



A CTO's guide to the 5G network

Technical capabilities and rollout timescales for 5G adoption planning

5G is happening – and it's set to transform UK businesses

5G brings many exciting and transformative possibilities for businesses large and small, across every industry sector.

In technical terms, 5G represents a significant step forward from 4G, on which it will initially build. As it evolves, 5G will bring major new technological capabilities that will support entirely new business models, sectors, and more efficient ways of working. This paper explains the key technological capabilities of 5G and the use cases they support.

It's important to note that while some services are available today, there's a lot to be done before some of the more advanced 5G services become reality. We'll look at what's possible today, what still needs to happen, and what we're doing to help businesses maximise the value of 5G as it rolls out.

We're here to help your business get maximum value from 5G

One unique aspect of 5G is the range of capabilities it will offer. What's critical for one business may not be relevant for another – so we're interested in working with your business to understand and shape the services that will help you transform the way you operate.

If you'd like to discuss specifics around the future availability of the capabilities set out in this paper, and how you might put them to use in your organisation, get in touch today.

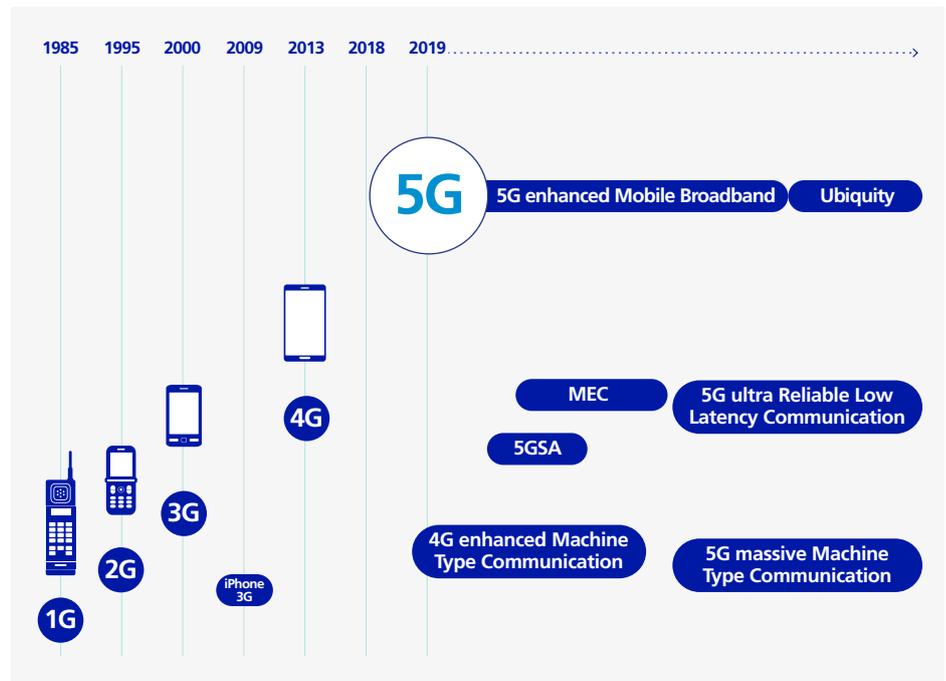
The path to 5G

5G will not arrive in big-bang fashion, but incrementally over the coming years as new networks are built out, new standards are set, new spectrum is allocated for 5G services, and new 5G-compatible equipment becomes available.

The difference between non-standalone and standalone 5G

The earliest 5G services build on the existing capabilities of the 4G network, and are termed non-standalone 5G (5GNSA). This simply means that a 5G network requires 4G to provide access to the 5G layer, which has higher speed and more capacity. These services are available from us today in some areas and will be rolled out to more locations as we continue to invest in our network infrastructure.

At the same time, we're working toward a standalone 5G network (5GSA). This will mean that 5G can operate on its own, allowing direct access for 5G mobiles to the 5G network. This will help support more advanced 5G technologies as they're standardised: from autonomous vehicles to remote maintenance of physical assets.



The evolution of mobile: 5GSA will enable many advanced use cases

What is 5G non-standalone (5GNSA)?

