# DAS Boot Camp
## - Next Generation Wireless Networks -

Mark Niehus, RCDD
Connectivity Wireless Solutions

Tyler Boyd
Connectivity Wireless Solutions

2017 BICSI *Fall*
CONFERENCE & EXHIBITION
SEPTEMBER 24-28 | LAS VEGAS, NV

# 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

- Next Gen Wireless Trends
- Next Gen Wireless Solutions
- Infrastructure Deep Dive
- Carriers and Case Studies

# NextGen Wireless Trends

## The Big Picture

80%
VOICE CAL S

90%
DATA USAG

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**

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## 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

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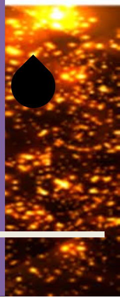
# Emphasis on increased capacity

Bulking up bandwidth and infrastructure



# Internet of Things

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

**24 billion** IoT devices installed by 2020 with

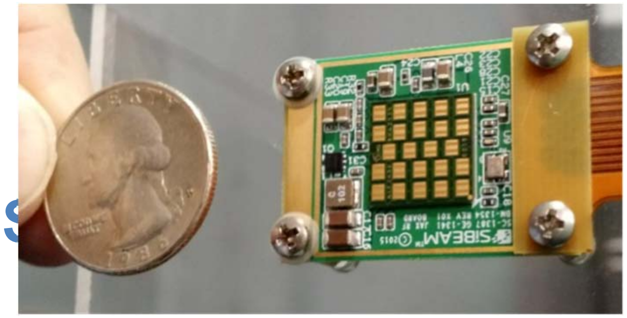
**$6 trillion** invested in IoT solutions over the next 5 years


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)

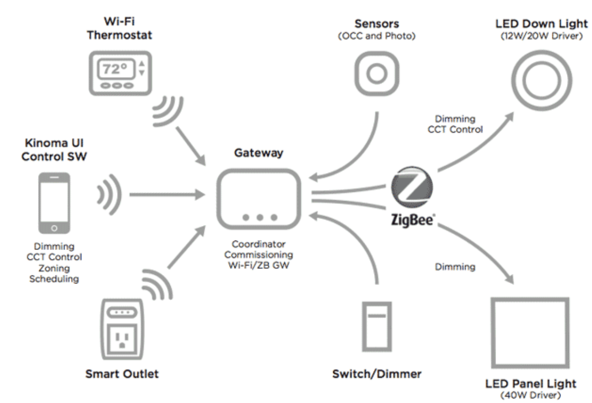


## COVERAGE IN AREAS INSIDE BUILDINGS

## LOW POWER, LOW SPEED, LOW COST

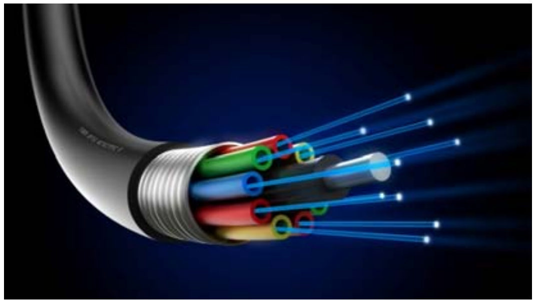
- Bluetooth
- Zigbee
- Zwave
- WiSun
- Near Field Communications (NFC)

ZIGBEE SMART LIGHTING REFERENCE PLATFORM



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 wherever people are: inside and outside of buildings


## SUPERCOMPUTER IN YOUR POCKET (4.7 HOURS PER DAY)

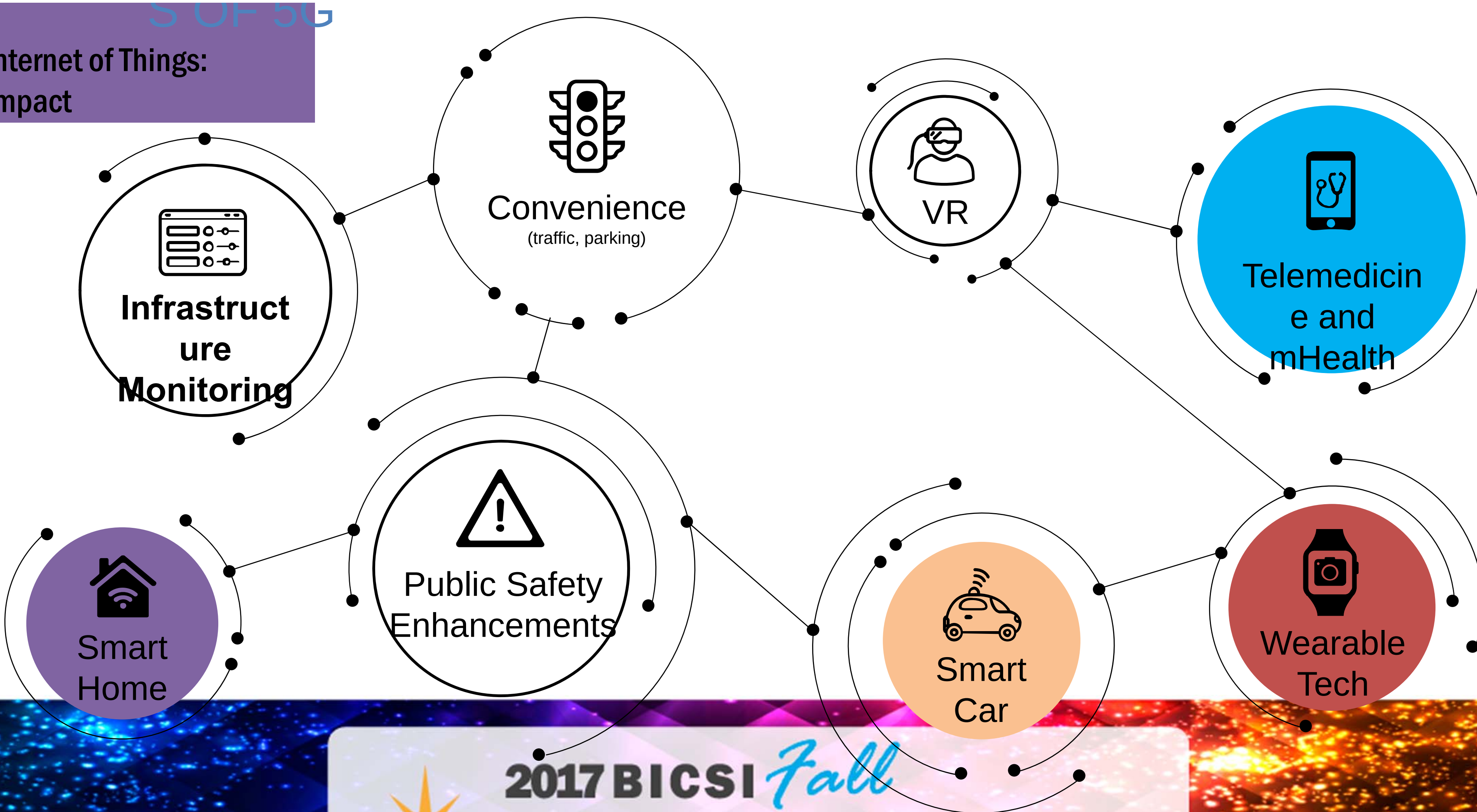
- Real-time language translation
- Augmented virtual reality (Oculus Rift)
- The Tricorder Project

## SELF-DRIVING CARS

## ROBOTS AND OTHER ASSISTANT DEVICES

S OF 5G

# 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?

### 2G
**GSM** – Global System for Mobile Comm

**iDen** – Integrated Digital Enhanced Network

**CDMA** – Code Division Multiple Access

### 2.5G
**GPRS** – General Packet Radio Services

**EDGE** – Enhanced Data Rates for GSM Evolution

### 3G
**UMTS** – Universal Mobile Telecom System

**HSPA+** – High Speed Packet Access

**EvDO** – Evolution Data Optimized

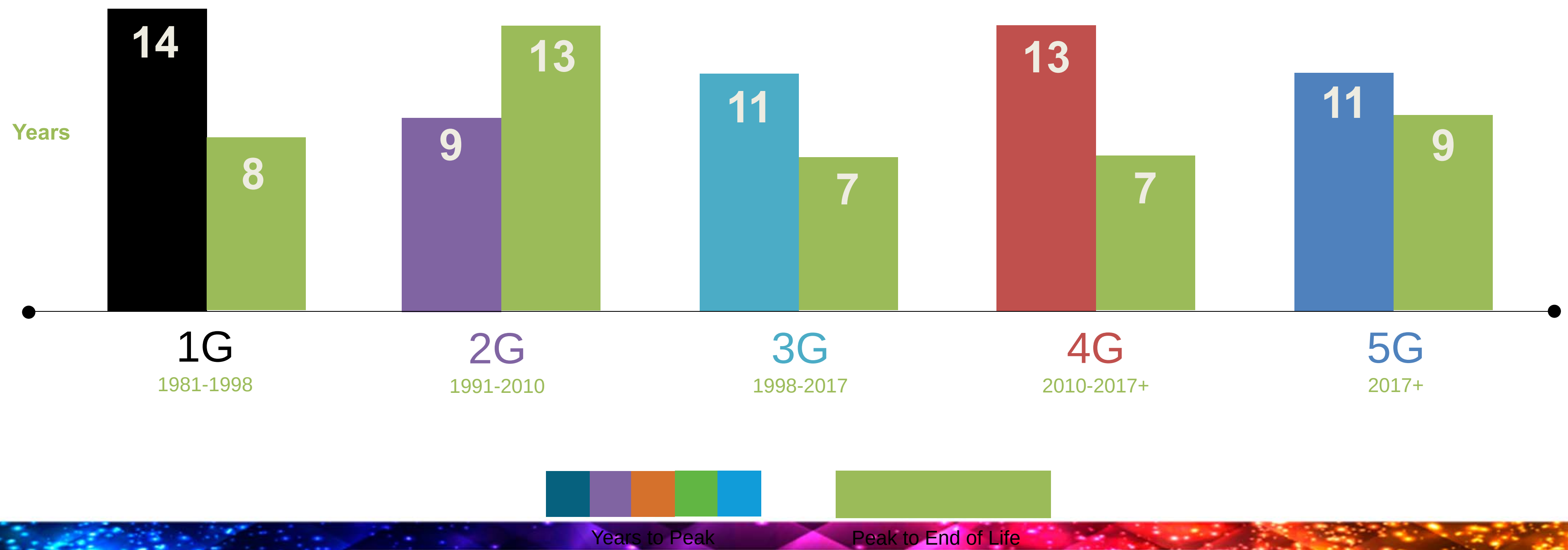
**WCDMA** – Wideband CDMA

### 4G
**eUTRA** – Evolved UMTS Terrestrial Radio Access

**WiMax** – Worldwide Interoperability for Microwave Access

**LTE** – Long Term Evolution

## 5G: A New Standard in Quality

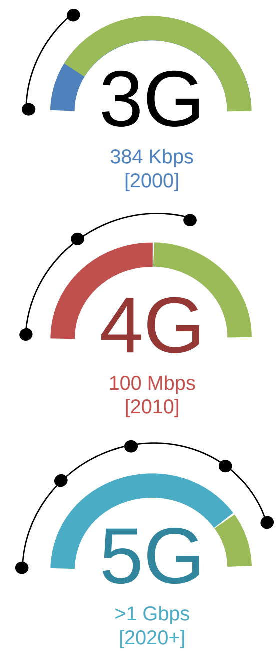


# 5G: A New Standard in Quality

**BRINGS MORE SPEED**
**(10 times faster)**

**CONNECTS MORE DEVICES**
**(100 times more)**

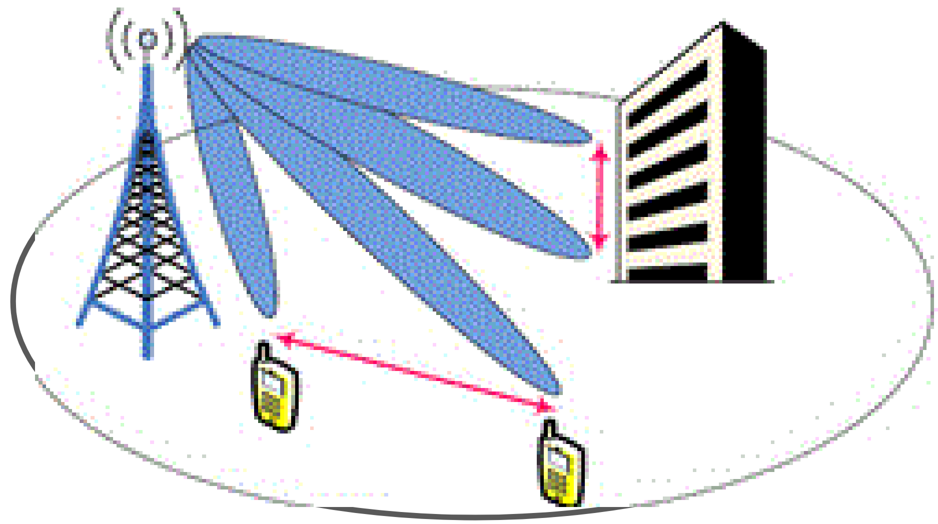
**ALLOWS FOR A MORE RESPONSIVE NETWORK**
**(5 times reduced end to end network latency)**



## 5G: What are the characteristics?

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

## **Beamforming,** or spatial filtering



# Used to improve gain over omnidirectional

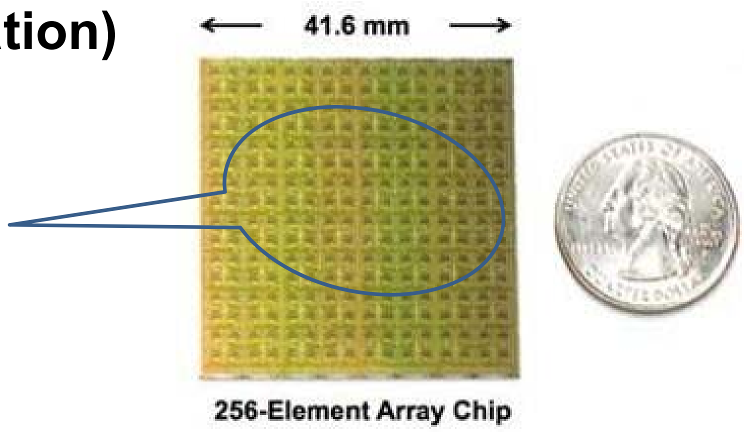
- Technique used for directional signal transmission
- Combination of elements in a phased array in such a way that signals at particular angles experience constructive interference and others experience destructive interference

# Massive Mimo

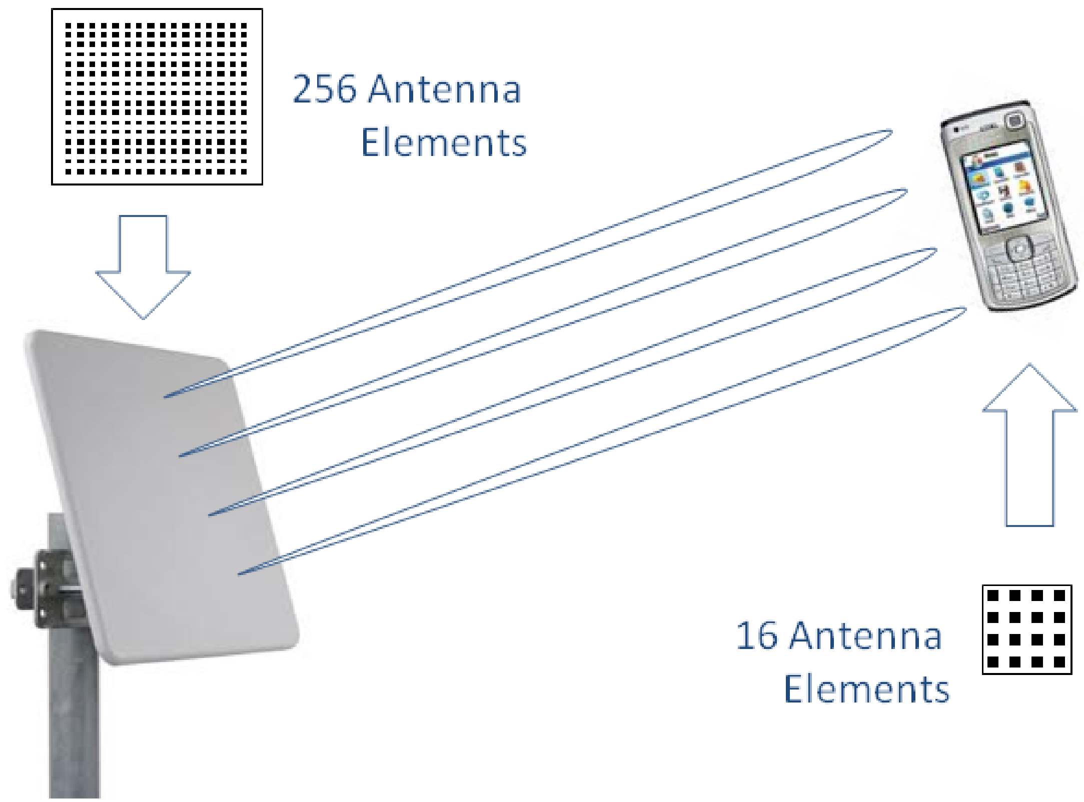
MORE ANTENNAS
**(up to hundreds of antennas at base station)**

