

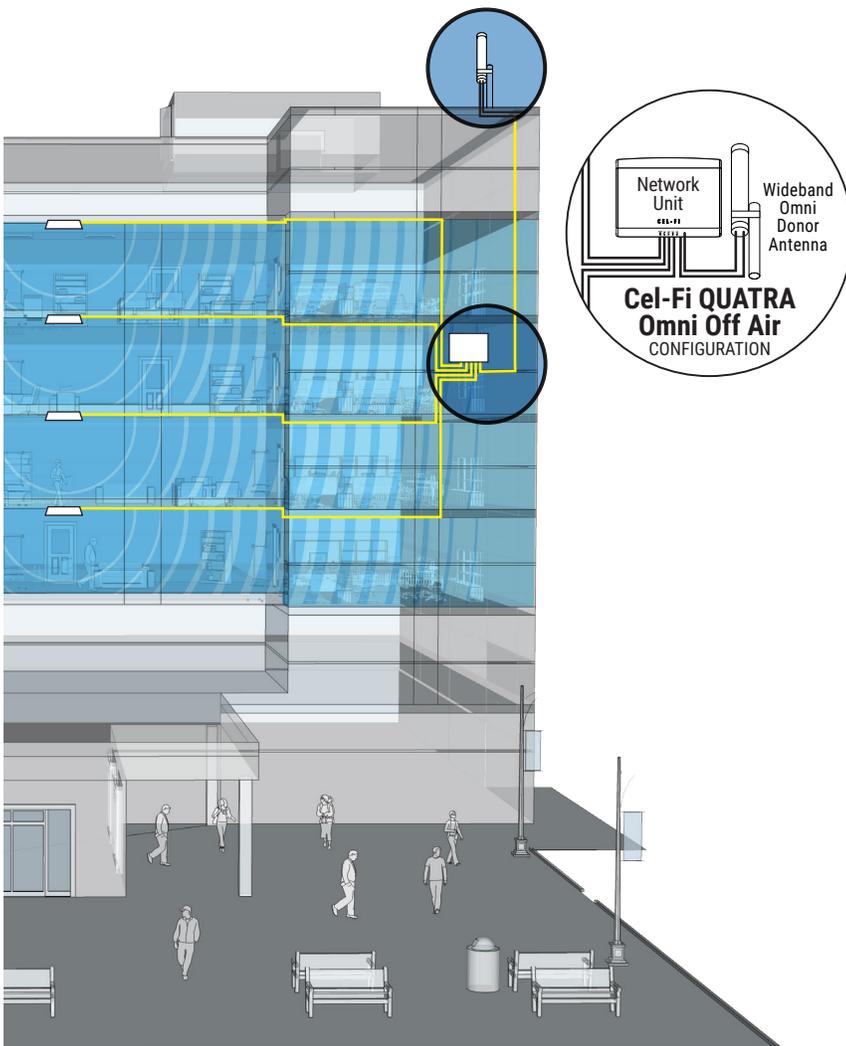


CEL-FI™ QUATRA

Active
DAS
Hybrid

Cellular Reception Challenges in Urban Environments

Cellular Reception Challenges in Urban Environments



In-building cellular coverage is all about distributing cellular signals to where they need to be: users. Over the last decade, there have been tremendous advances in the technology that amplifies the cellular signal from the macro network inside buildings, where cellular devices are used the most, so subscribers experience high-quality cellular connectivity without dropped calls, echoing, slow downloads and black holes.

An enormous investment in research and development by Nextivity has gone into a new breed of digital cellular coverage technology – the Cel-Fi product line. It has the system intelligence, power and gain to amplify cellular signal from a small cell or off air that uniformly lights up a building or campus to provide exceptional coverage – with the ease of installation and maintenance, and total cost of ownership not available with earlier technologies.

The case studies that follow show the effectiveness of this technology in resolving in-building cellular connectivity issues for all major carriers with Cel-Fi QUATRA, the active DAS hybrid that was developed by Nextivity specifically for the middleprise.



