Distributed Antenna Systems

BICSI US North-Central Region Meeting
Warrenville, IL | October 19, 2010
Agenda

• About Connectivity Wireless
• Market Opportunity
  – Public safety mandates
  – Cellular and wireless data growth/usage trends
  – DAS market
• What is a DAS?
• Unique challenges of DAS applications
• Distributed Antenna System-Design Presentation
Connectivity Wireless – Leader in DAS

- Headquartered in Duluth, GA
- Engineering resources in 5 states – FL, GA, NC, PA, TX
- More than 60 employees
- More than 700 in-building DAS installations
- 150+ years of DAS installation experience
- Complete turnkey solution provider
- Strong carrier relationships
- Integrator and premier vendor of:
  - Andrew/Commscope
  - ADC/LGC
  - MobileAccess
DAS Market Opportunity

1. Public safety
2. Mobile data and cellular growth
3. In-building wireless (IBW) market
DAS for Public Safety

1. Mandates for radio service for public safety

- Since 9/11, renewed focus on fail-proof emergency communications, especially for first-responders
- 700 & 800 MHz bands allocated for fire and police
- Indoor cellular/PCS service required for E911 location
- NFPA code and best practices call for indoor wireless
- 150+ local municipalities now mandate public safety coverage inside large buildings
- Hundreds of thousands of wireless 911 calls made daily (CTIA Wireless Semi-Annual Survey, July 2009)
Mobile Data and Cellular Growth

2 Strong, continued growth in wireless usage

- 276 million subscribers; 246 million data-capable devices
- 89% of US population uses wireless; 20% are wireless-only
- 94% live in counties with 4 or more wireless service providers
- 60% of mobile calls originating indoors, reliable wireless communication is a must-have productivity tool
- Government mandates for wireless broadband and E911
Wireless Data Growth

- “Triple Play” – voice, video and data (75% take rate)
- Smartphones and aircards
- Date revenue and usage growth
  - VZW 2Q2009 data revenue up 52.6% to $3.9B
  - AT&T 2Q2009 data revenue up 37% to $3.4B – (108B text msgs)
- $19.4B wireless data revenue 1H2009, up 31% over 1H2008
- Wireless data revenue 25% of total wireless
- Wireless data drives demand for in-building cellular more prevalent across the board
In-Building Wireless Market

Strong growth in DAS spending

Source: ABI Research
How It Works – Single Site

Donor Antenna

In-building Antennas

Fiber Distribution Remote Unit

Bi-directional Amplifier or Repeater

Fiber Distribution Head-End Equipment

Coax

Fiber Cabling

Head-end Equipment Room

Public Safety Donor Site

Cellular Signal Source
DAS in Multi-Site or Campus Setting

Fiber Links

Fiber Remote Units
Unique Challenges by Application (Verticals)

Healthcare

Public Venue

Hospitality

Mixed Use

Government & Education
Challenges of Healthcare

- Smart track (patient status tracking)
- Time and clock systems
- Patient, staff and equip tracking (IR & RF)
- Device temperature tracking
- HVAC controls (zigbee)
- Infant abduction/tracking
- Focus on aesthetics
Challenges of Mixed Use

- No wireless master plan
- No budget
- No space for equipment
- Typically not a single building – campus phasing required
- Diverse tenants – corporate, hospitality, retail, residential
Challenges of Hospitality

- Usually lack wireless master plan
- No budget
- Public safety coverage required
- Expect Wi-Fi/cell everywhere
- Don’t want to re-open ceilings
- Fast-track construction
Challenges of Government

- Multiple users, multiple departments
- Budget constraints
- Historical buildings
- Outdated construction methods
- Public safety, 2-way radio
- Wireless devices and applications to drive productivity and reduce operating costs
Connectivity Wireless Core Competencies

Master Planning

Installation

Design

Support

Specialists in the engineering, design, installation, and support of complex in-building wireless systems
The Master Planning Process

- Executive consulting
- Needs & usage assessment
- Stakeholder coordination
- Definition of required infrastructure
- Technology migration planning
- Wireless budget development
- Wireless Master Plan™ publication
The Design Process

- Site survey
- RF propagation mapping & modeling
- Equipment specification
- Bill of materials definition
- iBwave™ based system design
- iBwave™ based as-built documentation
The Installation Process