5GNSA uses the existing 4G core network to control and manage the data transmission, but requires modifications to existing 4G base stations to add access to the 5G service to deliver 5G speeds and bandwidth to 5G-capable mobile devices. We started to upgrade our 4G network to 5GNSA in 2019, and continue to roll out the enhanced service to new locations. Only 5G-capable devices can access the enhanced Mobile Broadband service.

What is 5G standalone (5GSA)?

The 5G ecosystem that will evolve towards 5GSA will allow direct access to the 5G network. It will have a software-defined core network and provide access to new 5G capabilities. In the near future, it will enable innovative use of spectrum bands to achieve the levels of speed, bandwidth and coverage required by business and society.

The key capabilities of 5G

Excitement around 5G is high, sometimes stimulating unrealistic expectations of what will be possible in what timeframe. Senior technology executives will need to explain to the business which 5G capabilities are accessible today and which are still to come – and why.

It's also important to know which capabilities will support which applications and use cases, so the business can plan effectively for the introduction of new 5G-enabled models, services and processes.

Broadly, those capabilities fall into the following categories:

Enhanced Mobile Broadband (eMBB)

Available today in some areas of the UK via 5GNSA, eMBB builds on the existing 4G network capabilities to deliver greater bandwidth and faster upload and download speeds. It also improves latency. Supporting services such as seamless 4K HD video streaming for use cases like videoconferencing, remote consultation and mixed-reality training.

Massive Machine-Type Communication (mMTC)

Available in the future, once the standards have been finalised, mMTC will greatly expand the machine-type communications possible today with 4G. It will support truly large-scale Internet of Things (IoT) deployments for use cases like remote asset monitoring, predictive maintenance, and smart city infrastructure. And will allow 1000's of connected devices rather than the 100's that are possible over enhanced Machine Type Communication (eMTC) today.

Ultra-Reliable Low Latency Communication (uRLLC)

This will reduce network delay to 1ms or less for specific use cases, enabling real-time autonomous decision-making and information provision. Mobile Edge Computing (MEC), network slicing and a network of networks will help deliver ubiquity and reliability. And will enable use cases like intelligent transportation systems, self-governing industrial robots and even remote medical procedures.

millimetre Wave (mmW) (also known as millimetre band)

Is a band of radio spectrum that is between 30 gigahertz (GHz) and 300 GHz. 5G Researchers are testing wireless broadband technology on mmWave spectrum, this is because there is enough spectrum available to provide ultra-wide 5G channels. Ultra-wide channels that are 5 times that of 4G, allowing 5G to make full use of the new technology opportunities.

Carrier Grade Security

5G standards will build upon 4G end to end, designed in 'carrier grade' security capabilities. 'Carrier Grade' refers to a system of both hardware and software components that have been designed from the ground up to provide the best possible security, that is rigorously tested to prove its capabilities, providing true end to end security for our customers. As opposed to corporate grade security which is 'layered' on top of an existing system after its built, like a VPN on a corporate LAN network.

Larger channels

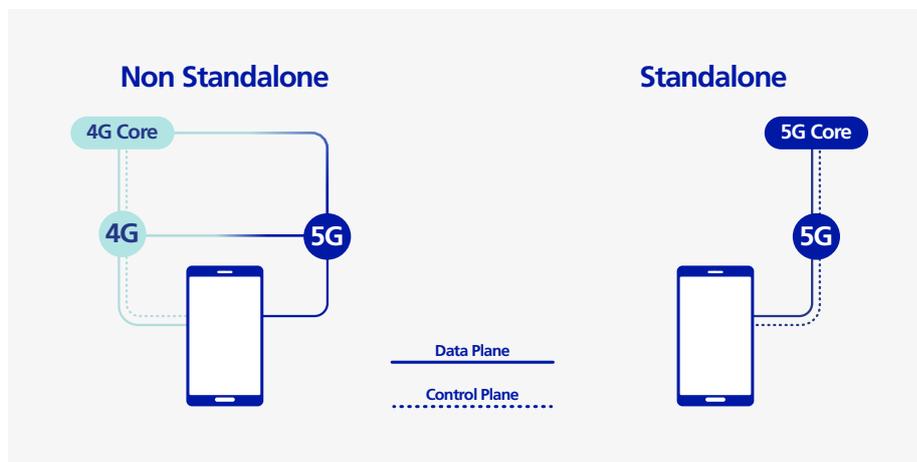
5G supports channel/Carriers that are 5x times larger than 4G, and allows these Carriers to be aggregated together to create a larger bandwidth. This means that 5G has the initial capability of being many times faster than 4G. And will help support 1000x the data volume that we expect to see with 5G. In the future with this and other 5G capabilities and spectrum evolution the connection speeds will approach 5 Gbps download and 2.5 Gbps upload.