SAMSUNG TEST PHONE WITH 32 LOW-PROFILE ANTENNA ELEMENTS

POSSIBLY 5X THE SPECTRAL EFFICIENCY

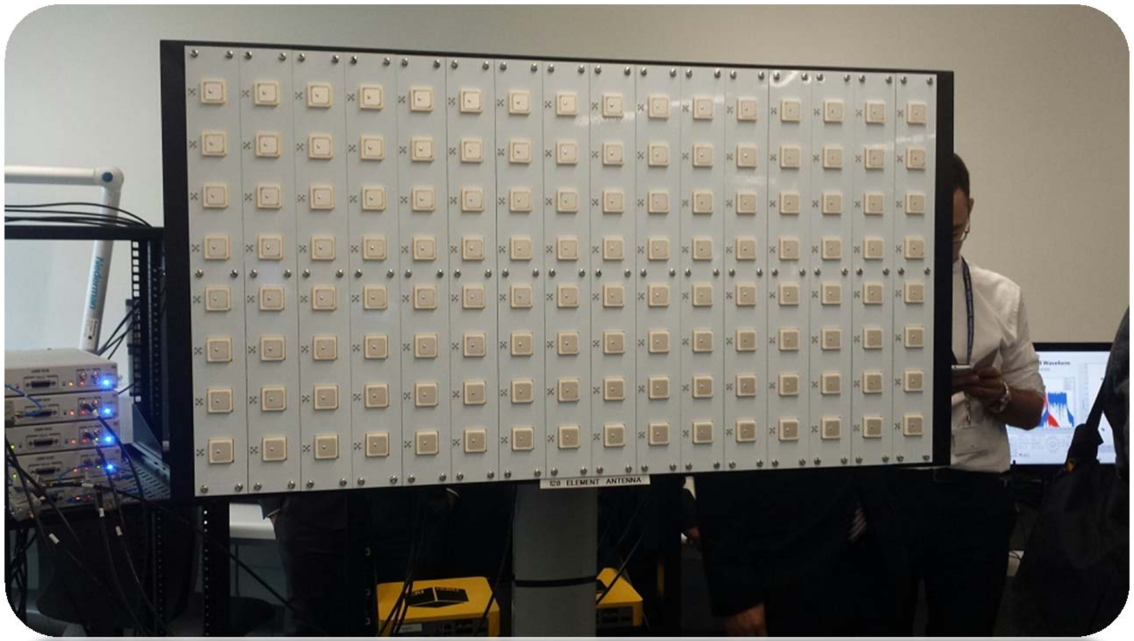


# Massive Mimo



Massive Mimo

# The architects are going to hate this…



## 5G: What Are Carries Doing?

RESEARCHING 5G

IMPROVING INFRASTRUCTU
**(carrier aggregation, VoLTE,**

EXPANDING INFRASTRUCTU
**(DAS, small cell)**

## Small Cells

48% CAGR

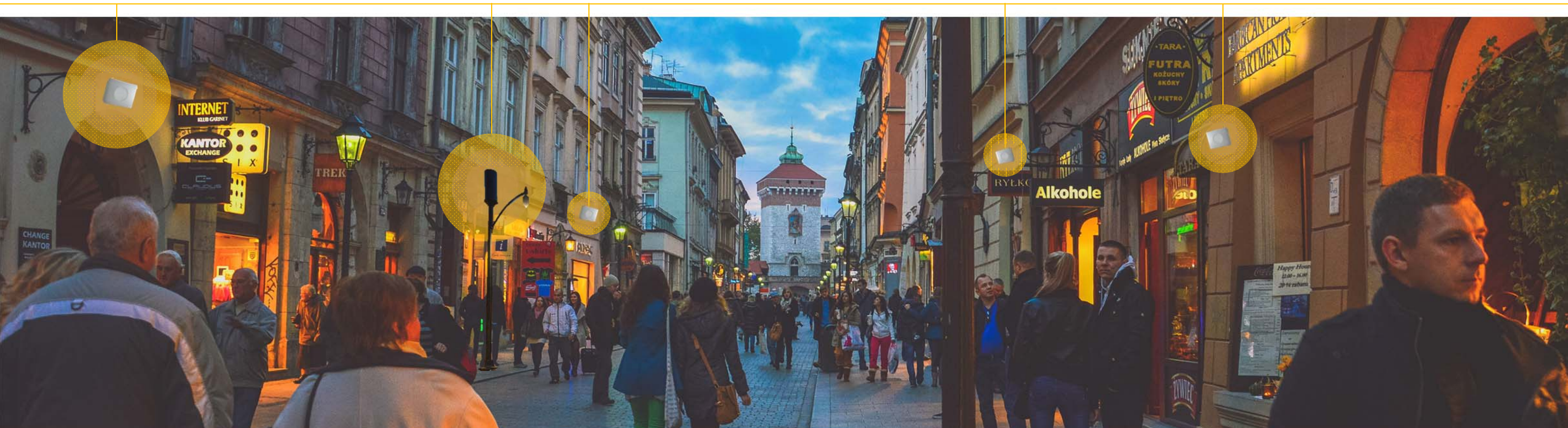
Through 2019

**$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

**CHALLENGES**

- Neighbor-width population
- Single-carrier solution

Virtual Reality

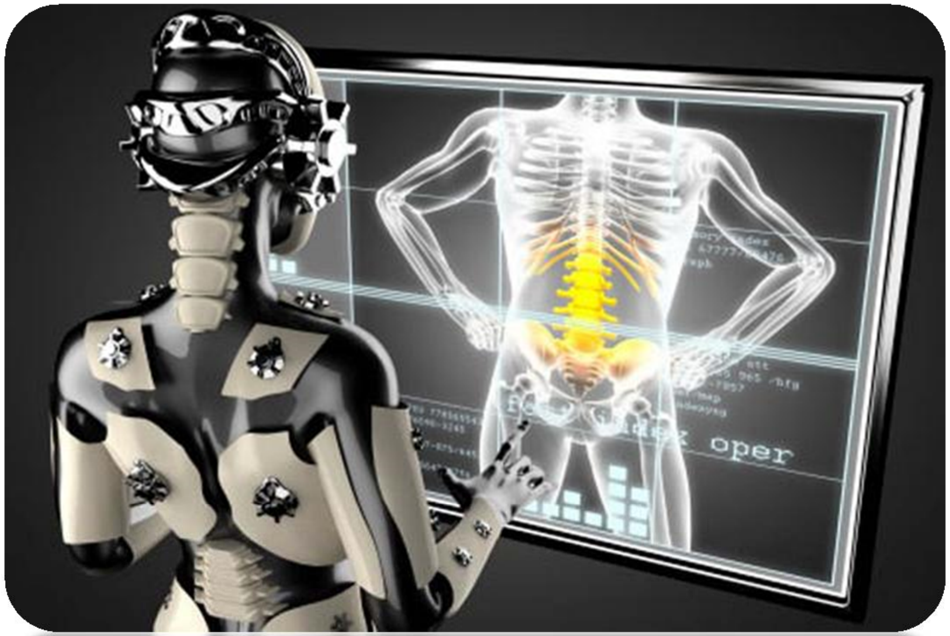
# Changes the way we

WOR
K
PLA
Y
INTERA
CT

## Virtual Reality: The Impact

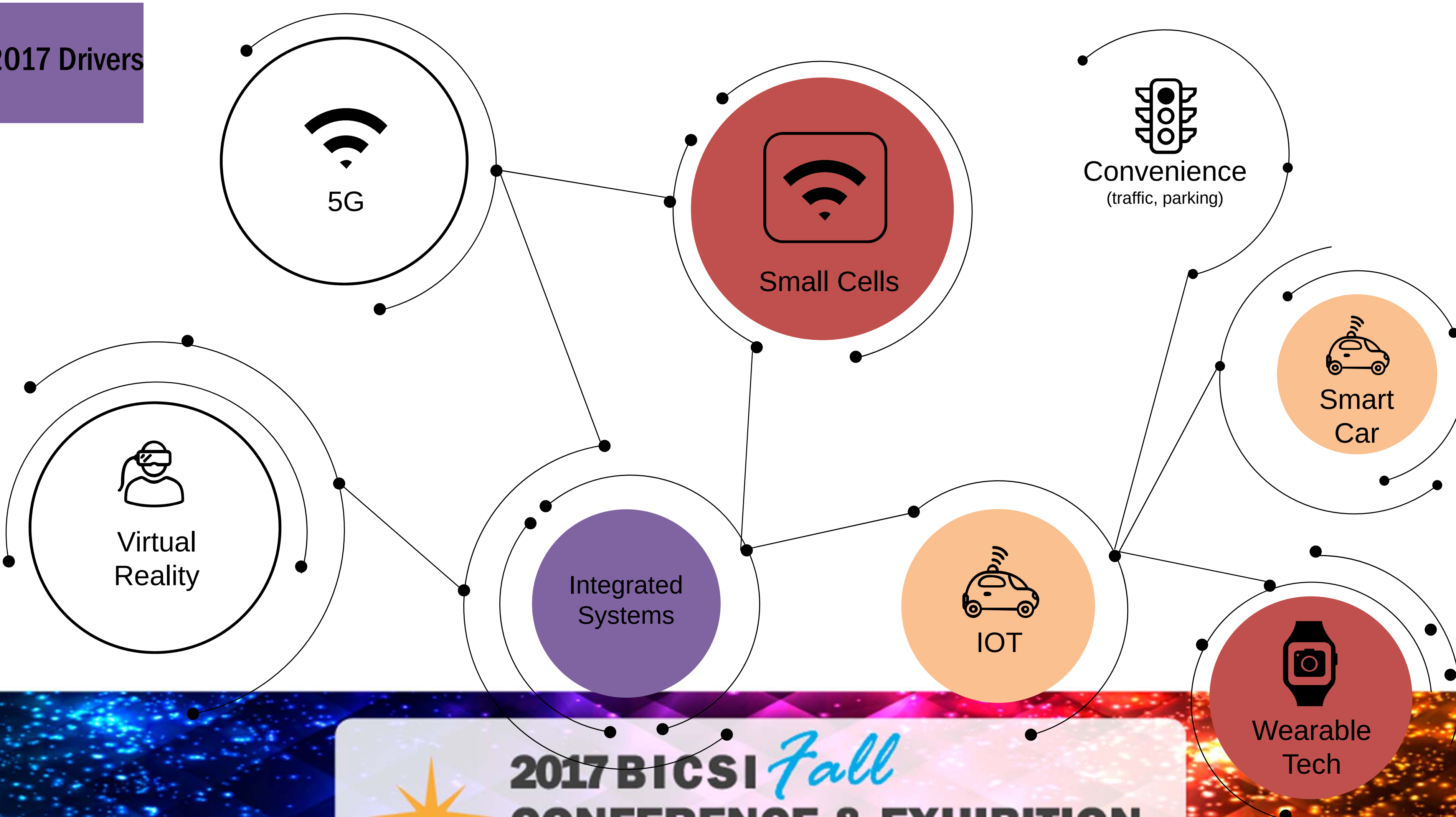
- SOCIALIZED ONLINE WORK / TEACHING ENVIRONMENTS
- VIRTUALDATING
- CULTURAL IMERSION EXPERIENCES /TRAVEL
- TRAINING SIMULATIONS

# Waaaay out there…the tactile internet



# The Tactile Internet

# 2017 Drivers



# The Problem

less about
COVERAGE

more about
CAPACITY

# One Simple Solution

DAS

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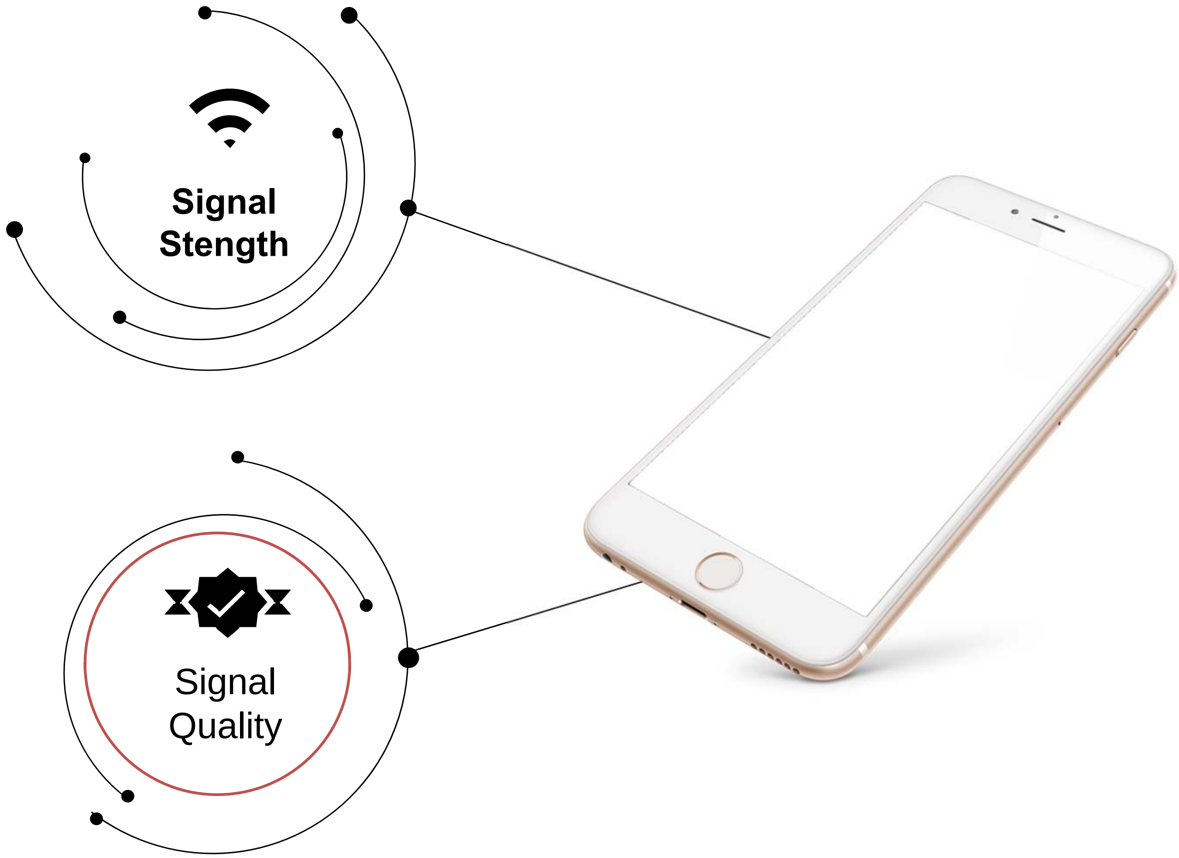
# NextGen Wireless Solutions

