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Private networks: A user guide

May 2022

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Foreword

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From healthcare to hospitality, windfarms to warehouses, education to manufacturing, private networks are delivering the fast, secure, and efficient connectivity that organisations need.

In practice, private networks in their various guises have been around for several years. The difference now is that, enabled by advances in technology, they offer much richer experiences.

While that technology is important – be it Wi-Fi, 4G or 5G – ultimately it is the business outcomes that drive private network deployment, not the other way around.

Enterprises that first identify the problem to be solved, then turn to the technology that enables them to resolve it.

New enablers such as 5G, IoT and data analytics are acting as accelerants at a time where organisations are adapting to cater for new customer needs, increased efficiency, and decarbonising.

In my role at BAI Communications, where we design and deploy shared systems to a variety of venues, places and transport systems – the key mantras of coverage, capacity, reliability and security must be borne in mind.

It is often a daunting landscape to navigate as a business or organisation, to consider these new solutions. This is why, as part of my role as Chair of techUK's Communications Infrastructure and Services Council, I'm really supportive of this new paper which acts as a practical guide to the choices presented, demystifying the technology to allow successful implementation for organisations within the UK.

Introduction

The UK is one of the most advanced economies in the world – a technological leader, open and dynamic. It has been set on a course to be an innovation superpower by the mid-2030s, with the Government keen to invest in building back better from the COVID-19 pandemic, levelling up nations and regions, and driving towards the goal of net zero[1].

There are many laudable benefits to innovation at a national level: boosting economic growth, increasing productivity, job creation, and building competitiveness. Technology is at the heart of this innovation—from AI to digital twins, to robotics and edge computing. In techUK's telecoms programme, our members are at the vanguard of enabling this innovation through world-leading communications infrastructure and services.

And here we will showcase how this innovation is advancing private network technology.

The power of enhanced private networks is in the enabling of new and transformative technologies for enterprise, helping to unlock efficiencies and advanced intelligence, and to strengthen security of organisations. Advanced private networks can be delivered by a number of technologies, like 5G and Wi-Fi, and it is estimated that the productivity and efficiency gains enabled by the deployment of 5G technology will drive business, skills and service change worth £43bn to UK GDP by 2030[2]. In parallel, by 2025 estimates are that Wi-Fi 6/6E deployments will drive an additional $10.7bn in economic value for the UK, yielding a total economic value of $108.5Bn[3].

In this guide, techUK aims to help prospective users to better understand the benefits of private networks, and the key considerations when building a business case for investment. The vision of this practical guide is to accelerate the adoption of enhanced private networks for all levels of UK industry, including SMEs, across a range of public and private sectors.

We will share valuable insights and learnings from different use cases in a variety of settings—ports and logistics, health and social care, and manufacturing—to help prospective private network users understand their own requirements, and how they stand to benefit from the digital transformation enabled by advanced connectivity.

The paper begins with a look at the principal benefits of private networks, and the key considerations an enterprise or public sector customer must be aware of as they build their own business case, and some of the challenges to be addressed. Our guide is technology neutral, and while benefits and advances in all communications technology will be explored, we are not advocating a single specific solution that addresses all requirements. As such we will use the term private network throughout, acknowledging that this can be realised using different wireless technologies and be fulfilled via a range of different delivery options. We will address the different technical deployments, explaining some of the options for private networks, including 4G, 5G and Wi-Fi 6, and setting out the enhanced wireless connectivity options available in the market today.

There are different ways to procure a private network – you might go to a Mobile Operator or Telco to do everything for you, a Hyperscaler for a cloud-based managed service, or a specialist organisation who may be better placed to implement and even operate the communications aspects alongside your existing operational technology. Alternatively, the enterprise could deploy the network directly by buying components in from equipment suppliers, although this may only be an option for larger enterprises with specific skills. The choice you take will depend on your specific needs and your organisation's approach to managing and implementing such a project. We refer to whoever you choose to build your network as the "solution provider" – whether this is within your own enterprise or via another organisation.

