

In-Building Solutions

Our solution approach
and its evolution

Autumn 2024

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The indoor coverage experts

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1. Introduction

Cellnex UK is a neutral host infrastructure and telecom connectivity solutions provider, and part of the Cellnex Group which operates in 12 countries across Europe with an annual turnover of 4 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 indoor mobile coverage solutions.

Innovative and technology agnostic, Cellnex UK are indoor coverage experts, offering a range of solutions and flexible commercial models to suit every kind of building and different business sectors. We continue to develop our solutions, 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. The Cellnex approach – a summary

Our approach to the development of In-Building solutions is one of evolution and close collaboration with the Mobile Network Operators (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 JOTS¹ specification and ICNIRP² 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, including the choice of MNOs to be connected. 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

Neutral host and new vendor solutions

DAS

Application

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

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

Multi-band solutions 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, major office buildings and hospitals

Cellnex acts as a single point of contact for in-building coverage projects – absorbing the complexity of multiple stakeholders, and a constantly evolving technical environment



¹ Joint Operator Technical Specifications

² International Commission on Non-Ionizing Radiation Protection



3. 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 coverage in offices, shopping centres, hospitals, hotels, entertainment venues, and government buildings, 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, and the impact can be significant. One example, highlighted by Cellnex UK in a recently commissioned survey, demonstrates how the lack of reliable mobile connectivity in the office affects hybrid workers. Here are the headlines, with further detail available at our website www.cellnex.co.uk.



The approach to addressing these challenges is similar: 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 for certain building sizes or levels of occupation. Plus, the need for relationships with multiple parties has been just too challenging for many building and venue owners to manage without a neutral host partner such as Cellnex UK.

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 best suited to smaller locations with light usage which are in areas where the external macro cells are not congested. This can include smaller retail, office or hotel environments.

Recently though, advances in technology and the increasing MNO acceptance of a greater level of shared infrastructure has paved the way for more affordable solutions for mid-sized buildings. Cellnex has innovated to reduce cost and complexity whilst providing a single point of contact for customers. The evolution path – which includes 'OpenRAN' and 'C-RAN' architectures – will simplify and optimise economics still further.

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, something Cellnex are experts in navigating.

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. This is progressing through regulatory approval, and it is possible that there will only be three MNOs in the near-to-mid-term.

4. Common 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.

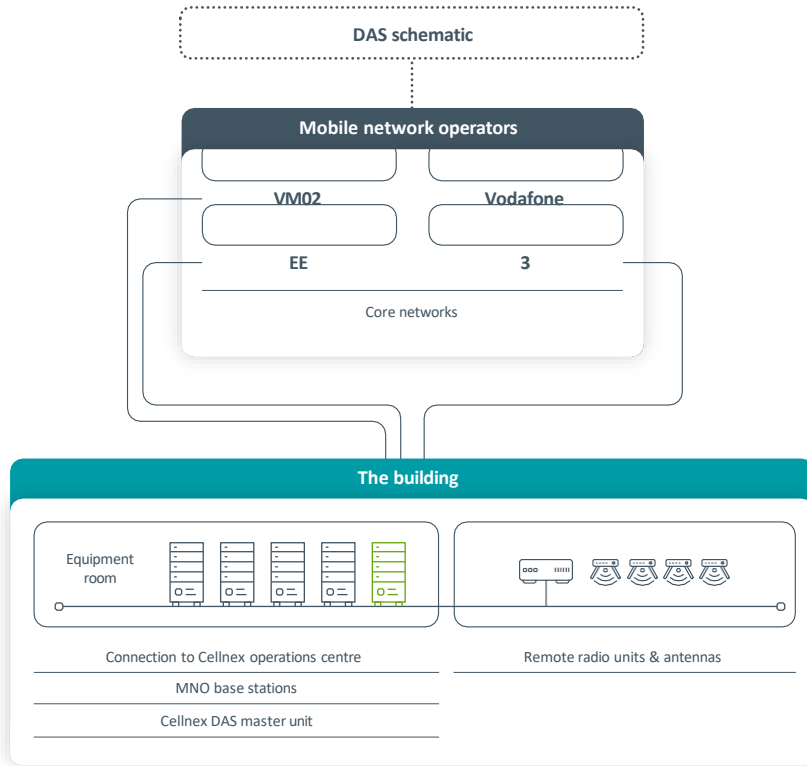
Whilst traditionally hosted in the building's main technical room, we can now locate equipment, including MNO base stations, off-site freeing up significant space in the building and reducing its electrical consumption.