Enhanced Mobile Broadband (eMBB)

The first 5G services to become available will be the greater bandwidth and faster data transfer speeds, with improved latency, termed enhanced Mobile Broadband (eMBB). The eMBB technology is supported by both 5GSA and 5GAA.

Structurally, it will initially entail building clusters of 5G cells within the existing 4G network, to create more bandwidth and allow more devices to connect to the network in a given area. Only 5G-capable devices will be able to take advantage of enhanced Mobile Broadband services. Our 5G rollout will start in densely populated areas including city centres, indoor locations, stadiums and other high demand areas, so we will all see improved coverage and speed.

In the future, businesses can also look to deliver super-fast enhanced Mobile Broadband within their buildings, on campuses and at events, possibly augmenting this with private clusters of 4G and 5G cells. When uRLLC arrives, it will allow 5G cells to seamlessly join existing wifi coverage to provide greater capacity, reliability and speed in specific locations. And 5G devices will have the possibility to handover between wifi, satellite and 5G without customer interaction. 4G does support wifi calling and wifi data usage, but this is not done in a truly seamless way today, 5G will do this natively.



Seamless mobile videoconferencing both in Ultra-High Definition (UHD) and High Dynamic Range (HDR)

With eMBB, remote employees and mobile workers will be able to enjoy seamless, high-definition videoconferencing on 5G-enabled smartphones and mobile devices in areas where public 5G is available. This will provide a colour rich and crystal clear display taking it far beyond the 4K experiences we enjoy today on mobile devices.

Remote expert

Technicians can also benefit from centrally-based engineering expertise and the use of AR, via a remote expert headset. This will reduce time to fix, by ensuring correct and faster diagnosis of faults. And help train field force technicians in an engaging way, this will help to extend the working lives of the highly-skilled and expensive engineering work force, reducing costs and improving utilisation.

Virtual presence

eMBB will also enable more advanced telepresence functionality, such as enabling remote consultations and allowing people to be 'physically' present at meetings without actually being in the room – via digitally generated holographic image of oneself. HD video, sound and low latency will provide the feeling of real interactions with people based on the timing of facial micro expressions detection and audible queues.

Virtual and mixed-reality training

eMBB will be able to support high-definition, seamless virtual and mixed reality training and sales opportunities as well as gaming. That creates many opportunities for safe and cost-effective workforce training, allowing people to train in virtual classrooms, in virtual locations, and scenarios without leaving their place of work. That in turn reduces travel costs, carbon emissions and downtime. But making the training more of a visual experience it will also help to make the training more effective too.

5G standards targets

- 1000x data volumes
- 1000's of devices versus 100's on 4G
- 10x data speeds of 4G
- 5 to 20x latency improvements, Mobile Edge Compute
- 99.999% Availability – Network of Networks – Ubiquity
- Extended battery life, 10 years for machine-type devices

massive Machine-Type Communications (mMTC)

While 4G has already started to make IoT a reality with enhanced Machine-Type Communication (eMTC), 5G will exponentially expand the possibilities, thanks to its support for massive Machine-Type Communications (mMTC).

