# THE KEY CONSIDERATIONS IN PLANNING 5G INDOOR DISTRIBUTED ANTENNA SYSTEM (DAS)

## Guide

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Comba Group

# Introduction

With the implementation of commercial 5G networks, the indoor connectivity demand, including speed and capacity, is also expanding. To enable high-quality indoor network coverage and performance for various 5G applications and use cases, we need to make some considerations during the design phase of In-building solutions (IBS). We summarized eight key considerations when designing 5G indoor coverage using Distributed Antenna System (DAS) for the planner.

1 | Venue type and traffic model

2 | Frequency band

3 | 5G numerology

4 | Multiple Input Multiple Output (MIMO) in the building

5 | Active DAS or Passive DAS?

6 | Link budget calculation

7 | Sectorization

8 | Characteristics of an excellent indoor DAS design

# 1 | VENUE TYPE AND TRAFFIC MODEL

Unlike device-centric LTE network, 5G enables service-based applications. It provides higher data throughput, fulfils the ultra-reliable low-latency requirement, and upholds a massive number of IoT devices, resulting in more types of traffic models compared to the LTE era.

Not only do hotels, offices, hospitals, airports, transportation hubs, retail outlets, and stadiums have different traffic models, but some of them also even have diverse traffic patterns within the same premises.

Identifying venue traffic models, including where the crowd is and what services the consumers use, helps planners decide the best indoor solutions to adopt.

# 2 | FREQUENCY BAND

The frequency bands for 5G networks come in two sets.

- FR1 (< 6 GHz) - frequency used in legacy mobile networks, and
- FR2 (> 24 GHz) - more commonly known as Millimeter Wave (mmWave)

Given mmWave band suffers from high penetration losses from drywall, wood, glass, concrete, etc., we have not seen any wide deployment of mmWave in buildings.

We need a broader bandwidth to achieve multi-Gbps peak data throughput. Today, the frequency spectrum in the sub-3 GHz range has already been occupied by 3G and LTE. Re-farming these frequencies for 5G may not be practical as there is still massive demand in LTE. Some may consider using dynamic spectrum sharing (DSS) technology to enable the parallel use of LTE and 5G in the same frequency band. However, 5G capacity is not guaranteed due to the bandwidth limitation.

Not surprisingly, C-band (n77, n78, n79) is becoming the focus of most countries for 5G deployment due to its large chunk of bandwidth and propagation behaviour.

However, based on the fact that the C-band signal deteriorates faster than sub-3 GHz when traveling through the passive DAS and indoor structures, planners should take the frequency band into consideration when planning the antenna placement.

# 3 | 5G NUMEROLOGY

Although 5G uses OFDMA technology, the concept of numerology differentiates it from LTE for the subcarrier spacing (SCS). In 5G NR, SCS of 15, 30, 60, 120, and 240 kHz are supported. The most common SCS used in C-Band is 30kHz. Planners should know which numerology is used in the network in the link budget calculation.

As defined in 3GPP TS 38.101-1, the channel bandwidth and SCS for FR1 are shown in the table below:

**Table 5.3.2-1: Maximum transmission bandwidth configuration $N_{RB}$**

| SCS (kHz) | 5 MHz | 10 MHz | 15 MHz | 20 MHz | 25 MHz | 30 MHz | 40 MHz | 50 MHz | 60 MHz | 70 MHz | 80 MHz | 90 MHz | 100 MHz |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $N_{RB}$ | $N_{RB}$ | $N_{RB}$ | $N_{RB}$ | $N_{RB}$ | $N_{RB}$ | $N_{RB}$ | $N_{RB}$ | $N_{RB}$ | $N_{RB}$ | $N_{RB}$ | $N_{RB}$ | $N_{RB}$ |
| 15 | 25 | 52 | 79 | 106 | 133 | 160 | 216 | 270 | N/A | N/A | N/A | N/A | N/A |
| 30 | 11 | 24 | 38 | 51 | 65 | 78 | 106 | 133 | 162 | 189 | 217 | 245 | 273 |
| 60 | N/A | 11 | 18 | 24 | 31 | 38 | 51 | 65 | 79 | 93 | 107 | 121 | 135 |

# 4 | MULTIPLE INPUT MULTIPLE OUTPUT (MIMO)

## IN THE BUILDING

There are numerous discussions about the benefits of massive MIMO and Beamforming in 5G, such as to mitigate interference, improve SINR, provide higher throughput, and etc. Considering cost-effectiveness, we recommend implementing massive MIMO antennas for hot-spot coverage in specific areas like exhibition halls or indoor stadiums.

Today, most in-building sites are deployed with Passive DAS 2x2 MIMO as the building owners do not want to have too many passive components and antennas installed on the ceiling. On top of that, the operators could add more frequency and a “small cell” layer to accommodate higher capacity demand. We are not expecting a sudden change in the norm of 5G indoor deployment, but most likely, 2x2 MIMO or 4x4 MIMO will still be operators’ preferred option as the baseline 5G coverage layer.