- Project and construction management
- Carrier signal-source installation
- Low voltage cabling and coax installation
- Antenna system installation
- System optimization, testing and certification
- WWAN antenna access points
- Public safety compliance and coordination
Support

- Single point-of-contact for owner’s wireless asset
- Promotion of neutral DAS to carriers
- Lease, licensing and system access negotiations
- Carrier integration engineering
- Wireless Asset Management™ reporting
- Warranty and technical support
- System monitoring
Partnering with Connectivity Wireless

Connectivity Wireless specializes in-building wireless systems.
Good Candidates for DAS

• **Hospitality**
  *Hotels, resorts, conference centers*

• **Public Venues**
  Convention Centers, stadiums, airports

• **Government & Education**
  Govt. offices/municipality, university campuses

• **Hospitals**
  Medium/larger hospitals more than 100 beds

• **Mixed Use**
  Malls, mix of residential, entertainment, and retail spaces

*Connectivity: Wireless Solutions*
Distributed Antenna System Purchases

DAS financial options:

1. Direct Purchase

2. Carrier Funded Options

3. Bank/Financial institution Financing

4. American Tower/Crown Castle assisted purchases
Advantages of Working with Connectivity Wireless

1. Connectivity Wireless
   We deliver in-depth industry expertise to every project

2. Integrated solutions with guaranteed results
   We bring a broad range of solutions/partners to the table

3. Track history of successful projects

4. Premier vendor of:
   - CommScope
   - ANDREW
   - Bicsi
Overview

- In-Building Basics - DAS
- Public Safety
- Engineering Processes
  - Coverage Needs Analysis
  - Site Survey
  - Design
  - Installation
  - Commissioning
  - Maintenance
  - Carrier Coordination
In-Building Basics
Why is indoor coverage poor?

• The building is acting as an RF shield
  – Fortified Construction; Hospitals, Government buildings, etc…
  – Highly tinted windows; Energy efficient, green building efforts
  – Lack of coverage in below grade floors
  – Elevators and center areas of the building

• High rise buildings (typically over 25 floors)
  – Above cell site tower coverage footprint
  – Bottom and below grade floors often shadowed and need a DAS
  – No dominant mobile control channels on upper floors

• The building is blocked from the tower by other buildings

• The WSP/PS Network Cell Site Tower is too far away
  – Some WSP tower locations may be closer than others
Common DAS Venues

- Hospitals
- Universities, Arenas, Stadiums
- Government Buildings
- Multi-tenant High-Rise
- Hotels and Casinos
- Corporate Offices and Campuses
Is a Coverage System Required?

Wireless Service Provider (WSP) Commercial Services
• Is there often less than 3 “BARS” on a phone?
• Do people complain about poor cellular coverage indoors?
• Do people need to stand next to a window to make a call?
• Does the owner want to guarantee full coverage?

Public Safety Services (police, fire, rescue)
• Does the city have a first-responder in-building coverage ordinance?
• Do first responders complain about poor 2-way radio coverage?
• Is there coverage in the stairwells and elevators?
• Do you have liability concerns?
In-building Distributed Antenna System (DAS)
DAS System Configurations

• Passive DAS - Coax used to distribute RF signals
  – Only active component – BDA/Repeater
  – Ideal solution for smaller venues <150K ft²
  – Limited growth or expansion capability
  – Parallel systems required for carrier and public safety

• Active DAS - Adds RF ↔ FO conversion, fiber, and distributed amplifiers
  – Scalable – Single to multi-band/operator installations
  – Cost effective multi carrier coverage over 150,000 ft²
  – Flexible for growth and expansion
  – One system for both Cellular Carriers and 700/800/900 Public Safety
Public Safety
Public Safety

• NFPA Guidelines
  – Annex O
  – Issued in April of 2009
  – Only applicable if the municipality adopts this portion of the code

• Require Public Safety coverage inside facilities
  – Fire, Police, First Responders
  – No building size is identified – defines coverage
  – If the municipality adopts the codes - it would be enforceable for existing and new buildings

• Includes discussion on retransmission agreements
  – Public Safety officials want permission before rebroadcasting
    – Poor designs can harm coverage
Public Safety

- 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 12 hour battery backup
- Annual testing required for active components and system
Engineering Processes

• Services Overview (A la carte or full turnkey)
  – Site Surveys
    • Ambient Coverage Analyses
    • Installation / Donor Signal Survey
  – In-Building System Design
    • Coax
    • LGC / ADC
    • Andrew
  – Commissioning and ATP Services
  – Maintenance
Coverage Needs Analysis
Coverage Needs Analysis

