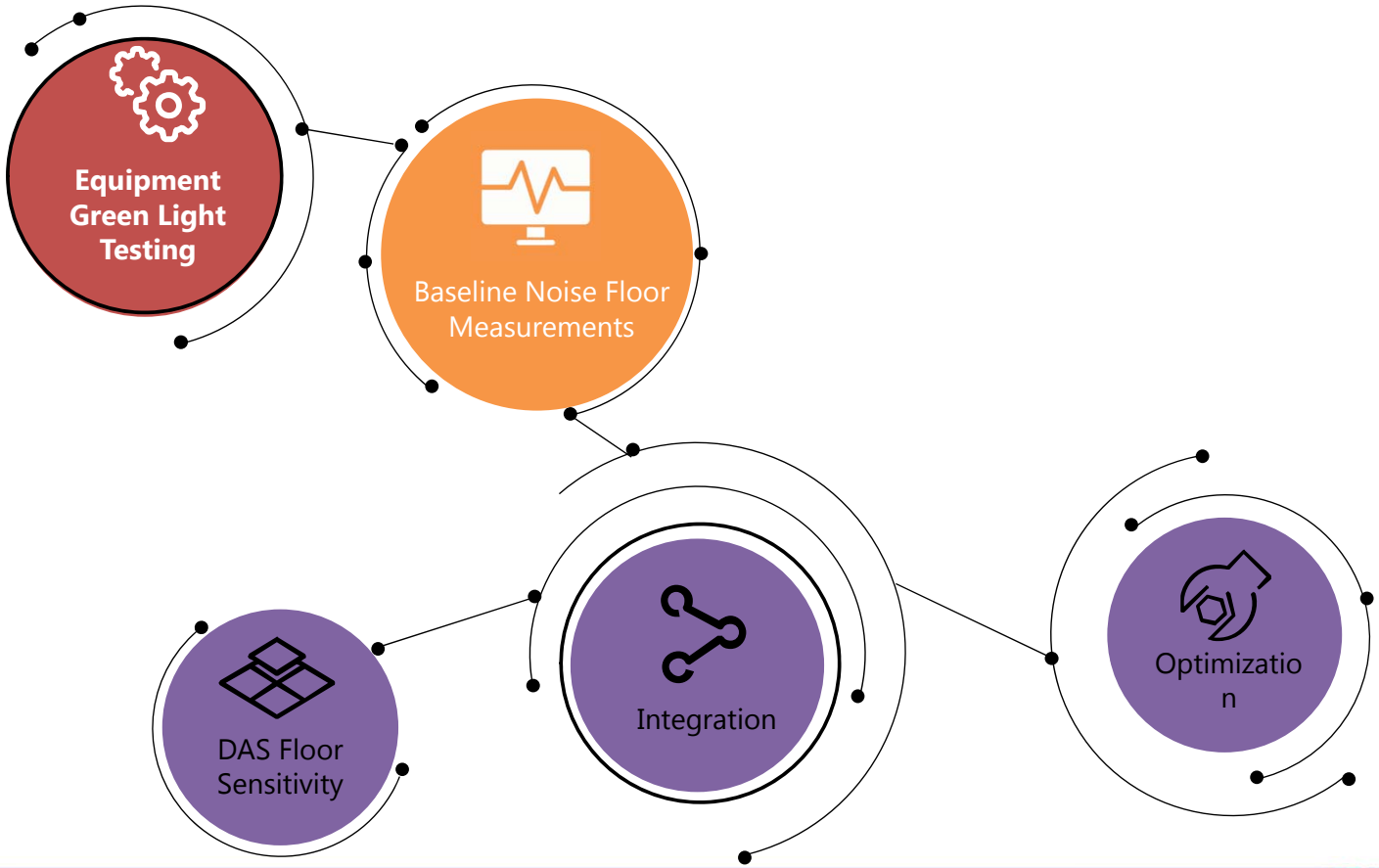


Data Processing:

What is PIM?