# So, why doesn't my phone work?



# Signal Strength and Quality

Signal Stength

Signal Quality

IMPACTED BY

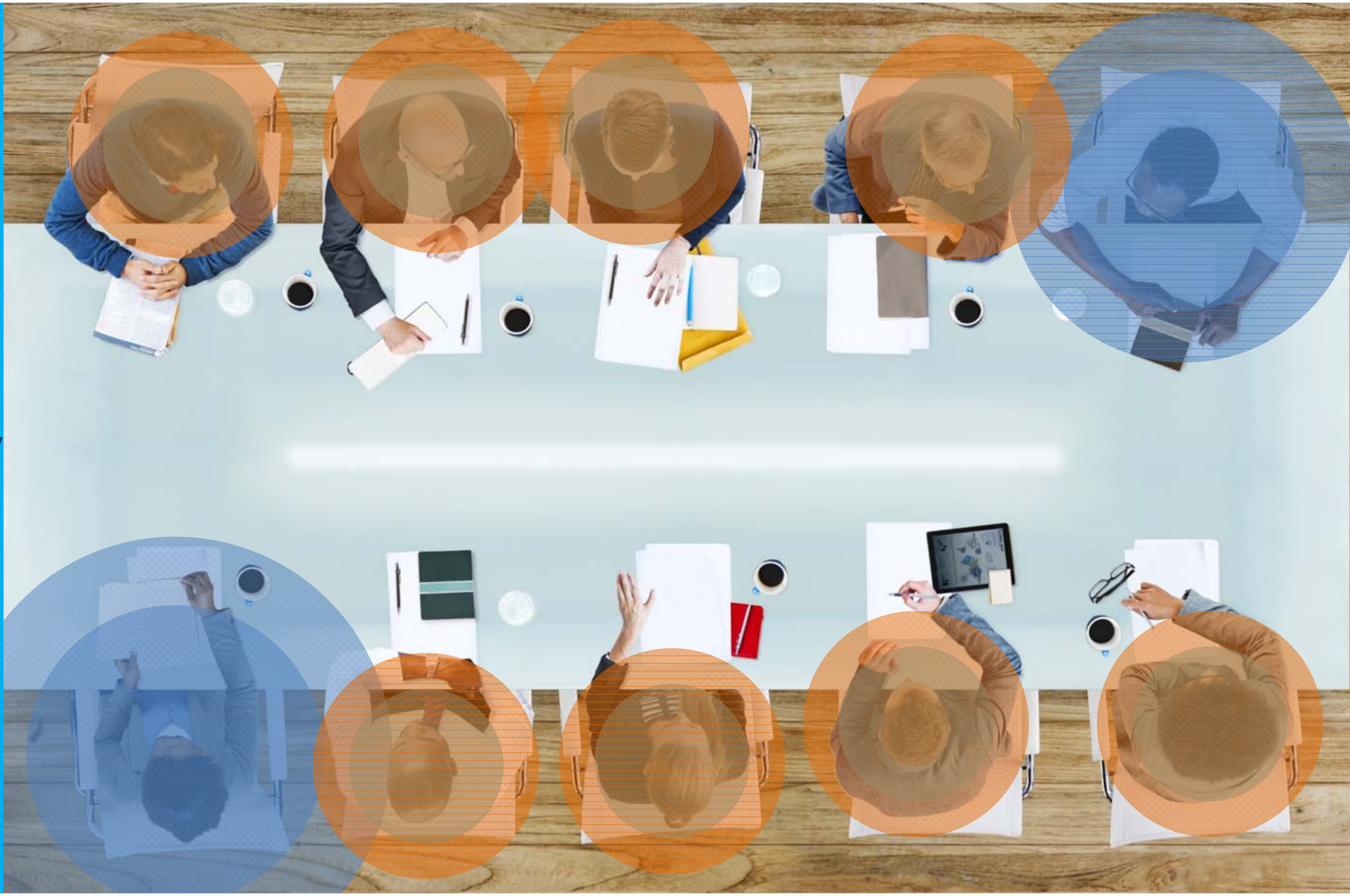
**Noisy Environment**


**Capacity Limitations**

Signal
Quality
Noise

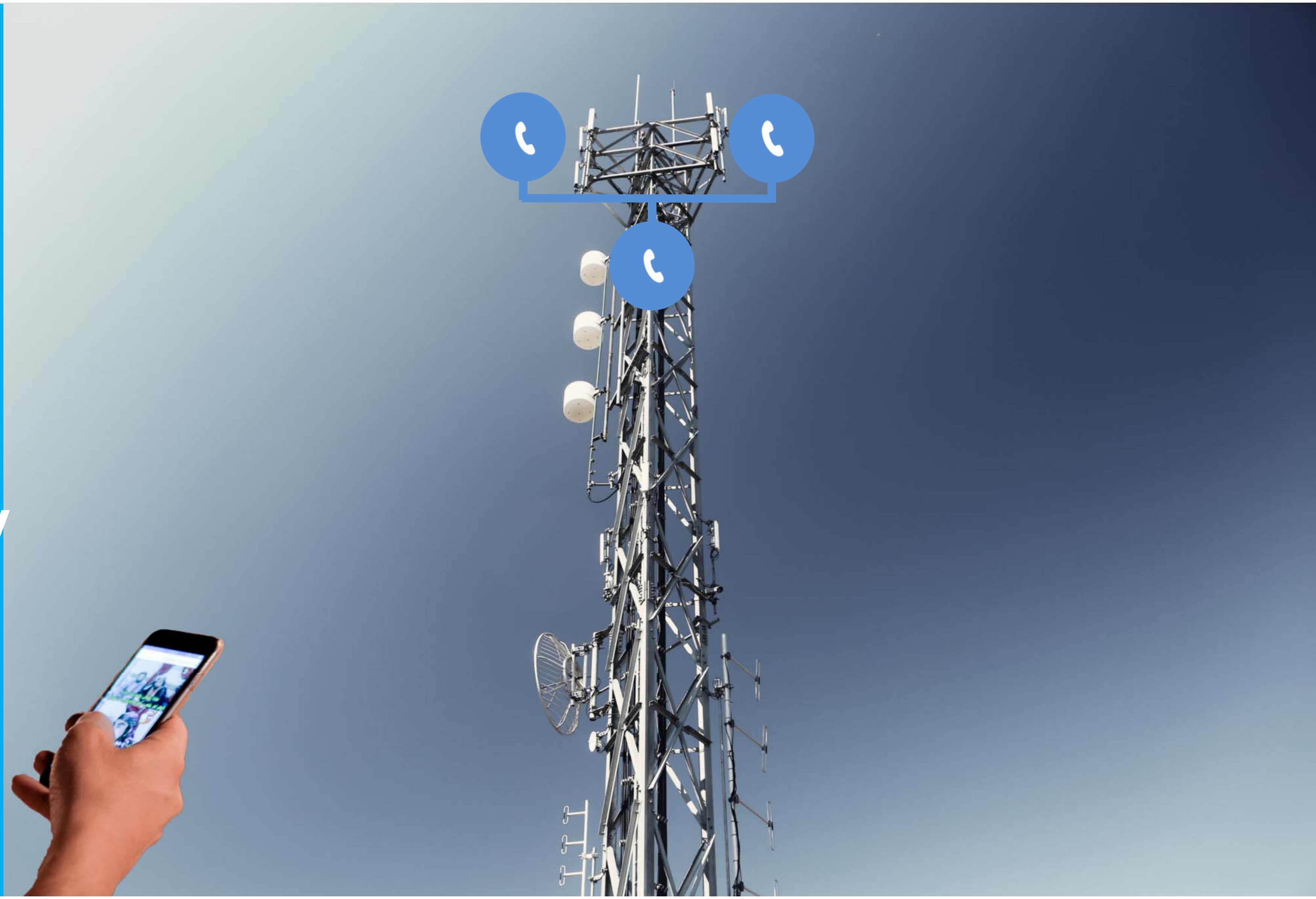
Signal
Quality
Noise

Signal
Quality
Noise



Signal
Quality
Noise

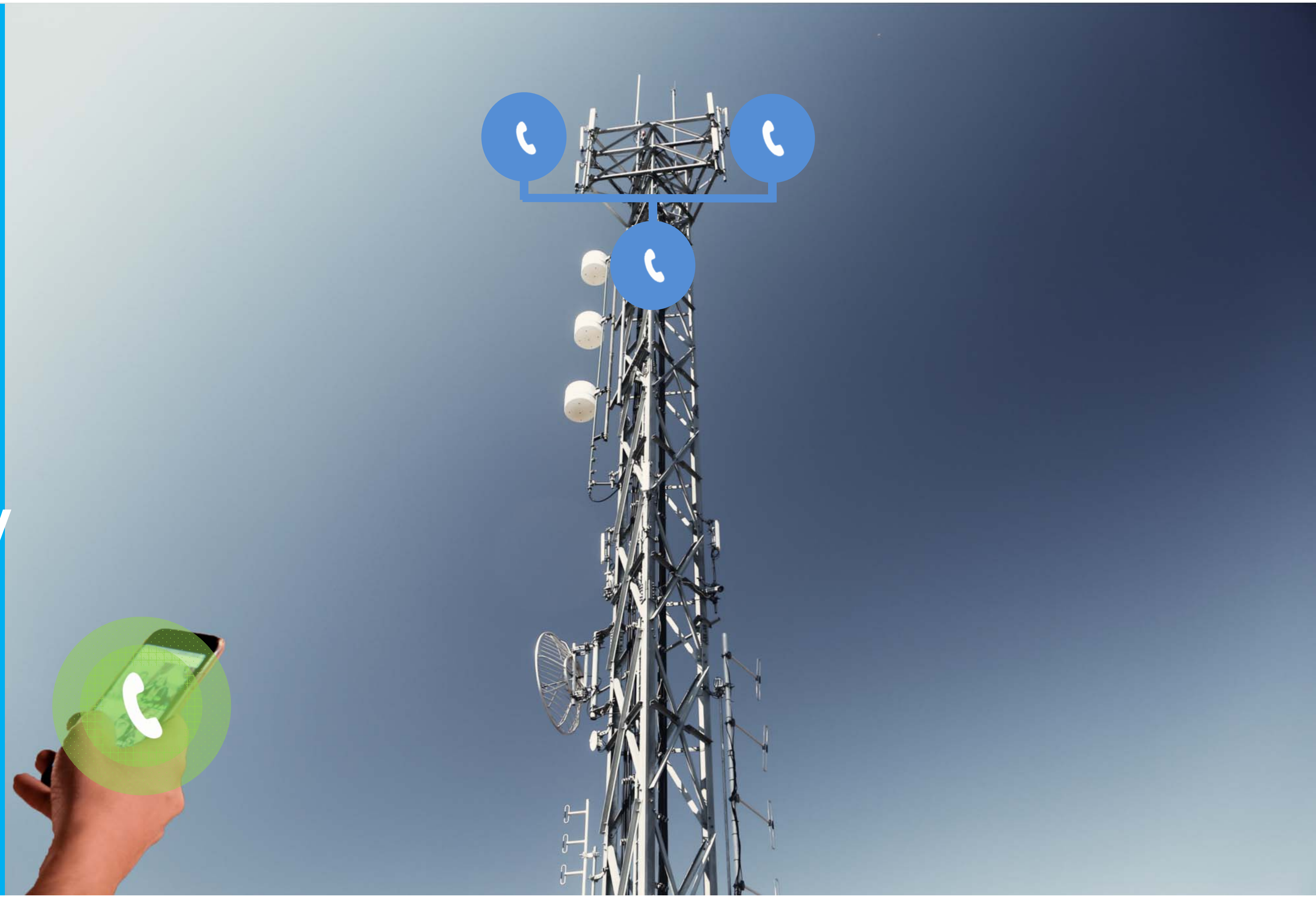
**Signal**
**Quality**
**Capacity**



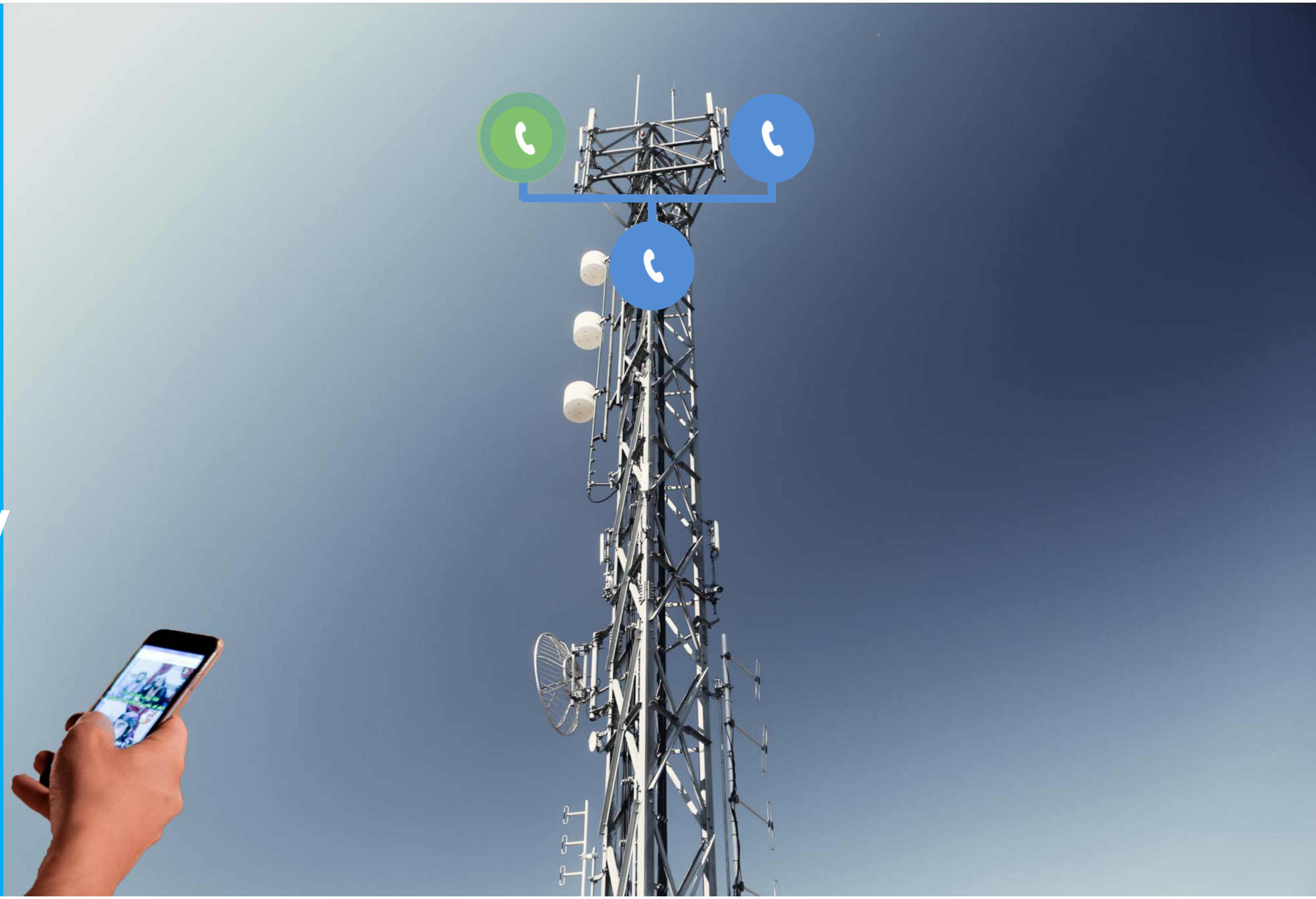
Signal

Quality

Capacity



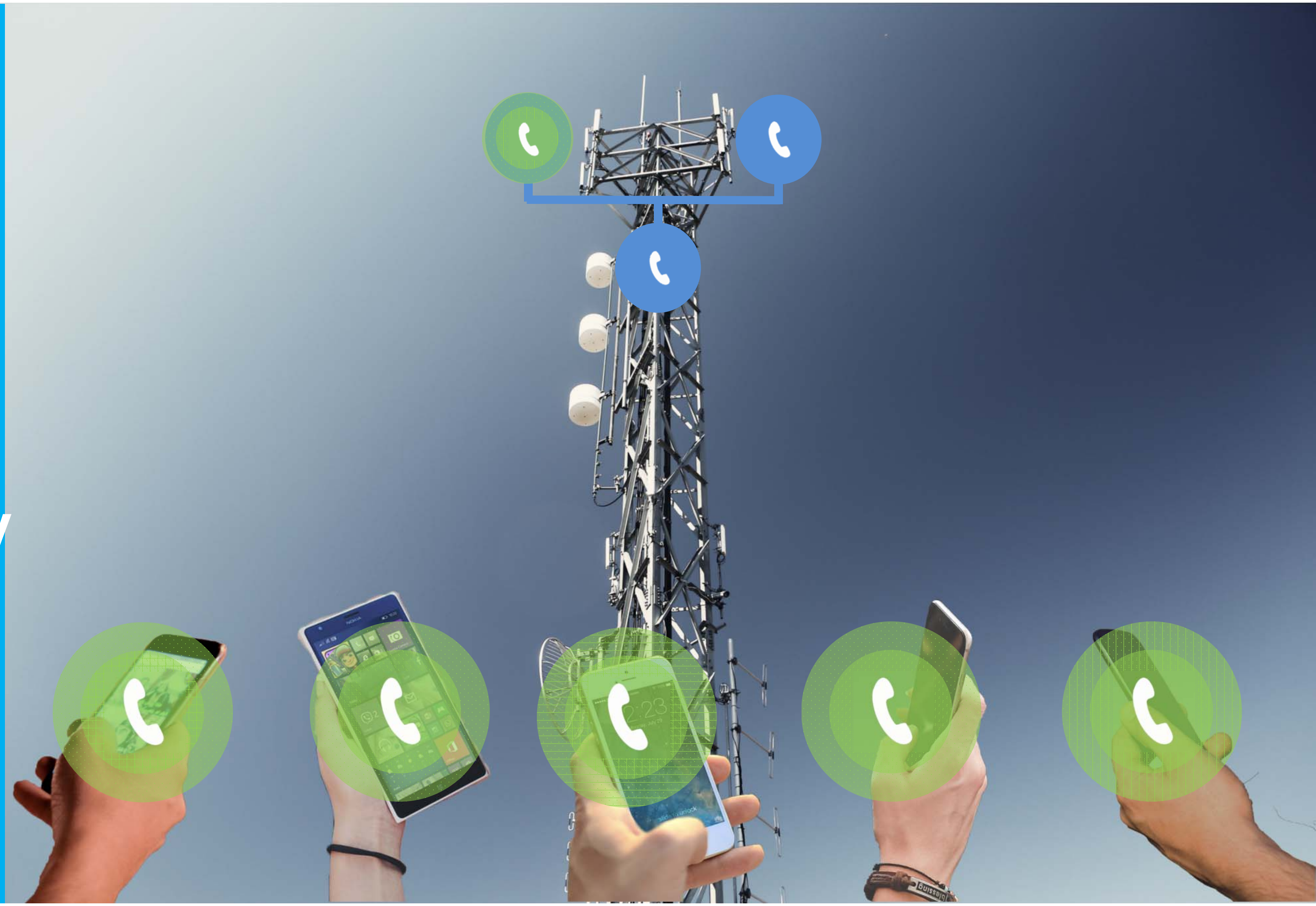
**Signal**
**Quality**
**Capacity**



Signal

Quality

Capacity



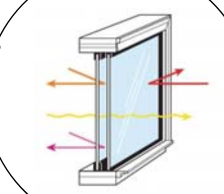
Signal

Quality

Capacity

# 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

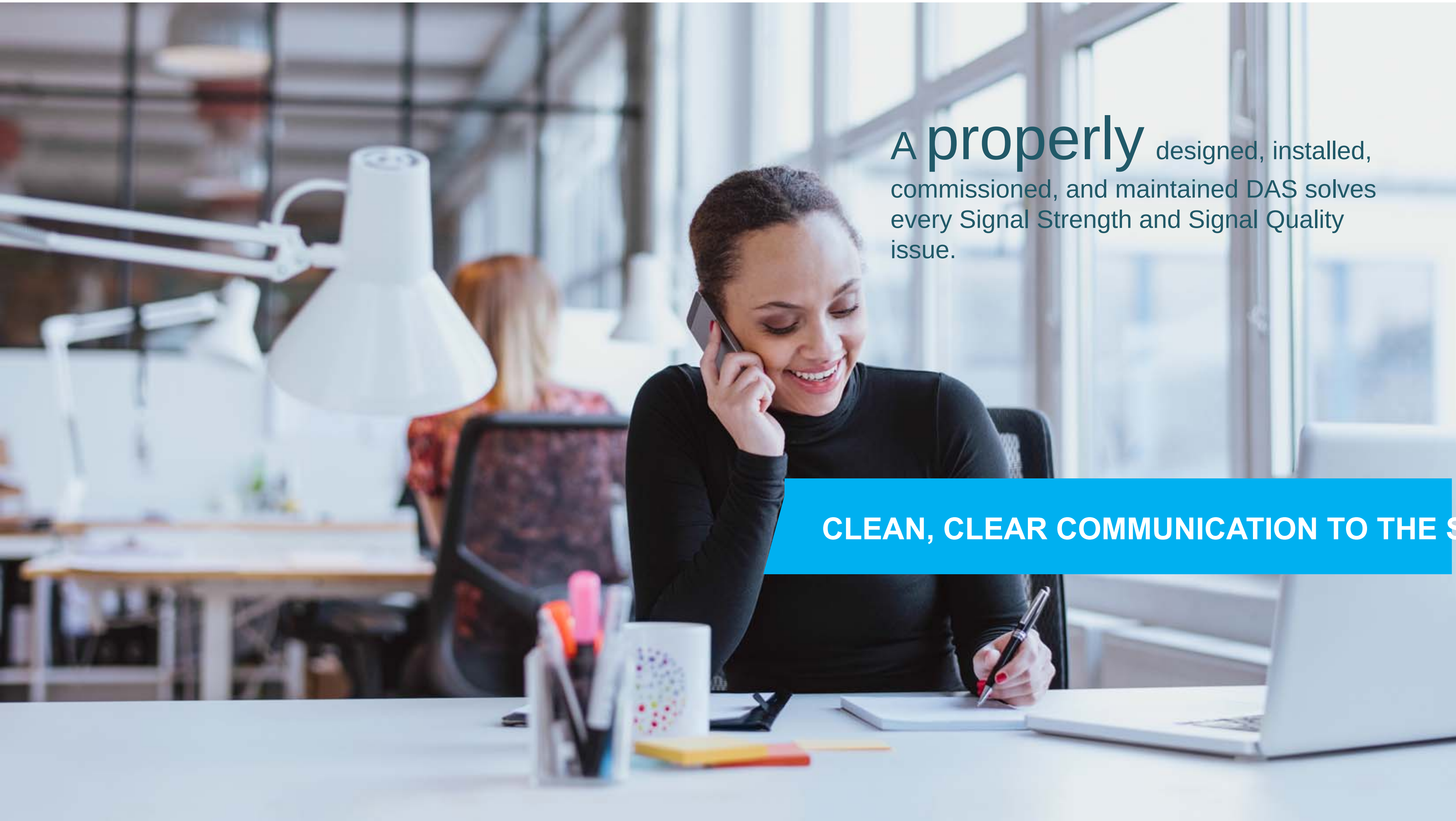
TOO MANY NEARBY MACRO TOWERS WITHOUT A DOMINANT SIGNAL

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

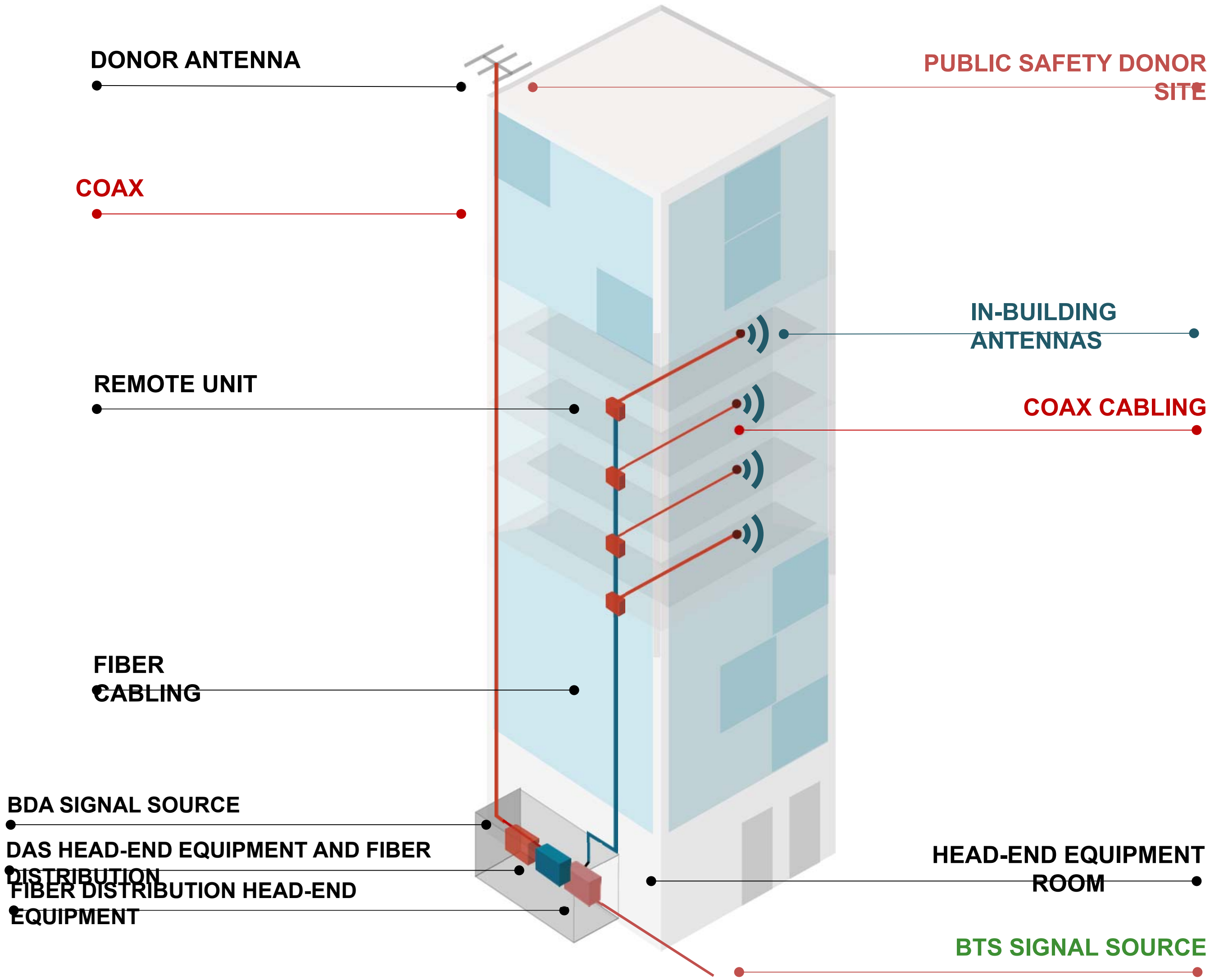


A properly designed, installed, commissioned, and maintained DAS solves every Signal Strength and Signal Quality issue.