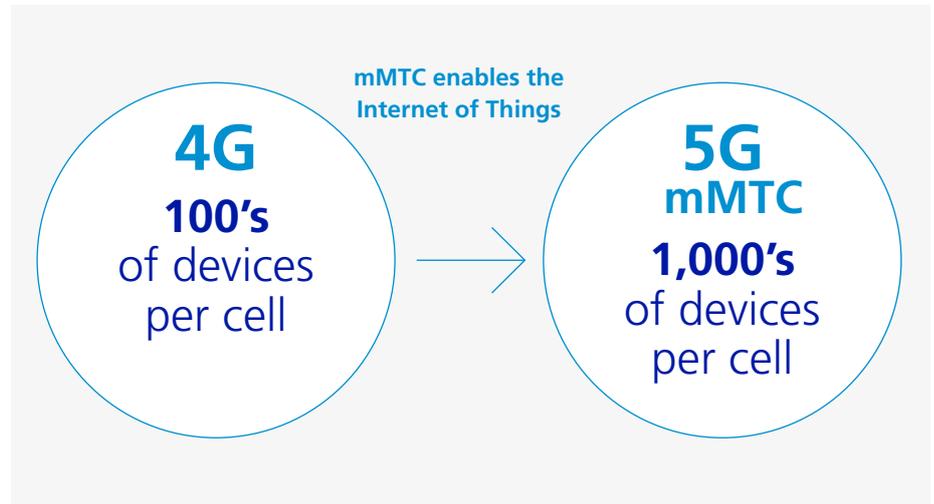
Today, 4G networks support device-to-device communications using two technologies: LTE-M and Narrow Bandwidth-IoT (NB-IoT), these are collectively known as enhanced Machine Type Communication eMTC. 4G's eMTC can support hundreds of sensor-equipped devices in one cell to send and receive data, enabling early IoT use cases like smart meters and other smart home technologies.

With 5G mMTC, there will be an order of magnitude increase in device connectivity allowing 1000's of connections in one cell. Driving towards the future, we might expect to see millions of connected devices per square kilometre.

As the number of 5G cells in the network increases, especially with the deployment of mmWave spectrum, it will mean the network will be able to support even more connected devices in a given area. It is estimated that 5G will need to support many millions of connected devices within a square kilometre, creating opportunities for use cases like:

Smart city infrastructure

Cities will be able to monitor activity like traffic, pedestrian and passenger flow, and energy, waste and water usage, and adapt their infrastructure to ensure safety and continuity of service.



Connected Intelligent Transport Systems

Vehicles connected to smart roadside infrastructure will be able to report their location, pay automatically for parking and tolls, and get time-critical information about traffic conditions, accidents and alternative routes.

Preventive maintenance

In this use case we would see sensors deployed within a factory or work environment, collecting large amounts of data, which is then analysed by AI systems. This will provide early detection of potential issues making it possible to fix faults before they happen. The diagnosis is based on analysis of changes within the local environment, such as; vibration, noise, humidity and heat. Allowing preventive maintenance to be scheduled in planned down time, maximising production efficiency, quality, and minimising the cost of repair.

Asset location and monitoring

Including:

- Tracking the physical location of 'tagged' assets such as; factory-floor equipment and physical assets, vehicle fleets, farm animals, containers, and goods both in a warehouse and in transit.
- Monitoring the status of infrastructure and items such as; street lighting, rubbish bins, fleet vehicles, and road signs.
- Allowing continuous monitoring of equipment health and status, allowing preventive actions to be taken ahead of any fault or issue developing. This allows preventive maintenance regimes to be put in place, minimising down-time and improving efficiency. In the future we can see this extending to augment open information exchange for buildings (Building Information Management BIM) and the National Road Authorities (NRA) where asset management is vitally important.
- Where shared location information for items such as; street furniture, water and sewage pipes, gas mains, power and communication cables is critical to avoid delays and disruption.

ultra Reliable Low Latency Communications (uRLLC)

uRLLC addresses issues of latency and reliability that in today's networks create barriers to many real-time automation and control use cases.

Three features of uRLLC enable high reliability and ubiquity, near zero-latency communications and network slicing – giving essentially no delay between data being generated/received by a sensor and it then triggering an action:

High reliability and ubiquity

Mobile networks alone won't provide truly ubiquitous coverage that businesses will need in order to rely on "5G everywhere".