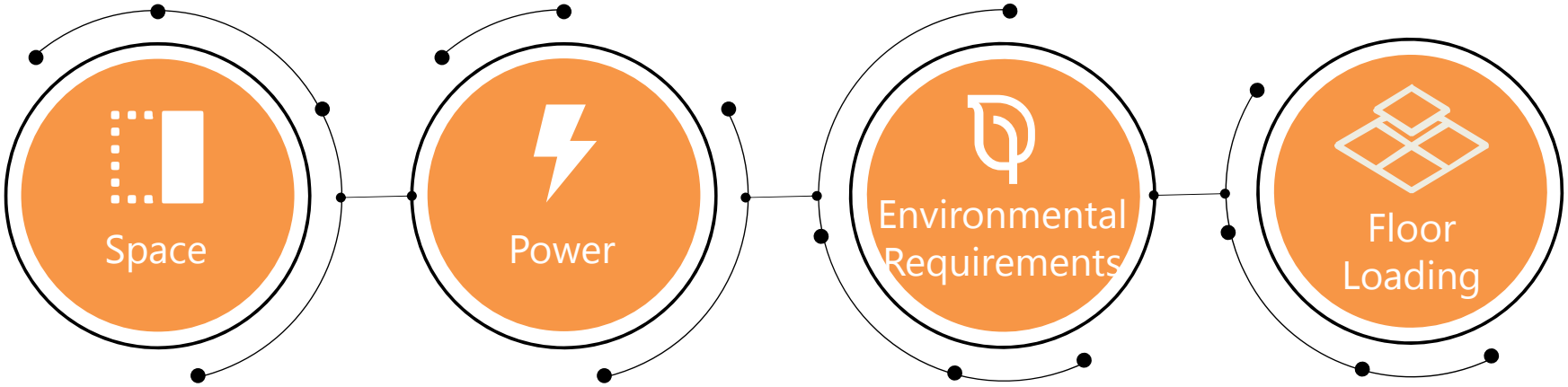
PIM Passive Intermodulation exists when two or more signals are present in a passive device that exhibits nonlinear response

Commissioning Pro



Head End Planning

LET'S TALK ABOUT THE HEADEND (MDF).



Head End Room: Requirem

SPACE FOR WIRELESS CARRIER BASE TRANSCEIVER STATIONS (BTS) – SINGLE SECTOR

- 200 square feet per wireless carrier
- 800 to 1,000 square feet to accommodate all carriers
- Typically utilize existing MDF, but rooms can be retrofit to accommodate head end equipment

POWER REQUIREMENTS FOR THE HEAD-END ROOM

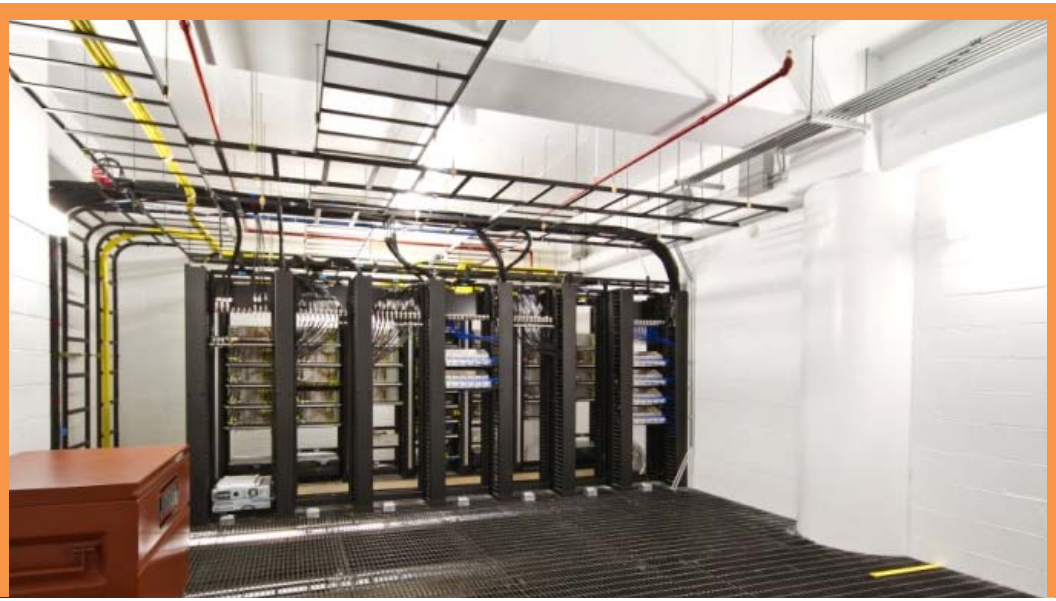
- 100 Amps 208 VAC three phase per carrier

