THE ULTIMATE GUIDE TO

Distributed Antenna Systems

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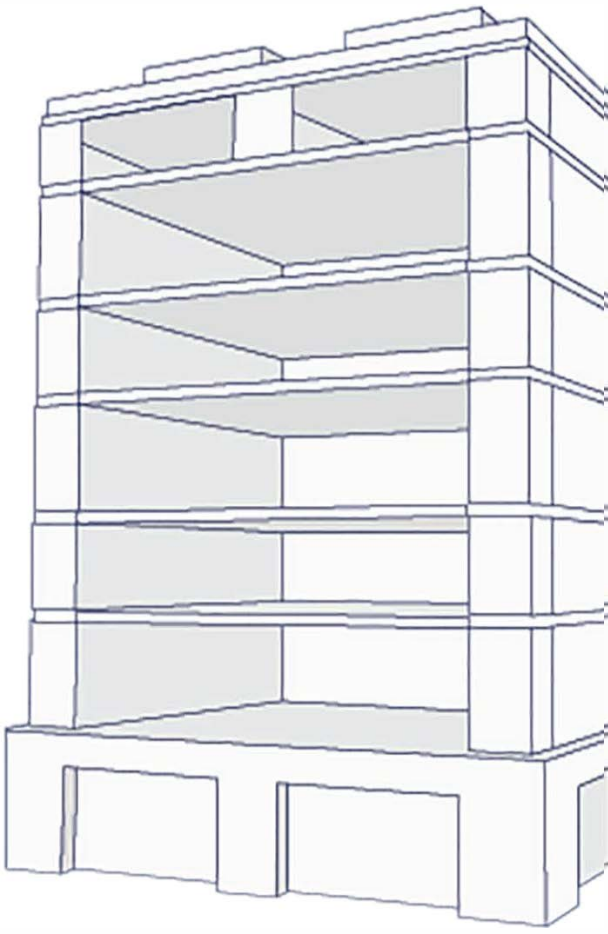

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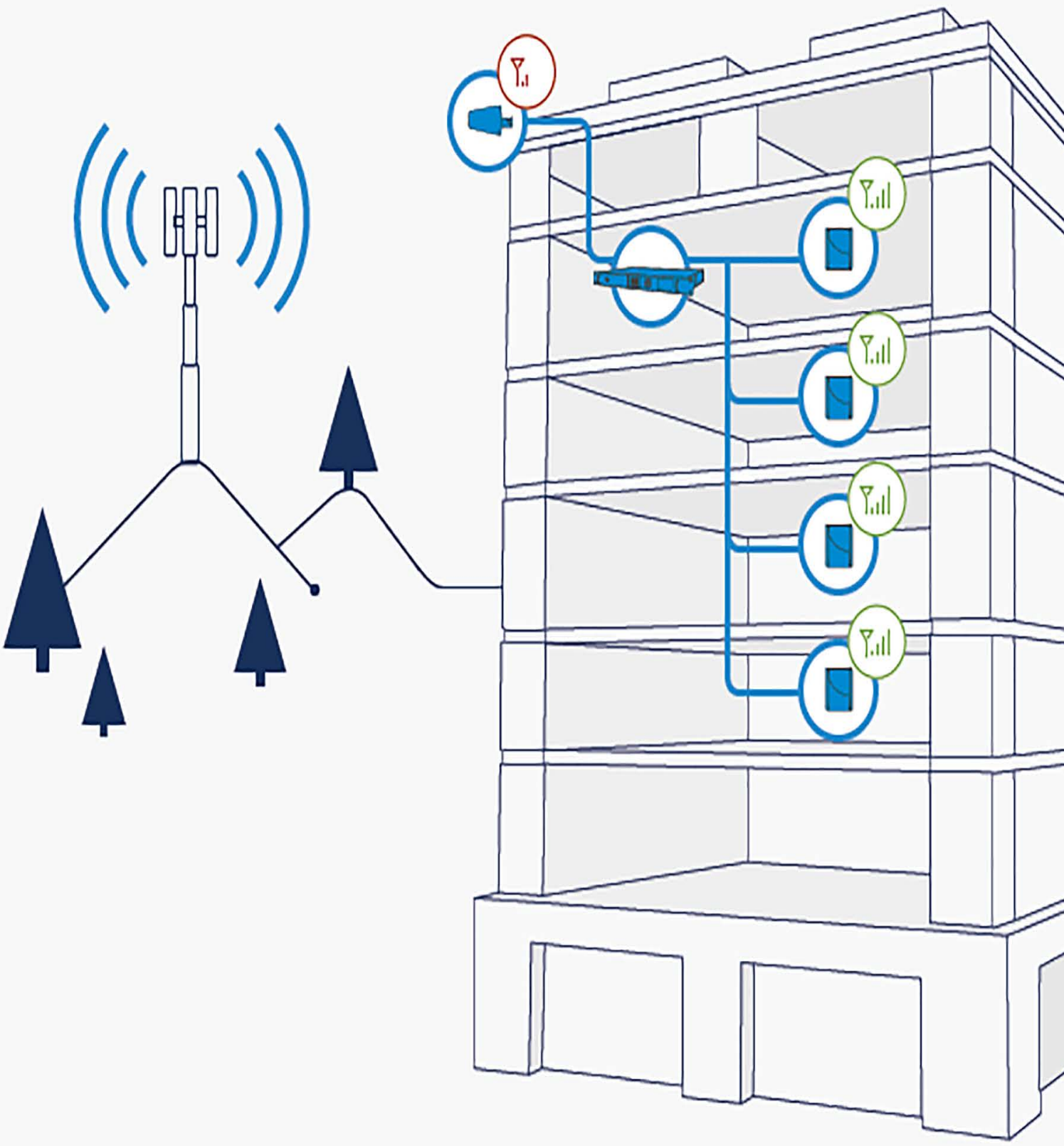


