

# In-Building Solutions

Our solution approach  
and its evolution

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The indoor coverage experts

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# 1. Introduction

Cellnex UK is a neutral host infrastructure and connectivity solutions provider, and part of the Cellnex Group which operates in 12 countries across Europe with an annual turnover of 3.5 billion euros. In the UK, we operate more than 9,000 mobile sites today, growing to 13,000 by 2031. We've deployed over 1,000 small cells, and are a provider of private networks and indoor mobile coverage solutions.

Innovative and technology agnostic, Cellnex UK are indoor coverage experts, working with partners to develop the next generation of indoor connectivity.

The purpose of this document is to present our approach to providing 4G and 5G mobile coverage for many types of buildings, outlining the solutions that are available today and the way these solutions will evolve in the medium term.

Many buildings in the UK suffer from poor mobile phone signal from one or more mobile networks. Solutions to this problem have existed for many years, but are not ubiquitous. Available budget, space and power, together with a complex ecosystem, means that many demands continue to remain un-served.

Technology, though, is evolving, as is the commercial model, meaning that the problem can now be solved for an increasing number of locations.

In this document, we will set out our approach to In-Building solutions, considering a number of factors, including cost profile, power consumption, installation disruption, continuing technology evolution, smart building applications and more.



## 2. Background and context

**Despite the anywhere/anytime connectivity enabled by today's mobile phone networks, the majority of calls and mobile internet sessions continue to originate from inside buildings. The quality of mobile network operator coverage in offices, shopping centres, hotels, entertainment venues, etc. is therefore critical to building owners, tenants, employees and visitors.**

However, thick walls, steel structures and the increasing use of metallised-glass in building design can have a major impact on mobile signals originating from outside the building – reducing their strength, or blocking them completely.

Regardless of the nature of the building use or customer segment, these challenges are common to all. The approach to addressing them is also similar for each: an In-Building solution may be similar for an office building, a retail destination or a transport hub, although each deployment will be tailored to the building footprint and dimensioned in terms of capacity according to the density of devices and the type of use.

Historically, the responsibility of rectifying the mobile coverage problem was seen to belong to the Mobile Network Operators (MNOs).

More recently, however, mobile coverage is seen more as a utility, where the building owner or tenant has the greatest interest in fixing the problem. The added complexity of mobile versus other utilities, is that a complete solution needs to include all four licenced mobile network operators.

To date solutions have typically comprised a distributed antenna system, known as DAS, into which the signals from multiple MNOs are injected. These are new signals, derived from MNO equipment located at the premises, and provide additional network capacity dedicated to the building. The solution includes separate base stations from each UK operator (Vodafone, VMO2, EE, and 3) located in an equipment room on site, each with their own 'backhaul' connections into their respective networks. The antenna system is shared, but the other elements aren't.

A DAS fed by base stations from each operator is a technically excellent solution; however, the power consumption, space requirement, cooling obligation and overall cost are sub-optimal. Plus, the need for relationships with multiple parties has been just too challenging for many building and venue owners to manage.

Another solution in use today is a repeater system – similar to a TV or radio booster system. The external signal is captured and distributed internally.

Repeaters do not provide any additional capacity, and are therefore only suitable for small locations with a light usage which are in areas where the external macro cells are not congested.

With advances in technology, the increasing appetite from building and venue owners to provide excellent mobile connectivity to users, and the increasing acceptance of a greater level of shared infrastructure, Cellnex is able to offer solutions that reduce the cost base today, with an evolution path that simplifies and optimises still further. These include vendors offering more multi-operator equipment, 'OpenRAN' and 'C-RAN' architectures, enabling us to provide a more complete solution on behalf of the operators and a single point of contact for customers.

One advantage in the UK, that is not seen elsewhere, is that the MNOs have jointly established a suite of technical guidance known as the JOTS (Joint Operators Technical Specifications), which specify the performance, coverage and reliability of wireless systems shared between UK mobile operators.

All multi-operator In-Building solutions deployed by Cellnex UK are fully JOTS-compliant.