ENVIRONMENTAL REQUIREMENTS FOR THE HEAD-END

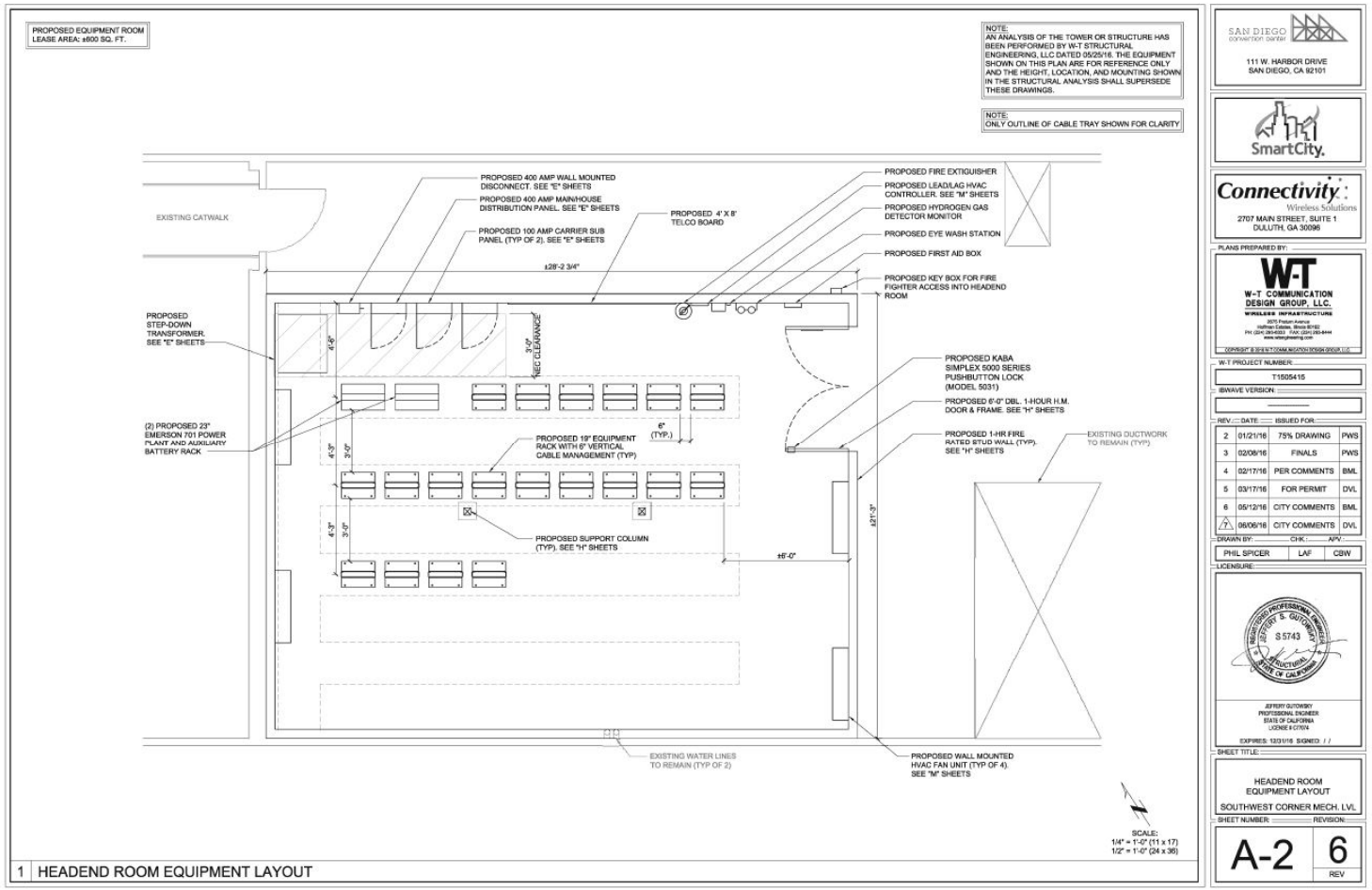
- 2 tons HVAC per wireless carrier

Floor Loading

- 125 PSF for BTS equipment



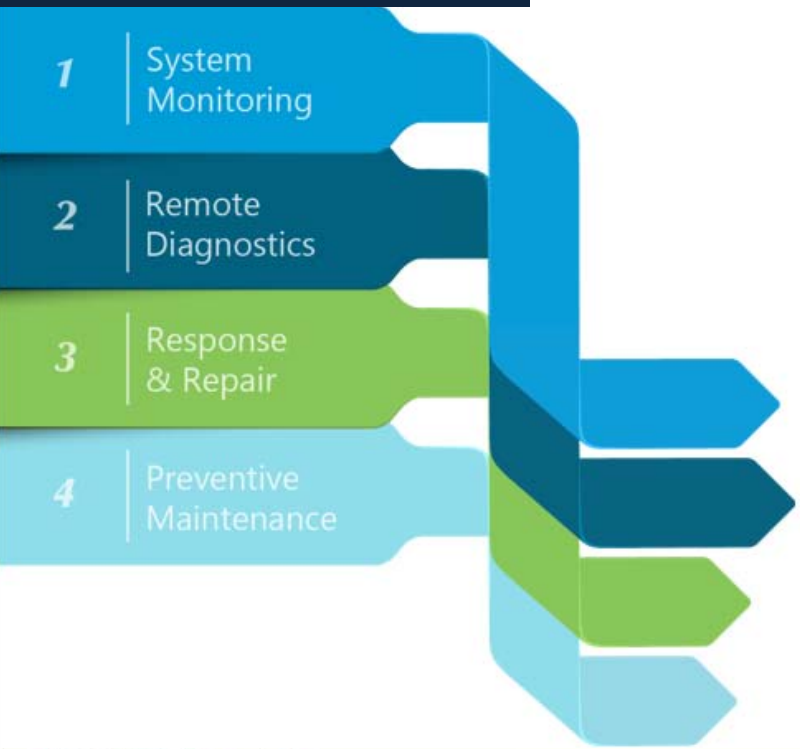
Head End Room: A&E Drav



Head End Room: Photos

Head End Room: Carrier Equipment

Monitoring and Mainter



ConnectProtect

Complex systems require maintenance and preventative checkups to ensure longevity and optimal functionality.

Carriers & Case Studies

2018 BICSI WINTER
CONFERENCE& EXHIBITION
Orlando, FL | February 4-8

BICSI

Ownership Mode

Carrier

100% FUNDED AND OPERATED BY
Carrier

Typically single carrier

Carriers may form consortium

Neutral-host model seldom materializes

Neutral Host

100% FUNDED AND OPERATED BY
Independent third party
(i.e., tower company)

Owner leases space back to the carriers

Neutral-host

Carrier participation is affected by cost model

Enterprise

OWNED AND CONTROLLED BY
Enterprise

Deployed and operated by DAS integrator

Enterprise can operate as neutral host provider

Multi-carrier funding available

Ownership Mode

Carrier

PROS

Free is good

No maintenance or operational issues

Coverage-issue solved for those with that specific carrier

CONS

Very challenging for other carriers to join the system

Pricing barriers

Technical barriers

Neutral Host

PROS

Free is good

No maintenance or operational issues

Neutral means that any/ all carriers can join system

Possible revenue share

CONS

'Anchor carrier' model puts unfair burden on 1st carrier to join- delays process of implementation

Heavy fee/ finance/ mark-up on top of the system costs can make deal unattractive to carriers

Customer cannot touch system- unable to control upgrades/ enhancements/ related fiber infrastructure

Enterprise

PROS

Neutral system that any/ all carriers can join

Customer owns and control technology and infrastructure, in same way they do with structured cabling, network equipment, security, A-V, etc.