The Ultimate Guide to Distributed Antenna Systems

During the second half of 2016, Americans reached an important milestone in the history of cellular communications: It was the first time that the majority of homes owned only wireless phones. According to the Centers for Disease Control, 51 percent of American homes owned at least one cell phone and did not use a landline.

With so much of America dependent upon cellular connections, individuals and businesses alike understand the frustration of weak cell signals, dropped calls, or being unable to get online. Just as the technology of smartphones has evolved, so too have the solutions for keeping the masses connected.

Whether using cell phones for personal or business purposes, consumers have come to expect five-bar, reliable service. Fortunately, Cellular Network Engineers have developed numerous solutions to meet modern cellular connectivity needs. Whether in remote areas or inside structures made of signal-sapping building materials, there are a variety of choices to solve lack of cellular signal and constant dropped calls. Passive and active distributed antennas systems (DAS) have become the most popular go-to solutions.

DAS can address problems and ease frustrations, from the biggest spaces to the smallest. In fact, despite the perception that DAS is only for arenas and other massive spaces, 90 percent of the DAS solutions in use today are actually used in smaller spaces.

Choosing the Best Distributed Antenna System (DAS)

DAS come in active, passive, hybrid, and digital forms. While smaller users with lower capacity needs can consider alternative wireless connectivity solutions for their businesses or homes, the decision for commercial users often comes down to two: passive or active DAS. It's the task of the integrator to determine whether passive or active DAS is the best solution for each client's unique needs.

While integrators certainly understand the difference, sometimes it's difficult to explain why one solution is better than the other to the customer. The following section can serve as a helpful resource for customers themselves, and for integrators looking to explain the various options to their customers.

Active DAS

The most robust and infrastructure-intensive cellular connectivity solution is an active DAS. Active DAS provide carrier-grade, high-capacity infrastructure solutions for large areas. It's commonly the first solution integrators and users turn to — but should it be?

An active DAS creates cellular signal to provide coverage. The system distributes the signal between a centralized signal source and remote nodes placed around a building. An active DAS system accommodates large areas where thousands of users access the network in a confined space. Think airports and arenas.

Despite the strengths of active DAS, the installation process is complex. An active DAS requires a significant investment of time, infrastructure and capital, including the construction of a dedicated backhaul.