It should be noted that the MNOs' standard practice is to sign-off new solutions before they are permitted to be connected into their network. One complexity is that they do this in different times and different ways.

Beyond traditional DAS deployments, there has been slow progress in encouraging each MNO to sign up to a common platform. Through extensive trialling and collaboration, though, Cellnex is able to offer a range of solutions which can suit any building type.

One final piece of market context which is crucial to understand: Vodafone and Three have announced an intention to merge. Whilst this is expected to take time to progress through regulatory approval, it is possible that there will only be three MNOs in the near-to-mid-term.

# 3. Traditional solutions

The two most commonly deployed multi-operator solutions in the UK to date are: distributed antenna systems and repeaters.

## Distributed Antenna Systems

The diagram below illustrates a traditional DAS deployment, where all participating MNOs install telecoms base station equipment within the building to provide

their signal. These signals are then distributed around the building via a network of radio units and low-profile antennas – wall or ceiling mounted. Each base station is typically an individual rack circa 1.5m high and in larger systems each MNO may have multiple base stations. The

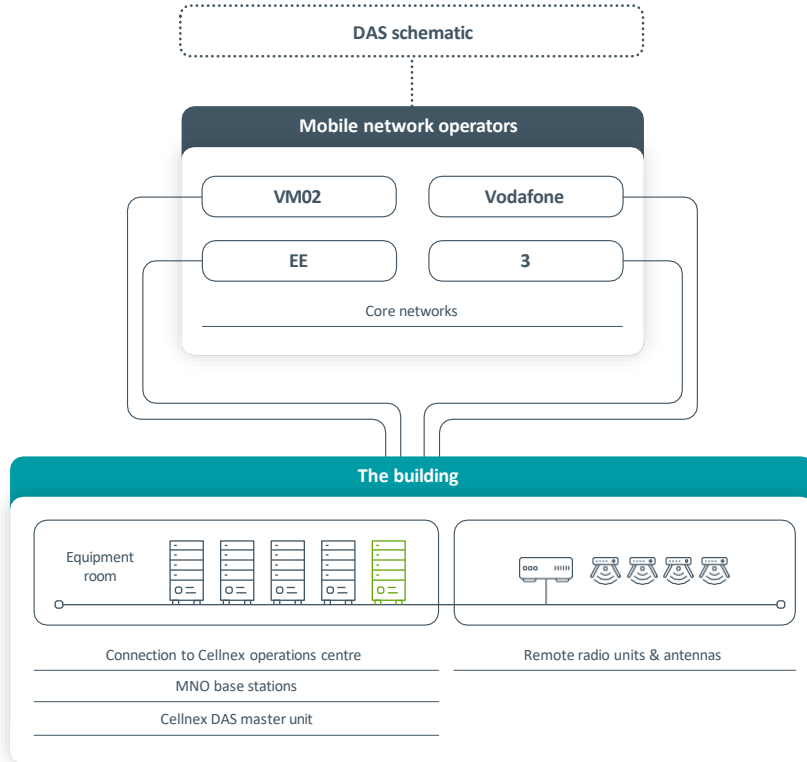
base stations are connected back into their respective networks via a backhaul transmission link, one for each MNO, who may use different transmission providers. All Cellnex UK DAS deployments comply with the JOTS Distributed Antenna System specification. Systems are

upgradeable and extendable to cater for new technologies, additional operator connections, and building expansion.



Whilst their use is being replaced for smaller and mid-sized locations, this solution will remain suitable for many years for the largest and busiest venues, such as large stadia, arenas, and top-10 shopping centres.

Cellnex UK offers this solution, and has a number of flagship deployments, including the Etihad Stadium, Sky campus at Osterley, the Cambridge Biomedical Campus, and the Bullring in Birmingham.