The next question of whether we should build a new infrastructure of 5G overlay or upgrade the existing DAS will be addressed in the next section.

# 5 | Active DAS or Passive DAS?

Building 4x4 MIMO with Passive DAS means installing four layers of passive components in parallel, adding complexity to the installation. Besides, achieving MIMO with multiple passive antennas is also challenging. Some areas could lose MIMO connectivity due to different coverages of individual antenna paths. Comba has published a white paper comparing Active and Passive DAS in 5G connectivity, with the recommendations of:

- Passive DAS for small venues
- Active DAS for medium-to-large venues

For more information, check out "THE FUTURE OF DAS - INDOOR CONNECTIVITY TOWARDS 5G" white paper here!

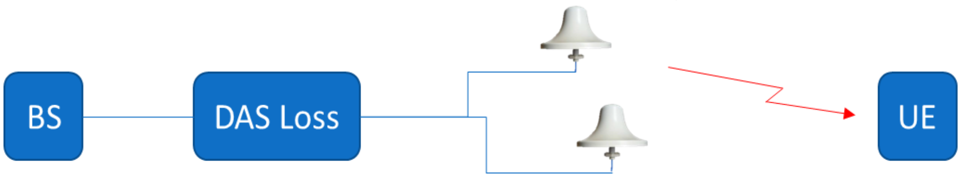
# 6 | Link budget calculation

The link budget calculates path loss between the transmitter and receiver, and estimates the antenna serving radius and number of antennas needed.

The calculation is based on reference signal received power (RSRP), which is the standard measurement at the user equipment. Below is the general formula of link budget calculation.

Passive DAS

$$\text{SS-RSRP}_{BaseStation} - L_{DAS} + G_{antenna} - PL(d) - \text{Margin}_{fading} = \text{SS-RSRP}_{receive}$$




Active DAS

$$\text{SS-RSRP}_{DPU} + G_{antenna} - PL(d) - \text{Margin}_{fading} = \text{SS-RSRP}_{receive}$$

Where:

$SS\text{-}RSRP_{receive}$: Received SS-RSRP at mobile

$SS\text{-}RSRP_{BaseStation}$: SS-RSRP at Base Station antenna port

$SS\text{-}RSRP_{DPU}$: SS-RSRP at DPU (included antenna gain)

$L_{DAS}$: DAS Loss

$G_{antenna}$: Antenna gain

PL(d): Path Loss at distance = d

$Margin_{fading}$: Fading margin

Note:

- $SS\text{-}RSRP_{BaseStation}$ and $SS\text{-}RSRP_{DPU}$ can be calculated from the output power and number of sub-carriers;
- Wall loss should be considered when the antenna is used to cover multiple rooms;
- Minimum 3dB additional margin is recommended.

# 7 | SECTORIZATION

Sectorization is a method used to design capacity for buildings with more than one sector. As discussed in the first section, planners should identify the building's traffic model and capacity requirement. We could design two sectors in a high-capacity area and one in a low-traffic area.

At the same time, planners should avoid overlapping more than three sectors in any handover border. When multiple sectors are serving at equal signal strength, it could cause unnecessary interference and ping-pong handover. If this is unavoidable due to site constraints, planners should adjust the handover border to low-traffic areas.

Another critical consideration is the coverage in elevators. We should make sure the elevator shafts are served by the same sector from the bottom to the top level, avoiding late-handover events and results in call drops, especially in high-speed lifts.

# 8 | CHARACTERISTICS OF AN EXCELLENT INDOOR DAS DESIGN

As indoor DAS installation involves mechanical and electrical (M&E) activity, minimum ceiling works for future maintenance and expansion should be in the design consideration.

An excellent indoor DAS design ensures:

- All intended areas are well covered;
- Evenly distribution of power among all antennas, except for those placed to cover a large area;
- No ping pong handover appears at any place, especially in an area with a void or air well;
- The design should cater to future sector split at minimum site works by placing the splitting point inside the riser. It is more accessible in active DAS as fibre optic or LAN cables are mostly used, and a sector split at the headend unit could be made;
- For Active DAS, the active equipment should be placed at a centralized location to allow the accessible provision of power supply, and in a non-public area to reduce the complexity of maintenance.

# CONCLUSION

The key points above are not limited to the 5G indoor networks but are also applicable to 2G, 3G and 4G networks.  This guide can help planners evaluate the requirements and resources, and decide the optimum indoor solution while using DAS.

# About Comba Group

Comba Group is a leading supplier of infrastructure and wireless enhancement solutions to mobile operators and enterprises to enhance and extend their wireless communications networks. With over 50,000 system deployments around the world including turnkey in-building systems, urban/rural wireless systems, and transport wireless networks, Comba Group's end-to-end network solutions include consultation, network design, optimization and commissioning. Comba Group's product portfolio includes DAS, small cells, tower mounted systems, antennas, subsystems, passive accessories, Wi-Fi systems and digital microwave links.

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