CommScope®

In-Building Wireless Coverage and the Case for Pre-wiring with CommScope's Wired for Wireless™ Solution

White Paper — March 2010

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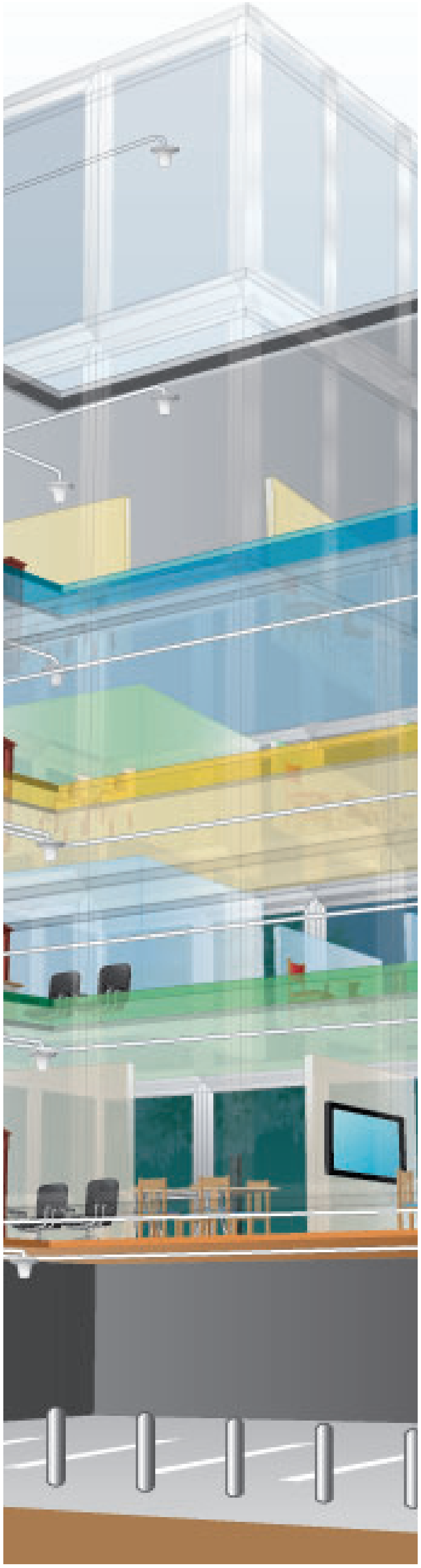

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Introduction

Wireless cell phone coverage in general, and In-Building Wireless Solutions (IBWS) specifically, have consistently grown over the past 20 years. What was once available only for high value executives is now indispensable for all. Technological changes have provided the platform for an unlimited number of wireless services available anytime, anywhere… as long as there is coverage. The wide-spread use of cell phones throughout every strata of society has made the mantra of "indoor coverage everywhere" a universal goal, from the high-rise office building and bustling manufacturing center to the local mall and big box store, from the apartment complex and hospital to the single family home. As subscriber penetration moves beyond 100%, expectation and real economics demand coverage everywhere. This need is juxtaposed with traditional ROI constraints as well as access and ownership issues, but perhaps the most difficult impediment of all is the mystique in planning such a system.

In-Building Wireless Design Considerations

In the macro world, over the past 20 years, the design of cellular systems has evolved from planning a purely coverage model (high power, high elevation sites) to a capacity model, lower power, lower elevation sites. Indoors, a similar phenomenon is also taking place. In the past, the only goal was for basic coverage, but today's requirements demand uniformity and future proof upgradeability. The key driver for this is the constant addition of new services and subsequently new frequency bands, utilizing more and more capacity and thus requiring higher and higher signal-to-noise levels. The need to future proof a building for indoor wireless coverage is critical as the cost and inconvenience of disturbing the building continues to rise.