Agilent: Ambient In-Building Coverage Analyses

• **Hand-Held Measurement**
  Record signal strength and quality readings from mobile handset(s) at pre-determined intervals for multiple wireless technologies and providers

• **Agilent E6474A Signal Documentation**
  Using RF scanning equipment to automatically record signal strength and quality for a more thorough analysis

Agilent: System Acceptance Testing (ATP)

• **Measure & Record**
  Document channel, signal strength & signal quality on floor plans through mobile handsets or Agilent E6474A test equipment

• **Ours or Theirs**
  Connectivity will ATP systems we manage or independently verify client’s system
Coverage Needs Analysis

• Two main factors that demonstrate signal
  – RSSI – Received Signal Strength Indicator
    • Measured in dBm
    • -85 dBm is the typical threshold
    • Lower dBm (e.g. -95 dBm) = lower signal
  – Quality
    • Typically a Signal to Noise based ratio – Ec/Io, SQE, C/I
    • Thresholds vary per service provider
    • Noisy room example (high rise)
Coverage Needs Analysis

• Methodology
  – Phone for each service provider
  – Agilent laptop and software
  – Data is collected and post-processed
    • RSSI and Quality
    • Overlay of floor plans
  – Public Safety – Spectrum Analyzer Methods
Coverage Needs Analysis

2ND FLOOR

<table>
<thead>
<tr>
<th>Color</th>
<th>RSSI</th>
</tr>
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<tbody>
<tr>
<td>Green</td>
<td>&gt; -85</td>
</tr>
<tr>
<td>Yellow</td>
<td>-85 &gt; -95</td>
</tr>
<tr>
<td>Red</td>
<td>&lt; -95</td>
</tr>
</tbody>
</table>

Legend:
- Sprint
- Verizon
- AT&T
- T-Mobile
Coverage Needs Analysis

PARKING DECK

<table>
<thead>
<tr>
<th>Color</th>
<th>RSSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>&gt; -85</td>
</tr>
<tr>
<td>Yellow</td>
<td>-85 &gt; -95</td>
</tr>
<tr>
<td>Red</td>
<td>&lt; -95</td>
</tr>
</tbody>
</table>
Coverage Needs Analysis

• Recommendations
  – Typically on a floor by floor basis
  – Design and implement based on analysis feedback
  – Where does the client request coverage?
Site Survey
Site Survey

Installation/Donor Signal Assessment

- **Dominant Server Analysis** – measure strength (RSSI) & quality (Ec/lo, C/I, SQE) of donor signal(s) to determine ideal RF donor sites
- **Spectrum Snapshots** – identify potential interference and noise floor design considerations
- **In-Building Transmitter Tests (When Warranted)** – analyze complex RF environment path losses using Praxsym transmitters and Anritsu spectrum analyzers
- **Installation Considerations & Pictures** – document key equipment locations, installation concerns, and notes directly on the building floorplans for easy reference and design translation
- **Code & Safety Documentation** – maintain client, industry & government safety regulations
- **Scope Confirmation** – confirm end user expectations match customer scope
- **Site Survey Package (A la carte)** - includes documentation of the preceding information
Site Survey

• Scope of Project
  – Floors and Square Footage
  – Service Providers
  – Building Environment – Dense, Open

• Floor Plans
  – Updated, accurate, interior walling

• Rooftop signal strength
  – Phones and Spectrum Analyzer readings
# Site Survey

### Rooftop Measurements

<table>
<thead>
<tr>
<th>Wireless Service Provider</th>
<th>Technology</th>
<th>RSSI</th>
<th>Signal Quality</th>
<th>Channel / PN</th>
<th>Channels in Band</th>
<th>Donor Site Azimuth</th>
</tr>
</thead>
<tbody>
<tr>
<td>VZW</td>
<td>CDMA</td>
<td>-68</td>
<td>-6</td>
<td>52</td>
<td>6</td>
<td>TBD</td>
</tr>
</tbody>
</table>
Site Survey

Spectrum Analyzer

M1: -97.46 dBm @ 899.0 MHz

CF: 881.5 MHz
RBW: 30 kHz
SPAN: 35.00 MHz
Attenuation: 1 dB

Serial #: 00844195
Model: MS2711D

Frequency (864.0 - 899.0 MHz)