5G will aim to solve this through creating a "network of networks", leveraging future common standards and infrastructure to integrate the cellular network with wifi, and new Low Earth Orbit (LEO) constellations of 5G satellites – such as the 8,000 Star Link satellites that SpaceX plans to launch by 2025. Other constellations are also being launched; OneWeb and Iridium NEXT to name but two.

Mobile edge computing (MEC)

MEC will see high-performance servers and software located close to or within the cellular core network or at the base stations. This technology would allow compute, data storage and processing to happen close to or within the cellular network, rather than the data being sent to a remote server and back over the internet. It will enable near-zero-latency, 1ms to 5ms, and allow for the efficient distribution of content (e.g. video content) and aggregation of data (e.g. sensor data) too, supporting use cases like:

- **Intelligent Transport Systems (ITS):** Is an advanced application of technology that aims to provide enhanced data and actionable information to traffic management systems and will enable travellers to make better informed decisions. Reducing delays, and enabling a smarter, safer and more coordinated rail and road transport systems.
- **Connected Autonomous Vehicles (CAV):** Using 5G, information about the road and rail conditions ahead or behind, would be provided to all road users in near real-time. The data would come from vehicles and trains themselves, monitoring systems such as roadside cameras and other road sensors. This information once processed would then be used to augment traffic management systems, electronic road signs and automated driving systems helping to avoid collisions and delays. One thing to note is that the vehicle needs to be able to drive itself without interaction with the network; the network is only there to help improve the quality of those decisions.

- **Computer vision – AI-powered:** UHD HDR camera feeds can be analysed by AI within the network every second of every day of every year using a MEC platform, enabling real-time identification of safety breaches or criminal incidents. It can also be used to spot crowd congestion opening alternative exits, and spot shopping behaviours allowing real-time optimisation of the shopping experience. Processing the imagery at the edge means that content is never sent into the internet, just the actionable meta data is used.
- **Collaborative robotics:** Will be able to adjust to tasks in near real-time; for example, recognising if an item is heavy or light, and adapting their grip accordingly. Reacting instantly to changes in environment or circumstance, correcting for errors such as misalignment too.

Network slicing

The 5G NGC (Next Generation Core) will be a software-defined network (SDN), supporting network function virtualisation, which will provide real-time adaptability, and a finer-grained control delivering flexible and efficient core network. Tailoring the network to truly meet the demands of the customer. One big advantage of this capability will be network slicing, where bandwidth can be layered and reserved for services like voice, messages and emergency communications. This will enable network reliability where it's most needed, for example:

- **Emergency services:** Network slicing can guarantee connectivity for critical services like police, fire, ambulance, coastguard and search and rescue, to assure safety of life.
- **Private 5G networks:** Businesses deploying private 5G networks will be able to reserve and guarantee bandwidth for services like asset monitoring, video monitoring, 'machine control' e.g. collaborative robotics or AGV's, and video conferencing.

There is a significant advantage to a network that can scale itself to meet instantaneous customer demands, and slice resource to ensure the quality of service maintained. However, care must be taken to consider net neutrality regulations and requirements.

What will the next few years bring?

The journey to 5G has already begun, and the transformative power of the network for business will only increase as time goes on.

We are investing £2m each day into our networks, working closely with customers to scope, architect and deliver the capabilities that will most benefit their business.

Here are some of the developments you can expect to see between 2020 and 2025:

New infrastructure

5G will require a massive investment in new infrastructure, this is magnified by the upcoming new spectrum and will require a higher level of densification to support demand.

What we're doing: We have embarked on a huge 5G network buildout, with an agreement reached with Vodafone to share 5G active equipment, such as radio antennas, on joint network sites across the UK¹. This means more people will get 5G sooner, helping to build a competitive digital economy and encouraging innovative new services that use 5G's speed and greater reliability. We're also collaborating where possible with fixed-line carriers and local authorities to use existing structures and ducts.

New standards

5G's architecture involves new standards for radio access, timing and synchronisation, security, safety, and interoperability with 4G, wifi and satellite networks. Many different bodies are working on the new standards, and many standards are still to be defined.

What we're doing: We are working with standards bodies to ensure we participate in the development of all relevant standards.