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, DAS will remain suitable for many years for the largest and busiest venues, such as large stadia, arenas, top-10 shopping centres, major office buildings, hospitals, or large government property estates.

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. A case study on the deployment at the luxury 'OWO' hotel is featured later in this guide.

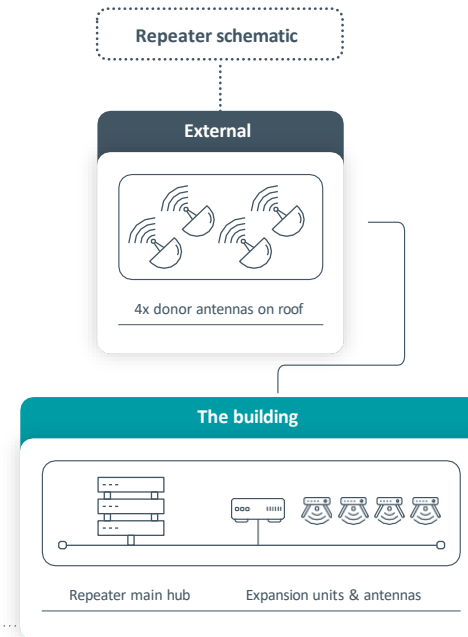


Repeater solution

Here, a 'donor antenna', installed on the roof captures the signals from outside, boosts and retransmits them inside the building via a network of antennas. 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 only where appropriate – typically smaller locations with a light usage requirement – and always optimises capacity through thoughtful consideration of multiple donor sites.



5. Architecture Evolution

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.

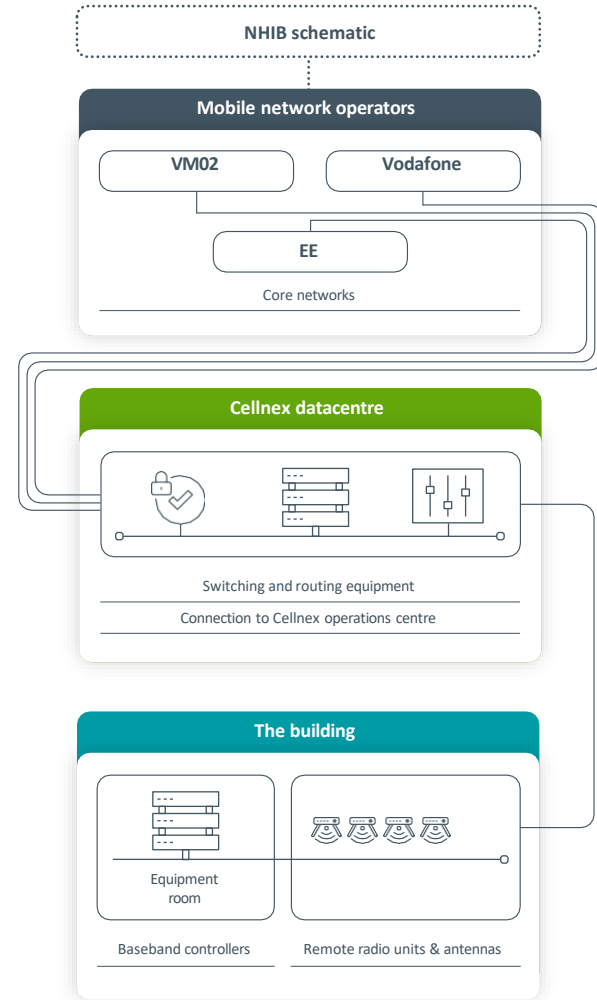
Offloading the direct connection between MNOs and the building makes it possible to remove the operator base stations entirely, with on-site telecoms equipment reduced to just a few units of rack space. This dramatic reduction in equipment

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. Further, the need for multiple backhaul links is removed, optimising deployment timelines.

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.

The Neutral Host specifications, including NHIB, continue to evolve. Cellnex UK remains closely engaged with the MNOs and continues to innovate.