In fact, active DAS can end up costing users millions of dollars and take a year or more to implement. A single-carrier active DAS costs between $2 and $4 per square foot. For a multicarrier solution, costs increase to $5 to $10 per square foot. In some cases, there are additional recurring support fees for the dedicated fiber optics and backhaul requirements.

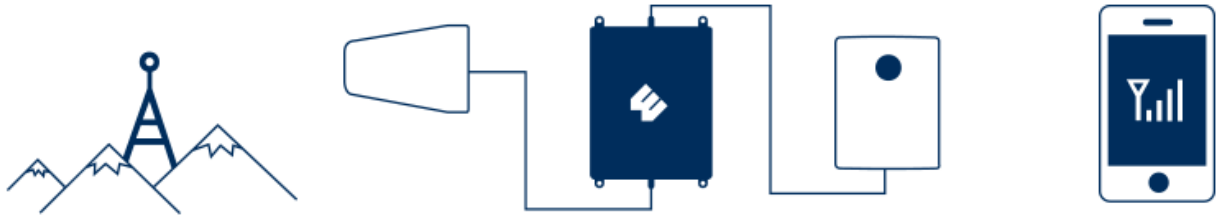
To put those numbers in perspective, consider these statistics:

- There are about 5.6 million commercial buildings in the United States.
- 94% of commercial buildings in the U.S. are smaller than 50,000 square feet, and 88% are less than 25,000 square feet.
- For business owners running the neighborhood pharmacy or a small boutique hotel at or below those footprints, the cost of active DAS per square foot simply doesn't make economic sense. It would not be a sound business decision for a 12-room hotel to invest half a million dollars in making sure their guests can browse Instagram or upload photos to the app in their rooms, for example.
- Only about 2% of the commercial facilities in the United States are good candidates for active DAS (because they're larger than 100,000 square feet in size.)

Another point to consider: Per FCC regulations, active DAS not only requires carrier approval, but requires coordination and integration with the carrier network. Therefore, carrier engineers must be involved in the deployment. Unless you're working on a large airport or stadium project, do you have the time and resources to work on multiple active DAS projects at once?

Passive DAS

A passive DAS (also known as a cell phone signal booster system) eliminates cellular connectivity problems by enhancing existing cell signal up to 32 times using antennas and amplifiers. It does not require new signal to be created as with active DAS.



The hardware and installation requirements of a passive DAS system are far less expensive and can be installed faster than what's required for active DAS:

- Donor antennas installed on the roof or near a window bring in the outdoor signal.
- Broadcast or "inside" antennas on the interior wall (panel antennas) or ceiling (dome antennas) then transmit the amplified signal to phones and other cellular devices indoors.
- Both types of antennas connect to the amplifier unit via coaxial cable.

Passive DAS conform to FCC regulations and generally do not require outside regulatory approval. Since most systems are pre-approved, and because of the low infrastructure requirements for installation, a passive DAS can be installed in a matter of days or weeks.

With less overhead, fewer regulations, and lighter equipment than other options, a passive DAS is a financially viable option for a wide range of users. Costs for hardware and installation of passive DAS range anywhere from 30 cents to 70 cents per square foot.

Going back to the example of that 50,000 square foot boutique hotel, it makes far more sense for the owner to consider a $15,000 investment in ensuring excellent cellular connectivity throughout the hotel vs. a $500,000 investment.

Plus, many passive DAS are carrier-agnostic and support multiple carriers simultaneously. So, whether your clients use major carriers like AT&T, T-Mobile, Verizon, and Sprint, or smaller regional carriers, a passive DAS ensures everyone gets the same amplified signal.

	WI-FI	NETWORK EXTENDER	DIGITAL APPLICATIONS	ACTIVE DAS	PASSIVE DAS
CARRIER AGNOSTIC	YES	NO	YES	NO	YES
BUILDING SIZE	Unlimited	<7,500 sq ft	Unlimited	>500,000 sq ft	Unlimited
USER CAPACITY/ RELIABILITY	Low	Low	Low	High	High
SECURITY	Low	Low	Low	High	High
BUDGET	$	$	$	$$$$	$$
EASE OF INSTALLATION	Easy	Easy	Easy	Difficult	Moderate

Applying DAS to Different Venues

Passive DAS should be considered as a viable option regardless of industry or the size of a business. Passive DAS can be effectively deployed in industries spanning retail, hospitality, hospitals/medical, and restaurants.