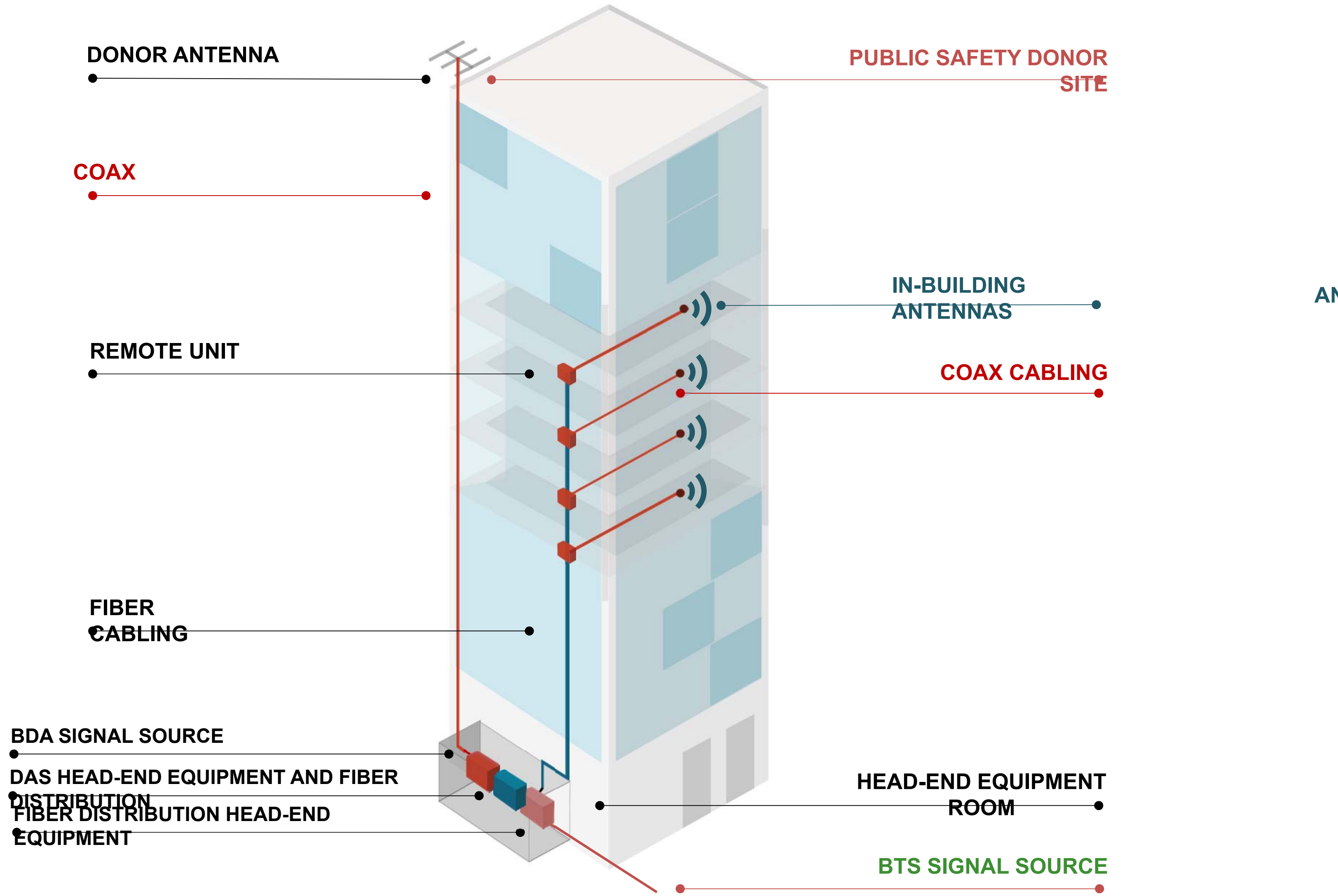
**CLEAN, CLEAR COMMUNICATION TO THE**

# Infrastructure Deep Dive

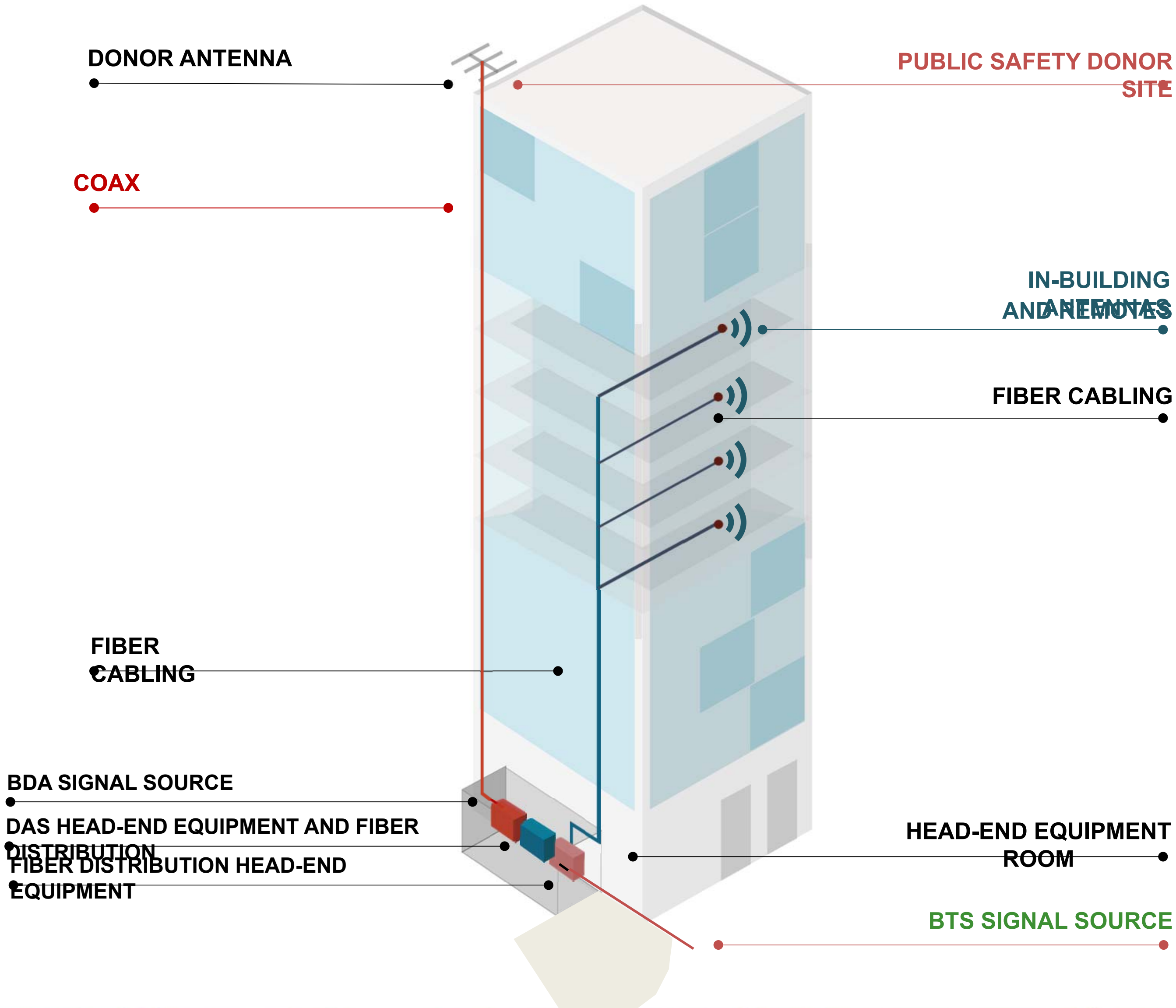
# DAS Architecture Overview



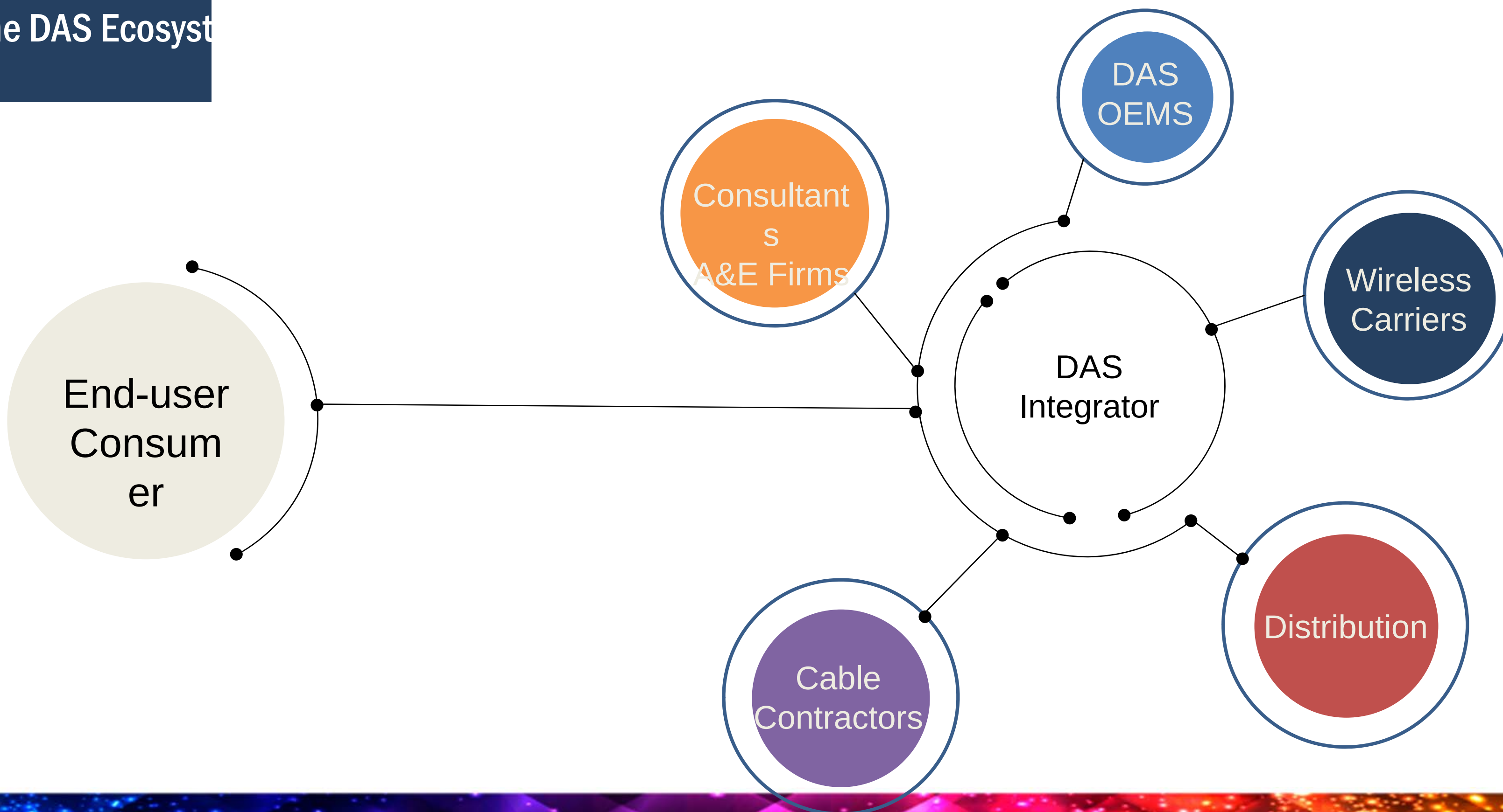
# Traditional DAS Architectu



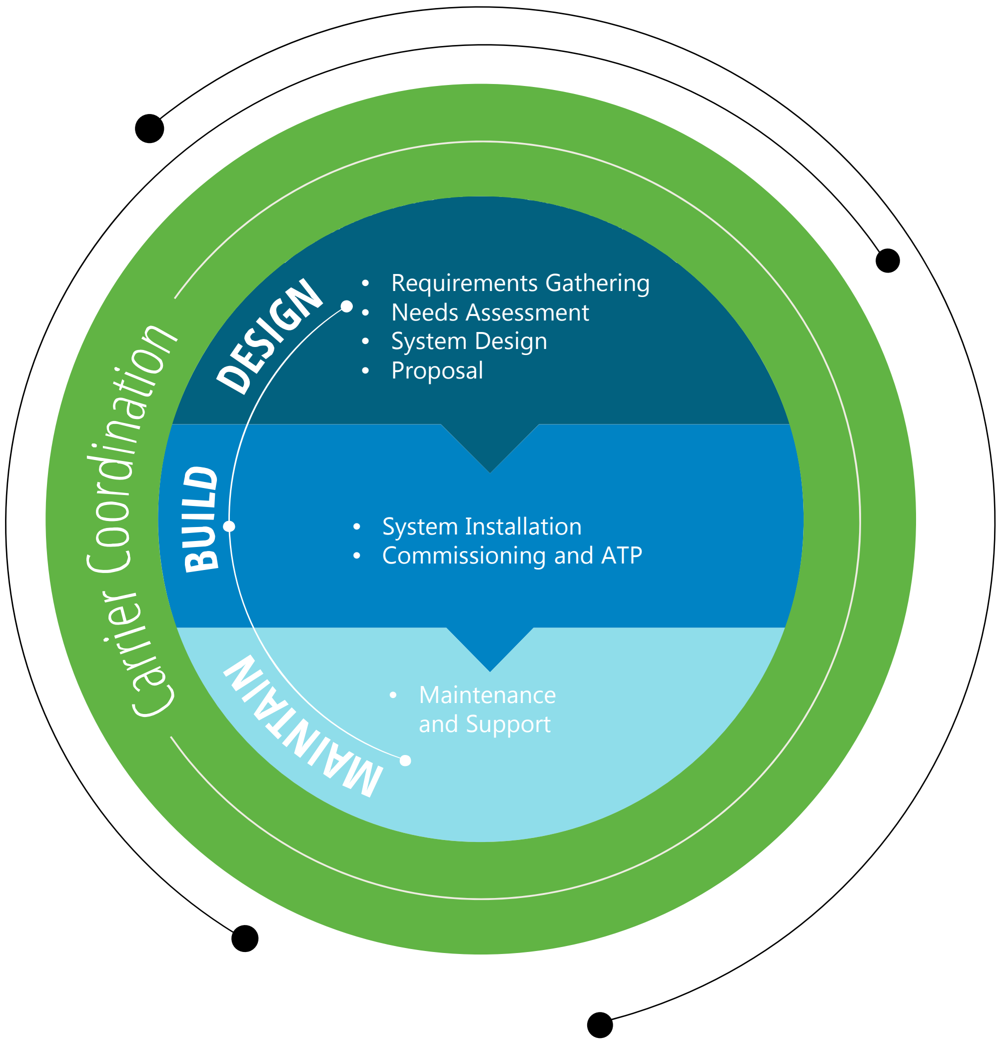
# Fiber to the Edge Architectu



# Players in the DAS Ecosyst



# DAS Lifecycle



Benchmark Data Collectio

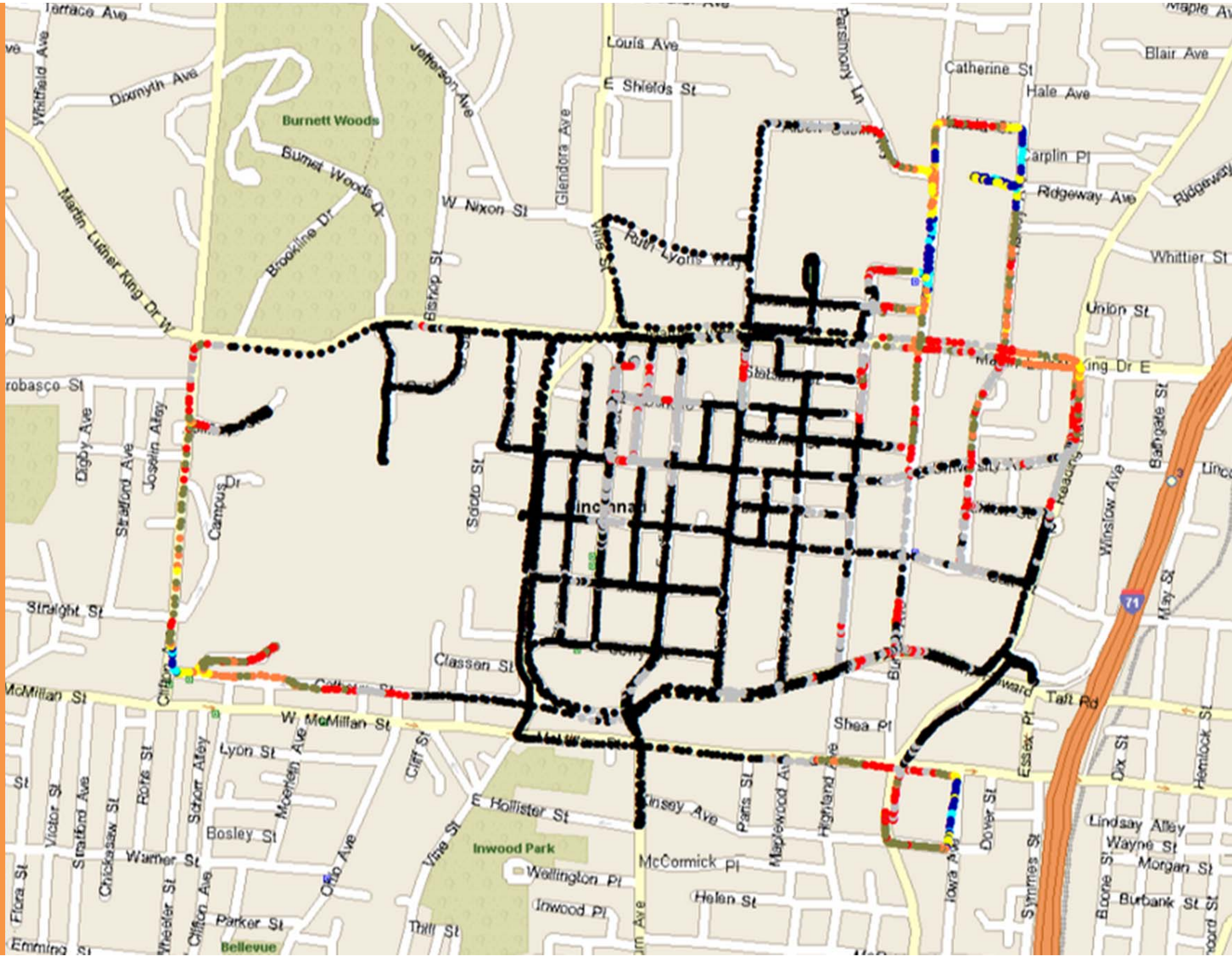
# Collecting and recording carrier data helps with

- CARRIER NEGOTIATIONS
- PROPER DESIGN

# Benchmark Data Collectio

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 Collectio

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

AT&T

| | 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

# Collecting and recording the characteristics of the facility helps with

PROPER DESIGN

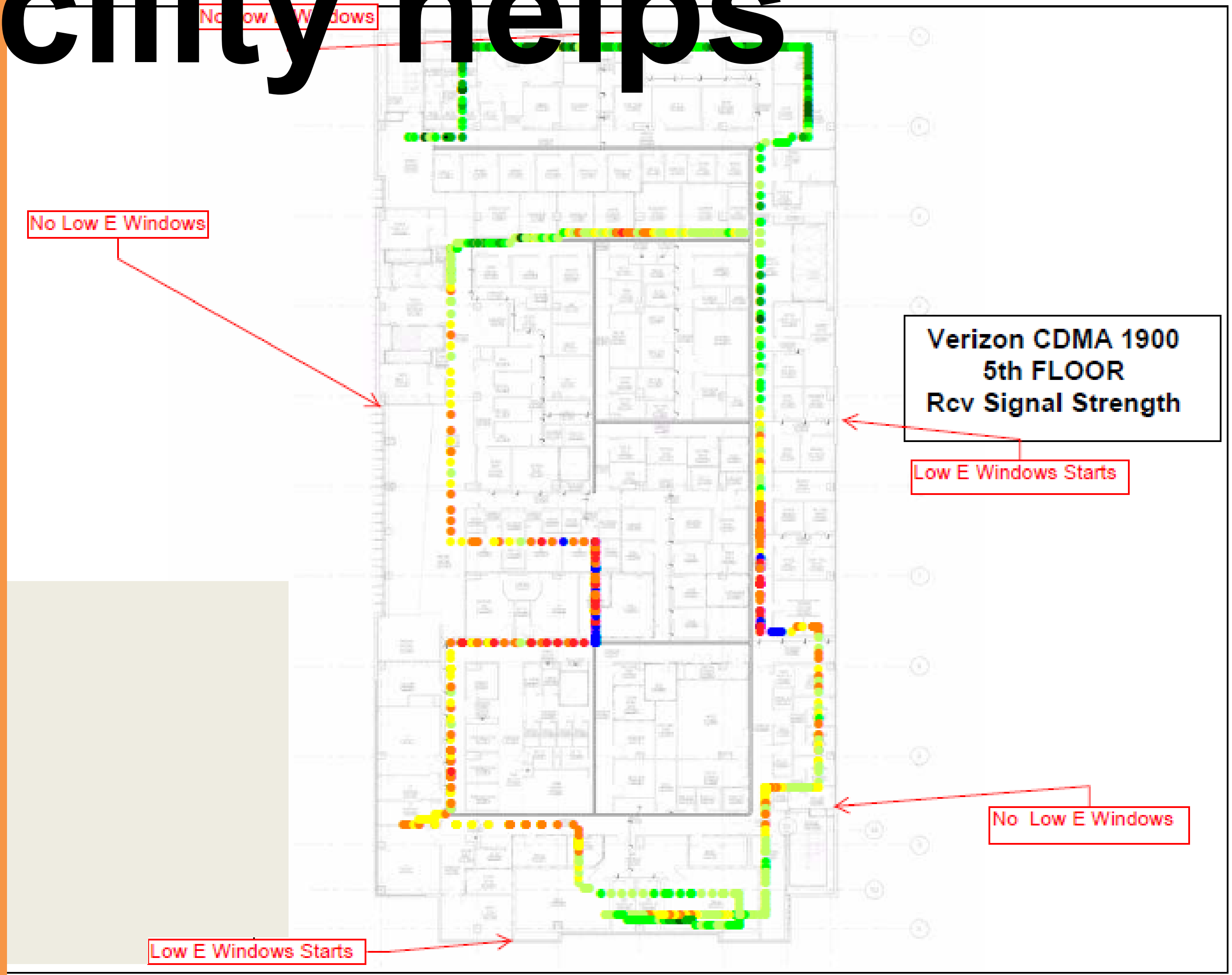
the facility helps with

## Data Collection Example

Blocked (0)
Dropped (0)
No Service (0)

Receive Power (dBm)

- -55 to -60 (36)
- -60 to -65 (83)
- -65 to -70 (139)
- -70 to -75 (179)
- -75 to -80 (147)
- -80 to -85 (127)
- -85 to -95 (40)
- -95 to -105 (22)



Carrier Coordination

# Site Survey

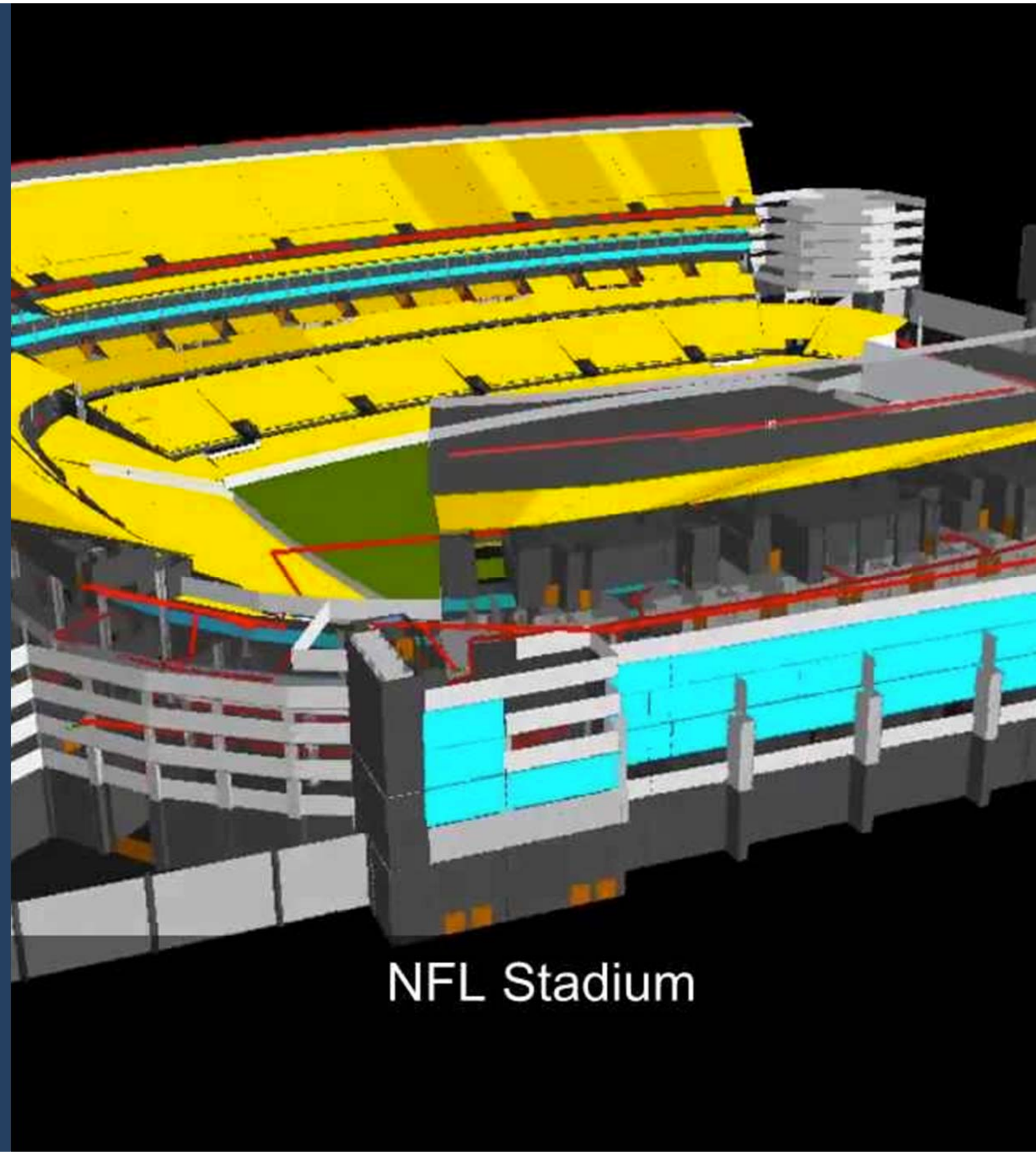
## OBJECTI VE

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 Thresholds

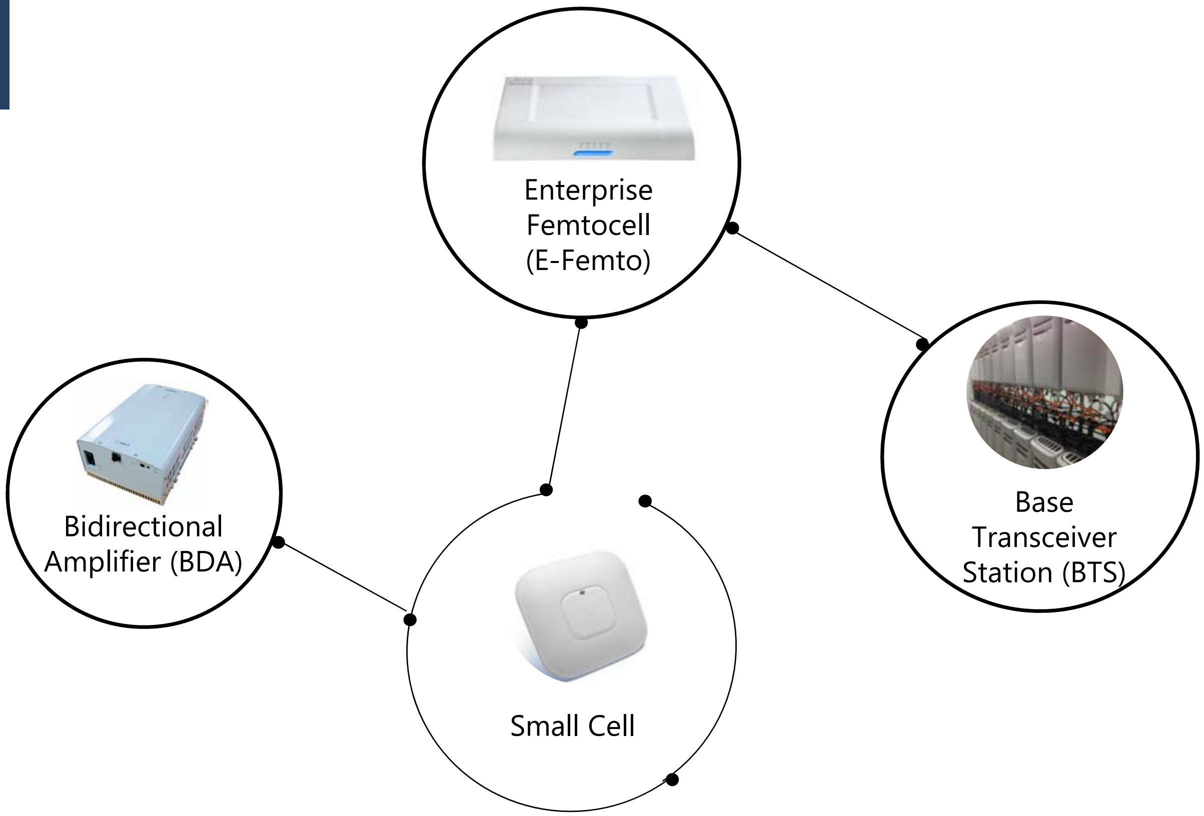
**OLD WORLD**

- 85 dBm mobile RSSI over 90-95% of the area for voice technologies
- 70 dBm for data centric technologies (EVDO, LTE, etc.)