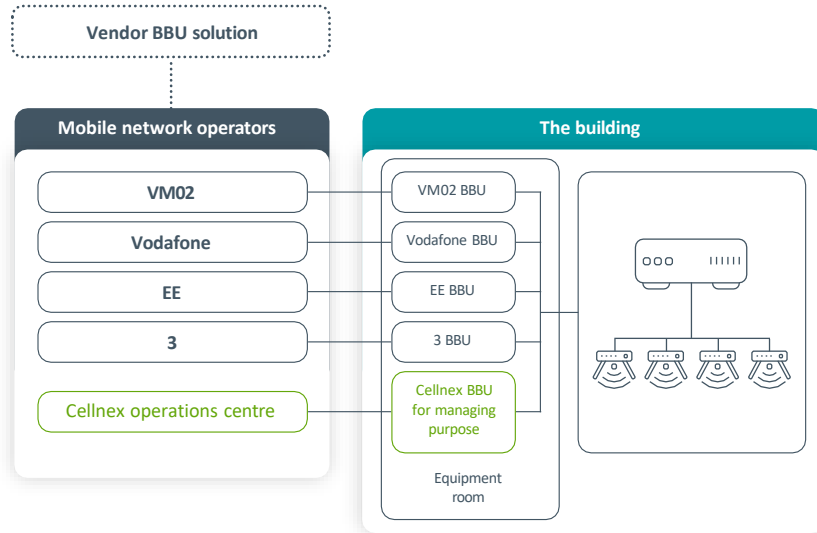
Cellnex UK has launched a solution conforming to NHIB architecture. It is currently available for small to mid-sized locations, and will include Vodafone, VMO2 and EE as standard



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.

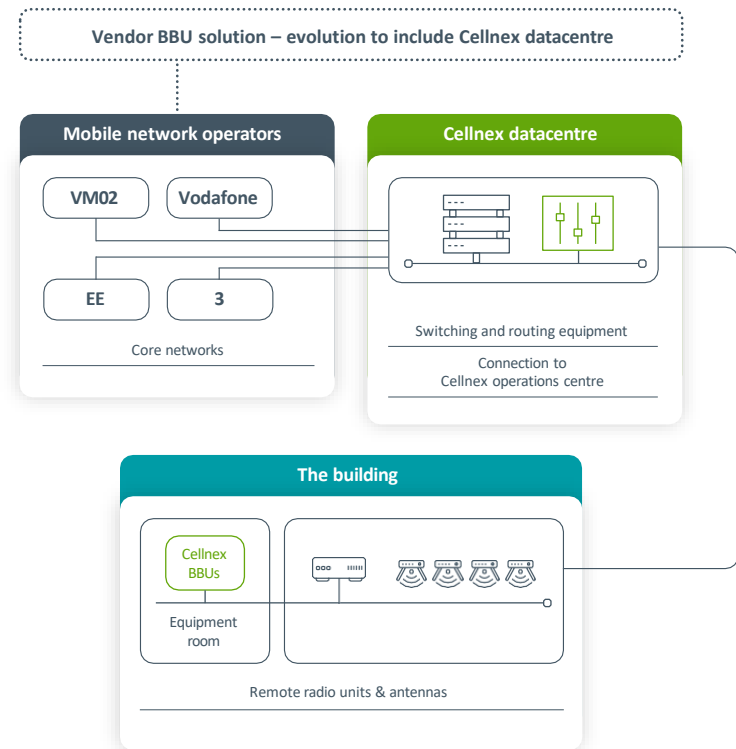
In the configuration below there is still the requirement for multiple backhaul connections, the space footprint and power requirement on site is much reduced versus traditional DAS deployment. Supporting multiple bands and multiple technologies (from 2G to 5G), it provides dedicated capacity well suited to medium to larger buildings.



An NHIB application of this solution is possible, since the baseband unit is capable of multi-operator operation. A neutral host provider, such as Cellnex, with its suitability configured datacentre and connections into each MNO, acts as a trusted partner operating and managing the BBU on behalf of all participating operators.

The result: a further reduction in on-site equipment and reduction in backhaul connections.

Cellnex continues to work with a number vendors and MNOs to continually enhance its solutions.



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.