Cel-Fi QUATRA Solves Cellular Coverage Problems for Premier Brooklyn Food Hall

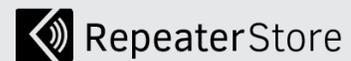


Showcasing 40 vendors that reflect the cultural and ethnic diversity of Brooklyn, NY, DeKalb Market Hall is a hub of innovative cooking and dining experiences for nearly 100,000 guests each week. While the large food hall brings cuisine from around the world to Brooklyn, poor cell reception was a problem in its below ground level location in the City Point Mall.

ABOUT THE PROBLEM

COMMERCIAL REAL ESTATE

- One of Brooklyn, NY's largest food halls with 27,000 sq. ft. one level below ground
- Needed coverage for all four major carriers at a reasonable cost
- Building's concrete shell blocked all cellular signals



RSRF, a division of RepeaterStore

- Founded in 2007
- Based in Laguna Hills, California
- Services include amplification solutions to improve wireless cell and data reception in buildings, homes, and vehicles

As a leading destination for locals and tourists alike, it was important that DeKalb Market Hall provide good cellular coverage for its patrons, many of whom are millennials who expect 24/7 access. RSRF, the systems integrator division of RepeaterStore, which specializes in providing cell phone coverage to buildings of all sizes, was engaged to provide a solution.

"They needed coverage for all four major carriers – AT&T, Verizon, Sprint and T-Mobile – throughout the space and they needed it at a reasonable cost as well," says Rick Bernas, director of engineering at RSRF. "Alternative solutions, like a DAS powered by small cells or an active DAS, where all the carriers bring in their equipment, were way out of the price range."

Instead, RSRF chose to implement Cel-Fi QUATRA, an active DAS hybrid that solves spotty in-building cellular coverage, poor voice quality, dropped calls, and dead zones for all major carriers in venues from 10,000 to 500,000 sq. ft. at a price point that fits virtually any middleprise budget.

Cel-Fi QUATRA delivers a cellular signal that is up to 1,000 times stronger than analog boosters and passive DAS technology with internal antennas that are intelligent and able to broadcast the strong signal amplification uniformly across all carriers, regardless of the varying power of the donor signals received. Because QUATRA uses Ethernet cabling and RF over Ethernet (RFoE), the signal does not attenuate the farther it travels from the system hub to the perimeter of the building as it would with other solutions that use coax cable. This was particularly important in the food hall because the site survey done by RSRF found that long cable runs were needed due to the layout of the building, explains Bernas.

"We chose to use QUATRA for several reasons," says Sina Khanifar, president of RSRF. "Firstly, it allows you to use Cat5e, which is normal Ethernet cable. That makes installing the system that much easier. Secondly, QUATRA is unique in that it has the ability to deal with a very common problem in dense urban areas, like Brooklyn, where signal levels vary between the different carriers. QUATRA has a unique ability to deal with that problem dynamically and made it perfect for this project."

BRINGING THE SIGNAL UNDERGROUND WHILE KEEPING COSTS DOWN

Dekalb Market Hall is a 27,000 sq. ft. food hall located below ground level at the City Point Mall. Setting up Cel-Fi QUATRA took only three days with a two-person crew, according to RSRF. A donor panel antenna was installed on an I-beam (a steel beam on the ceiling of the building) on the perimeter of the building. The donor antenna was then connected to two Cel-Fi QUATRA Network Units (NUs), the head ends of a QUATRA system. The NUs were installed inside a three-foot clearance in the hard ceilings; one of the NUs amplified AT&T and Verizon, while the other amplified T-Mobile and Sprint.

Using Cat5e cable, each NU was connected to four intelligent remote internal antennas (called Coverage Units or CUs) that broadcast the amplified signal throughout the common areas of the food hall. Because Cel-Fi QUATRA leverages Power-over-Ethernet (PoE), the eight CUs were conveniently placed at the optimum locations with no need to install additional power outlets.

Typically, to get sufficient signal power from the outdoor cellular network, a donor antenna is installed on the roof of a building and connected by coax cable to the Cel-Fi QUATRA NU(s) inside the building. In this case, it would have required around 200 to 300 feet of coax cable to get to the outside donor antenna, which would have driven up the costs.

However, with Cel-Fi QUATRA, RSRF was able to save the client a considerable sum by installing the donor antenna on the ceiling inside the food hall, requiring only five feet of cabling between the donor antenna and NU.