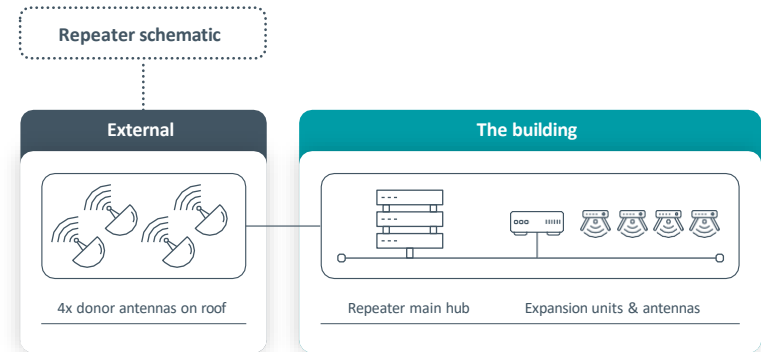


### Repeater solution

Here, a 'donor antenna', installed on the roof captures the signals from outside, boosts and retransmits them inside the building via an antenna or small DAS. The outside signal is effectively extended into the building. This provides strong signal strength but adds no extra capacity, so is only suitable for small buildings with light usage and where the operators' macro environment is not frequently in congestion.

Cellnex UK uses only those repeaters recognised by Ofcom as licence-exempt. Whilst other types of repeaters are available and can be legally purchased, they are not permitted for operational use in the UK.

Cellnex UK offers this solution for small locations with a light usage requirement.



## 4. The latest architecture

The JOTS forum has developed a second major specification for In-Building solutions known as NHIB (Neutral Host In-building). This sets out the technical requirements for shared In-Building solutions using small-cells and offers a more centralised approach, removing the MNOs' base stations from the building entirely.

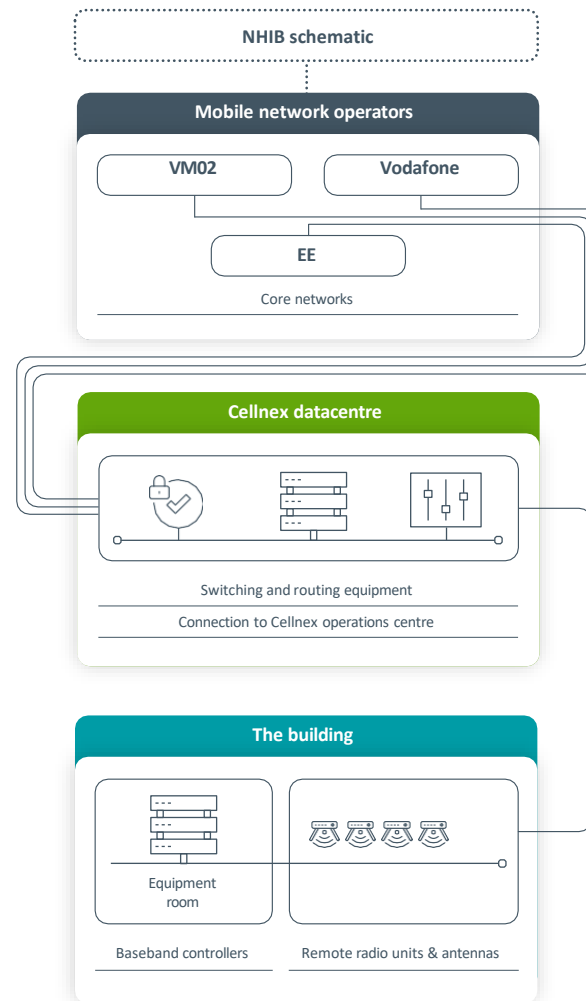
Instead, the MNOs connect back to their core network through the neutral host datacentre. The mobile traffic is then carried via a fibre connection to the building, where the signals are distributed via a series of radio points.

Offloading the direct connection between MNOs and the building makes it possible to remove the operator base stations entirely, with on-site telecoms equipment reduced to just a few units of rack space. This dramatic reduction in equipment

decreases the footprint, power consumption and cooling obligation, and makes the installation a simpler and less disruptive process. JOTS NHIB solutions can also take advantage of existing structured cabling within the building.

Whilst the specification has been agreed by the UK's four MNOs – VMO2, EE, Vodafone and 3 – each operator runs an approval process to integrate 'trusted' connections from the neutral host into its networks.