**NEW WORLD**

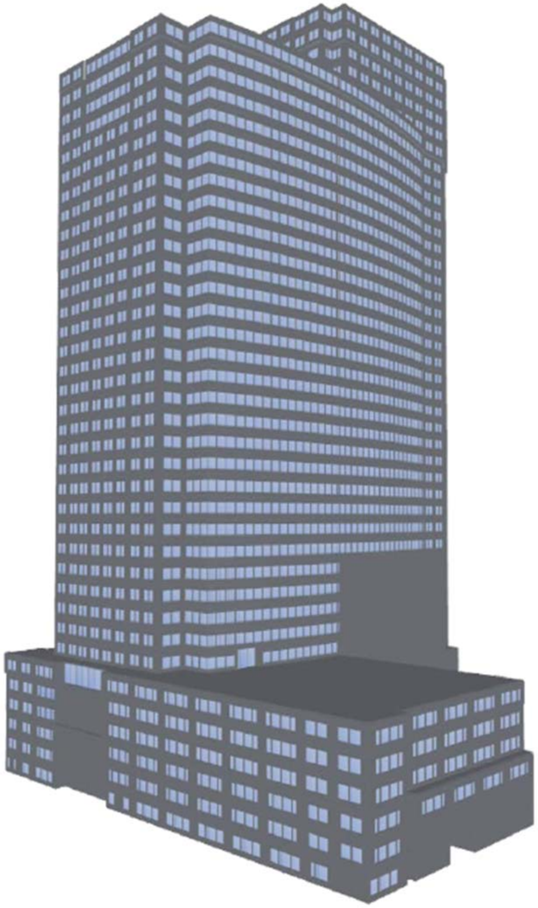
- 6-8 dB stronger than the macro network coverage bleeding into the building

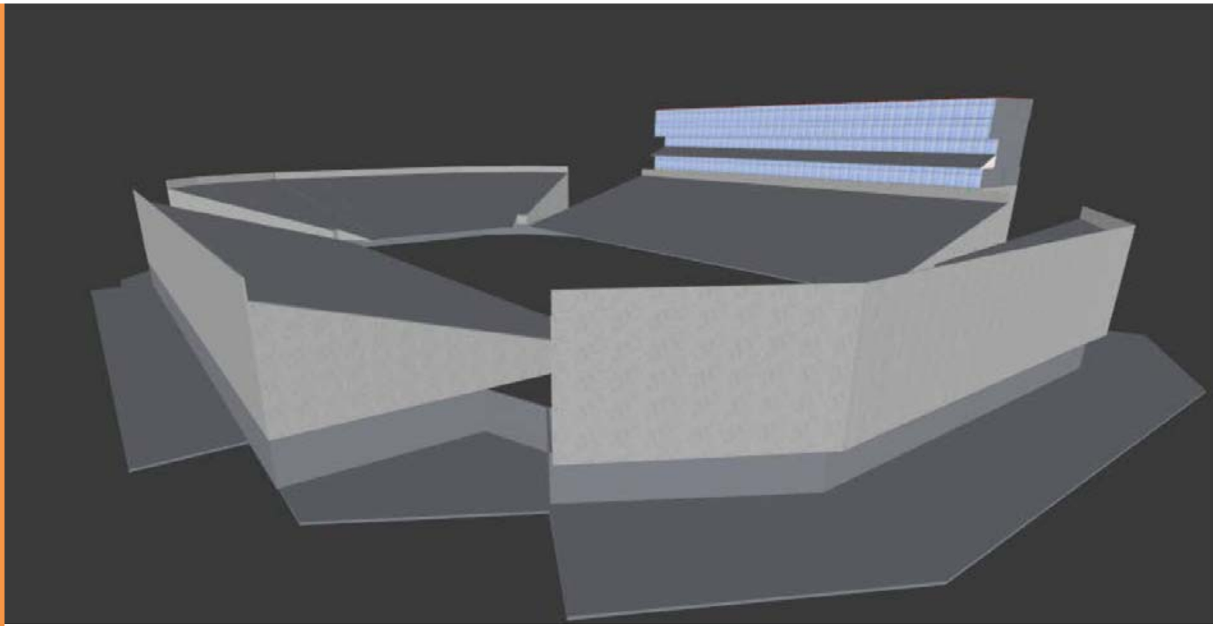
DAS

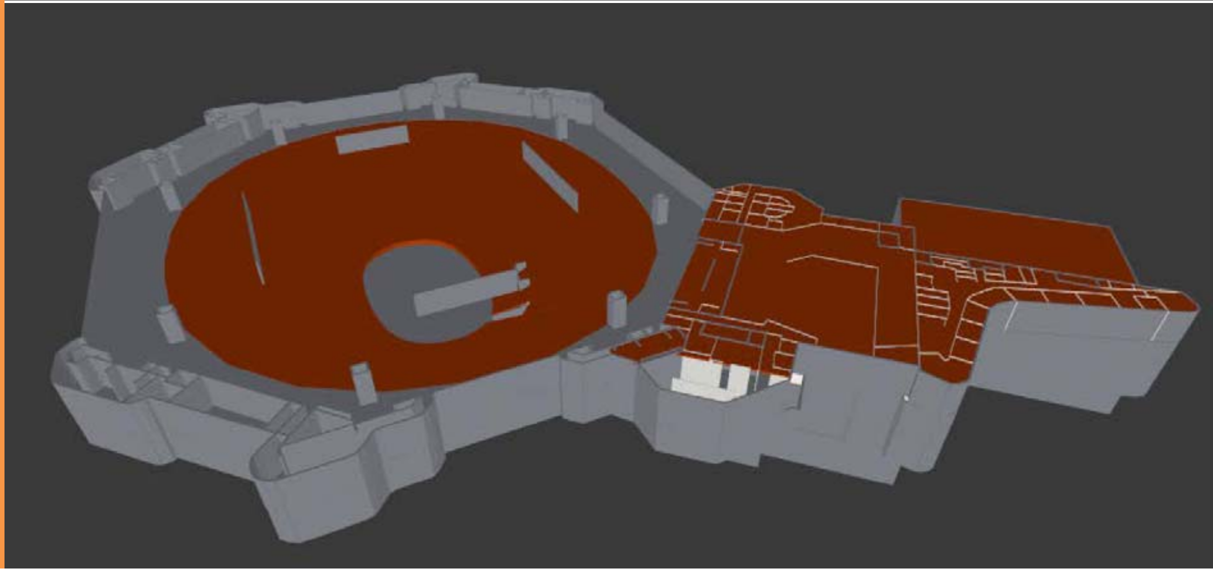



# RF Sources – What am I going to connect to the DAS?

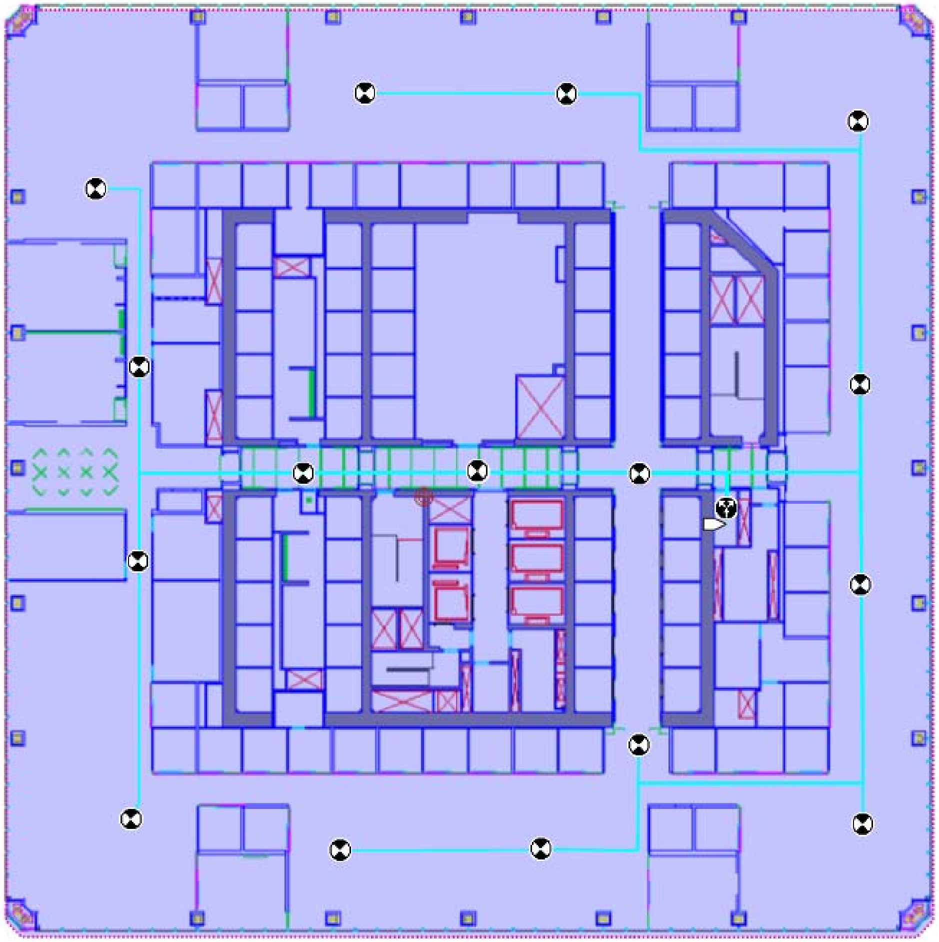
# Design: 3D Modeling

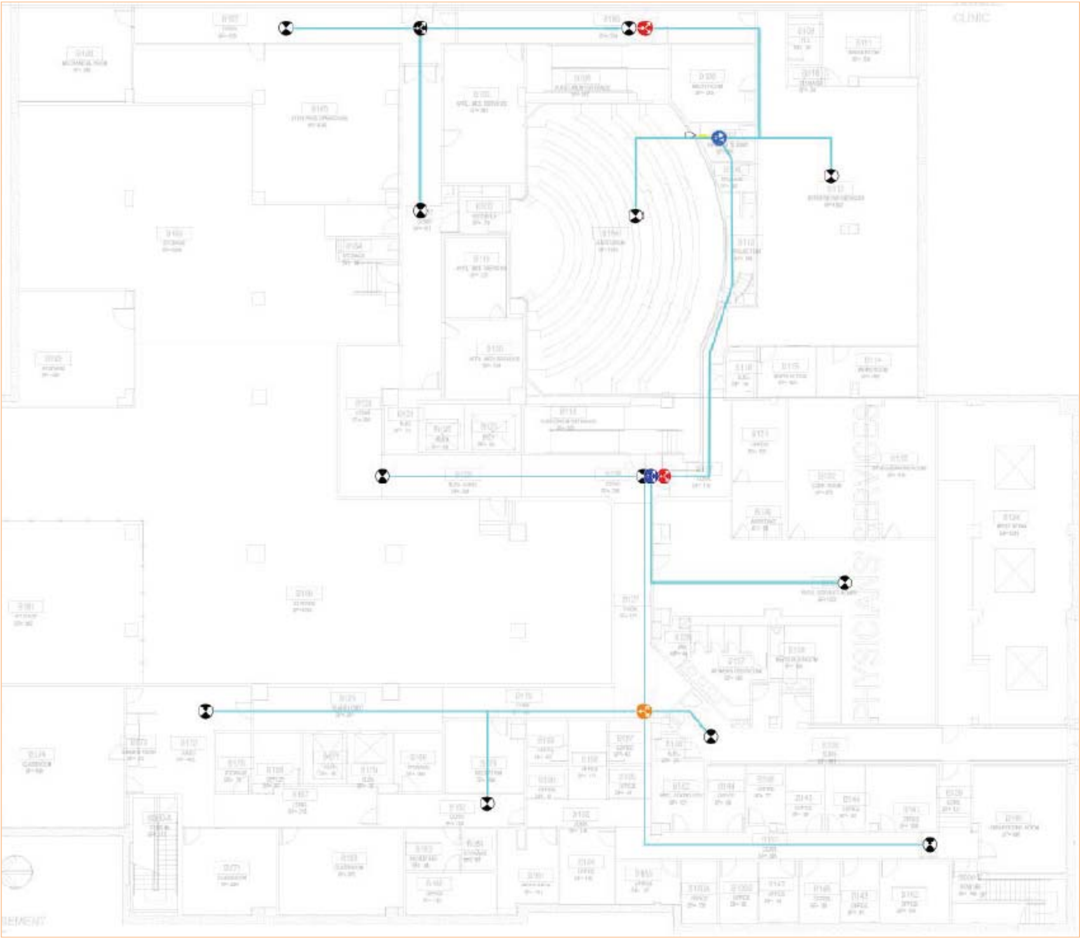




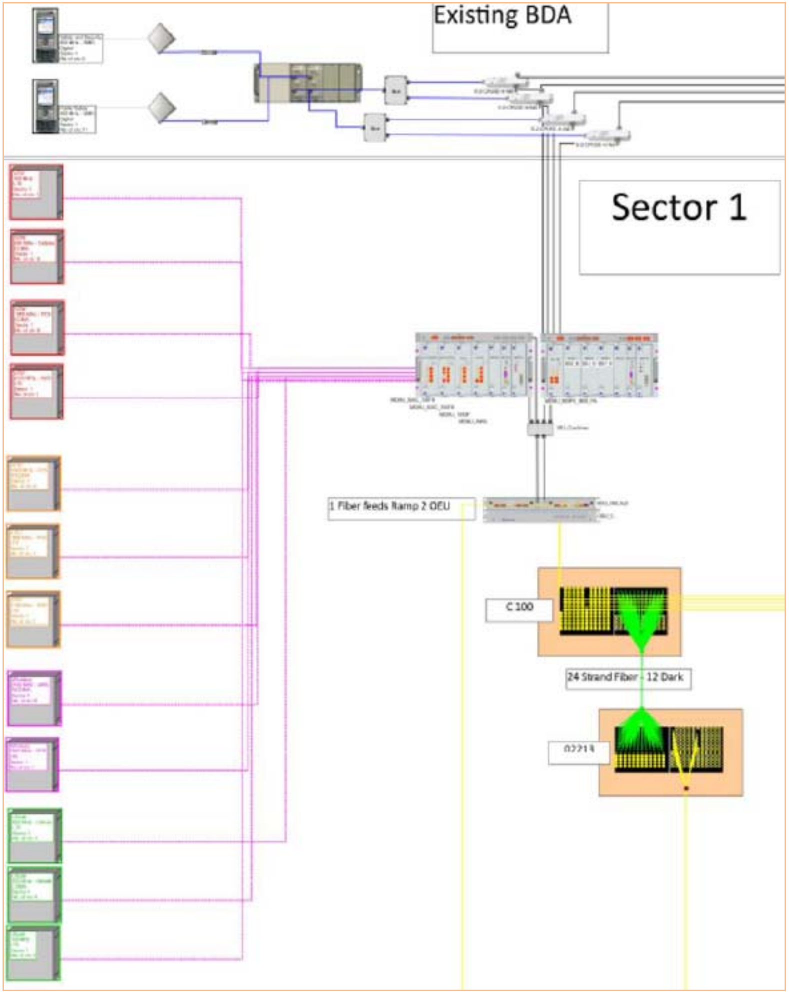


# Design: Antenna Layouts

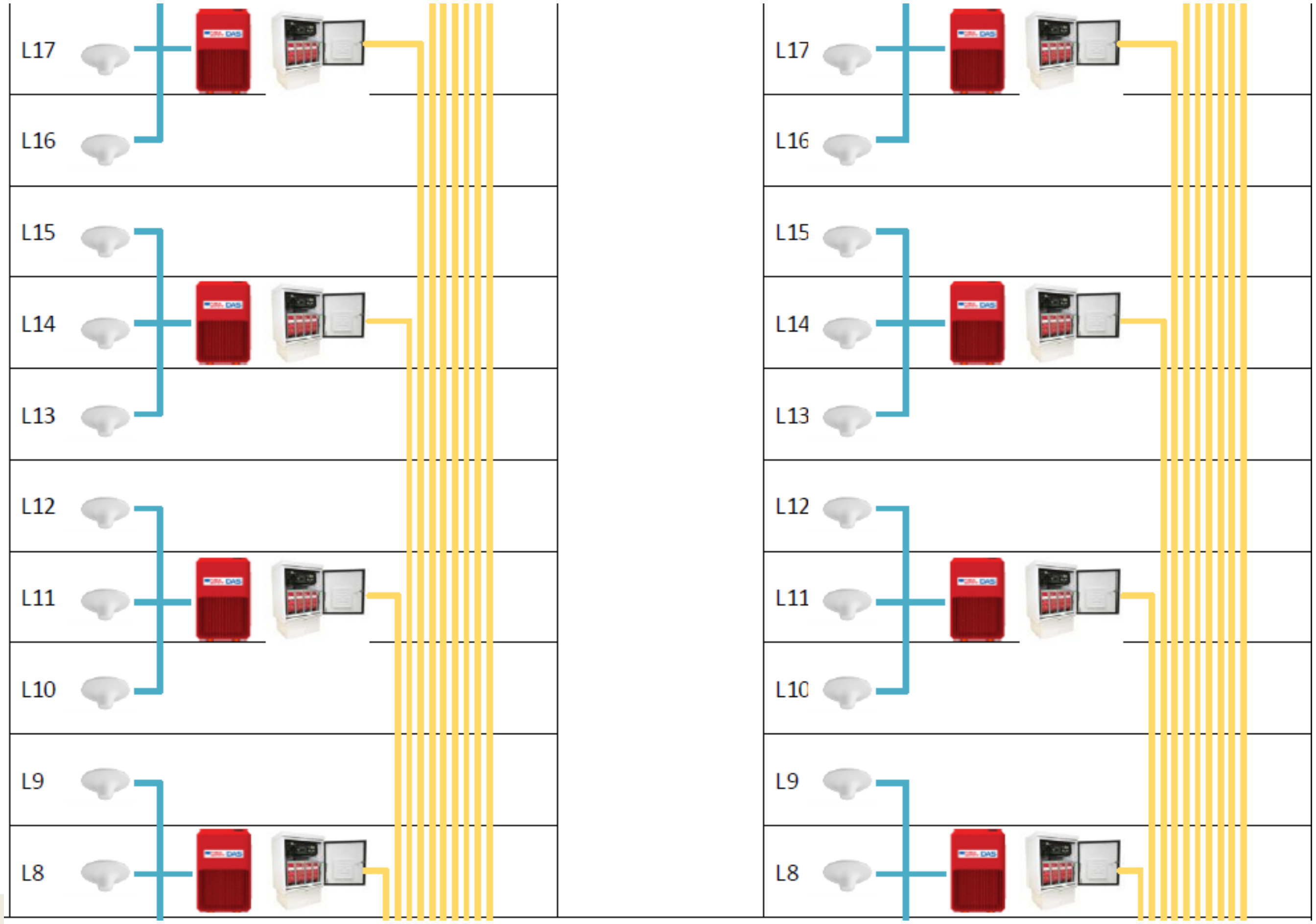




# Design: Riser Diagrams

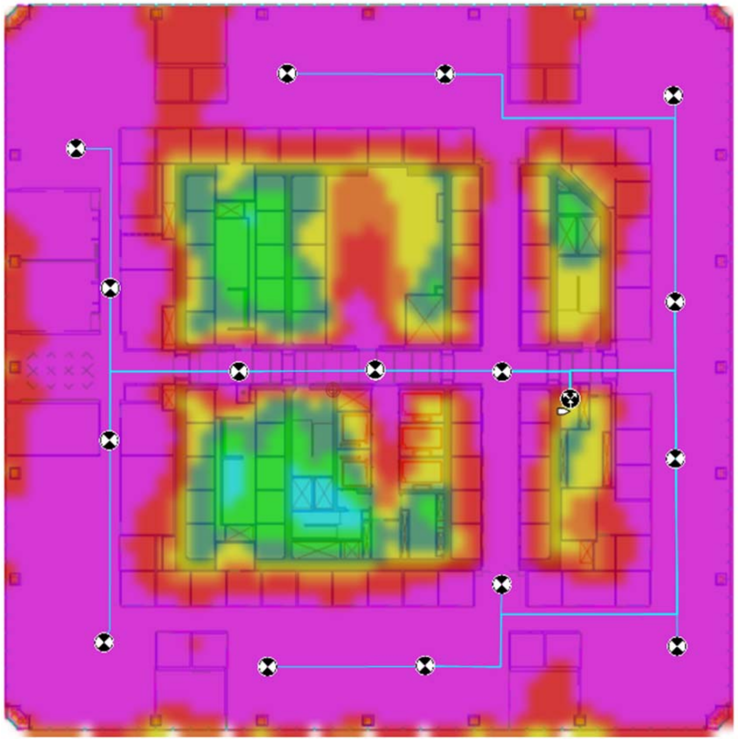



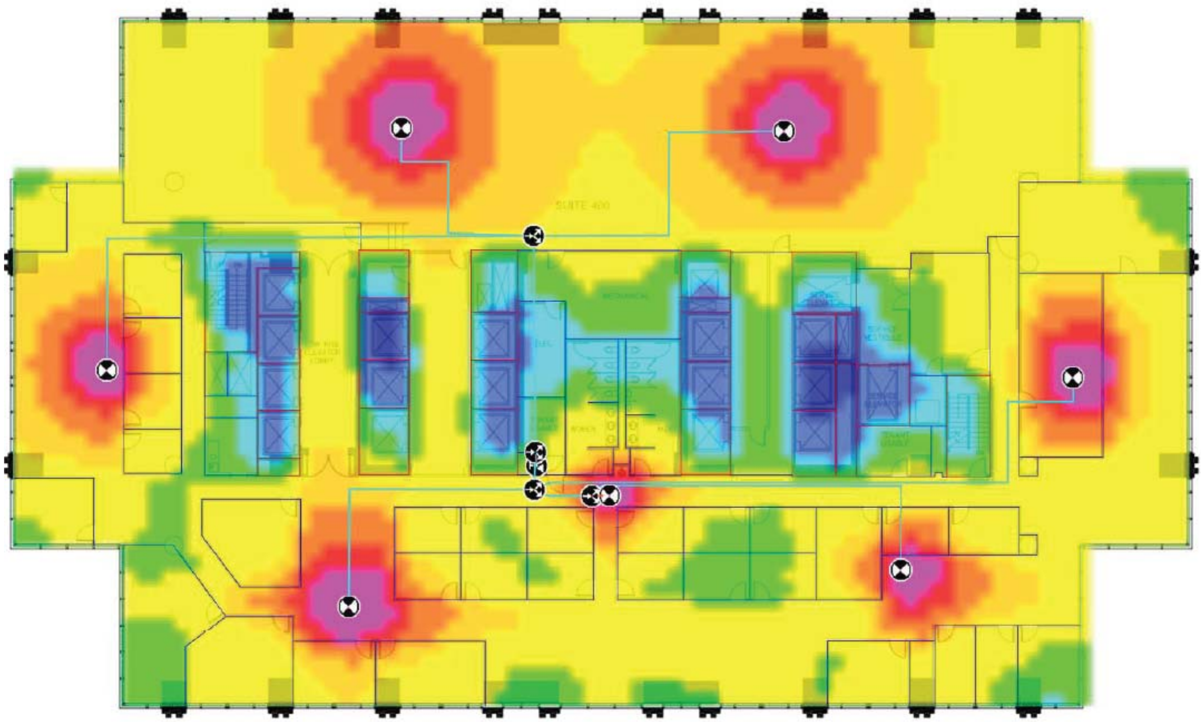
# Design: Riser Diagrams




| 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





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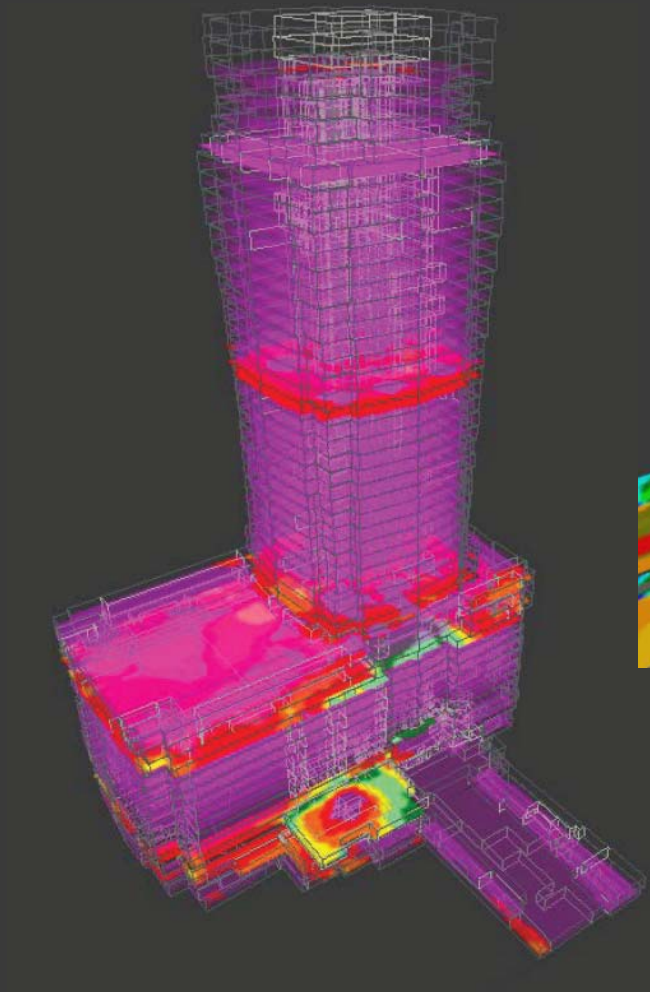