Ref Level: -30.0 dBm
dB / Div: 10.0 dB

Date: 08/27/2009     Time: 07:33:24
Min Sweep Time: 1.00 Milli Sec
Detection: Pos. Peak

Model: MS2711D
Serial #: 00844195
Site Survey: Additional Questions

- Existing RF systems
- Roof Mount Area
- Headend Equipment Room
- Power and Wall Space
- MDF and IDF locations
- Type of cable – fire vs. plenum
Site Survey

- RF Obstacles such as stairs and elevators
- Interior wall materials
  - Concrete vs. drywall
- Ceiling heights and type
  - Drop-tile or hard ceiling
- Purpose of building
  - Dense or open environment
- Vertical chases
  - Between floors
In-Building Design
Design

• iBwave (RF-Vu + RF-Propagation) – Industry standard software that predicts wireless coverage for all major wireless technologies (iDEN, CDMA, GSM, WiMAX, 802.11b/g/a) for a variety of DAS technologies used to produce:
  – Design Drawings – highly detailed & accurate depiction of equipment placement including riser diagrams and floor by floor layouts
  – “Heat” Maps – color coded representation of predicted received RF levels

• Bill of Materials Development – determining accurate material quantities and types based upon technical requirements and cost

• Design Package – Scope of Work, Bill of Materials, Link Budgets & Design Drawings
Design

• We know the scope, carriers, and donor signals
  – Now what?

• Type of DAS
  – Coax vs. Fiber

• Head End Location

• Equipment manufacturers
  – Andrew, LGC, Mobile Access
Design: Typical Frequency Bands & Technologies

- AT&T: 850/1900 MHz GSM and UMTS/WCDMA
- Verizon: 850/1900 CDMA and EVDO
- Nextel: 800/900 iDEN/SMR
- Sprint PCS: 1900 CDMA and EVDO
- T-Mobile: 1900 GSM and AWS
- Public Safety: Varies, 800 MHz
Design: Wireless Thresholds

- Applies to 800/850/900/1900 MHz Voice
- -85 dBm mobile RSSI generally accepted over 90% of the area
- Higher RSSI levels required to overcome outside influences
- Typical radius can vary from 50 ft in dense environments to 100+ ft in open areas
- 1900 MHz typically limiting factor if WiFi or AWS not included (2100 MHz)
Design: Link Budget

Free Space Loss = 20\log_{10}(\text{MHz}) + 20\log_{10}(\text{Distance in Miles}) + 36.6
Design: Keys to Link Budget

- Power output at repeater or fiber remote
- # of channels per service provider
- Splitter and cable loss
- Free Space Path Loss
- # of wall penetrations
- Fade Margin
- Use link budget as guide for RF design
## Design: Link Budget