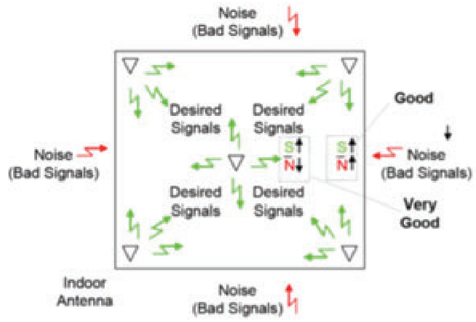
Minimum Signal Level Thresholds

For mobile devices to perform optimally they require a minimum signal-to-noise ratio. However, signal-to-noise ratios require an understanding of the particular environment's noise, which changes over time, by time of day, by year and by location, changes that are generally out of control of the designer of the indoor system. It is therefore critical to design the system in such a way that it will be fairly immune to the outside effects. This requires both a receive signal strength of -80dBm or better and an informed positioning of the antennas.

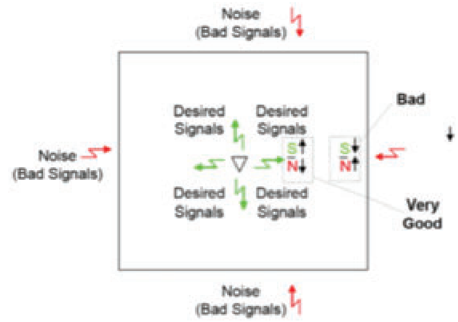
Antenna Locations

Placing antennas in the appropriate locations is one of the most critical factors in maximizing the effectiveness of the indoor wireless system and simultaneously making it future proof. In many environments that have partial coverage around the outer walls of the building, one might think of placing the indoor antennas purely in the center to provide coverage where there is none. This is often viewed as the least expensive solution, which may initially be true; however, it provides the worst possible system performance and the least likely future proof solution, making the total cost of ownership very high.

To ensure uniform coverage, the indoor antennas must be evenly spaced throughout the building, with no perimeter antenna further than 20ft (6m) from an outer wall. The outer ring of antennas can be directional (although omni-directional antennas will also work), pointing back into the building, almost as if the building is being covered by a blanket of invisible signals. In this way, the signals from the indoor antennas will swamp out the signals from the outside environment, forcing all devices in the building to gain network access through the building's system, thus making their experience uniform and controllable.