With the exception of extremely large venues, such as airports and arenas where thousands of people are consuming cellular bandwidth, passive DAS is a feasible and effective solution.

Passive DAS for retail

Retailers prioritize customer engagement and the in-store shopping experience. Increasingly, this includes providing strong connectivity in the store to allow shoppers easy access to the Internet and coupon apps. A passive DAS helps achieve this enhanced retail connectivity both outdoors and inside retail spaces, regardless of patrons' cellular provider. With passive DAS, all carriers are supported.

What's more, retail cell phone booster solutions like passive DAS enhance security and point-of-sale reliability. Just think about how a slow or unresponsive system, and the associated lines and waiting, can cost retailers a sale. Additionally, lack of a secure Internet connection can hinder credit card validation and increase fraud rates. A cellular backup can both alleviate these concerns and reduce costs over solely using a fixed line connection.

Passive DAS for commercial real estate

Despite sitting in range of multiple cellular towers, buildings located in crowded urban environments often suffer from poor cellular connection. It's a problem that frustrates even the most experienced commercial real estate developers, and it can often be attributed to new energy-efficient building materials that sap even the strongest cellular signals. As an integrator, you can offer these developers a commercial real estate cellular solution, thanks to passive DAS.

As a multi-carrier solution, passive DAS offers developers a connectivity solution that meets the needs of all of their tenants, regardless of what cellular provider they use. Additionally, the affordability and reduced installation requirements of passive DAS help developers meet their obligations when it comes to their bottom line.

Passive DAS for hospitals

Hospitals and other medical facilities increasingly rely on cell phones and wireless devices for their in-house communication, leaving doctors and caregivers more reliant than ever on consistent cellular and data signal.

Unfortunately, hospital cellular signals are easily overwhelmed by staff, patients and visitors, or negatively impacted by building materials like brick, concrete, steel and glass. When doctors, nurses, and other caregivers can't connect with one another, patient care suffers. That's where passive DAS comes in.

Many hospitals first consider active DAS as the solution for their connectivity problems. But with hospital budgets under scrutiny, administrators are increasingly looking for ways to lower costs while still prioritizing quality care. Passive DAS offers a cellular connectivity solution for hospitals with the added benefits of financial savings, reduced installation time, and multi-carrier capacity.

Passive DAS for live events

Modern event spaces need robust cellular signal whether they host local weddings and parties or the Grammys. Live tweeting, streaming, and instagramming are all critical parts of a modern event's success, but without a strong, carrier-agnostic cellular and data connection, it's all virtually impossible.

Passive DAS systems provide an event cellular connectivity solution and have been deployed with great success at New York Fashion Week and other events. As an integrator, you can help event coordinators check the cellular connectivity box on their planning checklist.

Passive DAS for hotels

The demands of hotel guests used to be relatively simple: clean sheets, a comfortable bed, and good customer service. Today, that's not enough. Cellular connectivity is not another critical area where all hotels need to deliver superior service to guests.

Business travelers need to check email and make work calls from their cellphones and leisure travelers need to check in at home, read up on local restaurants, and more. Plenty of hotels offer Wi-Fi, but without a strong hotel cellular signal to supplement it, guests might as well be living off the grid.

Passive DAS provides a time- and cost-effective connectivity solution for hotel developers and IT managers. Whether the hotel is under construction or up and running, you can offer a way to enhance cellular service for their guests.

Passive DAS for public safety

Coordinating responses to emergency situations relies on connectivity. A reliable cellular signal can reduce response times, help first responders prepare for situations, and increase the odds of positive outcomes.

When emergency medical teams and public safety officers can access a strong cellular network, they are better able to utilize critical location services and maps, and communicate with one another to do their jobs. Passive DAS can help improve cellular network access in police stations, firehouses, courthouses, and emergency vehicles. With a passive DAS in place, the improved connection results in safer, more efficient operations and enhanced public safety.