<table>
<thead>
<tr>
<th>Project Name:</th>
<th>Hilton Bonnet Creek</th>
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<tbody>
<tr>
<td>Antenna #:</td>
<td>ANT13</td>
</tr>
<tr>
<td>Distribution Cable:</td>
<td>Trilogy 1/2^2 Plenum</td>
</tr>
<tr>
<td>Distribution Antenna:</td>
<td>Andrew Omni</td>
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</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
<tr>
<td># of Channels:</td>
<td>8</td>
<td>8</td>
<td>2</td>
<td>12</td>
<td>6</td>
<td>2</td>
<td>Channels</td>
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<tr>
<td># of Additional WSP's Sharing Remote:</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<td>Remote Sharing Loss:</td>
<td>3.0</td>
<td>3.0</td>
<td>3.0</td>
<td>0</td>
<td>3.0</td>
<td>3.0</td>
<td>db</td>
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<tr>
<td>Type of remote:</td>
<td>Cell/PCS</td>
<td>1200 Bolt-On</td>
<td>1200 Bolt-On</td>
<td>Cell/PCS</td>
<td>Cell/PCS</td>
<td>1200 Bolt-On</td>
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<tr>
<td>Output at RHU Per Channel:</td>
<td>4.0</td>
<td>9.0</td>
<td>14.0</td>
<td>9.0</td>
<td>5.0</td>
<td>5.0</td>
<td>14.0</td>
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<td># of 2-Way Splitters:</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>db</td>
</tr>
<tr>
<td># of 3-Way Splitters:</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>db</td>
</tr>
<tr>
<td># of 4-Way Splitters:</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>db</td>
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<tr>
<td>Directional Coupler Loss:</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>db</td>
</tr>
<tr>
<td># of Connectors:</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>db</td>
</tr>
<tr>
<td>MA860's Present (1 = Yes, 0 = No):</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<td>Distribution Cable Length (50 Ohm):</td>
<td>250</td>
<td>5.9</td>
<td>8.8</td>
<td>8.8</td>
<td>5.9</td>
<td>8.8</td>
<td>8.8</td>
<td>db</td>
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<tr>
<td>Distribution Antenna Gain:</td>
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<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
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<tr>
<td>Signal Strength at Antenna Output:</td>
<td>-2.9</td>
<td>-0.8</td>
<td>4.2</td>
<td>-4.8</td>
<td>-14</td>
<td>4.2</td>
<td>dbm</td>
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<tr>
<td>Antenna Radius [ft.]:</td>
<td>85</td>
<td>59.8</td>
<td>66.6</td>
<td>66.6</td>
<td>59.8</td>
<td>66.6</td>
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<td># of Concrete Wall Penetrations:</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>db</td>
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<tr>
<td># of Sheetrock Wall Penetrations:</td>
<td>3</td>
<td>6.0</td>
<td>7.5</td>
<td>7.5</td>
<td>6.0</td>
<td>7.5</td>
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<td># of glass Window Penetrations:</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>db</td>
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<tr>
<td>Additional Clutter / Wall Loss (dB):</td>
<td>0</td>
<td>0</td>
<td>1.5</td>
<td>1.0</td>
<td>0</td>
<td>1.0</td>
<td>1.5</td>
<td>db</td>
</tr>
<tr>
<td>Body Loss:</td>
<td>1</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.5</td>
<td>db</td>
</tr>
<tr>
<td>Cubicles (1 = Yes, 0 = No):</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>db</td>
</tr>
<tr>
<td>Total Free Space / Clutter Loss:</td>
<td>66.8</td>
<td>75.1</td>
<td>75.6</td>
<td>75.1</td>
<td>66.8</td>
<td>75.6</td>
<td>db</td>
<td></td>
</tr>
<tr>
<td>Fade Margin (5 dB normal, 8 dB dense):</td>
<td>5</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>db</td>
<td></td>
</tr>
<tr>
<td>50% Loading (CDMA Only):</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>db</td>
<td></td>
</tr>
</tbody>
</table>

Mobile Rs Signal Strength at 85 ft.:  
- AT&T: -74.6 dBm  
- Verizon: -80.9 dBm  
- T-Mobile: -76.4 dBm  
- CDMA: -84.9 dBm  
- UMTS: -76.1 dBm  
- GSM: -79.4 dBm
## Design: Clutter Loss

<table>
<thead>
<tr>
<th>Clutter Type</th>
<th>800/900 MHz</th>
<th>1800/1900 MHz</th>
<th>2.4 GHz</th>
<th>5.8 GHz</th>
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<tbody>
<tr>
<td>Drywall</td>
<td>2</td>
<td>2.5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Plywood</td>
<td>1</td>
<td>2.5</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>Cubicles</td>
<td>1</td>
<td>1.5</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Glass (no shielding)</td>
<td>2</td>
<td>2.5</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Concrete</td>
<td>18</td>
<td>20</td>
<td>30</td>
<td>unk</td>
</tr>
<tr>
<td>Lead</td>
<td>45</td>
<td>50</td>
<td>60</td>
<td>unk</td>
</tr>
</tbody>
</table>
Design

Panel antennas in corridor facing out towards exterior

Panel antennas at windows facing interior core

Omni antennas in corridor or within tenant spaces
Design

Head-End and located in 1st floor Room # 100
Design

Hilton Lobby
Design

Convention Center 1st Floor

Connectivity

Hilton Bonnet Creek

Frank Pulido

Connectivity Wireless Solutions

9/29/2009
Installation
Installation

• Install In-Building Distributed Antenna Systems of All Sizes (5k - > 5M ft2)
• Offer Turn-Key or Stand-Alone Installation Services
• Manage Standardized Installations Nationwide
• Provide On-Site Project Management for Each Installation
• Maintain “Professionalism is Paramount to Connectivity” Motto
  – Professional Attire (Connectivity Logo Shirts, Brown/Black Steel Toed Boots, Khaki/Brown Pants)
  – Professional Treatment of Customers’ Facilities (Daily Work Site Clean-Ups, Minimal Ceiling Tile Openings, etc.)
  – Professional Installations (Cabling is professionally dressed, building and local codes exceeded)
• Create As-Built Documentation for Each Project
• **In-House Installation Team**
Installation – Potential Assumptions

• No core boring is required to properly install this distributed antenna system.