"Cel-Fi QUATRA provides up to 100 dB of gain whereas other cellular amplification systems only have up to 72. With any other system, to get enough signal to power all the internal antennas, we would have had to put the donor antenna outside. But with QUATRA, because of that 100 dB of gain, the donor antenna could be placed indoors," explains Bernas. "The signal was much clearer on the lower levels of the building than on the roof, improving the performance of the system overall."

Coverage in the washrooms was also a necessity, but signal was spotty in these areas because the washroom walls were made of cinder block and tile. For further cost savings, RSRF extended the signal amplified by QUATRA by installing dome antennas in the washrooms.

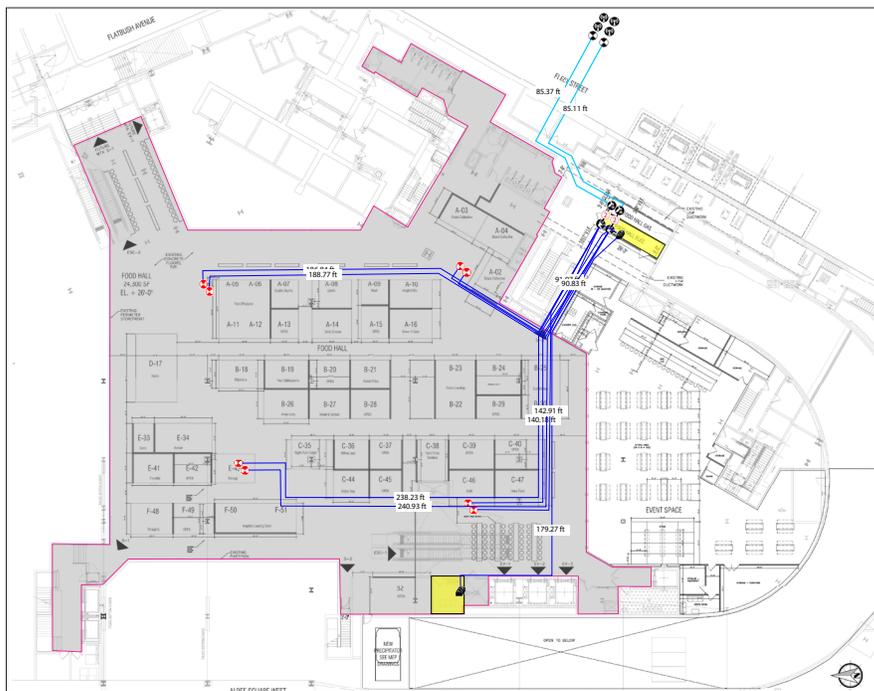
"Cel-Fi QUATRA has the ability to extend beyond the coverage units themselves," says Rick. "Using the Cel-Fi WAVE portal, the online user interface for QUATRA, you can disable the internal antennas of the CUs and tell them to pass the signal power to external ports. Then you connect the CUs with coax cable to dome antennas or panel antennas – just like a regular DAS."



ENSURING COVERAGE EVERYWHERE

In total, the installation included one donor panel antenna, two NUs, eight coverage units and three dome antennas. Despite all the new units and cabling, the system blended well with the appearance of the public space.

"Since the Cel-Fi QUATRA system uses Ethernet cables and the client already had Ethernet cable running all around the basement, it was just a couple of extra internal cables and nobody actually noticed when the system was finished. It looked exactly like it did before," explains Rick.



