SOLiD™

Tech Brief

How to Make the Most of 5G for Improved In-Building Connectivity

The evolution to 5G technology is well underway, promising an array of desirable new services and capabilities such as higher mobile capacity, faster data speeds, and ultra-reliable low-latency connectivity. These advancements are due to fundamental changes in mobile network communications architecture. The 5G New Radio (NR) air interface is one of the most substantial transformations compared to legacy 4G LTE networks. Gaining a better understanding of 5G NR will help you extract the most value from in-building connectivity systems.

What is 5G NR?

The 3rd Generation Partnership Project (3GPP) developed 5G NR as part of the overall 5G architecture standardization process. The 5G NR standard sets the stage for a more capable, unified, wireless air interface to deliver significantly faster and more responsive 5G mobile experiences.

5G NR technology supports both high-bandwidth applications, such as streaming video and virtual reality (VR), as well as low-bandwidth massive connectivity for the Internet of Things (IoT), machine-to-machine (M2M) communications, and similar smart device connections. In addition, support for new mission-critical use cases like vehicle-to-everything (V2X) communications, smart manufacturing, and VR-assisted telemedicine requires very low latency transmissions.

The 5G NR standard introduced several key features and capabilities to the mobile network architecture to accomplish these goals:

Enhanced Mobile Broadband
More throughput at faster speeds for enhanced data rates, expanded coverage, and improved data-sharing efficiency

Ultra-Reliable, Low-Latency Connections (URLLC)
Near real-time interaction and controls allow the network to support innovative use cases in manufacturing, healthcare, and military applications

Massive IoT and M2M Communications
The ability to support many more devices per unit of area than 4G LTE while enabling longer battery life in connected devices

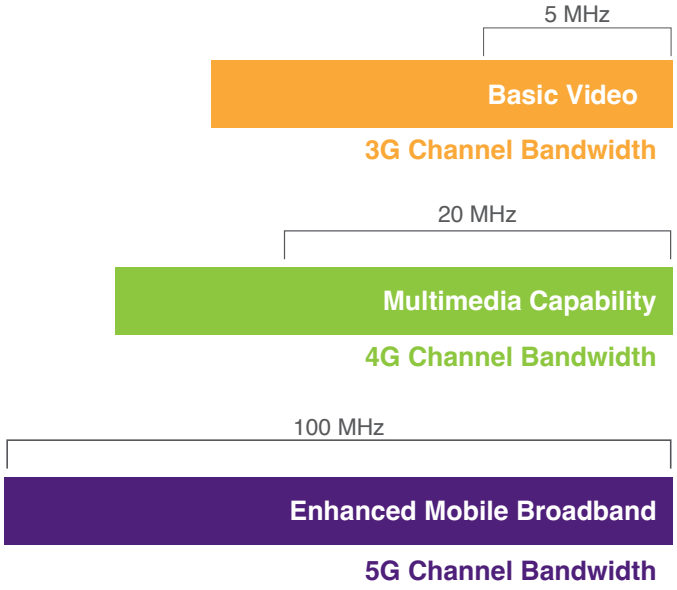
Network Slicing
Virtual logical networks, or 'network slices,' within a single physical network allow segregation of targeted use cases with varying levels of service and security.

Evolutionary Adaptations

As mobile networks evolve from 4G LTE to 5G NR, several important differences exist in the radio access network (RAN) design and operation. Primarily, these advancements enable the 5G RAN to use radio frequency (RF) spectrum more efficiently to accommodate the large blocks of contiguous spectrum needed to enable high capacity throughput.

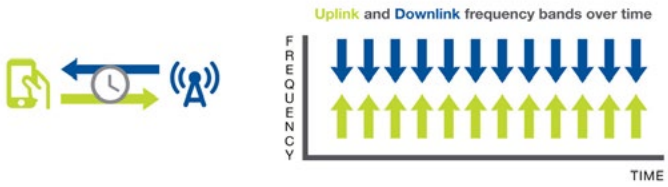
The 5G NR standard identifies two main frequency range (FR) classifications, known as FR1 and FR2. The FR2 frequencies (24.25 GHz - 52.6 GHz), which support channel widths up to 400 MHz, are focused on short-range, high data rate capabilities in the mmWave spectrum above 24 GHz. On the other hand, the FR1 bands (410-7125 MHz) operate in frequencies below 6 GHz and support up to 100 MHz channel widths.

Networks operating in the FR1 bands provide an optimal balance between range and performance, while networks using FR2 bands can achieve gigabit data rates or higher with low latency. 5G networks use a combination of FR1 and FR2 bands; however, most traditional mobile communications traffic uses the FR1 bands. These new frequency bands unlock the true promise of high-speed mobile connectivity by enabling support for larger channel widths.