• End-user will allow use of existing 110 VAC for all DAS equipment. Any back-up power (UPS or generators) will be provided by the customer or the end-user.

• End-user will allow use of all existing cable trays and other cabling support structures (J-Hooks, etc.)
Installation – Potential Assumptions

• Customer/end-user has secured landlord and all other necessary approvals prior to installation.

• An existing roof penetration is available for donor antenna cabling. In the event that rooftop cabling cannot utilize existing penetrations, the owner of the roof system warranty must create an additional penetration.
Installation: Sample Donor Antenna

**MECHANICAL**

- Weight: 2.2 kg (5 lb)
- Dimensions (LxWxD): 787 x 152 x 25 mm (31 x 6 x 1 in)
- Max. Wind Speed: 201 km/h (125 mph)
- Hardware Material: Galvanized Steel
- Connector Type: N-Type Female (1, Bottom)
- Color: Gold
- Standard Mounting Hardware: V-Bolts
Installation: Sample Roof Mount

Non-Penetrating Flat Roof Mounts

<table>
<thead>
<tr>
<th>Part #</th>
<th>Description</th>
<th>Weight (Lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>103469</td>
<td>FRM Non-Penetrating Roof Mount (1.25&quot; O.D. Tubing, 60&quot; Overall Mast Height)</td>
<td>31.0</td>
</tr>
<tr>
<td>103490</td>
<td>FRM Non-Penetrating Roof Mount (1.50&quot; O.D. Tubing, 30&quot; Overall Mast Height)</td>
<td>29.0</td>
</tr>
<tr>
<td>103491</td>
<td>FRM Non-Penetrating Roof Mount (1.66&quot; O.D. Tubing, 30&quot; Overall Mast Height)</td>
<td>30.0</td>
</tr>
<tr>
<td>103492</td>
<td>FRM Non-Penetrating Roof Mount (2.375&quot; O.D. Tubing, 30&quot; Overall Mast Height)</td>
<td>32.0</td>
</tr>
<tr>
<td>103493</td>
<td>FRM Non-Penetrating Roof Mount (2.375&quot; O.D. Tubing, 60&quot; Overall Mast Height)</td>
<td>37.0</td>
</tr>
</tbody>
</table>
**Installation: Sample Repeater**

<table>
<thead>
<tr>
<th>Dimension (W x H x D)</th>
<th>1900</th>
<th>14.6 x 19.3 x 9.0 inches (370 x 490 x 229 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1900-1W</td>
<td>14.6 x 19.3 x 9.0 inches (370 x 490 x 250 mm)</td>
</tr>
<tr>
<td></td>
<td>1900-2W</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>1900</td>
<td>47 lbs (21.3 kg)</td>
</tr>
<tr>
<td></td>
<td>1900-1W</td>
<td>60 lbs (27.2 kg)</td>
</tr>
<tr>
<td></td>
<td>1900-2W</td>
<td></td>
</tr>
<tr>
<td>RF Connector</td>
<td>N-Type (Female)</td>
<td></td>
</tr>
<tr>
<td>Control Interface</td>
<td>RS232</td>
<td></td>
</tr>
<tr>
<td>Weather Resistance</td>
<td>NEMA 4, IP65</td>
<td></td>
</tr>
<tr>
<td>Power Supply</td>
<td>90 – 130 V, 45 – 65 Hz</td>
<td></td>
</tr>
<tr>
<td>Operating Temperature</td>
<td>-22 °F to +140 °F (-30 °C to +60 °C)</td>
<td></td>
</tr>
<tr>
<td>Cooling</td>
<td>External Convection</td>
<td></td>
</tr>
</tbody>
</table>
Installation: Sample ½” Coax

Premium Performance Cable

Center Conductor
The center conductor of the cable consists of a copper clad electrical grade aluminum wire, nominal 10% copper by weight which conforms to ASTM B-566, class 10A. This lightweight conductor provides both high quality and strength.

Conductor Adhesive
The center conductor is coated with a proprietary adhesive that ensures the discs are securely bonded to the center conductor.