LEGEND

-  MIMO Panel Antenna
-  Network Unit
-  Coverage
-  Omni Dome Antenna

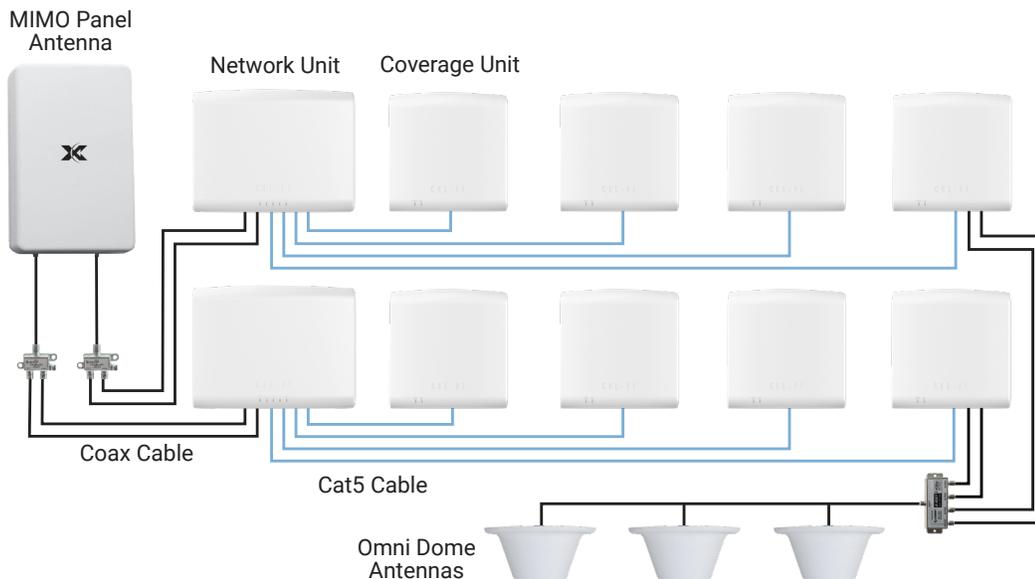
"We were also able to hide a lot of the cables and the antennas above the many vents throughout the space."

As in the case with most commercial spaces that service the public, the ease and aesthetics of the installation were concerns of Jason Feinstein, the general manager of Acadia Realty, who runs the day-to-day management of the building that houses City Point and the Dekalb Market Hall, helping to ensure everything runs smoothly and maintaining positive relations with the tenants.

"Everyone was happy. We picked access points with devices that you can't see or even tell they are there," says Feinstein. "My biggest concern is making sure we don't disrupt the tenants. The installers were very professional, knew what they were doing and were easy to work with."

Since completing the installation, Cel-Fi QUATRA is providing the cellular connectivity the flourishing food hall needs. Feinstein adds, "The basement was a dead zone but RSRF helped us to get access. We get cell phone reception down there now and it is fantastic."

CEL-FI QUATRA 2000 WITH PASSIVE DAS ANTENNAS



Cel-Fi QUATRA can be configured with an off-air donor signal, as in the diagram above, or it can be integrated with a carrier small cell for the donor signal, creating a Supercell.

RF-over-Ethernet (RfE) to extend the capacity provided by the small cells throughout the building to the CUs. As soon as the small cell was connected, the Supercell lit up the building with the cellular coverage needed.

"We like the QUATRA technology. It's cost effective, and the turnaround time to install a system is relatively short," says Dan Connelly, president of ATG. "It gives us the diagnostic tools we need to confirm it is working well, or if there is a shortcoming, to rapidly understand where the shortcoming is."

To ensure the installation provided good cellular coverage throughout the venue where needed, ATG always uses the Cel-Fi WAVE application, according to Connelly. "It's the kind of tool that validates that everything looks good, and we've got enough signal coming in. That's definitely a part of the installation process. We were able to get this location from zero bars to five bars pretty quickly."



Metropolitan Transit Agency Uses Cel-Fi QUATRA Supercell™ to Resolve Pilot Pollution and In-building Coverage Challenges

ABOUT THE PROBLEM

TRANSIT AUTHORITY

- Southern California-based metropolitan transit system occupying the 9th and 10th floors of an office building in a downtown core, with a combined square footage of 40,000
- Dropped calls and poor cellular connections were a constant employee complaint
- LEED glass windows and concrete floor construction blocked the carrier signal
- Roof-top antennas were not an option due to a helicopter pad and pilot pollution

Employees of a public transit service provider operating in Southern California were constantly complaining about dropped cellular calls or not being able to make calls at all while inside the agency's offices located in a busy, downtown core. To provide a solution that would solve the frustration that its employees were feeling, the transit agency brought on board Pacific Services, a San Clemente-based wireless integrator and Verizon and AT&T Solutions Provider for public safety, cellular, Wi-Fi, and microwave systems.

Pacific Services found that LEED glass windows and concrete floors were blocking the cellular signal. Compounding the problem, the 9th and 10th floors where the offices were located were above the height of the macro towers. To resolve the poor cell reception, Pacific Services decided to install a Cel-Fi QUATRA Supercell.