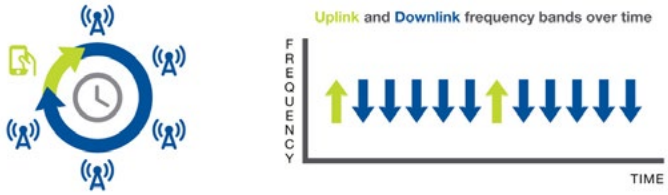


Frequency bands separate their uplink (UL) and downlink (DL) transmissions in the frequency or time domains. While these duplexing methods are not new to 5G, most of the new spectrum allocated for 5G uses Time Division Duplexing (TDD) rather than Frequency Division Duplexing (FDD). All but one of the 4G frequency bands used FDD.

TDD enables UL and DL functions to occur on the same frequency, providing greater capacity and flexibility than FDD, which requires separate RF frequencies to send and receive data. Because TDD bands don't allocate half of their spectrum to the uplink, they provide more contiguous spectrum to support larger channel widths. The FDD bands support a maximum channel width of 20 MHz for 4G, and because of their limited contiguous spectrum, they typically limit 5G to channels of 40 MHz or less.



FDD: Two dedicated frequency bands that are used at the same time



TDD: One dedicated frequency band that is split between time slots

Frequency Adjustments

The combined new features and capabilities of 5G NR enable significant gains in capacity, throughput, and coverage to improve network service quality, resilience, and performance. Ultimately, this transformation also impacts how 5G networks perform in conjunction with in-building Distributed Antenna System (DAS) systems.

Networks operating in the FR2 bands experience significant atmospheric attenuation and path loss that reduces propagation. With the reduced penetration power, large-scale mmWave 5G deployments pose a challenge for network operators and system integrators, particularly indoors. The FR1 bands can deliver better range and indoor propagation versus FR2 bands.

When deploying and configuring a DAS system today, consider all the 5G frequencies that mobile network operators (MNOs) use in adjacent macrocell networks. The frequency bands most relevant to each deployment will depend on availability and the type of building or event venue in question.

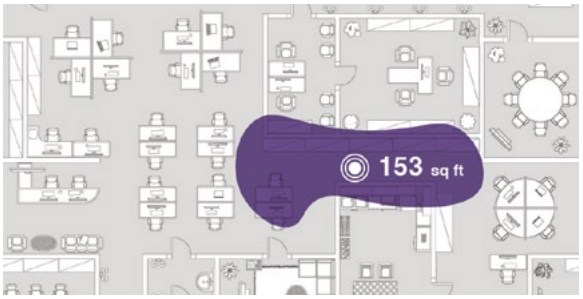
Sub-2.4 GHz: The cellular bands below 2.4 GHz all use FDD duplexing, and the amount of spectrum in each band (600, 700, 800, 850, 1900, 2100, 2300 MHz) is small compared to the TDD bands. The MNOs used these bands for prior mobile generations, and while most continue to offer 4G service, they will eventually migrate to 5G alone. Because of the channel size limitations in these bands, they do not provide all of 5G's enhancements unless carrier aggregation bonds multiple channels into a larger virtual channel.

2.5 GHz TDD: Alternatively referred to as n41 or the 2.5 GHz 5G band, MNOs previously used this band for 3G and 4G networks. The 2.5 GHz band spanning 194 MHz became more valuable for 5G, offering a good balance of coverage and capacity while supporting larger channel widths.

C-Band: This popular mid-band spectrum provides two frequency ranges in the US — 3.45-3.55 GHz and 3.7-3.98 GHz. The Federal Communications Commission (FCC) recently made 3.45-3.55 GHz available after close coordination with the Department of Defense (DOD) to avoid interference with existing military operations in these frequencies, yet the FCC auction limited each MNO to 40 MHz ownership of this spectrum. Conversely, the 3.7-3.98 GHz frequency range offers greater capacity with channel sizes up to 100 MHz. However, the C-Band frequencies typically do not penetrate building materials very well. And with one-fourth (or less) of the legacy mobile communications bands' signal propagation characteristics, similar coverage areas require more output power. Furthermore, the FCC is making this C-Band spectrum available in two phases as they clear it; therefore, roll-outs in this band will occur throughout 2023.

Legacy — AWS Band with a 20 MHz Channel

Mid-Band — C-Band with a 100 MHz Channel



Relative coverage comparison for one antenna with equal power.

CBRS Spectrum: Three tiers of users share the CBRS spectrum (3.55 – 3.7 GHz) with varying priority levels. The first tier includes incumbent mission-critical users, such as the US military and satellite ground stations. Next are the priority access license (PAL) holders, including telecoms, internet service providers, and large enterprises. The remaining tier of CBRS users has access to general authorized access (GAA) channels, which anyone can use freely as long as they do not interfere with traffic on the first two tiers.