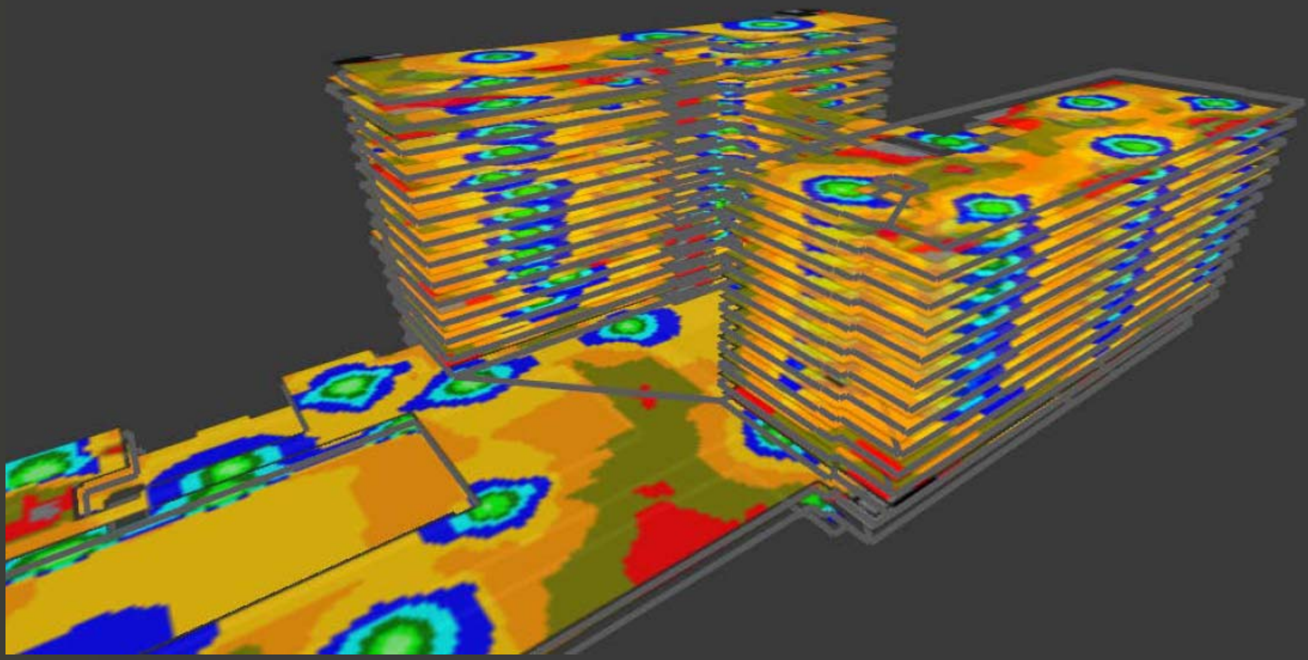

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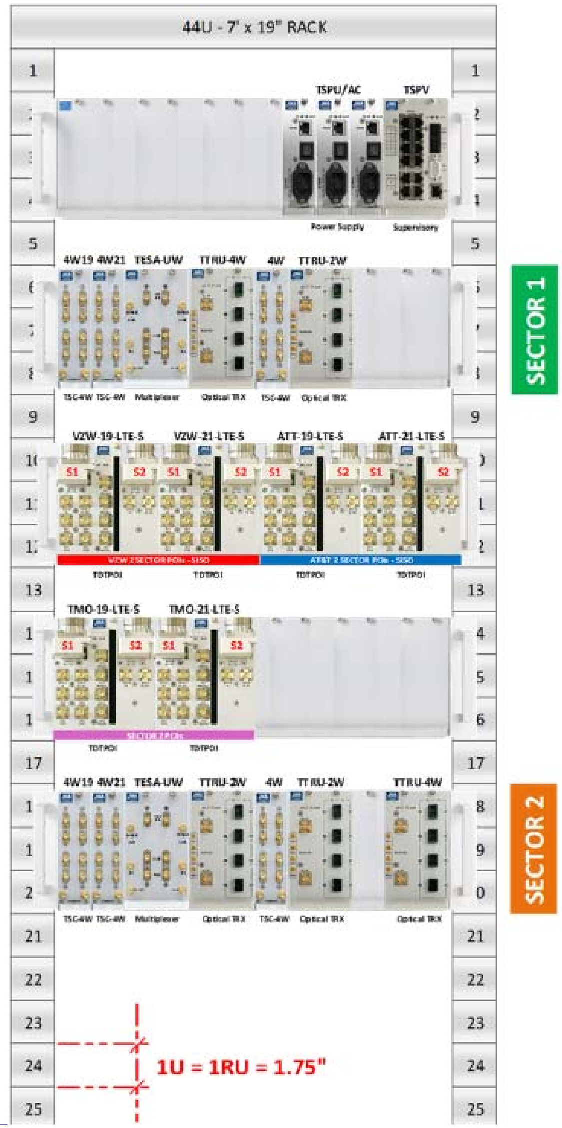
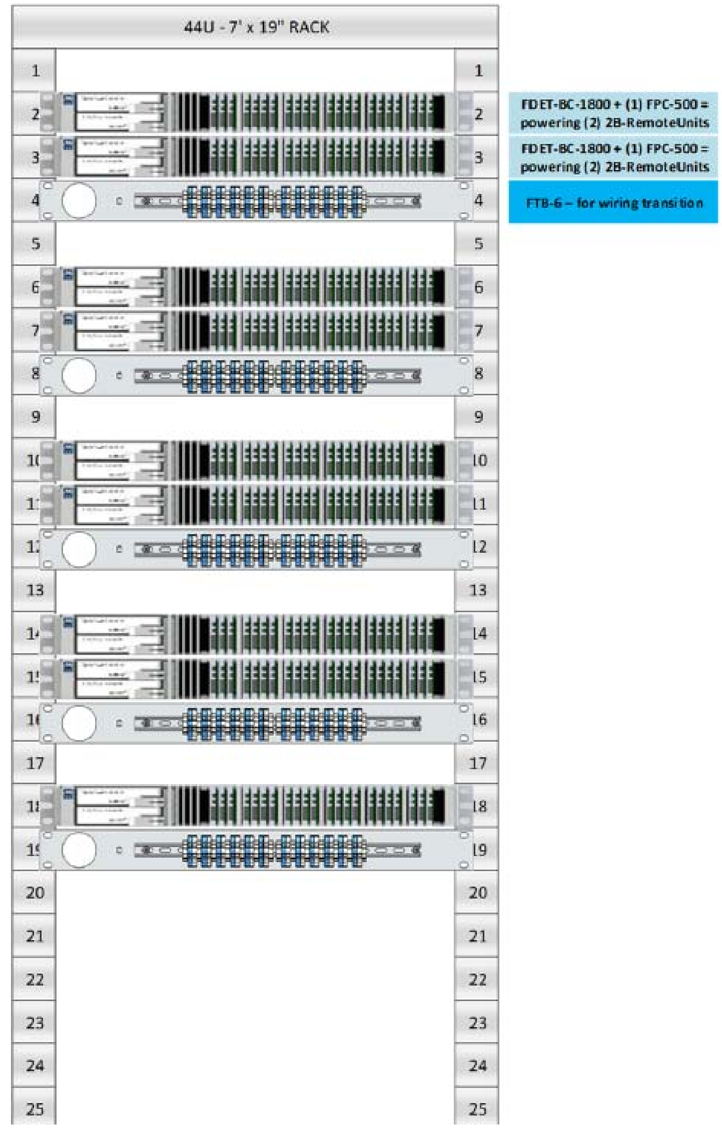
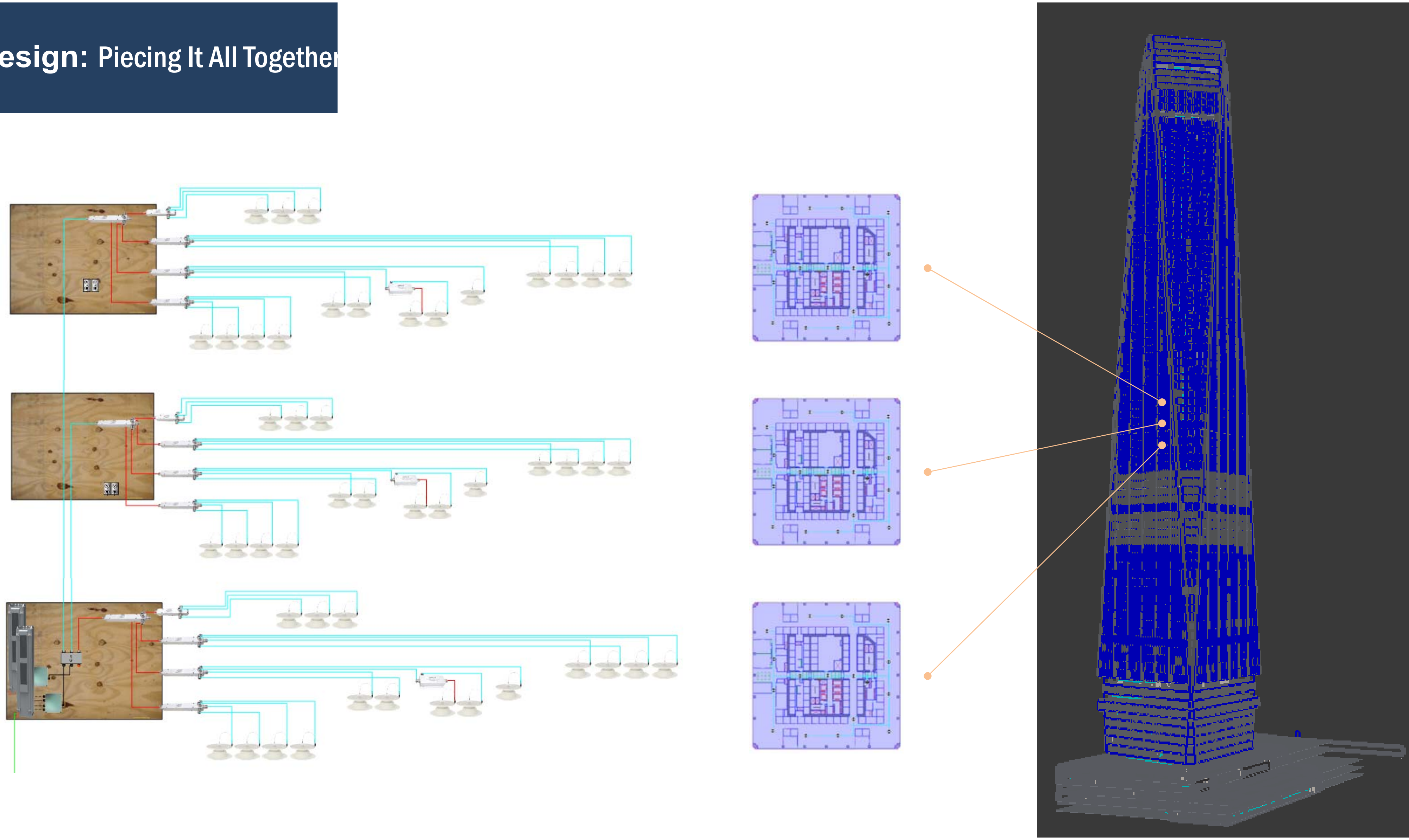
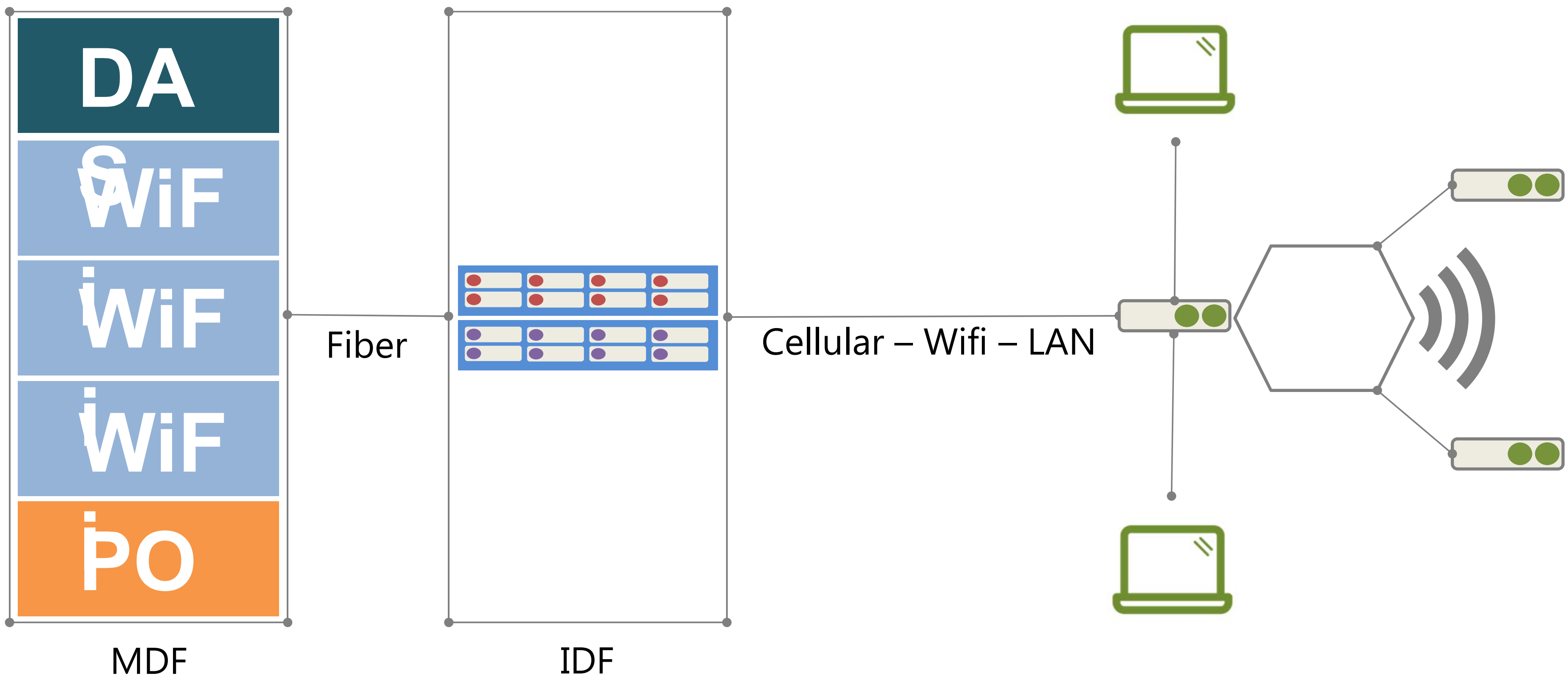