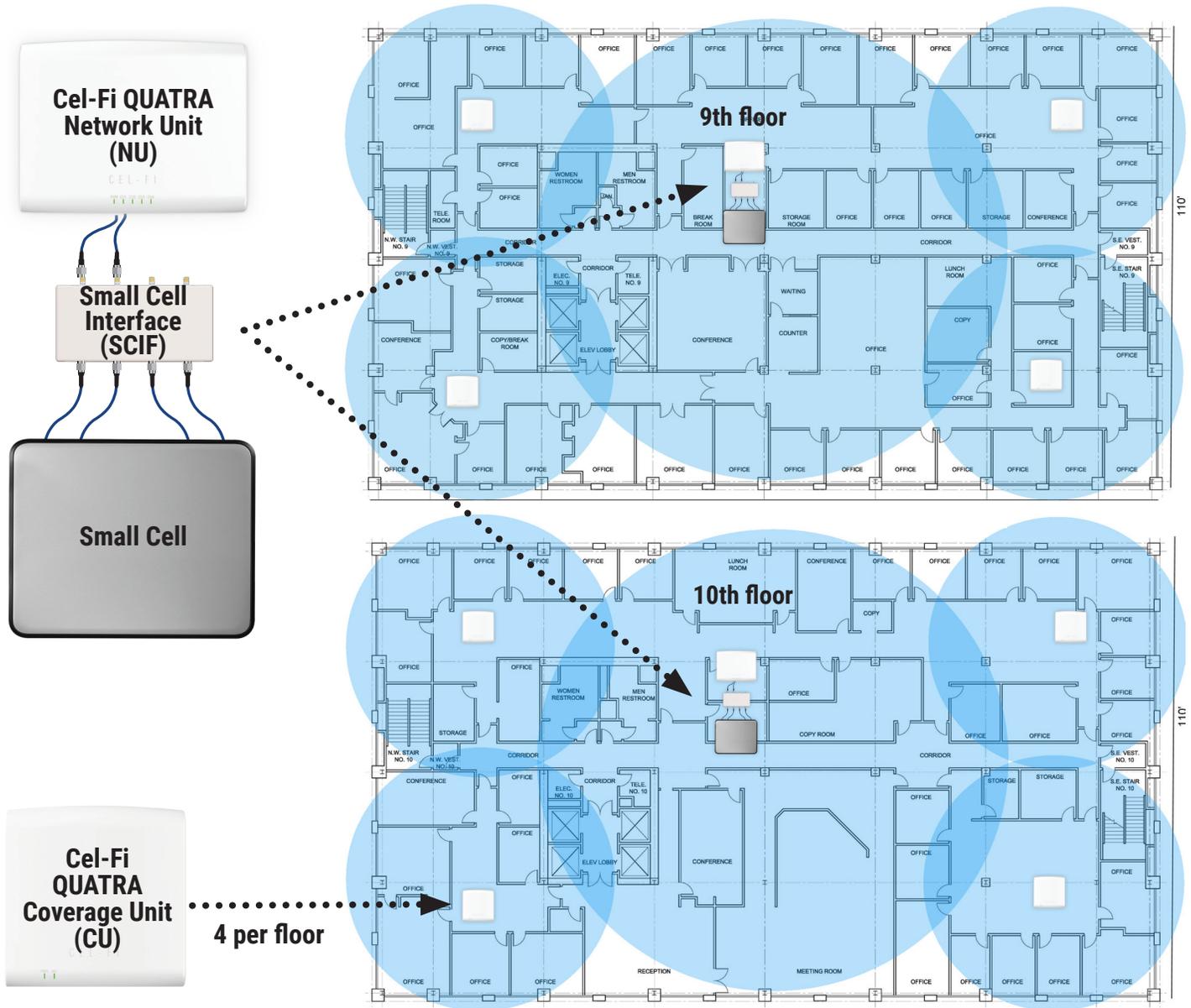
Initially, Pacific Services looked at installing QUATRA off-air, but the building owner would not consider placing an antenna on the roof as there was a roof-top helicopter pad. Although the macro signal outside the building was good, pilot pollution was a concern as there were too many pilot cell sites visible.