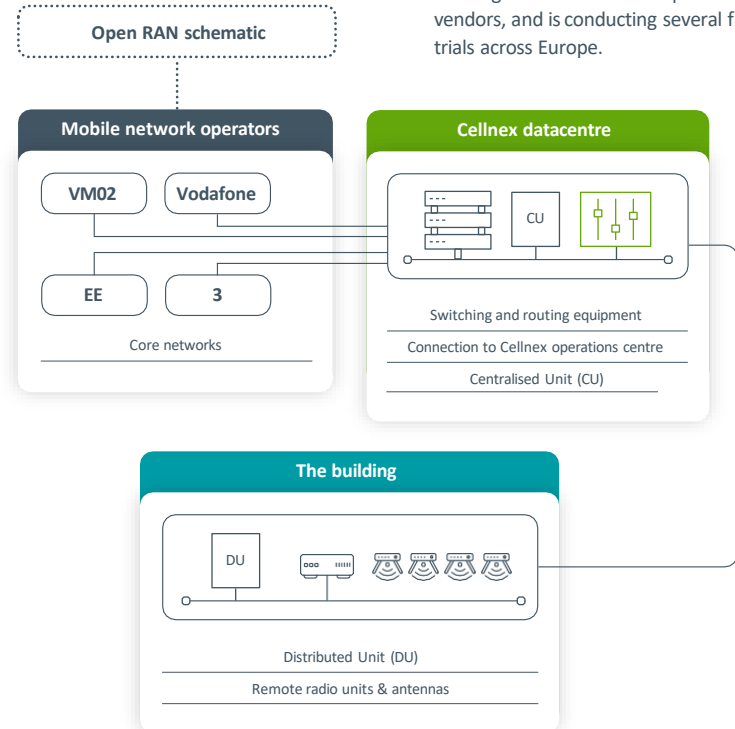
The virtualised baseband unit can be operated by each individual MNO or by Cellnex UK as a trusted partner.

Trialling and adoption within the technology sector is underway, but not yet widespread. We may not see adoption in the in-building market in the near term.

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 in-building 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 is keeping a close eye on developments, is working with a number of OpenRAN vendors, and is conducting several field trials across Europe.



9. Cellnex solutions and roadmap

Following development and testing, Cellnex UK has launched its multi-operator In-Building Solution for small and mid-sized buildings, based on the NHIB architecture. Available today as a single-band 4G system with frequency re-use technology, and an upgrade path to 5G, it's an optimum solution for mid-size buildings.

We have established the datacentre capability and inter-connection with MNO core networks which underpin the solution. Extensive testing, integration and acceptance have been conducted with both Vodafone and VMO2, and we are progressing the necessary activity to integrate EE.

The platform is scalable, and has been dimensioned ready to support additional systems to meet our customers' needs. The platform stands ready for integration with new vendor equipment as technology evolves, and we are seeking to develop further pilots in line with this evolution.



Whilst less relevant to indoor coverage, Cellnex UK is also pioneering the adoption of the Neutral Host architecture in complex outdoor environments, establishing a pilot small cell deployment in London.

And we've embraced the technology ourselves, and customers are welcome to visit our office in the centre of Reading to see the solution in action.

We are ready to accept orders from owners and developers of suitable small to mid-sized buildings who require Vodafone, EE, and VMO2 connectivity

10. Annexes

A. About Cellnex

Cellnex UK is the UK's largest and fastest-growing independent owner and neutral operator of wireless telecoms infrastructure. It's part of Cellnex Telecom, which operates in 12 countries across Europe. Through 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.

Cellnex UK: The indoor coverage experts

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. Case Study

Delivering in-building connectivity for The OWO and Raffles London

Reimagining connectivity for the 21st century without compromising an iconic building's historic aesthetic.

Located in the heart of Whitehall, the Old War Office is a Grade II* listed building that's been meticulously restored and extended. Renamed The OWO, this landmark destination houses an iconic 120-bedroom Raffles Hotel, 85 luxury private residences, boutique shops, and more.

Alongside powering commercial operations across the site, providing fast, consistent and reliable 4G voice and data coverage is essential for delivering the seamless connected experiences guests, visitors and residents expect.

A sensitive transformation

From day one, the forward-thinking developer knew implementing mobile coverage was a must. It turned to Cellnex UK to implement a Distributed Antenna System to deliver indoor connectivity, for all UK mobile operators, against a host of complex requirements.