Throughout this paper we aim to build an awareness of the private network value chain, and the various roles and responsibilities of the players within the ecosystem, through the theme of collaboration. The key stakeholder is our reader—the enterprise customer—the beneficiary of the innovation, agility, and productivity that private networks enable. But we will also help readers understand the expertise on offer from the telecoms sector: network operators, service providers and system integrators, cyber security and interoperability experts, and hardware suppliers.

Understanding private networks for enterprise

Our aim is to help the users of private networks—primarily enterprise customers such as a manufacturer or logistics company, as well as public services like healthcare providers—to understand what a private network can do and how to work with the communications industry on finding the right solution for their business, public sector organisation or service.

What is a private network?

For a simple definition, a private network is communications network infrastructure that is used exclusively for serving the business needs of an end user organisation.

Private networks are built from a combination of fixed technologies, based on copper and fibre connectivity, and wireless connectivity, provided by a variety of technologies, including Wi-Fi, fixed wireless access, terrestrial mobile wireless networks, and satellite (non-terrestrial) networks.

This table sets out basic definitions of private network and related technologies:

Wi-Fi	Wi-Fi is a **wireless** networking technology that provides local area networking connectivity to devices such as computers (laptops and desktops), mobile devices (smart phones and wearables), and other equipment (printers and video cameras).
Mobile	A **mobile private network** uses mobile (cellular) technology to deploy private 4G/LTE and 5G services: often the term "Non-Public Network" (NPN) is used to describe private 4G/5G[4]. An NPN can be delivered with dedicated equipment at the NPN location, or using Network Slicing, which enables a mobile network provider to deliver slices of the network which are completely decoupled from each other.
Fixed wireless access	**Fixed wireless access (FWA)** is the process of providing wireless broadband using radio links between two fixed points. In other words, fixed wireless is an alternate method of providing internet access to homes or businesses while eliminating the need for physical connections (phone lines, cable, or fibre)[5].
PMR	**Private Mobile Radio (PMR)** – sometimes called Professional Mobile Radio – was developed for business users who need to keep in contact over relatively short distances with a central base station / dispatcher – a typical example is a taxi company. PMR is also widely used by emergency services[6].
Satellite	**Satellite broadband** is network connectivity provided through low Earth orbit (LEO) or geostationary (GEO) satellite systems. These systems are typically formed of three main components: One or more **gateway earth stations** which connect the satellite broadband network to the internet or private network; one or more **satellites** used to relay traffic between the gateway and **user terminals**; to provide broadband connectivity to end users, typically comprising of an antenna and user equipment[7]. Although not exclusively a private network technology, satellite is included for completeness as it can provide important coverage where there are gaps in outdoor public connectivity services, for example in rural settings.

An alternative way to understand private networks today is to look at the three market areas for private network technology, as proposed by Disruptive Analysis[8]:

Critical communications network	Deployments of these private networks are well established in sectors like mining, utilities, transport hubs, and defence and have typically been based on technologies like private mobile radio (PMR), TETRA and the ESN, but use of 4G and 5G is increasing. Readers of this guide are likely familiar with private network technology, and the need to separate from any public mobile network. However, the key features in critical communications networks are increasingly seen in other industrial use cases, in tandem with other wireless IT applications, like edge computing, for critical systems with high resiliency requirements.
Indoor mobile phone or campus networks	The evolution of these private networks has seen increasing deployments in locations such as stadiums or venues, retail centres, offices or universities. Private mobile (4G and 5G) is an option, as well as Wi-Fi. As Disruptive Analysis has suggested, this market segment is “most likely to require interconnection with the public mobile infrastructure”.
Cloud and IT/IoT networks	This market segment aligns closely with the digital transformation promise of private networks, as a key enabler of new and innovative applications and services for enterprise, such as Industry 4.0 and the Internet of Things (IoT). For enterprise users and the public sector, cloud-based networks offer access to the latest experimentation and innovation but may not be as widely deployed.