"One of the challenges on cellular systems when you put up a donor antenna is to pull the signal from a certain macro site. That's called the pilot. Most donor antennas have a beam width that's fairly wide, which means they can see multiple sites or you might have a site close by but there's another one behind it. The system sometimes will try to jump from one to another," explains Gary Greening, Vice President of Operations at Pacific Services. "In a fairly populated metropolitan area where there are sites all around it, it becomes more difficult to isolate the one you want to pull the signal from. In this case, too many sites were seen which would confuse the system. We decided to isolate it down to a small cell, which we can control, and it's only one pilot source for the signal."



Pacific Data Comm

- Established in 1985, based in San Clemente, CA
- Wireless integrator and for public safety, cellular, Wi-Fi and microwave systems
- Customers include government agencies, major telecom carriers, long haul fibre companies, Fortune 500 companies, United States Marine Corps, and Air Force
- Verizon and AT&T Solution Provider



The public transit agency occupies the ninth and tenth floors of a 10-storey building with a total square footage of 40,000 on the two floors.

SETTING UP THE SUPERCCELL

A Verizon small cell was installed in the IT closets in the center of each floor. Each small cell was connected to a Cel-Fi QUATRA Network Unit (NU) that was mounted on a wall in the closets.

Using Cat 6 cable, the NUs were connected to four remote internal antennas (called Coverage Units or CUs) on each floor to extend the capacity provided by the small cells uniformly throughout the floors. As QUATRA leverages PoE, the CUs were conveniently placed at the optimum locations, evenly spaced per floor on the ceiling tiles facing down, without the need to add power outlets.

“The QUATRA Supercell greatly enhances the ability of a small cell to extend to a lot of different areas,” says Greening. “You can broaden the footprint in a building or multiple floors, or we even have done multiple buildings off one small cell signal source.”

This has a major impact on the cost of the solution, according to Greening. “Every time you put in another small cell, each one costs \$3,000 to \$5,000. Each one has to have its own GPS antenna. Each one has to have a backhaul connection to the ethernet network. It’s not convenient. If it’s in different parts of the building, you may not have a way to get that GPS antenna on there, and you may not have the power where you want it.”

“As Cel-Fi QUATRA uses PoE, it’s really easy. Just extend the cable out and hang a coverage antenna where you need coverage,” Greening explains. “Cel-Fi QUATRA is one of our leading solutions for medium to small clients under 500,000 square feet, and it’s been very successful. We have been able to install a QUATRA Supercell for 50 to 60 percent less than the cost of other proposals the clients received.”



Cel-Fi QUATRA Supercell™ Brings Cellular Service to Multi-Use Buildings

ABOUT THE PROBLEM

MULTI-USE COMMERCIAL REAL ESTATE

- 200,000 square-foot, multi-use building with commercial and residential tenants and below ground level parking garage
- Spotty cellular coverage in the parking garage caused safety concerns
- Commercial and residential spaces are not wired for traditional phone lines

Complying to Public Safety Regulations

A new 4-story building in Korea Town, Los Angeles needed to comply with National Fire Protection Association (NFPA) regulations for emergency responder radio coverage. To bring the public safety frequencies inside the building and the two parking garage floors below ground level, the building owners engaged Pacific Services.

Simultaneously addressing cellular coverage issues

As the building owners were concerned about the safety of their tenants in the below ground parking garage, Pacific Services recommended also testing cellular coverage while testing the emergency responder frequencies.

“When tenants are in the parking garage at night, even though there are cameras in the garage, having a cellular phone connection makes the garage much safer for them in an emergency,” says Gary Greening, VP Operations at Pacific Services. “After surveying the garage and finding no cellular coverage down there at all, we went ahead and surveyed the rest of the floors of the building. There was basically spotty coverage everywhere.”

In the parking garage, the thick solid concrete walls and underground location blocked any macro cellular signal. The building itself is in a pocket of other high rises – an 8-story building on one side and a big commercial building behind it – that blocked sufficient macro signal from penetrating into the upper floors. The entire ground floor of the building is occupied by retail stores, while the three floors above are apartments. These residential floors were all wired for cable and Wi-Fi, but not for conventional phone lines, so tenants were expected to use their own cell phones.