Cellnex UK has now launched a solution conforming to this architecture. It is currently available for small to mid-sized locations, and will include Vodafone, VMO2 and EE as standard. More detail is provided in the next section.



## 5. Our NHIB solution

**Following development and testing, Cellnex UK has now launched its multi-operator In-Building solution for small and mid-sized buildings, based on the NHIB architecture. It's a single-band 4G system with frequency re-use technology, and is therefore an optimum solution for this size of building.**

We have established a datacentre capability which underpins the solution, and have conducted testing and acceptance with both Vodafone and VMO2. The activity to integrate EE into this solution is underway, and will be completed in Q1 2024.

The platform is scalable, and has been dimensioned ready to support additional systems to meet our customers' needs. Further, the platform stands ready for integration with new vendor equipment as technology evolves.

We have also deployed a system of radio points at our office in the centre of Reading, which has been integrated into two mobile networks and is carrying live traffic.



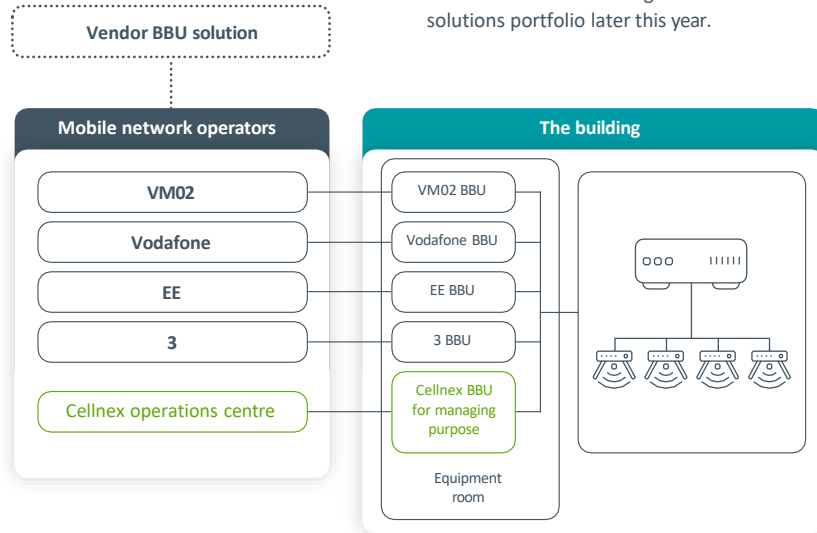


# 6. Evolution of DAS and base station technology

Base station vendors have now brought to market a solution where small cell baseband units (BBUs) connect into a proprietary system of radio points. Single unit BBUs rather than full rack base stations can be installed on site for each MNO. These solutions are currently going through the MNO acceptance processes.

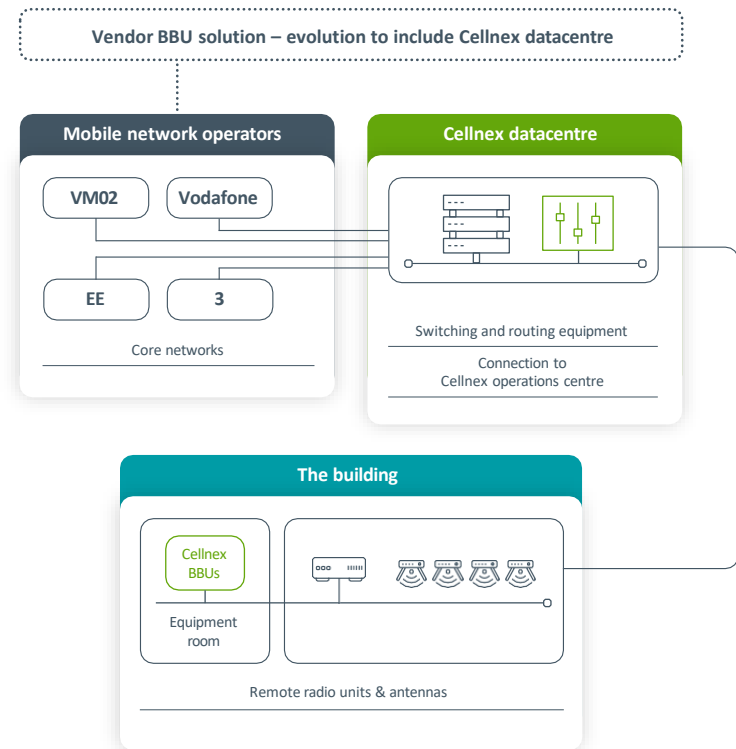
Whilst in the configuration below there is still the requirement for multiple backhaul connections, the space footprint and power requirement on site is much reduced versus traditional DAS deployment. Supporting multiple bands and multiple technologies (from 2G to 5G), it offers much greater capacity than the NHIB solution referred above, and is well suited to medium to larger buildings.