The scale of the task confronting Cellnex was considerable. Alongside ensuring the solution was non-intrusive and in-keeping with the building's unique and impressive architecture, Cellnex needed to apply some clever thinking to overcome the significant challenges posed by the building's sheer scale and the signal blocking materials that make up much of the building's fabric.

Constructed of Portland stone, the site features a four-storey basement extension, rooftop terraces, a cinema, spa and swimming pool. Delivering connectivity at scale and across all these indoor areas was a complex proposition – particularly in underground spaces such as the Whitehall Ballroom, London's largest subterranean ballroom, as well as into the two car lifts used to transport vehicles and large production sets direct from street level into the hotel's underground event spaces.

Cellnex UK ensured that the building's Edwardian architectural features – which include wood panelling and hand-laid mosaic floors – were sensitively preserved

A collaborative effort

To accommodate these needs, Cellnex worked hand in glove with the site's development teams to identify where and how best to integrate the required connectivity infrastructure into the fabric of the building as the refurbishment programme progressed. By making its inbuilding infrastructure 'invisible' to the naked eye, Cellnex was able to ensure the visual integrity and aesthetic of the historic building was never compromised.

The highly dynamic nature of the project required close collaboration with multiple specialist contractors throughout the 8-year renovation programme.

Coordination was key and the Cellnex UK team had to work in a highly proactive and iterative way. This flexibility was particularly important in reducing project disruption during the COVID-19 pandemic.

While ensuring its solution was non-intrusive and in keeping with The OWO's original architecture, Cellnex UK was able to accommodate all design changes and amendments requested by stakeholders during the extensive building transformation process. Today, the Cellnex in-building connectivity solution provides fast, consistent mobile signal and data coverage across this iconic building. Which means that visitors to this historic and glamorous London venue are assured of experiencing the modern-day connectivity that is essential for today's 21st century lifestyles.



Benefits and outcomes

- **Ultra-fast** voice and data connectivity for guests, visitors and staff
- A **multi-network operator** solution.
- **Future-proofed** infrastructure, featuring an upgrade path to 5G.
- **Seamless cross-site coverage** in all indoor areas, including the hotel's subterranean 600 capacity ballroom, nine restaurants, three bars, and 85 private residences
- A **fully supported and managed** solution

C. Glossary of terms

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

Term	Description
3GPP	The 3rd Generation Partnership Project, an umbrella term for a number of standards organisations which develop protocols for mobile telecommunications.
4G	The fourth generation of wireless networks that provide faster internet speeds, improved voice quality, and support for advanced mobile services.
5G	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.
Backhaul	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.
BBU	Baseband Unit, manages the baseband signals for transmission and reception.
CAT6	A standardised Ethernet cable that supports high-speed data transfer.
C-RAN	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.
CU/DU	Split architecture for 5G networks where the baseband functionality is split into two physical units: a Centralised Unit (CU) and a Distributed Unit (DU).
DAS	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.
ETSI	European Telecommunications Standards Institute – a non-profit organisation which produces telecommunications standards for use throughout Europe.

ICNIRP	International Commission on Non-Ionizing Radiation Protection, the organisation that determines exposure limits for electromagnetic fields.
In-Building Solution	A wireless infrastructure system designed to provide reliable and efficient cellular coverage within a specific building or venue.
JOTS	Joint Operator Technical Specifications, established by the four UK mobile network operators.
MNO	Mobile Network Operator, there are four in the UK: EE, Virgin Media O2, Vodafone, and 3.
NHIB	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.
Ofcom	Ofcom is the regulator and competition authority for the UK communications industries.
Ofcom License Exempt	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.
OpenRAN	A technology concept that promotes the disaggregation and interoperability of radio access network components.
Private Network	A dedicated business network providing secure and controlled connectivity.
RAN	Radio Access Network, part of a mobile telecommunication system responsible for connecting user devices to the core network.
Repeater	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.
RRU	Remote Radio Unit, converts radio signals to a form suitable for transmission over a fibre optic or coaxial cable.
Smart Building	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.

D. 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 (such as, 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

E. 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.

F. 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

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

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

www.cellnex.com/gb-en/das-lp





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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