The building owners were willing to invest in good cellular coverage for better safety in the parking garage and for tenant use on both the commercial and residential floors. Pacific Services decided to install a Cel-Fi QUATRA Supercell as the solution to amplify both AT&T and Verizon signals inside the entire building.

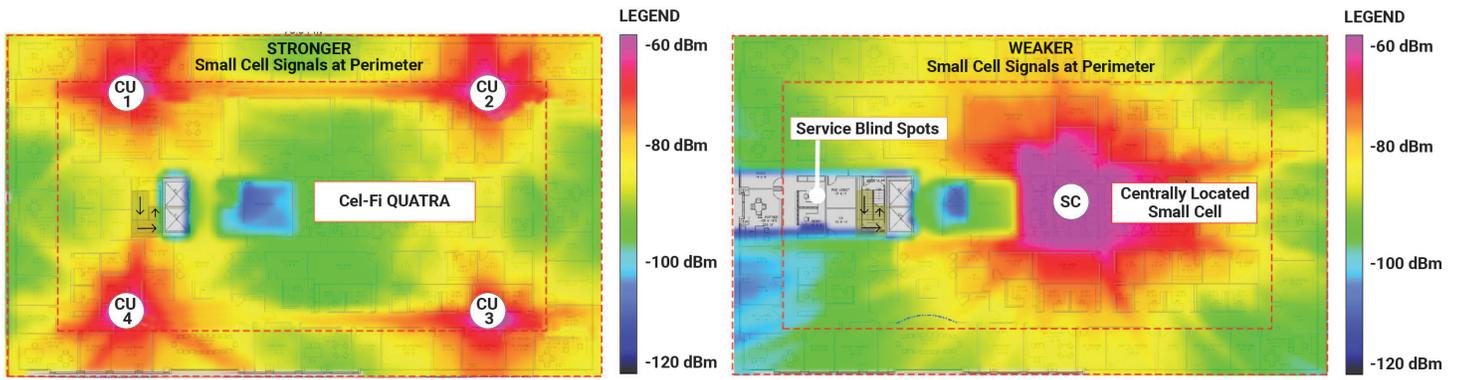


DEPLOYING THE SUPERCCELL TO ADDRESS SAFETY CONCERNS AND MORE

Pacific Services ordered two small cells from AT&T and two from Verizon. The small cells were installed in the utility closet on the bottom level of the parking garage. Five Cel-Fi QUATRA Network Units (NUs) were installed in close proximity to the small cells inside the utility closet and each NU was connected to one Verizon small cell and one AT&T small cell.

According to Greening, conduit had already been installed from the basement utility closet to all floors of the building, so Pacific Services ran Cat 6 cabling from the NUs vertically up the conduit to access panels on each floor. The cabling was then run down the halls to the Cel-Fi QUATRA coverage units (CUs). The CUs were attached exposed on the ceilings. Greening prefers an external attachment as it makes it easier to access the CUs during installation and afterwards for maintenance, and as they matched the paint on the hallways, the contractor was happy with how they looked.

A Cel-Fi QUATRA Supercell uses RF-over-Ethernet (RfOE) to extend the capacity provided by the small cells throughout the building to the CUs. In addition, the system uses PoE, so Pacific Services was able to place two to three CUs in optimum locations in the hallways on each floor



and in the parking garage, without having to add power outlets. The CUs were only needed in the hallways on the upper floors to provide good signal inside all the apartments and shops.

"We have tested other competitive products at the low end that would not be able to do that. We would have had to put antennas inside each of the apartments to try to get that kind of coverage," says Greening. "The output power of Cel-Fi QUATRA is very good when it has a clean donor signal like in a Supercell, and the penetration is excellent."

The Supercell install took two days to complete once the small cells were deployed. The public safety system was installed at the same time. The intuitive management tools provided by Nextivity helped to ensure a faster installation and facilitate more efficient technical support and maintenance.

"If there's a problem with the network, the Cel-Fi Wave application will tell us. It has a great interface, so you can quickly see what your network is doing from a cell phone, or from a laptop or an iPad," says Greening. "The management is very good through the portal, and if we see the signals from the small cell have stopped working, we can call the right technical people at the carriers to say we need some assistance to get it working again, before we dispatch a truck to get out and see the customer."