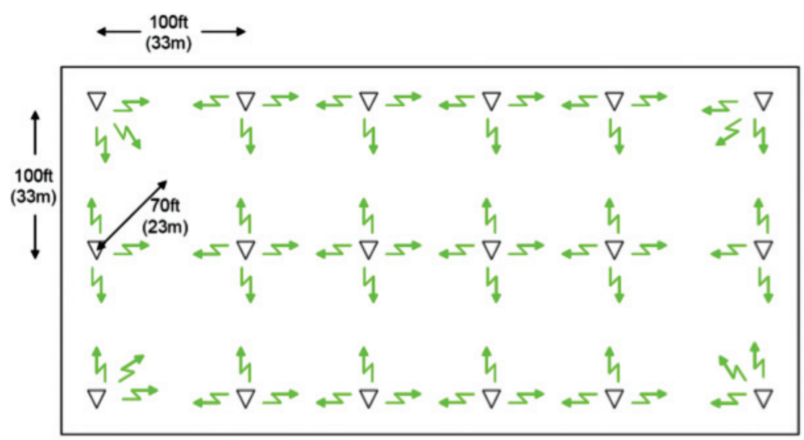


Desirable Antenna locations



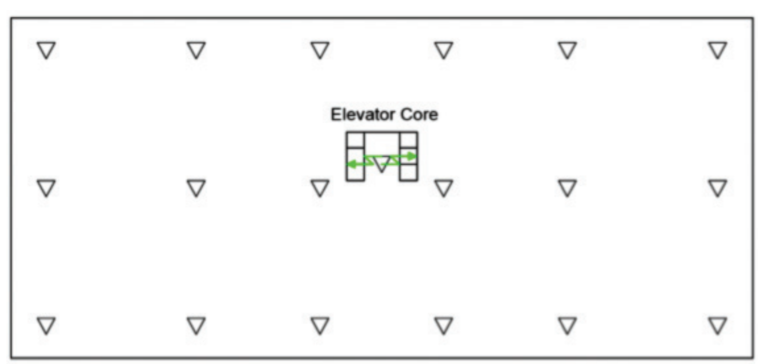
Undesirable Antenna Locations

In addition to placing antennas at the edge of the building, it is ideal to spread them evenly throughout the building, in a grid pattern that is much the same as used for Wi-Fi (802.11) systems in the 2.4GHz band. To ensure uniform coverage, antennas are placed throughout the building at 100ft (30m) intervals. This will provide an antenna point within 70ft (23m) of any user, which provides homogeneous RF coverage and thus uniform service throughout the structure.



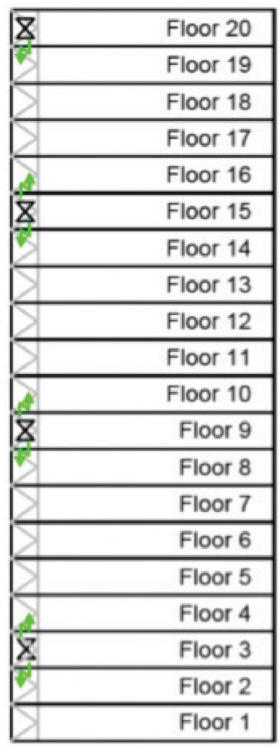
On Grid Antenna Locations

There are two other situations that dictate where antennas should be placed. In the event there is an elevator core, an antenna must be placed on each floor within 20 feet (6m) of the elevator. In this case the requirement is to penetrate what is mostly a metal box, which is highly resistant to RF penetration.



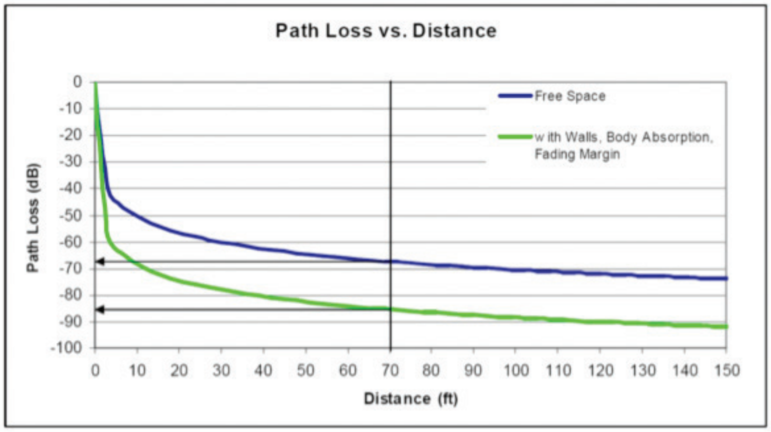
Coverage of the Elevator

The final coverage requirement (mostly for public safety applications) is to cover stairwells. Typically stairwells are shielded by massive amounts of concrete and steel rebar and very little RF can penetrate such a structure. An antenna must be placed on every 6th floor (starting with floor 3) within the stairwell itself. This requirement changes to an antenna every other floor if the stairwell has no central opening (if you cannot see floor to floor in the stairwell). In stairwells the antenna should be a wall-mounted omni-directional antenna or two directional antennas may be used, one pointing up, the other down, so each antenna covers 3 floors up and 3 floors down. Since this is an area which does not have a great deal of traffic for commercial purposes, the deployed frequencies may only be public safety, however, the media (cable) and antennas will, in all cases, work for both systems.