Installation Planning Guidelines for Success Inside and Outside

Of course, there are a number of steps that will ensure a successful installation, starting with a site survey. Knowing the layout of the building and existing cell signals will give you the

information you need to speak with your customer about why their calls are dropping and how you plan to fix the problem.

This begins with using a signal meter to test for signal strength.

While the average consumer may not realize it, installers know well that measuring signal strength based on where the service *seems* the best is not the proper way to gauge cell phone signal strength. We place a lot of weight on the signal bars we see on our phone, but in reality, there's no standard for what those bars mean. Furthermore, the number of bars can vary widely based on how a person holds their phone, or based on the phone's manufacturer.

Using a signal meter is the most effective way to test for signal frequency, bandwidth, and strength down to the decibel-milliwatt (dBm) not the "bar." Signal meters read the signal level for all frequency ranges and bands in order to test for any carrier and make sure the signal will work for all users. It also updates in real time, which means an installer will never have to wait for accurate signal readings.

What is cellular signal, really?

If you could use help explaining to your customer how cellular signal works, try these handy explanations:

The signal every mobile phone receives from a cell tower is measured in decibel-milliwatts (dBm). Understanding how decibel-milliwatts work comes down to three basic elements:

1. One milliwatt of power equals **zero** dBm. Since cellular signals operate on just a tiny fraction of a milliwatt (0.0000000001 mW or less,) dBm signal strength is measured using negative numbers. As the signal moves closer to the 0 dBm reading on your signal meter, (for example, from -85 dBm to -70 dBm) the signal is getting stronger.
2. The milliwatt scale is logarithmic, not linear. That means when the dBm changes, the change is exponential. For example, −70 dBm (0.0000001 mW) is ten times more powerful than −80 dBm (0.00000001 mW), but it's a hundred times more powerful than −90 dBm (0.000000001 mW). In other words, every little step toward 0 dBm is actually a *huge* step toward more reliable connectivity.
3. Any change in dBm is described in ±dB. So if your initial reading is −90 dBm and you install a signal booster system that provides +30 dB of gain, the resulting signal will be as high as −60 dBm.

Signal Strength (in dBm)	Practical signal strength
Greater than -60	**Excellent** signal, no chance of dropped calls, optimal voice quality and data transmission speed.
-60 to -75	**Very good** signal, unlikely to experience dropped calls or quality issues that affect performance. *(This is usually the best available unless you're directly next to a cell tower.)*
-76 to -90	**Good** signal, while reliability and quality are generally adequate, interruption by building materials or other obstructions could make the difference.
-91 to -100	**Fair** signal, voice quality and data transfer speed are noticeably affected, dropped calls are more common.
-101 to -110	**Poor** signal, dropped calls and extremely slow data transfer are a constant problem.
Less than -110	**No** signal, for all intents and purposes, there is no connectivity possible without a signal booster.

Signal Meters and Spectrum Analyzers

"You can select from multiple types of signal meters, from simple, inexpensive handheld meters to more sophisticated meters and spectrum analyzers that can cost hundreds or even thousands of dollars. Spectrum analyzers can examine any part of a radio frequency and can even identify individual carrier bands."

Performing the initial site survey

The initial site survey is critical in determining the needs of a client's facility. Therefore, it's helpful to review best practices for a site survey, step by step:

1. Look at the building's floor plan to familiarize yourself with the site. This will help you map out signal areas once you're on site and performing the survey.
2. Once you're on site, start your survey on the roof. Walk around to different sides of the building and, using your signal meter, note the signal reading on each side. Record the readings for all channels and frequencies each time.

3. After you find the location of best signal, slowly swivel 360 degrees to find the source of the signal. Once you find it, note the direction it came from. This tells you the direction of the nearest cell tower. (If installing a passive DAS, this is where you'll install and orient the donor antenna.)
4. Proceed down through the building, carefully noting signal strength in every room and corridor, making note of how signal strength fluctuates based on where you are in the building.
5. Upon completion of the physical site survey, all the signal strength notations will allow you to go back to the floor plan and map out a strategy for placing indoor server antennas in order to maximize the boosted signal coverage inside. (Many integrators find the easiest and most effective way to accomplish this is by using iBwave or a similar network planning software.)