The equipment is available today, and Cellnex will be adding it to the solutions portfolio later this year.



A further evolution of this solution is that the baseband unit will be capable of multi-operator operation. Cellnex, with its suitability configured datacentre with connections into each MNO, would then act as trusted partner operating and managing a single BBU on behalf of all participating operators. The expected

result: a marginal reduction in on-site equipment and reduction in backhaul connections. We are not yet convinced that the additional savings would outweigh the significant development costs. However, we will continue to monitor the ecosystem, and make decisions accordingly.



# 7. Virtualisation

Baseband software is being developed which will run on standard IT hardware. This will further reduce the space requirement on site, lower the cost of installation and enable remote system upgrades.

Existing IT equipment rooms can be used, with little additional power or cooling.

The benefits include the flexibility to add or remove sites with minimal effort, and enables resources to be scaled elastically to address changing network demands.

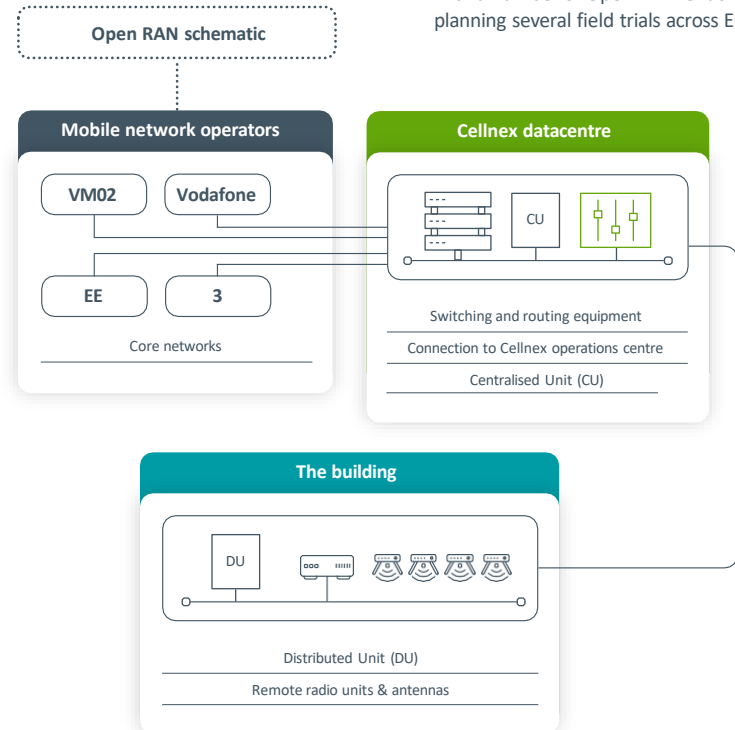
The virtualised baseband unit can be operated by each individual MNO or by Cellnex UK as a trusted partner.

Trialling and adoption within the technology sector is not widespread, and we may not see adoption in the in-building market for some time.

# 8. OpenRAN

Vendor-specific integrated equipment is set to evolve towards a more open system of hardware and software components all working to a common open standard. In time, this is expected to reduce costs of telecoms equipment. An overview is provided in the Annex.