Coverage of the Stairs

In the final analysis the objective above is to blanket the entire building with signals that are received by the mobile devices at -80dBm/carrier or better. Although this paper will not go through the math required for link budget analysis it is valuable to see how RF signals attenuate with propagation and to understand that other materials such as walls or people also absorb RF energy and therefore attenuate signals as well. In a custom designed building, test transmitters are temporarily setup and RF losses are measured, and in addition a signal scan is performed to measure the outside environment. With the above mentioned design principles, this costly and time consuming design step is eliminated and a slightly more conservative design approach is taken with respect to antenna placement. By reducing the spacing between antennas it is safe to conclude that any point in the building is no more than 2 walls away to the nearest antenna and thus attenuation factors can be managed. With these design rules the attenuation from walls can safely be approximated by 10dB of path loss. Furthermore the reduction in distance allows a fading margin to be established at a scant 5dB. Finally, free space loss can be determined explicitly for the maximum distance of 70ft (23m).



Path Loss in a Building with a 100 ft Antenna Grid

At 70ft (23m) one can see there this is 85dB of attenuation. Since the antennas used in an installation have approximately 3dB of gain, then to attain the -80dBm receive signal strength, the signal into those antennas should be +2dB. How one would get this output power to the antennas is the subject of the next section.

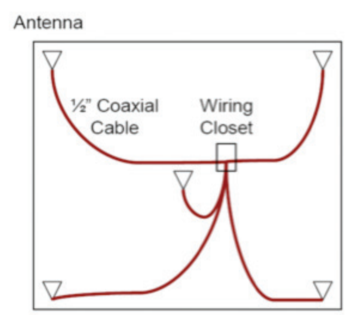
The Antenna Location Design Rules

- Perimeter antennas within 20ft of the edge of the building
- Antennas spaced at 100 ft intervals
- 1 antenna per floor within 20 ft of the elevator core
- 1 back-to-back antenna every 6 floors in the elevator shaft starting on floor 3 (unless the stairwell has no central opening, i.e. you cannot see floor to floor in the stairwell, in which case antennas are required on every other floor).

Path Loss vs. Distance

Laying the Media

Once the prior design rules are understood, it becomes easy to establish where the antennas should be located. The antennas must be connected to a signal source somewhere. The first leg of this connection is a ½" coaxial cable. The reason for this choice is one of bandwidth. Just as the antenna is capable of passing multiple signals and multiple services, so is coaxial cable. To ensure a future proof design, the antennas are each connected to their own coaxial cable and the cable is in turn routed directly above the drop ceiling back to a wiring closet. Both sides of the coax are terminated in an N-type male connector. To limit the loss within the coaxial cable to 10dB, no cable run may be longer than 300ft (91m). The length of each cable and the location of the antenna with which the cable is mated must be recorded so as to make the rest of the system design easy.



Routing the coaxial Cable

The Coaxial Cable Routing Rules

- Each antenna shall be connected by ½" plenum rated coaxial cable
- The coaxial cable shall run directly from the antenna to a wiring closet within 300ft (91m)
- Each end of the coax shall be terminated with a N-type male connector
- Records shall be kept on the length of each cable and the location of the antenna mated to it

The Rest of the In-Building Wireles Solution
At this point IBWS architectures tend to vary. Some will connect to passive equipment with additional lengths of coaxial cable, while others will connect with active equipment (Remote Units) which will backhaul the signals over fiber. This paper is targeted at design and installation of the final leg of the IBWS and thus will not discuss the merits and faults of each system. Instead it wishes to stress that regardless of the rest of the IBWS and its frequencies, and the services that are desired today or tomorrow, the passive infrastructure investment will be viable.

Why Design and Install the Horizontal Runs for an IBWS During Initial Building Construction?

There are two fundamental reasons that make the installation of passive media for IBWS during construction desirable and intelligent: Cost and Convenience.