Dielectric Discs
The dielectric discs are injection molded from virgin polyethylene (ASTM D-1248). These discs are regularly spaced to provide structural integrity while minimizing attenuation.

Aluminum Outer Conductor
The outer conductor is a continuously formed corrugated and welded electrical grade aluminum tube. In-process monitoring assures weld integrity maintains proper aluminum thickness, and corrects physical dimensions.

Jacket
The jacket is composed of a highly flame retardant, low smoke material meeting the fire resistant provisions for plenum applications. Consequently, this cable is certified according to the test methods of UL 910 and the listing requirements of NEC 820.51 and NEC 820.53 (b) for CATV cables. In addition, it exceeds F16 provisions of the Canadian Electric Code.

Mechanical Characteristics

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Single</th>
<th>Multiple</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min. Bend. Radius, in (mm)</td>
<td>2 (50.8)</td>
<td>5 (127)</td>
</tr>
<tr>
<td>Cable Weight, lb/ft (kg/m)</td>
<td>0.129 (0.192)</td>
<td></td>
</tr>
<tr>
<td>Bending Moment, ft.lb (Nm)</td>
<td>1 (1.4)</td>
<td></td>
</tr>
<tr>
<td>Tensile Strength, lb (kg)</td>
<td>250 (114)</td>
<td></td>
</tr>
<tr>
<td>Flat Plate Crush, lb/in (kg/mm)</td>
<td>78 (1.39)</td>
<td></td>
</tr>
<tr>
<td>Number of Bends, minimum</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>Number of Bends, typical</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Temperature, °F (°C)</td>
<td>+5 to 194 (-15 to 90)</td>
<td></td>
</tr>
</tbody>
</table>

Recommended Install: +5 to 194 (-15 to 90)
Recommended Storage: +5 to 194 (-15 to 90)
Installation: Sample Distribution Antenna

**CELLMAX-O-25**
Cell-Max™ Omnidirectional In-building Antenna, 806–960 MHz and 1710–2700 MHz

### Mechanical Specifications

<table>
<thead>
<tr>
<th>Mounting</th>
<th>Thru-hole ceiling mount (optional)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pigtail Length</td>
<td>254.0 mm</td>
</tr>
</tbody>
</table>

### Environmental Specifications

<table>
<thead>
<tr>
<th>Application</th>
<th>Indoor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Temperature</td>
<td>-40 °C to +60 °C (-40 °F to +140 °F)</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>Up to 100%</td>
</tr>
</tbody>
</table>

### Dimensions

| Diameter, maximum         | 165.00 mm | 6.50 in |
| Height                    | 85.00 mm  | 3.35 in |
| Length                    | 165.00 mm | 6.50 in |
| Net Weight                | 0.30 kg   | 0.66 lb |
| Width                     | 165.00 mm | 6.50 in |
Commissioning
Commissioning

Commissioning Services

- Coaxial Cable and Fiber Testing
  - Coaxial Cable Sweeps
  - Fiber OTDR Results

- Active Component Commissioning
  - Bi-Directional Amplifier Set-Up
  - Fiber DAS Commissioning (LGC, Andrew)
  - Measure and Record RF Input/Output Levels for All Active DAS Components

- Customer Defined “Checklists”
Maintenance
Maintenance Services

• Preventive Maintenance Routines
  – Quarterly, Semi-Annual, or Annual
  – Cable Sweeps and OTDR testing
  – Comparison of baseline RF to current RF environment
  – Equipment inventorying and labeling
  – Update as-built documentation

• Response & Repair
  – 24x7x365
  – Customized SLAs and Maintenance Contracts
  – Regular Updates
    • Ticket received, in-route, on-site, problem isolated, problem fixed

• System Monitoring
  – Monitor In-Building DAS elements from all vendors
  – System impairment communication management
  – Personnel dispatch
  – 24x7x365
  – Customized Monitoring Contracts
Carrier Coordination
Carrier Coordination

- Necessary to obtain permission from wireless service providers
- Purchased frequencies from FCC/US Government
- Re-transmission agreements
  - Repeaters or microcell
- Potential RF issues generated
  - Noise floor, oscillation, frequency-specific, etc
- Carrier monitoring/database
- Public Safety
Thank You. Questions?

Bryce Bregen
Sales Director
602.321.6555
bbregen@connectivitywireless.com

Connectivity Wireless Solutions
3400 Corporate Way, Suite G
Duluth, GA 30096
www.connectivitywireless.com