At present, OpenRAN equipment is nascent and in development but evolving rapidly. Timelines for practical deployments are not clear due to limited multi-operator OpenRAN equipment currently being available, and the additional investment required for new platform management tools. However, Cellnex UK is keeping a close eye on developments, is working with a number of OpenRAN vendors, and is planning several field trials across Europe.



# 9. Private Wireless Network functionality

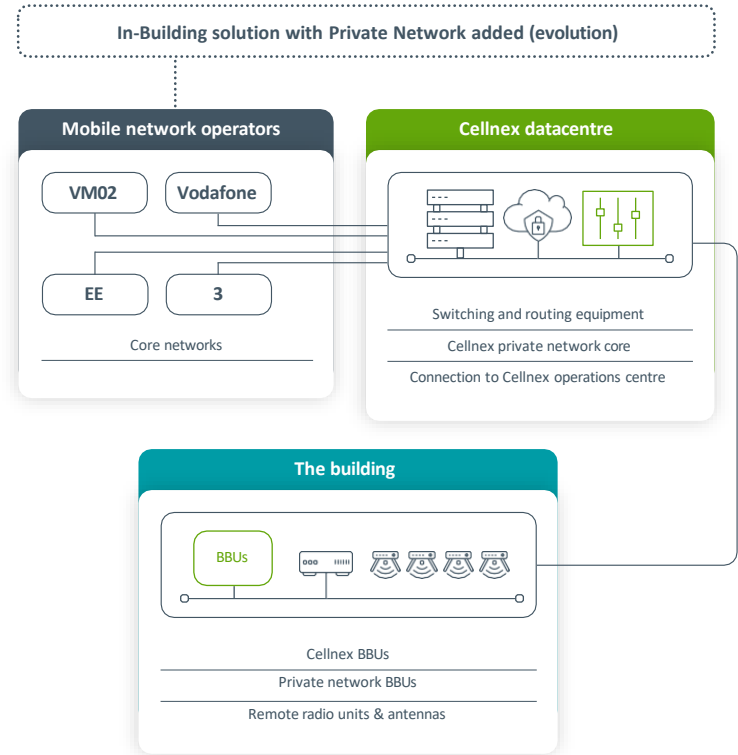
A Private Wireless Network is a dedicated business network – fully secure and tailored to its environment. It allows businesses to interconnect people and things using 4G or 5G technology, without relying on public networks which may be congested or not available.

Many use cases are supported by such networks, and they vary from sector to sector, but include:

- Smart buildings
- Mission critical communications
- Asset health monitoring and predictive maintenance
- Location tracking
- Environmental sensors

Typically, all equipment is located on the premises including the private network core. However, the private network core can be shared – which reduces costs per customer, and useful for multi-location use cases. It is therefore possible for Cellnex, as a trusted partner, to host the private network core in its data centre, as per the diagram opposite. The private network will also be able to share much of the same infrastructure (including active equipment) as the In-Building solution, further reducing overall cost and simplifying deployment.

Cellnex is a leading provider of industrial-grade Private Network solutions, with a large number of case studies across Europe. We have the expertise today to implement both an In-Building solution for public mobile coverage and a private wireless network for business-critical applications within the same project.



# 10. Closing Summary

**Our approach to the development of In-Building solutions is one of evolution and close collaboration with the MNOs. We consider the technology, architecture and technical acceptances available today, whilst understanding how they will evolve tomorrow. This manages the cost of installations whilst providing an upgrade path and maximises MNO connections.**

As the indoor coverage experts, we look at every requirement in detail before selecting the right solution for each project. We conduct surveys of the building and understand fully the requirements of the users, which may include multiple tenants across a building.

A detailed design is then undertaken in full compliance with the appropriate JOTS specification and ICNIRP exposure levels for transmitting radio frequencies, followed by system installation and commissioning.

Every In-Building solution is therefore tailored to meet our customers' specific business requirements. We remove the complexities of dealing with multiple stakeholders, by acting as a single point of contact. Once installed, the system is fully managed and monitored 24x7x365.