Cost
Placing cable in cable trays or above a drop ceiling before a building is completed is quick and easy. Installing electrical wiring, communication wires or for that matter plumbing, when a building is initially built is efficient, while adding post construction infrastructure is costly, and the same applies for the placement of coaxial cables and antennas. It is not uncommon for the cost of a major retrofit to a building to be so high that it is demolished and rebuilt rather than retrofitted. It is estimated that the installation cost post-construction for the horizontal runs of an IBWS is more than 4 times that of pre-construction work. Furthermore the installation of a length of coaxial cable post-construction can run 2 to 4 times greater than the cost of the coaxial cable itself. When designing the cabling in a building today, one often puts in more material than is needed. An office might have 2-4 times as many electrical outlets than are used at any one time, or have 2-4 structured cabling jacks, even though less than that are initially in use. This is good, future proof planning, and a similar strategy should be taken with horizontal portion of an IBWS. Assuming conservatively that a single antenna and cable feed will cover approximately 5000 ft^2, and that an office is approximately 10ft x 12ft, a cubical 8ft x 8ft and 20% of building is common space (hallways, bathrooms, etc), then each antenna will cover between 15 and 20 people. This same group of people will require more than 60 power outlets and 30-40 structured cabling jacks and a bathroom. The cost of the vital wireless IBWS horizontal feed communication channel pales in comparison to every other service.

Convenience
Just as the cost increases steeply when adding new infrastructure after a building is completed, so does the disruption to the building occupants. Adding additional wiring to a warehouse is relatively easy, as there are no ceilings to contend with and few people are disrupted. In a typical office this becomes more intrusive as a drop ceiling must be removed, and people may have to be displaced during installation. In certain structures, like airports, infrastructure must be renovated during the night so as to minimize this disturbance (which increases costs). Perhaps the most difficult structure of all to retrofit is a hospital. Not only can it have public spaces which can be accessed only during restricted times, but it has requirements for air quality and thus special care and equipment must be used to eliminate particulates. This takes time and slows down the installation process and thus creates an even bigger inconvenience and cost.

Summary

Most companies and individuals consider their wireless services (both commercial and public safety) to be indispensable. The future holds more services that will become even more critical to everyone's day-to-day life. Pre-wiring a building with broad band coaxial cable and antennas during construction and/or installation of other structured cabling systems is a cost effective, non-disruptive, and intelligent way to plan for today and tomorrow.

CommScope's Wired for Wireless™ Solution

CommScope's Wired for Wireless™ Solution is a carrier-neutral structured infrastructure solution that enables mobile communications inside buildings eliminating dead zones and spotty coverage. The Wired for Wireless Solution's unique structured design makes wireless coverage inside buildings dramatically more affordable by simplifying installation and eliminating the need for costly site surveys and custom network designs. The solution's design includes coaxial cables, connectors, antennas and cable management apparatus connected together in such a way as to provide a blanket of wireless coverage throughout an entire building. Designed with your future in mind, the Wired for Wireless Solution will help you meet your evolving indoor wireless needs for years to come. Backed by CommScope's 20 Year Product Warranty and installed by a trained CommScope BusinessPartner, the Wired for Wireless Solution has your wireless future covered.

CommScope Wired for Wireless™ Solution Components

High performance indoor antennas, coaxial cables, connectors, and cable management apparatus ensure that the Wired for Wireless Solution delivers a cost and performance optimized platform that is ready for carrier-neutral and uniform wireless coverage in Enterprise buildings.

CommScope Wired for Wireless™ Antennas
The Wired for Wireless Solution includes two multi-band indoor antennas from the Andrew Cell-Max® family. Cell-Max antennas feature a multiband design that allows a wide range of frequencies to be transmitted and received by a single, small antenna. Designed for ease of installation and minimal visual impact, these compact and unobtrusive antennas include a built-in low loss coaxial pigtail with N-type female connectors.