Leverage of system and infrastructure (fiber) for Wi-Fi

When structured correctly- system can be funded by carriers

CONS

Potential gaps between cost of system and funding by carriers

Carrier Coordinat

FCC released a new order for use of Enterprise DAS amplifiers:

FEBRUARY 20TH, 2013, FCC REPORT AND ORDER 13-21

Maintains that signal boosters require an FCC license or express licensee consent to install in commercial and industrial space.

The authorization process ensures that devices are operated only by licensees or with licensee consent and are adequately labeled to avoid misuse by consumers.

Wireless carrier coordination is **critical** to the success of any DAS project

CarrierConnect™

Wireless Carrier Coordination Methodology

PHASE 1

INITIATION

- Ecosystem Summary
- Carrier Engagement
- Carrier Registration
- RF Source Qualifying

PHASE 2

FUNDING

- Business Case Development
- Carrier Financial Analysis
- Funding Decision

PHASE 3

DESIGN

- Design Review
- Design Acceptance
- RF Source Specification

PHASE 4

REGULATORY

- Submittals
- Review
- Acceptance

PHASE 5

AUTHORIZATION

- Agreement Development
- Agreement review
- Agreement Execution

PHASE 6

Integration

- RF Source Installation
- RF Source Commissioning
- RF Source testing

Case Study

CHURCHILL DOWNS

CUSTOMER CHALLENGE:

- Historic venue called for sensitive design and installation
- Sheer size and density of the coverage required to meet the needs of the facility
- Tight project timeline to optimize prior to Kentucky Derby weekend

CONNECTIVITY'S SOLUTION:

- Installed a 51-sector DAS to provide extensive coverage throughout the facility, including infield, suites, luxury suites, six main floors and two sublevels
- Designed using Corning equipment, 271 antennas and more than 1 million ft of fiber

RESULT:

- Supported the record-breaking data demand at a single event of 5 terabytes to sere combined Derby and Oaks attendance of 290,000 people
- Second largest system in the nation by sector count; covers 4.68 million
- Installation and Optimization efforts were met on time for the 2015 race while maintaining excellent signal throughout the venue
- AT&T and Verizon 4G and LTE coverage

Case Study

KINNICK STADIUM

University of Iowa

CUSTOMER CHALLENGE:

- Historic Kinnick Stadium of the University of Iowa was challenged to provide reliable wireless and data throughput speeds to fans during events.
- Strict aesthetic requirements coupled with the need for ubiquitous, robust coverage to meet the 70,000 maximum capacity requirements for multiple carriers.

CONNECTIVITY'S SOLUTION:

- Designed a 23 zone, neutral-host, 'fiber to the edge' Corning ONE DAS for the university.
- DAS designed for dominance for all wireless carriers, supporting the technology and frequency bands owned in the market today with infrastructure to allow for future upgrades.

RESULT:

- Installed and concealed 180 antennas, 360 remotes, and 58,000 ft. of fiber/composite cable. Allowing for excellent coverage while adhering to uncompromising aesthetic requirements.
- DAS network provides ubiquitous coverage to fans inside the facility - servicing a total of 700,000 square feet.

Case Stud

HAWKEYE – CARVER ARENA University of Iowa

CUSTOMER CHALLENGE:

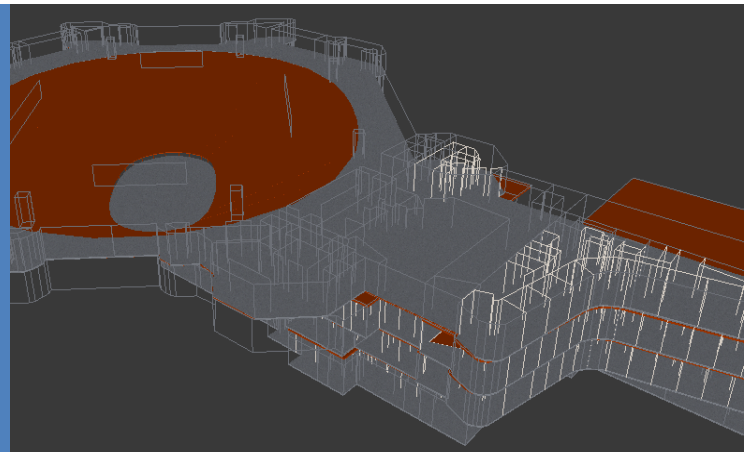
- Historic Carver-Hawkeye Arena of the University of Iowa was challenged to provide reliable wireless and data throughput speeds to fans during events.
- Strict aesthetic requirements coupled with the need for ubiquitous, robust coverage to meet the 16,000 maximum capacity requirements for multiple carriers.