The solutions available from Cellnex today are summarised in the table opposite.

## Solution

Repeater system

NHIB

Vendor solution

DAS

## Application

For small buildings with a low-capacity requirement where good macro coverage and capacity is available outside

Single band solution for small to medium-size buildings with a medium capacity requirement

Multi-band solution for medium to larger-size buildings with a medium-to-large capacity requirement

For large venues with high footfall such as large stadia, arenas, top-10 shopping centres, etc



# 11. Annexes

## A. About Cellnex

**Cellnex UK is a Critical National Infrastructure Provider, and part of Cellnex Telecom, Europe's largest independent telecoms infrastructure provider. With the wireless infrastructure foundation that we deliver across rural and urban areas, Cellnex UK connects everyone, everywhere.**

Our commitment to connectivity extends beyond infrastructure; we are dedicated to closing the digital divide in the UK, helping people stay connected by promoting digital skills and providing access to digital devices and services to the communities that need it most.

Cellnex UK are indoor coverage experts and have extensive experience deploying In-Building solutions in sports stadia, transport hubs, commercial real estate, hospitals and more.

We're trusted by organisations to deliver best in class In-Building solutions; our references including Etihad Stadium, Sky campus at Osterley, Addenbrooke's Hospital. We operate as a neutral host – we partner with all four MNOs – and are technology agnostic, resulting in the best possible solution for every location.



To find out more and book a meeting with our in-building connectivity experts, get in touch at:

**In-BuildingSolutions@  
cellnextelecom.co.uk**

## B. Glossary of terms

Key terms used in this document and others widely used are explained in the following table:

Term	Description
<b>3GPP</b>	The 3rd Generation Partnership Project, an umbrella term for a number of standards organisations which develop protocols for mobile telecommunications.
<b>4G</b>	The fourth generation of wireless networks that provide faster internet speeds, improved voice quality, and support for advanced mobile services.
<b>5G</b>	The fifth generation of wireless networks that offer even faster internet speeds, lower latency, and support for advanced technologies like virtual reality, Internet of Things, and autonomous vehicles.
<b>Backhaul</b>	The connection between a mobile network operator's base station and the core network, or backbone network, and the small subnetworks at the edge of the network.
<b>BBU</b>	Baseband Unit, manages the baseband signals for transmission and reception.
<b>CAT6</b>	A standardised Ethernet cable that supports high-speed data transfer.
<b>C-RAN</b>	A centralised architecture for radio access networks, where the baseband units (BBUs), located centrally, are separated from the remote radio units (RRUs) which are located on-site.
<b>CU/DU</b>	Split architecture for 5G networks where the baseband functionality is split into two physical units: a Centralised Unit (CU) and a Distributed Unit (DU).
<b>DAS</b>	Distributed Antenna System, a network of antennas and other components that enhances wireless coverage and capacity in areas with high user density or challenging RF environments.
<b>ETSI</b>	European Telecommunications Standards Institute – a non-profit organisation which produces telecommunications standards for use throughout Europe.

<b>ICNIRP</b>	International Commission on Non-Ionizing Radiation Protection, the organisation that determines exposure limits for electromagnetic fields.
<b>In-Building Solution</b>	A wireless infrastructure system designed to provide reliable and efficient cellular coverage within a specific building or venue.
<b>JOTS</b>	Joint Operator Technical Specifications, established by the four UK mobile network operators.
<b>MNO</b>	Mobile Network Operator, there are four in the UK: EE, Virgin Media O2, Vodafone, and 3.
<b>NHIB</b>	Neutral Host In-Building, a JOTS specification where a third-party provider offers connectivity services from multiple mobile network operators within a building or venue.
<b>Ofcom</b>	Ofcom is the regulator and competition authority for the UK communications industries.
<b>Ofcom Licence exempt</b>	Types of repeater which meets the technical criteria specified by Ofcom. It is illegal in the UK to use other types of repeater to transmit MNO signals.
<b>OpenRAN</b>	A technology concept that promotes the disaggregation and interoperability of radio access network components.
<b>Private Network</b>	A dedicated business network providing secure and controlled connectivity.
<b>RAN</b>	Radio Access Network, part of a mobile telecommunication system responsible for connecting user devices to the core network.
<b>Repeater</b>	A device that receives a signal and retransmits it with greater power, so that the signal can cover longer distances or be received on the other side of an obstruction.
<b>RRU</b>	Remote Radio Unit, converts radio signals to a form suitable for transmission over a fibre optic or coaxial cable.
<b>Smart Building</b>	A building, which uses digital technology to collect various types of data (related to occupancy rates, temperature, lighting, etc.) in real time, allowing action to be taken, often automatically.