Cell-Max® Omnidirectional Antenna
The CELLMAX-O-CPUSE antenna is a ceiling mounted omnidirectional indoor antenna designed for the 698-960 MHz and 1710-2700 MHz frequency ranges. It supports all modulation formats and technology including, Analog, iDEN, GSM, GPRS, EDGE, UMTS, HSDPA, HSUPA, LTE, CDMA2000, EV-DO, Wi-Fi, Wi-Max and many more.
CELLMAX-O-CPUSE

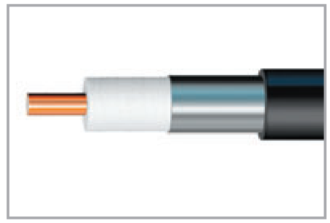
Cell-Max® Directional Antenna
The CELLMAX-D-CPUSE antenna is a wall mounted directional indoor antenna designed for the 698-960 MHz and 1710-2700 MHz frequency ranges. It supports all modulation formats and technology including, Analog, iDEN, GSM, GPRS, EDGE, UMTS, HSDPA, HSUPA, LTE, CDMA2000, EV-DO, Wi-Fi, Wi-Max and many more.
CELLMAX-D-CPUSE

Wired for Wireless™ Cables and Connectors

CommScope's Wired for Wireless Solution includes two high performance ½ inch 50 ohm coaxial cables from the Andrew HELIAX® cable family, and N-type male coaxial connectors designed to match each cable. The Low Smoke Zero Halogen FXL-540-NHR and the Plenum AL4RPV-50 cables, and their matching connectors, provide optimal options for horizontal, riser rated and plenum applications.

Low Smoke Zero Halogen FXL-540-NHR HELIAX® Cable and EZFit® 540EZNM Connector

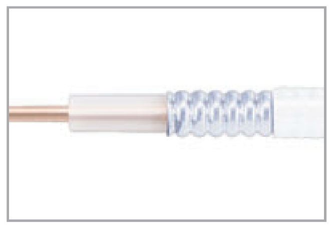
FXL-540-NHR HELIAX® cable
The FXL-540-NHR cable is a flexible ½ inch 50 ohm coaxial cable, with a black PE jacket, a smoothwall aluminum outer conductor, foam PE dielectric and a copper clad aluminum inner conductor. With its light-weight and cost effective construction, the FXL-540-NHR cable is easy to install and delivers excellent transmission performance. FXL-540-NHR HELIAX® cable



EZFit® Connector for FXL-540-NHR cable
The 540EZNM EZFit® connector is a high performance N-type male connector that is a perfect match for the FXL-540-NHR cable. The 540EZNM is a small and lightweight two-piece connector designed for easy installation and optimal electrical performance. High precision cable preparation and 540EZNM connector attachment is achieved with the 12-HPT EZFit hand prep tool or the 540-ZPT EZFit drill prep tool.

Plenum Rated HELIAX® AL4RPV-50 Cable and LT4NM-PSA Positive Stop® Connector

AL4RPV-50 HELIAX® cable
The AL4RPV-50 cable is a flexible ½ inch 50 ohm plenum rated coaxial cable, with an off-white PVC jacket, a corrugated aluminum outer conductor, a PE Spline air dielectric and a copper clad alumimum inner conductor. With its light-weight and cost effective construction, AL4RPV-50 cable is easy to install and delivers excellent transmission performance.



Positive Stop® Connector for AL4RPV-50 cable
The LT4NM-PSA Positive Stop connector is a high performance N-Type male connector that is the perfect match for the ALPRV-50 cable. The LT4NM-PSA Positive Stop connector is a small and lightweight connector designed for ease of installation and optimal electrical performance. The LT4NM-PSA connector can be installed with standard tools. Cable preparation for LT4NM-PSA-PSA connector attachment can be achieved with MCPT-L4 EASIAX® manual cable prep tool or the drill-assisted EASIAX® Plus CPT-L4ARC1 automated cable prep tool.

Wired for Wireless 20 Year Extended Product Warranty

Because CommScope has such high standards for performance and reliability — and understands that the right network infrastructure is essential to the successful operation of today's business — CommScope stands behind our products for up to 20 years. Our commitment to quality is also shared by our extensive global network of authorized BusinessPartners. Our global footprint ensures that your Wired for Wireless solution, when designed and installed by a CommScope BusinessPartner, will be backed by a comprehensive 20 Year Product Warranty. CommScope's Wired for Wireless Solution has the Enterprise covered.

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