"The best part is the customer and the tenants now have peace of mind, and the reality is this solution might save a life," he adds.



CEL-FI
QUATRA

BEYOND
BETTER
COVERAGE

- High-quality solution for the middleprise
- Supports multi-carrier 3G/4G/LTE voice and data
- Carrier-approved and unconditionally network safe
- Can be monitored and managed using Cel-Fi WAVE

Specifications

Power 54 VDC @ 2.22 Amp via external supply (51.3 to 56.7 VDC tolerance)
(network unit) External supply: 100 to 240 VAC, 47 – 63Hz
 Power consumption less than 120W max
 Network Unit provides power to Coverage Units over Cat5e (PoE)

Environmental Operating temperature: 0° to 40°C
 Storage temperature: -25° to 60°C
 Convection Cooling
 Relative humidity: 0% to 95%, noncondensing
 RoHS II 2011/65/EU
 IP20

Installation Mounting hardware included
 NU may be wall mounted (solid or hollow)
 CU may be wall or ceiling mounted
 1 NU supports 1 to 4 CUs
 iBwave supported

Radio Performance Total boost all-channel bandwidth 75 MHz (2x2 MIMO uses double bandwidth per channel)
(check product version for specific band support) DL Maximum NU in-band donor level -40dBm
 DL Maximum NU survival donor level 30dBm
 UL Maximum CU donor level -20dBm.
 Maximum UL power 24dBm EIRP bands 1, 2, 3, 4, 7, 8
 Maximum UL power 20dBm EIRP band 5, 12, 13, 20
 Maximum DL power 12dBm per 5 MHz EIRP bands 1, 2, 3, 4, 7, 8
 Maximum DL power 10dBm per 5 MHz EIRP bands 5, 12, 13, 20
 LTE 5/10/15/20 MHz and WCDMA 3.84/5 MHz bandwidths

Physical Specifications

Network Unit	Coverage Unit
264 x 185 x 62mm 1.2 kg (40.8 oz.)	225 x 185 x 37mm 0.83 kg (29.2 oz.)

Connections 4x CU RJ45 Proprietary Gigabit link
 100m max CU cable length Cat5e
 200m max CU cable length with Cel-Fi QUATRA Range Extender (Cat5e or Cat6)
 PoE IEEE 802.3at
 RJ45 LAN management port (10/100 Fast Ethernet)
 RJ45 LAN management output port (10/100 Fast Ethernet)
 2x MIMO External RF Input (QMA Female 50 ohm)

Compliance 3GPP TS 25.143 Rel.10
(check individual product version for specific regional compliance) 3GPP TS 36.143 Rel.10
 CE
 FCC Part 15, 20, 22, 24, 27
 ISED Canada
 UL 62368-1/CSA C27.2
 Bluetooth BQB

System Management Cel-Fi WAVE cloud portal
(software) Cel-Fi WAVE Remote Management:
 • Status (list and map) • Settings
 • Commissioning • Reporting
 • Diagnostics • Alarms & Notifications
 • Software Updates

Product Name	Model Number	Frequency (MHz)	Bands Supported	MIMO Support	Crossover Support
QUATRA 1000	Q34-2/4/5/12	1900 / 1700 / 850 / 700a	2, 4, 5, 12	4, 12	2, 5
QUATRA 1000	Q34-2/4/5/13	1900 / 1700 / 850 / 700c	2, 4, 5, 13	4, 13	2, 5
QUATRA 1000	Q34-1/3/8/20	2100 / 1800 / 900 / 800	1, 3, 8, 20	3, 20	1, 8
QUATRA 1000	Q34-1/3/7/8	2100 / 1800 / 2600 / 900	1, 3, 7, 8	3, 7	1, 8
QUATRA 1000	Q34-1/7/8/20	2100 / 2600 / 900 / 800	1, 7, 8, 20	7, 20	1, 8
QUATRA 1000	Q34-3/5/7/28	1800/850/2600/700 APT	3, 5, 7, 28	3, 28	5, 7
QUATRA 2000	Q34-4/5/12/13/25	1700/850/700a/700c/1900	4, 9, 12, 13, 25	n/a	n/a

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