Passive DAS Installation Best Practices

If you want to avoid issues like oscillation and overload (see insert section below) and ensure a high-performance system for your clients, you need to follow a few passive DAS installation best practices. Poorly placed antennas and inefficient cable runs can quickly eliminate any enhanced cell phone signal.

We've already discussed one of the most important parts of the professional passive DAS installation process: the site survey. But, what's next? Here are a few more tips to get you started:

1. **Communicate the importance of a certified professional installation to the client.** It seems obvious, but many clients might want to cut costs by having their internal IT team install their new system. Professionals that have experience in DAS best understand the nuances of frequency and signal strength. It's important for clients to understand that paying for professional installation will reduce the ongoing maintenance costs that will surely come up if they attempt to install a new system themselves.
2. **Select the right donor antennas.** Once you determine where the donor antenna should be placed and in what direction it should be pointed, you need to make sure you select the *right* antennas for the job.
    - **a.** Omni antennas receive signal from a 360-degree field and capture all available outside signals. Because Omni antennas capture signal from various towers, they offer the best solution for buildings with good signal strength because there's less of a need to strategically position the antenna to maximize incoming signal.
    - **b.** Yagi antennas are directional, which means they must be pointed in a specific direction. Pointing a Yagi antenna at a very weak signal source can ensure a boost in every radio frequency wave from that source.
3. **Select the right broadcast antennas.** Likewise, choosing the right broadcast antennas for various applications is also vital.
    - a. Dome antennas (normally installed on the ceiling) offer a 360- degree spread with minimal signal loss in any direction, so they work best for individual rooms or larger open spaces.
    - b. Panel antennas (normally wall-mounted) emit a more focused signal in the direction the panel faces, so they work well for corridors and other long spaces.
4. **Minimize your cable runs**. (See the insert section below.)
5. **Properly terminate your cable.** Make sure to use the appropriate connectors, cable strippers, and crimp tools associated with the cable you are installing. Proper termination techniques will help ensure the complete transfer of the cellular signal.

How to handle oscillation and overload with a passive DAS

Passive DAS offer a time- and cost-effective alternative to active DAS, but before we get carried away, let's address the elephants in the room: oscillation and overload. It's a common myth that passive DAS are unusually susceptible to shutdown caused by oscillation and overload.

If you're concerned about oscillation and overload, rest assured. In the rare event they occur, these issues require only minor system adjustments, and they can often be avoided completely by choosing the right equipment for each application and using proper installation techniques. In contrast, infrastructure-heavy active DAS requires significant ongoing support.

Oscillation occurs when a system's donor antenna (outside) and broadcast antenna (inside) are positioned too close together. The proximity between antennas causes a feedback loop and can

damage the system. Per FCC regulations, all cell phone signal boosters are built to auto-detect oscillation and power down or shut off when the condition occurs. This situation can be remedied or prevented simply by increasing the distance between the donor and broadcast antennas or shielding the antennas from one another by creating a barrier between them with material such as a metal radiant barrier.

Another common concern is overload, which occurs when the outside signal is too strong for the booster and causes the booster to shut down. In the past, if overload occurred, users could aim the donor antenna away from the offending tower, move the antenna to a different location, or install a filter.

Now, with the introduction of Extended Dynamic Range (XDR) technology, overload is a thing of the past. With XDR technology, passive DAS amplifiers immediately and automatically adjust themselves to any changes in outside signal, up or down, virtually eliminating the chance of the system shutting down and cellular signal dropping out.

Minimizing Cable Runs

Minimizing the amount of cable and antenna used in the DAS installation is one of the most important factors in keeping costs down, and is also necessary for an effective result. You can maximize the performance of a passive DAS with the proper selection and placement of antennas and cables.