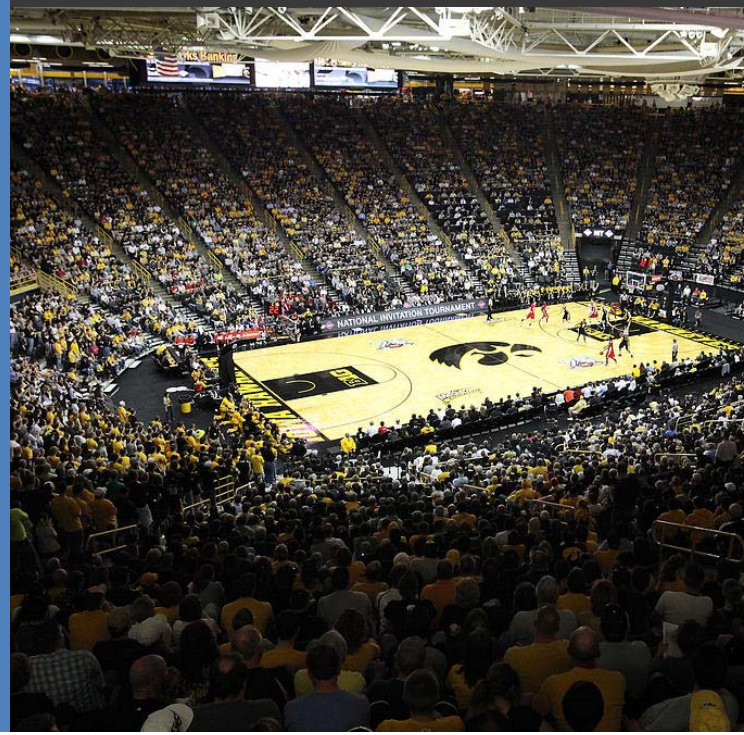
CONNECTIVITY'S SOLUTION:

- Designed a 7 zone, neutral-host, 'fiber to the edge' Corning ONE DAS for the university.
- DAS designed for dominance for all wireless carriers, supporting the technology and frequency bands owned in the market today with infrastructure to allow for future upgrades.

RESULT:

- Installed and concealed 84 antennas, 168 remotes, and 29,000 ft. of fiber/composite cable. Allowing for excellent coverage while adhering to uncompromising aesthetic requirements.
- DAS network provides ubiquitous coverage to fans inside the facility - servicing a total of 500,000 square feet.





Case Study

ONE WORLD TRADE CENTER New York

CUSTOMER CHALLENGE:

- Glass and steel architecture of building prevented cellular service from reaching the core and sub-levels of building; minimal coverage in tenant floors up to 45th floor
- Tenant-Building management contracts required wireless coverage on occupied floors
- Located in one of the most densely populated business districts in the world, causing capacity issues in and around the building
- One World Trade Observatory handling an average of 12,000 visitors per day (more than half a million visitors in the first three opening months)
- One-third of building tenant-occupied upon installation start.
- Security of building required increased administrative work to arrange access for work, deliveries and testing

Case Study

ONE WORLD TRADE CENTER New York

CONNECTIVITY'S SOLUTION:

- More than 200,000 feet of ½' coax and 7,000+ feet of fiber
- 1,250 antennas
- 24x7 construction, installation and commissioning hours to complete two floors per weekend.
  (Total of 24 floors)
- One project manager on site with three construction managers throughout the installation, adding one performance engineer for commissioning and testing
- Verizon 4G and LTE
- Completed in fewer than seven months. UL/DL testing completed in one week; six weeks ahead of schedule

Questions?
- Thank you -

Tyler Boyd

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206-380-0082
mniehus@connectivitywireless.com

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