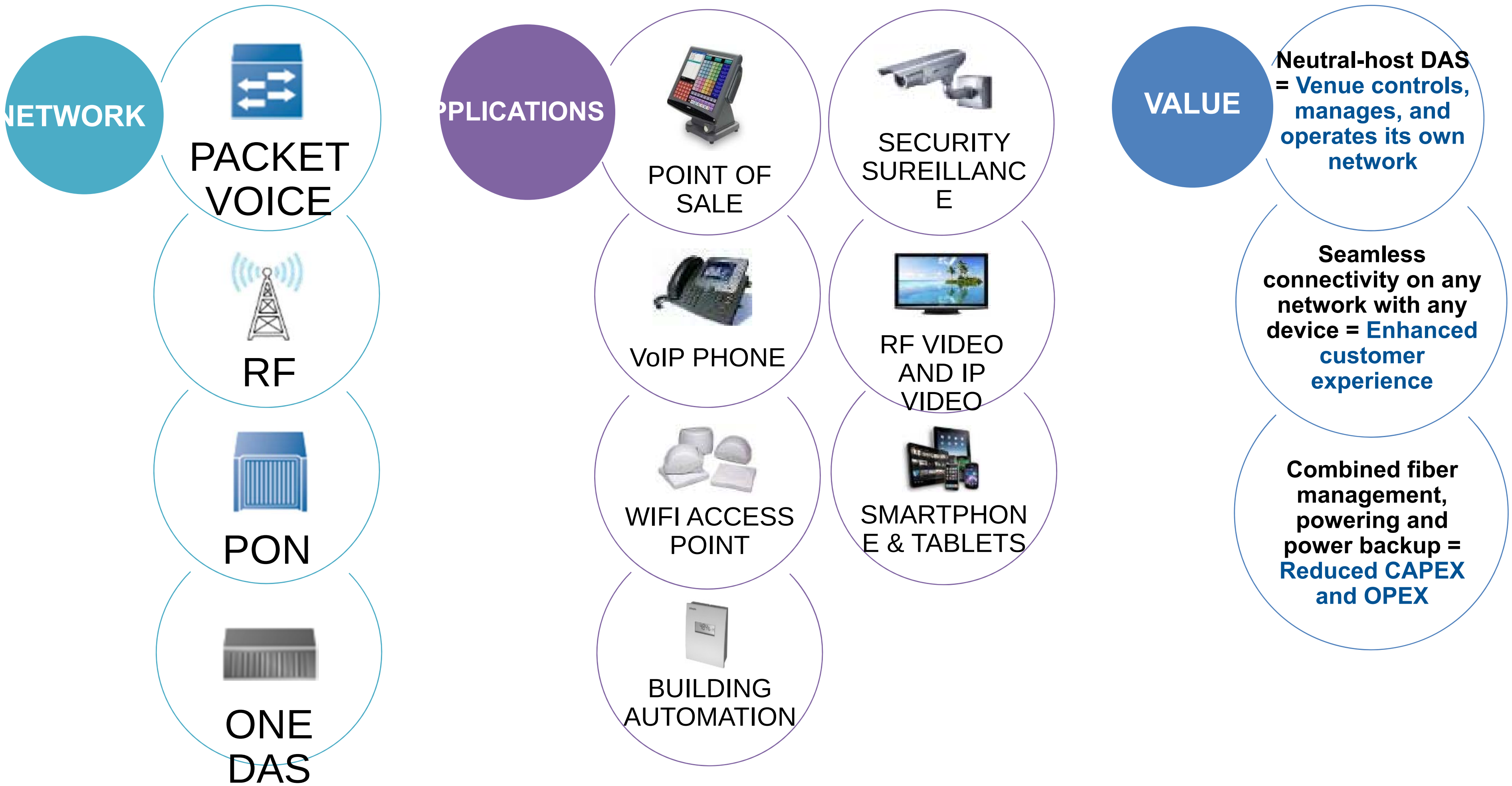
# Design: Piecing It All Together



# **Design:** Converged Networks

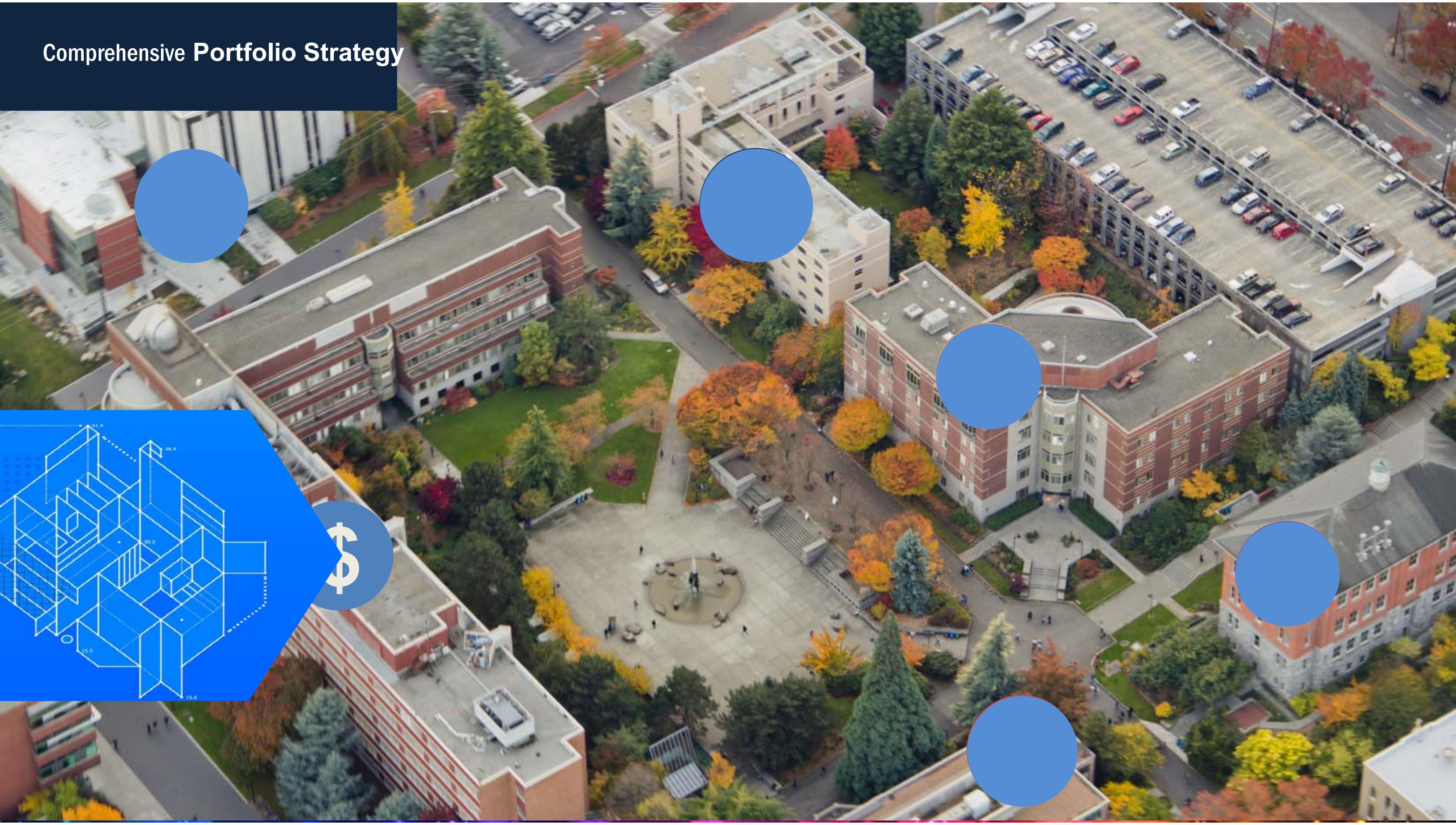


# **Design:** The Value of Convergenc

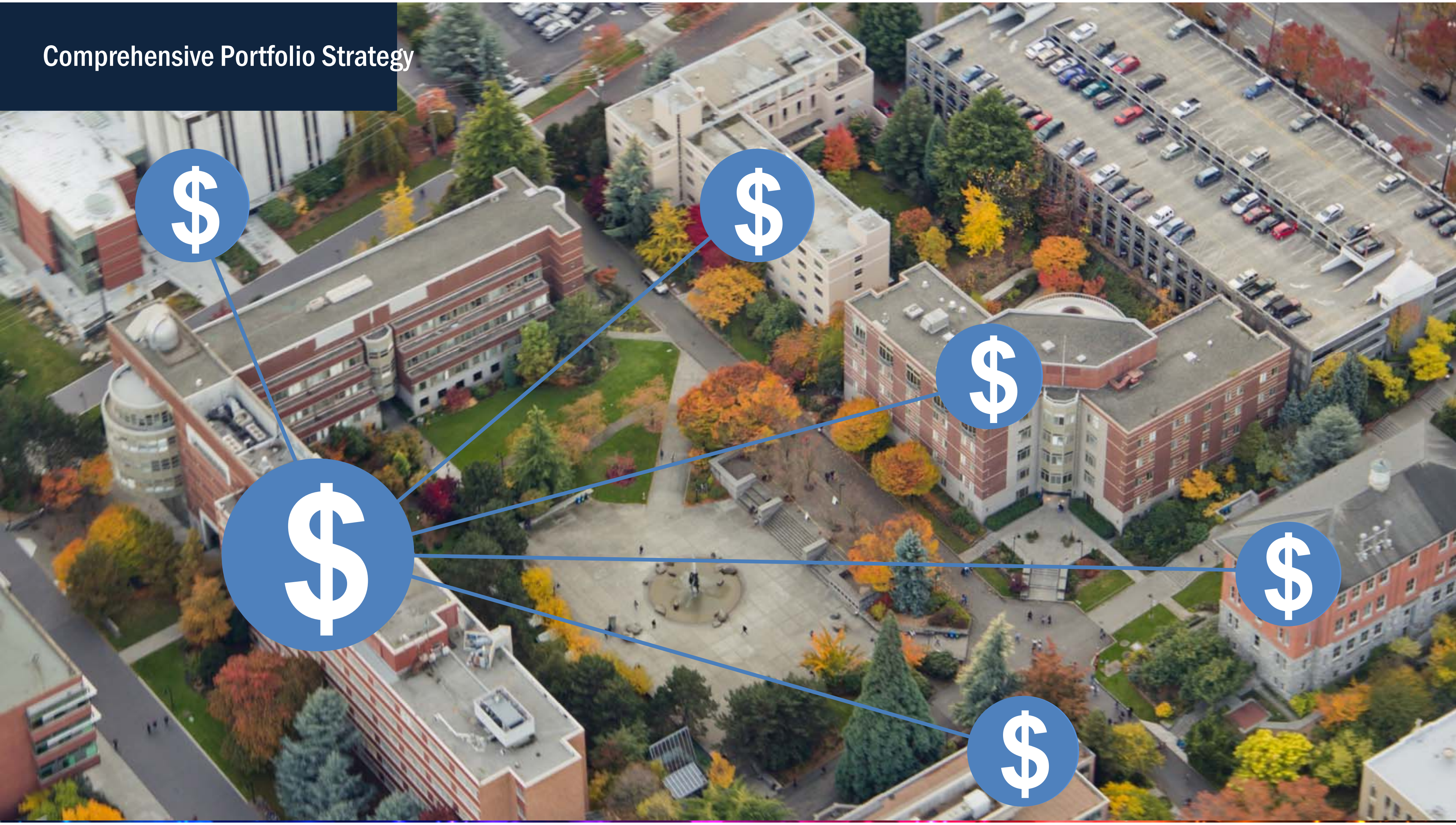


# Traditional Implementation Strategy

# Comprehensive **Portfolio Strategy**



# Comprehensive Portfolio Strategy



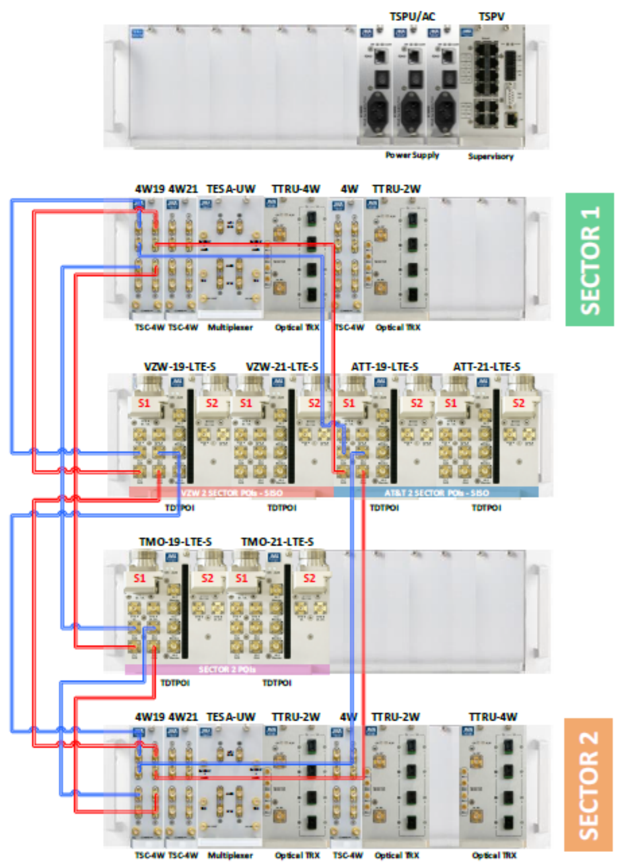
Best Practices

# DAS Installation

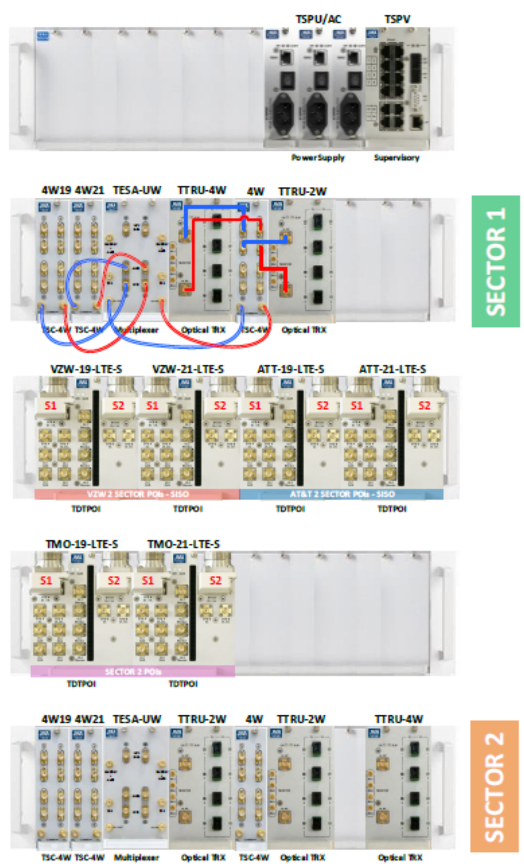
- IN-HOUSE TEAM OR DIRECT MANAGEMENT
- ON-SITE CONSTRUCTION MANAGEMENT
- PROFESSIONALISM
- DETAILED DOCUMENTATION FOR EACH PROJECT
- STRATEGIC INSTALLATION APPROACH
- SWEEP, PIM AND OTDR STANDARDS

# Installation Documentatio

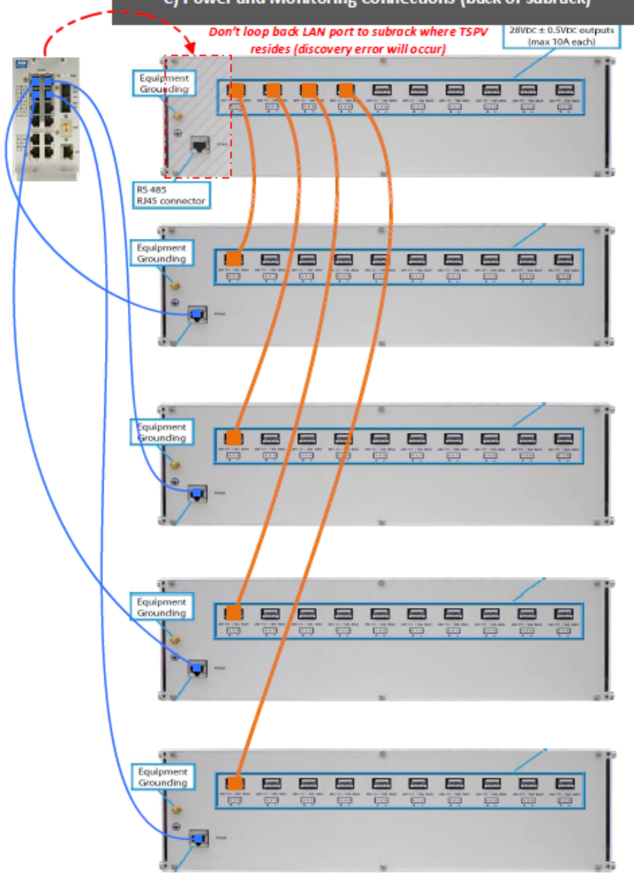
## A) Sample Connection from 1900 POI (S1 and S2) to Respective Sector 1900 TSC-4W Combiners (Repeat Same Procedure For AWS)



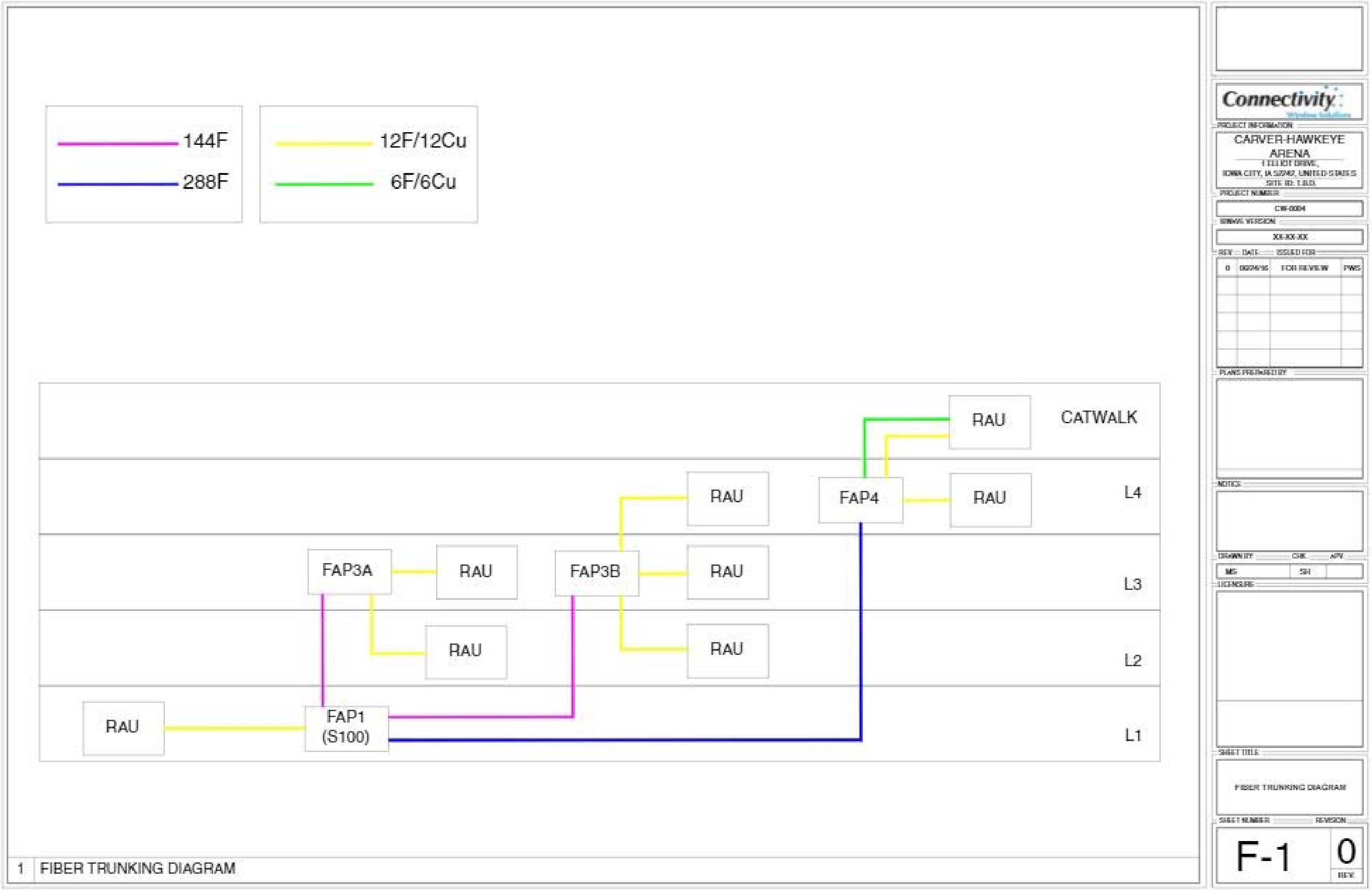

## B) Interconnection from TSC-4W >> TESA-UW >> TSC-4W (Post TESA) >> TTRU/OTRX




## C) Power and Monitoring Connections (back of subrack)



# Installation Documentatio



## Installation Componen

**BASE STATIONS**

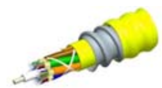
**Head-end radio equipment, provided by the wireless carriers, that provides the RF signal source to drive the DAS**

**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**

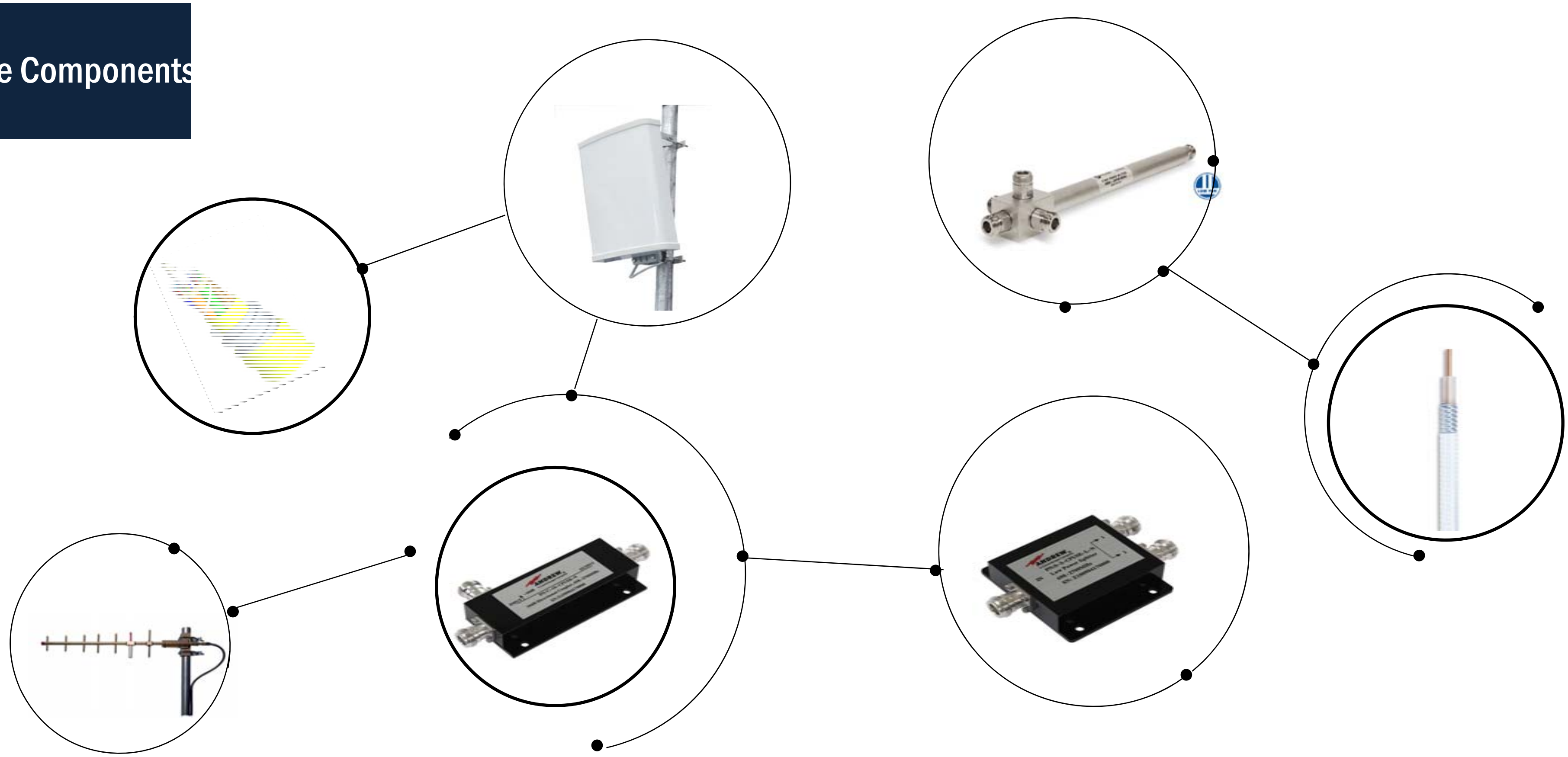
**SPLITTER**

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

**COVERAGE ANTENNAS**

**emits multi-band RF signals to the coverage area**

# Passive Components



# Active Components



## Sample Remote Photos


# Sample Remote Photos


# Sample Antenna Photos

# Sample Antenna Photos

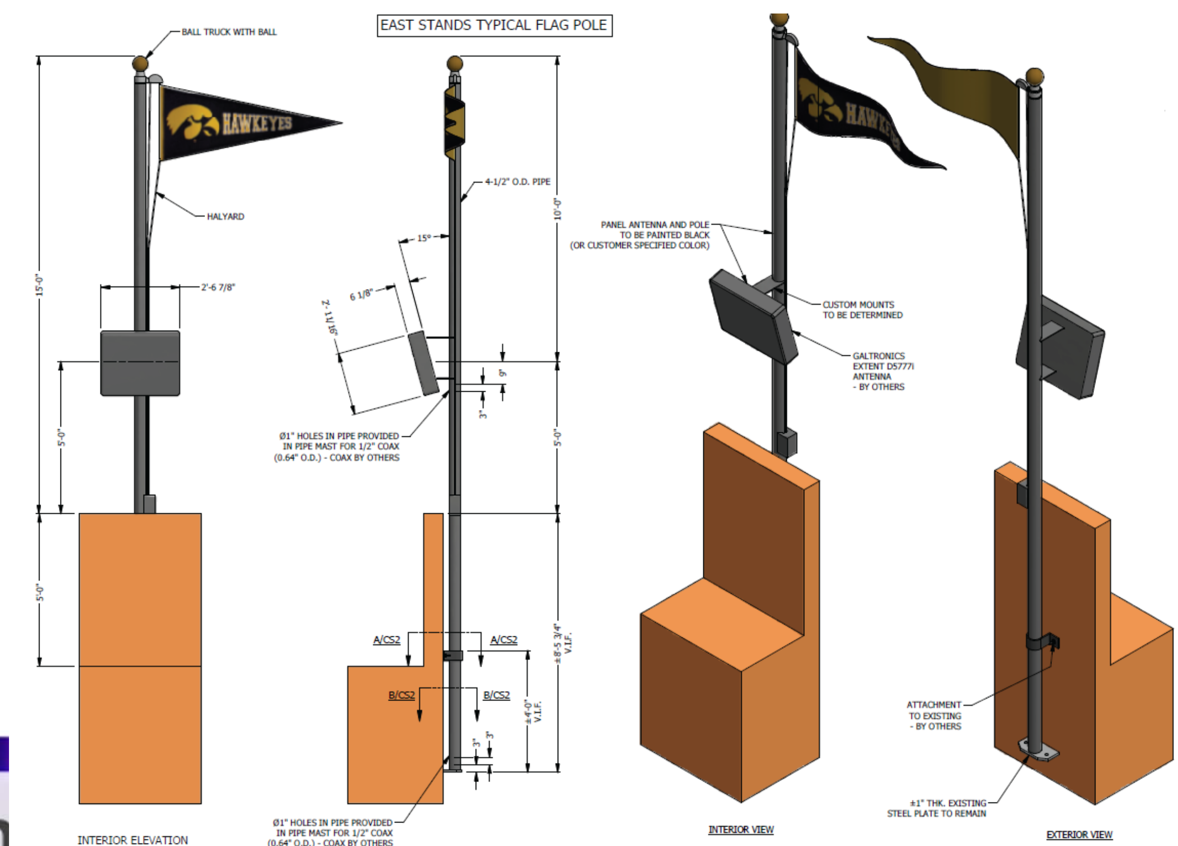

# Sample Antenna Photos

## Aesthetics


Before


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

# Aesthetics




CONFERENCE & EXHIBITION

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## Commissioning

DAS

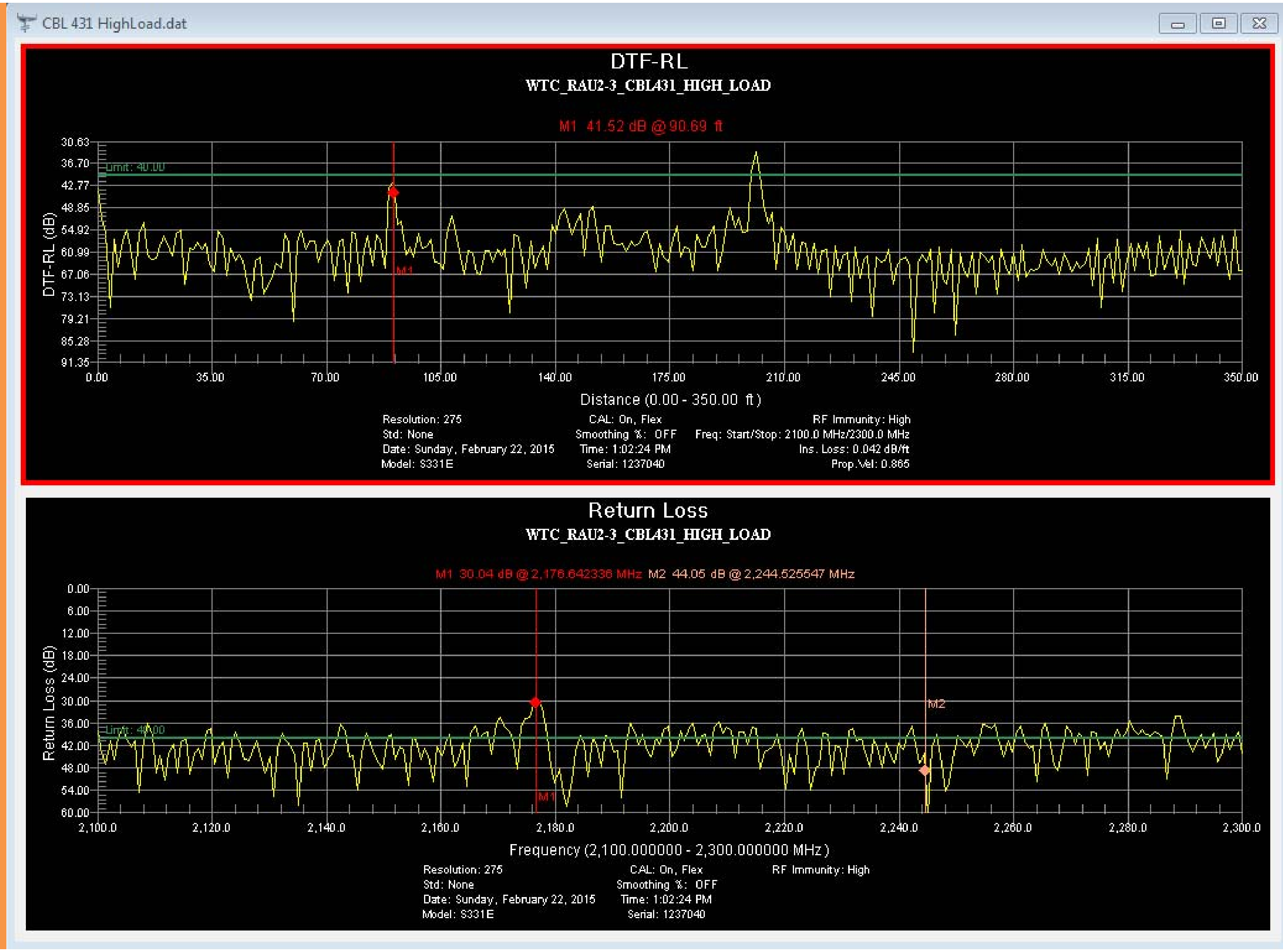
**Commissioning is generally defined as the industry approved process and methodology of systematically verifying that the:**