CBRS spectrum, divided into fifteen 10 MHz blocks, is used as a supplementary capacity enhancement in public mobile networks and dedicated capacity for private networks. Private networks can use licensed, unlicensed, or shared spectrum, and there are several available business models: they can be owned and operated by an enterprise, run as hybrid private-public networks in the cloud, or provided as a dedicated service by an MNO via network slicing. Because CBRS spectrum use does not require a license, it allows a new generation of Greenfield network operators to start offering private wireless services.

Timing and Delay Management

Timing synchronization and delay management are critical to 5G. This is particularly important in the TDD bands because synchronization is necessary to avoid interference between UL and DL transmissions. Mobile devices can only identify and connect to mobile networks within 3GPP standards-defined delay windows.

Failing to synchronize timing and minimize delays will result in poor network performance and user experience. The benefit of properly managing these factors is to unleash the scheduling flexibility of 5G NR in TDD bands, which enables channels to assign more transmission slots for UL or DL to meet the particular needs of a venue or service.

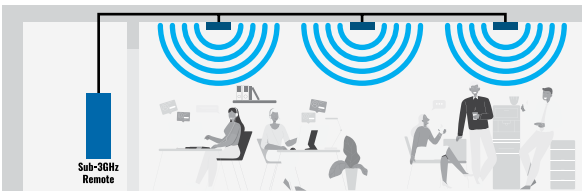
A Solid Choice

To take full advantage of the potential that 5G offers, network managers need to optimize in-building connectivity for high quality and maximum service availability. The deployment of the C-Band spectrum will often require the replacement of existing antennas and coaxial splitters. An overlay with new infrastructure is an alternative when retrofitting the existing infrastructure is not feasible.

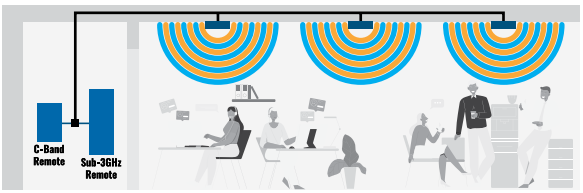
Adding the C-Band to a sub-3 GHz DAS typically results in one of three scenarios.

First, add a legacy DAS using 2W or 5W remotes to support sub-3 GHz frequencies by upgrading a high-power C-Band remote. A good choice is the SOLiD ALLIANCE HROU_4000 which provides 32W of C-Band 3.7-3.98 GHz and 20W of C-Band 3.45-3.55 GHz. This modular remote accommodates up to four amplifiers to support one or two sectors of single-input single-output (SISO) or one sector of 2x2 multiple-input multiple-output (MIMO) for both portions of the C-Band. This scenario results in a balanced system when adjusted for propagation, band size, technology, and coverage requirements.

Scenario 1



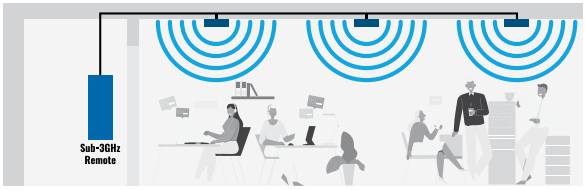
Sub-3GHz DAS with 2W or 5W Remotes



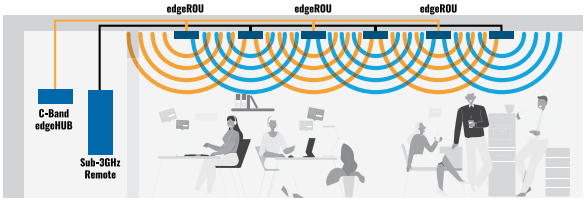
Sub-3GHz DAS with 2W or 5W Remotes + High Power C-Band Remotes

Second, when an existing sub-3 GHz DAS uses 20W or 40W remotes or has a coaxial distribution impractical to upgrade to support C-Band, the SOLiD ALLIANCE edgeROU fiber-to-the-edge DAS is an overlay alternative. DAS engineers specifically design the overlay system for the propagation characteristics and network requirements of 5G in the C-Band.

Scenario 2



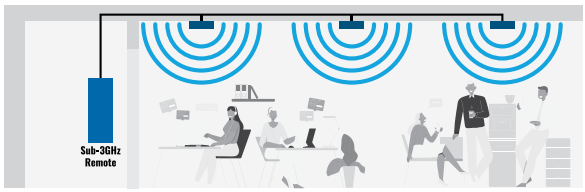
Sub-3GHz DAS with 20W Remotes



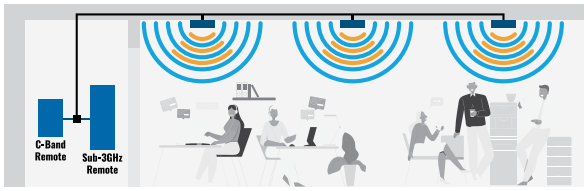
Sub-3GHz DAS with 20W Remotes + Fiber-To-The-Edge C-Band Overlay

Third, a legacy DAS designed with high-power remotes and a coaxial distribution supporting C-Band could integrate the HROU_4000. Knowing that the reduced propagation of the C-Band will result in some coverage gaps, deploy edgeROUs in those areas as needed. Because all SOLiD ALLIANCE DAS remotes share a common headend, network designers can mix and match different power classes of remotes for maximum design flexibility and efficiency.