## C. The Joint Operator Technical Specifications (JOTS)

The JOTS forum has been established to specify the performance, coverage and reliability of wireless systems that are shared by mobile operators. They are referenced by providers, including Cellnex UK, when deploying shared radio solutions on behalf of their customers.

The UK JOTS forum was founded in 1999, by the then four UK MNOs. Since then, the specifications have been updated to include the latest technology and additional architectures.

There are two specifications for In-Building solutions:

- JOTS Distributed Antenna System specification (DAS)
- The JOTS Neutral Host In-Building (NHIB)

Under the specifications, a Neutral Host provider (for example, Cellnex UK), will install the in-building connectivity solution into the building or venue. The provider will be responsible for adherence to the requirements of JOTS.

The technical solutions are detailed and include:

- ensuring that appropriate assessments are carried out;
- that new deployments don't compromise existing technologies and devices;
- that all mobile operator spectrum requirements are met; and
- that the solution meets current 3GPP and ETSI standards.

It is important for building owners and businesses to choose a certified and experienced partner with a deep understanding of the specifications together with the capability and experience to deploy and manage the solution.

JOTS is a UK initiative, and is currently not an approach adopted elsewhere in the world. More information is available at [www.mobileuk.org/jots](http://www.mobileuk.org/jots)

## D. OpenRAN

**The radio access network (RAN) is part of a mobile telecommunication system. Conceptually, it resides between a device such as a mobile phone, and the operator's core network.**

Each MNO has one, although there is an element of sharing between some operators. It comprises the base stations, or baseband and radio units, and antennas. Historically baseband units or base stations have been provided as integrated units by a small number of vendors such as Ericsson, Nokia and Samsung.

OpenRAN allows for the separation between hardware and software components, all built to industry-wide specifications. This means that different suppliers can contribute parts to the system, safe in the knowledge that components will work together and with the rest of the network. Widening

the pool of suppliers and lowering the barrier of entry for smaller companies and specialists is expected to lead to greater competition, which will in turn lower the cost of delivering connectivity solutions and provide a catalyst for innovation.

MNOs are piloting OpenRAN configurations, but widespread adoption is not yet underway.

## E. Additional sources

**Cellnex UK In-Building video:**

[www.youtube.com/  
watch?v=aiXFj9QZlJA&feature=youtu.be](https://www.youtube.com/watch?v=aiXFj9QZlJA&feature=youtu.be)



**JOTS website:**

[www.mobileuk.org/jots](http://www.mobileuk.org/jots)

**Cellnex UK website In-Building pages:**

[www.cellnex.com/gb-en/technology/  
in-building-solutions](http://www.cellnex.com/gb-en/technology/in-building-solutions)



**OpenRAN links:**

[www.gov.uk/government/publications/uk-open-  
ran-principles/open-ran-principles](http://www.gov.uk/government/publications/uk-open-ran-principles/open-ran-principles)  
[www.o-ran.org](http://www.o-ran.org)

**Cellnex UK resource centre,  
collateral and case studies:**

[www.cellnex.com/gb-en/das-lp](http://www.cellnex.com/gb-en/das-lp)







[cellnextelecom.co.uk](http://cellnextelecom.co.uk)

CellNex plays a key role within the telecoms sector enabling connectivity throughout Europe. In the UK, as the country's leading independent telecoms site partner, CellNex provides critical national infrastructure & services to telecoms operators, emergency services organisations and many other enterprises.

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