- 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 Success

# Data Processing

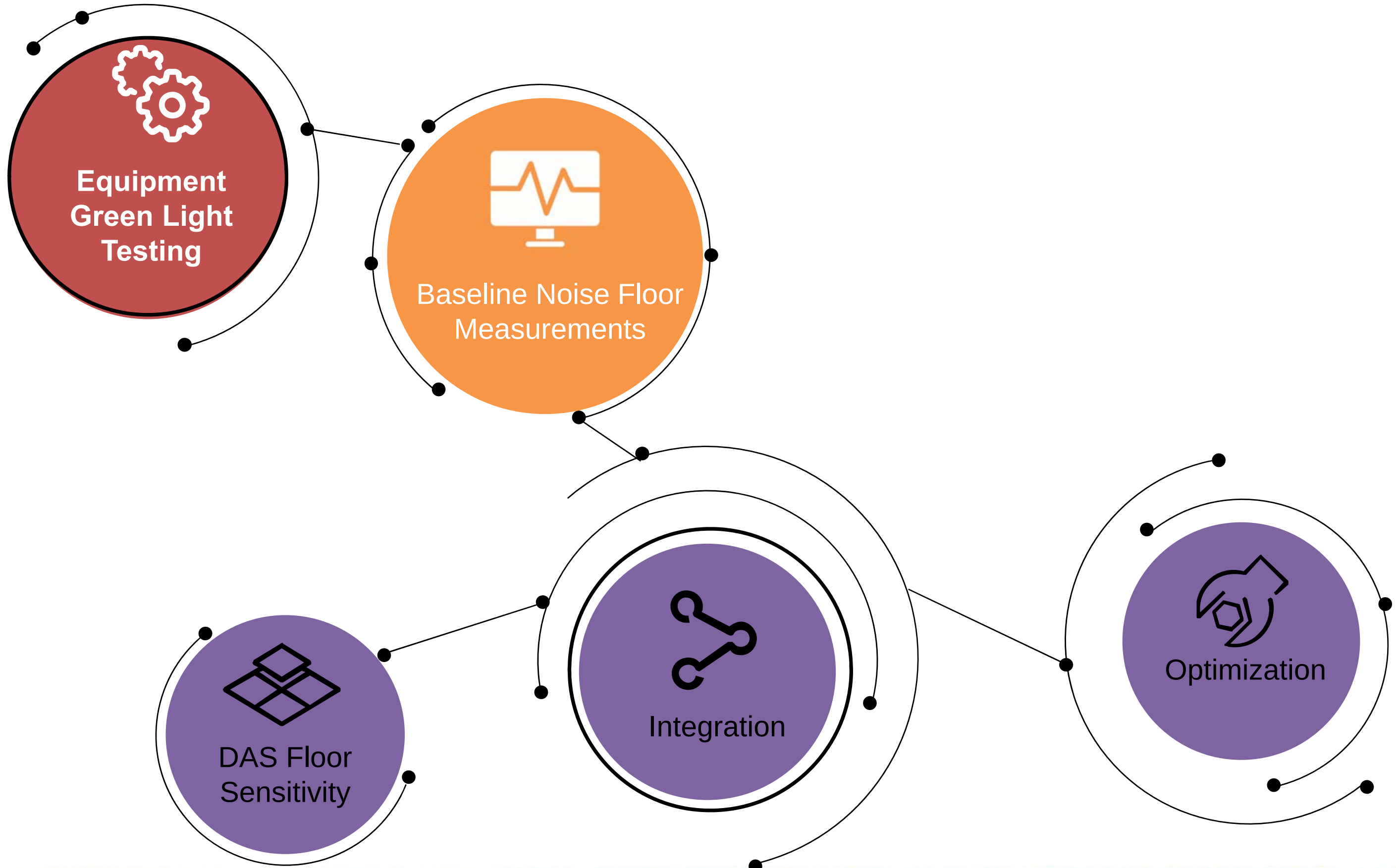
- SWEEPS –RL/DTF
- PIM
- FIBER



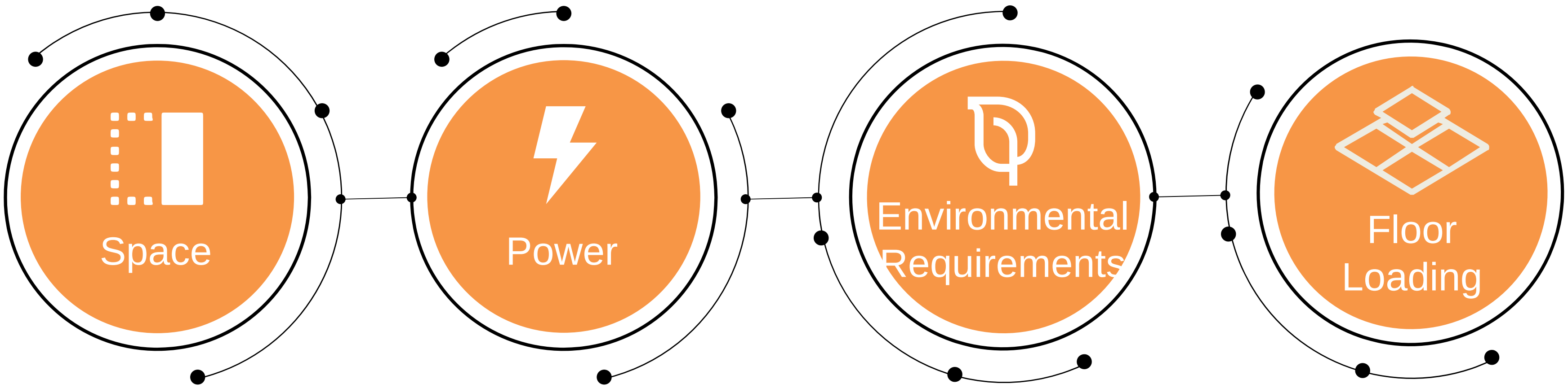
# What is PIM?

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

# Commissioning Pr



# LET'S TALK ABOUT THE HEADEND (MDF).



# Head End Room: Requirements

## 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

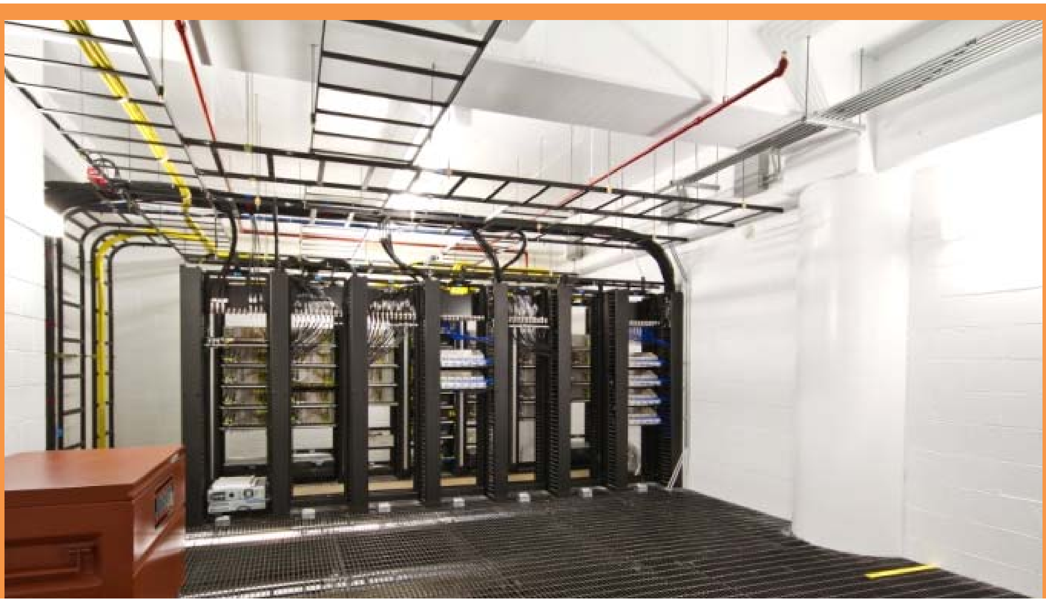
- 100 Amps 208 VAC three phase per carrier

## ENVIRONMENTAL REQUIREMENTS FOR THE HEAD-END

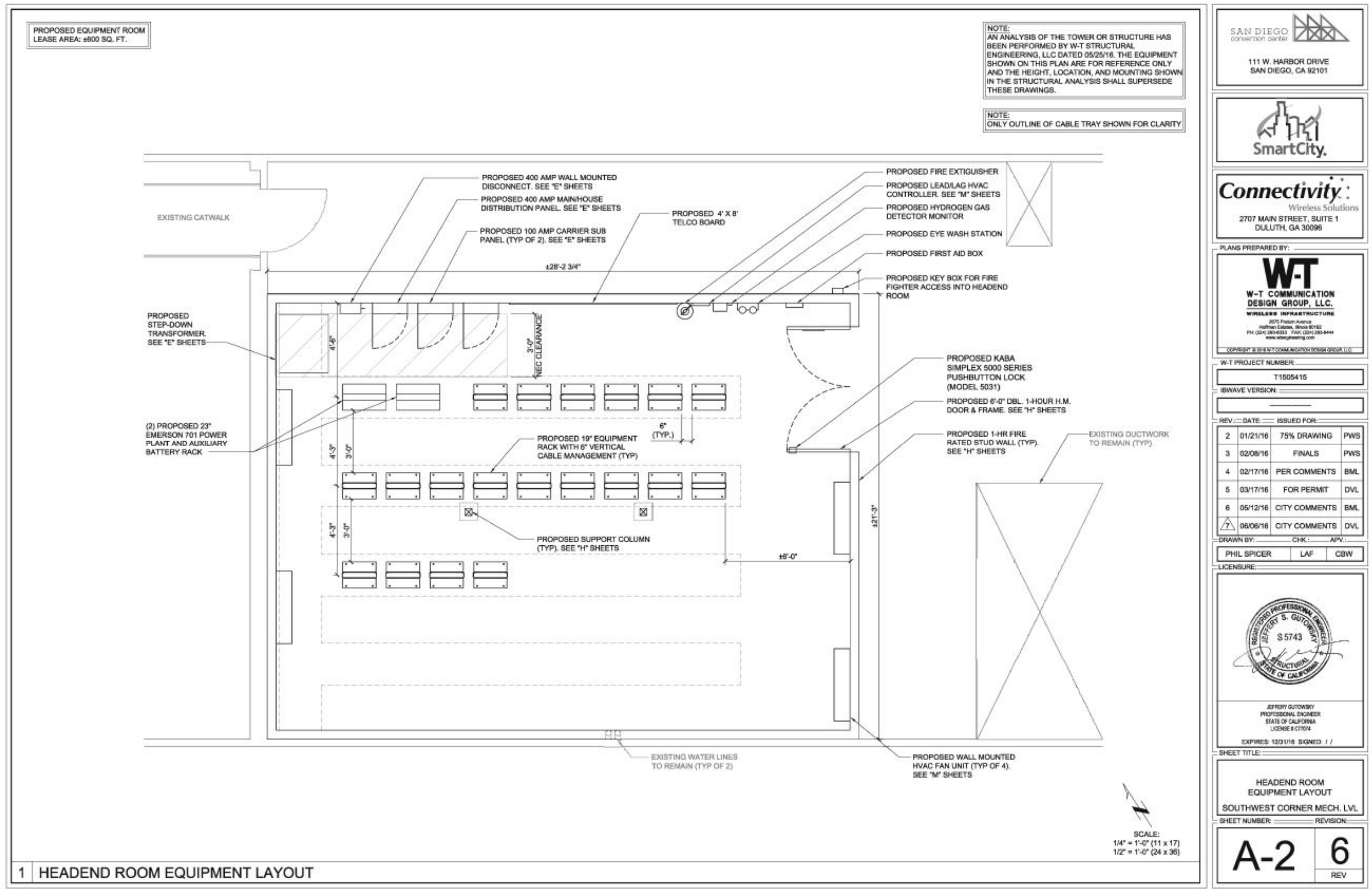
- 2 tons HVAC per wireless carrier

## Floor Loading

- 125 PSF for BTS equipment



## Head End Room: A&E Drawings

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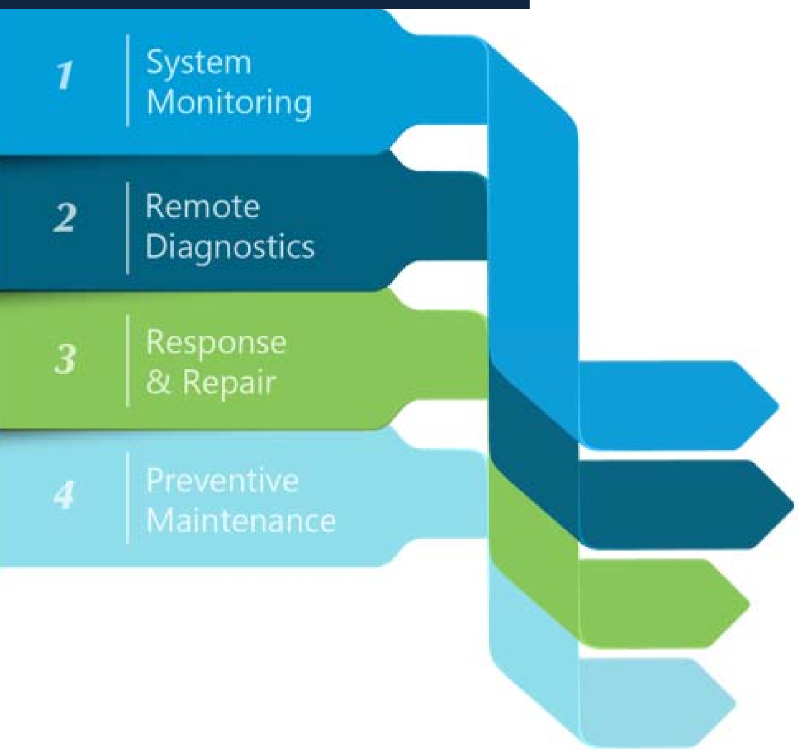
# Head End Room: Photos

# Head End Room: Carrier Equipment

## Monitoring and Maintenance




ConnectProtect

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

# Carriers & Case Studies

## Ownership Models

| Carrier | Neutral Host | Enterprise |
|---|---|---|
| 100% FUNDED AND OPERATED BY **Carrier** | 100% FUNDED AND OPERATED BY **Independent third party** (i.e., tower company) | OWNED AND CONTROLLED BY **Enterprise** |
| **Typically single carrier** | **Owner leases space back to the carriers** | **Deployed and operated by DAS integrator** |
| **Carriers may form consortium** | **Neutral-host** | **Enterprise can operate as neutral host provider** |
| **Neutral-host model seldom materializes** | **Carrier participation is affected by cost model** | **Multi-carrier funding available** |

## Ownership Models

## 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

# 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 coordinatio is **critic** 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:

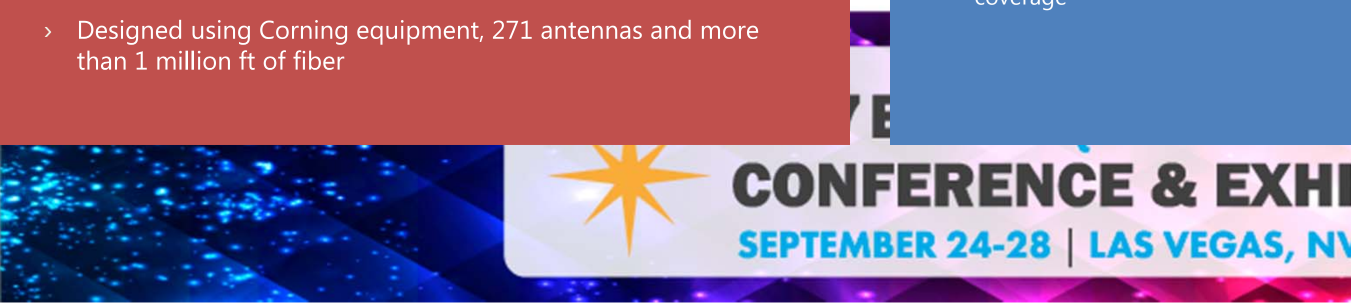
- Historic venue called for sensitive design and installation
- Sheer size and density of the coverage required to meet the needs of the facility
- Tight project timeline to optimize prior to Kentucky Derby weekend

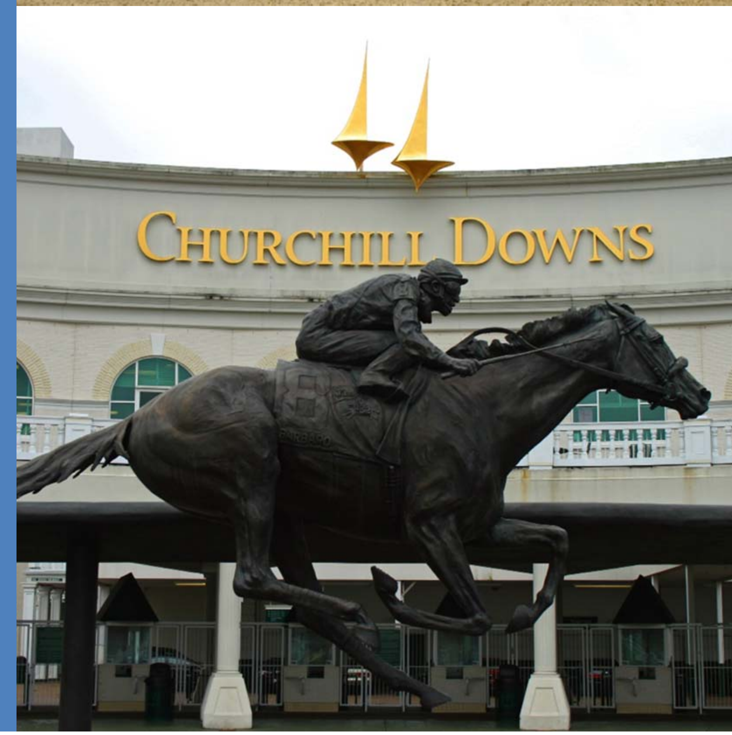
## CONNECTIVITY'S SOLUTION:

- 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:

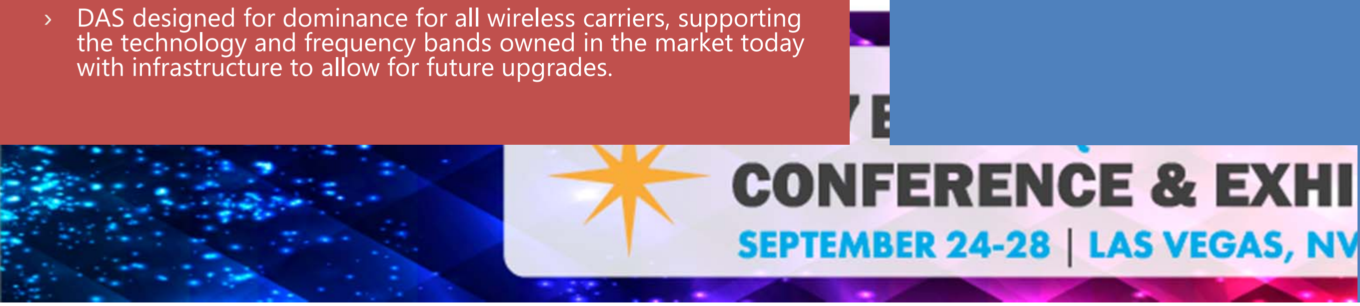
- Historic Kinnick Stadium of the University of Iowa was challenged to provide reliable wireless and data throughput speeds to fans during events.
- Strict aesthetic requirements coupled with the need for ubiquitous, robust coverage to meet the 70,000 maximum capacity requirements for multiple carriers.

### 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:

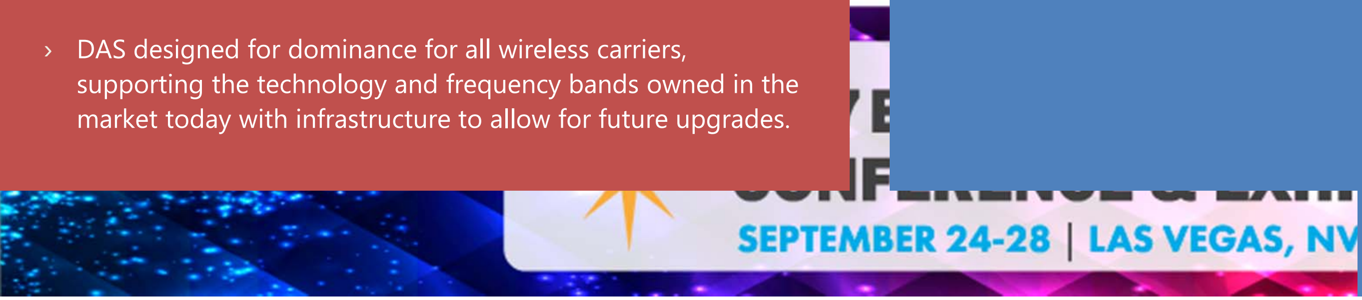
- Historic Carver-Hawkeye Arena of the University of Iowa was challenged to provide reliable wireless and data throughput speeds to fans during events.
- Strict aesthetic requirements coupled with the need for ubiquitous, robust coverage to meet the 16,000 maximum capacity requirements for multiple carriers.

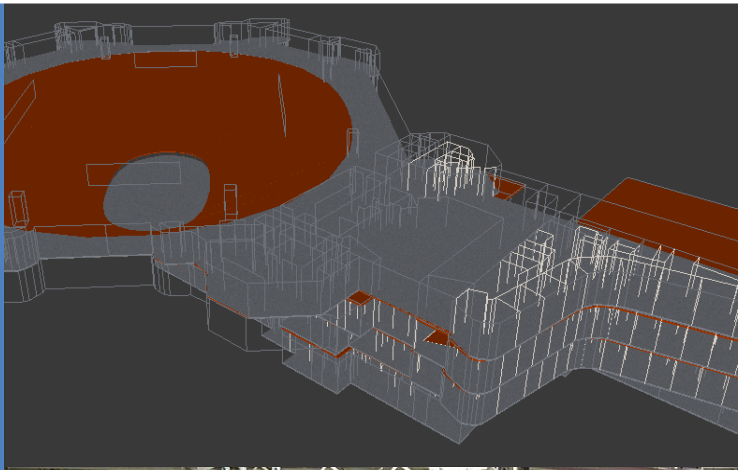
## CONNECTIVITY'S SOLUTION:

- 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

[redacted]

# Questions?

## - Thank you -

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