New spectrum

To derive the benefits of 5G it will need to operate over many different spectrum bands, including low bands and new mmWave bands which will vastly increase network capacity and connectivity.

What we're doing: We continue to make significant spectrum investments to support our 4G and 5G network services. In 2018 our parent company Telefónica invested £523m in new spectrum for 4G and 5G, making O2 the largest owner of mobile spectrum in the UK. Ofcom has announced plans to auction new 5G spectrum in 2021, and we will continue to invest as spectrum is made available.

Is 5G safe?

We're excited about the benefits that our 5G network will bring for customer and business, but we understand there are some questions being asked about the impact on our health.

The WHO and the International Telecommunication Union (ITU)

recommend that governments adopt the radio-frequency exposure limits developed by the International Commission on Non-Ionizing Radiation Protection (ICNIRP).

In the UK, the Government has adopted these exposure limits developed by

ICNIRP and mobile network operators are required to operate within these guidelines.

If you want to know more you can visit the [NHS](#), [World Health Organisation](#) or [Mobile UK](#).

¹ <https://news.o2.co.uk/press-release/o2-and-vodafone-finalise-5g-network-agreement-in-the-uk/>

New trials and proofs of concept

5G creates opportunities for entirely new use cases, applications and vertical business models. While some of these are known, others have not yet been imagined.

What we're doing

We are working closely with customers, academia and partners to explore use cases and run trials and proofs of concept. Some of these include:

- **Intelligent Transport Systems Test Bed at the Millbrook Proving Ground:** As part of the AirSpan consortium, we are working with partners at Millbrook Proving Ground to test the role of 5G connectivity in Intelligent Transport Systems, and how those Networks will interact with Connected Autonomous Vehicle platforms of the future.
- **5GIC:** We've been a partner of the University of Surrey's 5G Innovation Centre since 2014, helping to conduct leading research into 5G and pioneering new industry use cases. The 5GIC brings together leading academics and key industry partners in a shared vision to help define and develop the 5G infrastructure that will underpin the way we communicate, work and live our everyday lives in the future.
- **5G at The O₂:** We have successfully deployed our 5G testbed network at The O₂ arena. This is allowing us to trial innovative applications such as real-time remote-controlled robotics and holographic calling/telepresence.
- **Digital Greenwich – SMLL Ltd:** The Smart Mobility Living Lab: London (SMLL) aims to build the UK's most advanced environment for developing future transport technologies, services and business models.
- **SPRING:** We're part of 5SPRING, the UK's first 5G commercial application accelerator. Our aim is to help organisations of all sizes harness the power of 5G to deliver growth and innovation throughout the West Midlands and beyond. Whether you are from the private or public sector, our cutting-edge facilities and expertise can help you understand 5G, its applications and how you can unlock its potential.
- **5G New Thinking:** The 5G New Thinking project will look at the provision of mobile/wireless connectivity primarily using the shared spectrum and local spectrum licencing options announced by Ofcom in July 2019. Working closely with communities, the project will develop a community toolkit to allow the creation of networks that provide rural connectivity for cooperatives of consumers, local enterprise, councils and other stakeholders.
- **Project Darwin (European Space Agency):** An ambitious multi-year trial to pave the way for next generation connectivity solutions for connected and autonomous vehicles (CAVs). The project aims to test new technology and end-to-end connectivity solutions including 5G and satellite communications and to ultimately to help support the CAV industry vertical.

Why O₂



We are the comms integrator of choice for UK plc, supporting industry, government, utilities, emergency services, and businesses of all sizes.



We consistently build our network around our customers, using our insights into the needs of business and the public sector to design and deliver the right services for the future.



We continue to invest £2m each day in our network rollout, capacity uplift and technology development, as well as opening up innovation spaces and proving grounds to allow customers to trial new 5G use cases.

We are working around the clock to continue to strengthen our 4G network and build and deliver a 5G network that will bring transformative advantages to UK businesses and their customers.

If you'd like to learn more about how we can help you maximise the value of 5G to your business, call us on **01235 433507** or visit our [website](https://www.o2.co.uk/business)