Cell signal loses strength as it travels through cable. The most efficient cell phone signal booster systems minimize the length of cable runs to maximize signal boost. The shortest route from the outside antenna to the booster and onto the interior antennas determines optimal cable placement. Sharp bends or kinks in cable will also hurt signal transmission, so factor that in when planning to lay cable in tight spots or corners. If you can't avoid long cable runs, consider installing a passive DAS with an "inline" cellular amplifier, like the new WilsonPro 1050.

Outside signal strength primarily influences the wireless architecture of a passive DAS. If an outside signal is low, more hardware is required to both capture the signal and boost it inside the building. Identifying the strongest signal outside and identifying weak areas inside will enable installation of broadcast antennas in the most effective locations and minimize cable runs between booster and donor antennas.

Passive DAS Case Studies

Like all good integrators, you're focused on results. There's no use in highlighting all the benefits of passive DAS if you can't point to real-life scenarios where the technology has been

deployed and produced the desired results. That's why we want to provide you with a few passive DAS case studies.

New York department store boosts cell signal with passive DAS

A luxury New York department store's announcement that a remodeled flagship location would open in its original location thrilled shoppers. Store officials planned for a modernized version of the brand, with a contemporary design and updated amenities. Unfortunately, the age of the building and the modern materials used in the renovation created challenges when it came to achieving cellular coverage inside the building.

Construction was well underway by the time officials realized the problem — and what a problem it was. Cellular connectivity would be vital for both sales associates, who needed to use cellular connections for on-the-spot customer checkout, and shoppers who needed the ability to call, text, and access data while inside the store.

A timely solution that could fit within the strict design specifications of the remodeled store was needed, so the company's IT manager called WilsonPro integrator RepeaterStore for a solution. The integrators immediately knew a passive DAS was right for the job. The system required multiple boosters designed for large commercial spaces in order to generate seamless cellular coverage and data transfer capability. The integrators recommended WilsonPro 70 Plus signal boosters for the job.

System installation took only four days, and was completed just as the department store opened its doors to customers. By the time customers began shopping, they were able to send and receive phone calls, texts, and access cellular data from every floor without a problem. Plus, the store clerks used their tablets to access the network for faster customer service and sales processing.

For more on this story, download our full case study.

Montreal condo building overcomes connectivity challenges with passive DAS

All modern luxury condo buildings need to offer top-of-the-line amenities to stay competitive. Doormen, gyms, and pools are almost a given these days, but what about cellular connectivity? With all new energy-efficient building materials being used to construct condos, poor cell phone signal is an increasingly common problem for condo developers.

That problem became glaringly apparent during the recent construction of a condo building in downtown Montreal. As the condo neared its grand opening, developers noticed that the building's key systems were not functioning due to lack of cellular service. The glass windows and doors that covered the building interfered with the signal that drove the building's intercom, security, and elevator telephone systems, despite the fact that the antennas operating those

systems were located just a few feet from the glass doors. When the glass lobby doors were open, the cellular signal was a strong -60 decibels, but as soon as it closed, the signal fell dramatically to -120 decibels.

With little time to waste before the opening, building developers and Bell Canada contacted Stephen Friedman, vice president and chief operating officer of WilsonPro integrator Cellworx. It was soon clear to Friedman that the building required a passive DAS to enhance the cell signal inside the building.

After installation, all systems inside the building were up and running with improved cell signal in time for the opening. Passive DAS enhanced the signal inside the building to approximately -50db, far improved from the -120db the lobby received before the project began.

For more on this story, download our full case study.

Conclusion

As a professional integrator, we know quite a bit of what you read in this Ultimate Guide was probably review for you. But, hopefully, you found some nuggets you can use to help explain your recommendations to customers who aren't quite as savvy when it comes to cellular signal amplification.

You're the expert, and an integral part of what makes WilsonPro successful, so we're interested in helping you do your job as efficiently and effectively as possible, whether you're using a WilsonPro product or not. Please contact us with any questions or suggestions that will help us accomplish that goal.

Finally, if you're not already enrolled, we'd love to have you join the WilsonPro Integrator Partner Program, which offers comprehensive training, product resources, access to leads, post-installation support, and much more.

Visit the WilsonPro Integrator Partner Program webpage for more details and enrollment instructions.