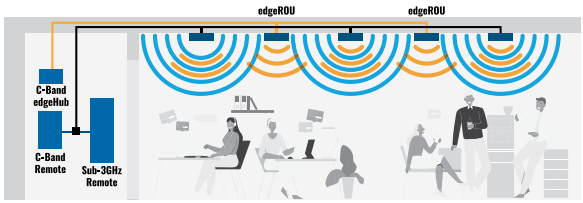
Scenario 3



Sub-3GHz DAS with 20W Remotes



Sub-3GHz DAS with 20W Remotes + High Power C-Band Remotes



Sub-3GHz DAS with 20W Remotes + High Power C-Band Remotes + Fiber-To-The-Edge C-Band Overlay to Fill Coverage Gaps

Whichever solution fits the situation, the edgeROU and HROU_4000 deliver the fully occupied bandwidth of both portions of the C-Band with 2x2 MIMO – 760 MHz of spectrum over a single fiber.

The SOLiD ALLIANCE DAS platform supports the fully occupied bandwidth in every 5G NR FR1 band to deliver enhanced mobile broadband and ultra-reliable low-latency connections, enabling maximum carrier aggregation flexibility. In fact, the ALLIANCE 5G DAS platform supports the speed, capacity, and capabilities of 5G in several ways.

Enhanced Mobile Broadband:

SOLiD ALLIANCE DAS supports the larger channel bandwidths of the 5G NR standard in all licensed cellular FR1 frequency bands below 6 GHz

- 600 MHz, 700 MHz, 800 MHz, 850 MHz, 1900 MHz, 2100 MHz, 2300 MHz, 2500 MHz, 3.45 GHz, 3.55 GHz, and 3.7 GHz
- Supports the fully occupied bandwidth in every one of these bands – for example, you can use all 280 MHz of 3.7 GHz C-Band spectrum simultaneously to maximize 5G speed and capacity
    - Using carrier aggregation, two or more FR1 bands can bond to create virtual 5G NR channels up to 100 MHz.

Time-Division Duplexing

- With nearly 20 years of experience in TDD DAS technologies, SOLiD has designed a superior method of synchronization for TDD systems
    - Synchronizes like a mobile device with just one data parameter
    - Synchronization is performed at the DAS remote (>2W remotes) or the edgeHUB for edgeROUs, providing greater reliability and avoiding the single point of failure when synchronizing at the headend
    - Supports 4G LTE and 5G NR for current and future 3GPP releases

Ultra-Reliable, Low-Latency Connectivity:

URLLC depends on minimal latency from each network element, and the analog nature of the SOLiD ALLIANCE DAS minimizes its latency contribution

- The edgeROU round-trip delay is typically less than 1 microsecond (1/1000th of a millisecond), starkly contrasting with digital systems contributing 20X or higher latency

Massive IoT and M2M Communications:

IoT and M2M communication typically occurs in the lower frequency bands that are less suitable for the high throughput and faster speeds of 5G

- Since the ALLIANCE DAS supports up to 8 frequency bands over a single fiber optic strand, it can support IoT/M2M in all listed bands

Network Slicing:

Network slicing may occur in any band and is unaffected by the DAS

Building tenants, employees, and visitors expect seamless, always-on mobile connectivity everywhere. As the adoption of 5G continues to escalate, is your DAS in-building equipment ready to support the demanding requirements of 5G NR to deliver true high-speed connectivity?

Contact SOLiD to learn how to ensure reliable, high-quality 5G connectivity in your building.

EDGE CONNECTIVITY. SOLiD COVERAGE.

SOLiD enables indoor and outdoor cellular and public-safety communications at many of the world's best-known and most challenging venues. From the busiest airports and subways to Fortune 500 corporate buildings, hospitals, hotels, universities, professional and college sports venues, and government, industrial, and logistics facilities, SOLiD's modular solutions scale to every challenge. SOLiD continuously innovates to deliver best-in-class solutions with ALLIANCE 5G DAS, RocketWAVE 5G repeaters, Infinity Access optical fronthaul and backhaul, and Open RAN (O-RAN) networks.

To learn more about our unmatched cellular coverage solutions,visit solid.com/us/ or call 1-(888) 409-9997.

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