Advances in private network technology

The need to understand the benefits of private networks stems from the advances seen in the communications technologies available to enterprise and public sector users today, which include both Wi-Fi and mobile technologies, as well as other low power radio technologies. These can be deployed in private networks to deliver a range of advanced capabilities to the end user.

It is now much easier for UK businesses and organisations to exploit private network technologies, which are no longer the preserve of specialists. The technologies are within reach from an economical perspective. Plus, some recent regulatory changes have unlocked further innovation in the private network space[9].

Wi-Fi

The latest Wi-Fi standard, specified by IEEE, is Wi-Fi 6, which adds additional efficiency, flexibility, and scalability that provides existing and future networks with increased speed and capacity to enable next-generation applications and services[10].

Upgrading existing enterprise networks with Wi-Fi 6 delivers a 4x increase in network capacity, a 50% improvement in battery life, and a 2x increase in bandwidth over previous generations. Wi-Fi 6 allows private enterprises and service providers to support new and emerging applications and services on the same infrastructure while delivering a higher grade of service to legacy applications.

Mobile

Recent advances in mobile technology offer new benefits for private networks for enterprise. 5G can offer greater speed and capacity than 4G, and the architecture flexibility to scale—enabling millions of devices to be connected simultaneously—as well as lower latency, which reduces the delay between a device being instructed to perform an action and that action being carried out.

For a private network in the manufacturing sector, 5G can improve the interconnectedness and responsiveness of both machines and workers, and increase the amount of data available for analysis to optimise systems for high reliability, security, control and efficiency when compared with previous 4G technology[11]. The flexibility provided by private networks in a manufacturing facility can improve the productivity and efficiency of both people and processes thus creating new business models.

Growth of public and private 5G networks

The UK is considered by many to be a leader in 5G deployment and the development and uptake of advanced digital technologies[12]. For public mobile consumers, 5G is now widely available across the UK from all four major mobile network operators (MNOs) and on handsets produced by multiple smartphone vendors like Samsung and Apple[13].

The acceleration of private 5G adoption in the UK has been boosted by the 5G Testbeds and Trials Programme, delivered by the Department of Digital, Culture, Media and Sport (DCMS). The Programme began awarding funding for 5G trials in 2018, with 30 projects live to date[14].

Globally, it is hard to determine the exact number of existing private mobile network deployments, as details are not often made public. However, GSA (Global mobile Suppliers Association) has published recent figures that estimates 656 organisations known to be deploying private mobile networks in 58 countries and territories.[15] And here in the UK, over 950 shared access low power licenses have been issued for private mobile network deployments[16].

In addition, Release 17 of the 3GPP standards for 5G, scheduled for release in 2022 will include non-terrestrial networks, including satellite. This new release will enable the provision of 5G via satellite and other non-terrestrial networks across the UK.

Satellite

Non-terrestrial capability (e.g., Satellite, High Altitude Platforms (HAPS)) provide an alternative approach, by offering high-speed, highly reliable wireless connectivity for private networks from a network of equipment above the Earth. Non-terrestrial delivery enables a broad coverage pattern to be delivered, as satellites are well placed to provide backhaul capability for local private networks, especially in rural and remote areas where terrestrial connectivity is not economically feasible.

Today non-geostationary satellite orbit (NGSO such as LEO) and GSO satellites are both providing a wealth of high-speed broadband and narrowband services to users across the UK and the globe for backhaul, IoT and other uses including supporting private networks. The new generation of LEO satellites are already providing low latency, high-throughput connectivity to any spot on the surface of the earth – extending mobile operators' coverage and providing broadband backhaul for mobile or Wi-Fi networks. It can also provide broadband connectivity to and from private networks in remote locations for critical services such as offsite data backup or rapidly extend a private network across various remote locations. GEO satellites with their wider coverage are well placed for offering resilient connections to protect critical network connections.

The key takeaway is that whichever technology is used to deploy your private network, the latest technological advances in communications infrastructure are now available to enable your enterprise, no matter the size, to digitally transform business operations.

What are the opportunities and benefits enabled by private networks?

Commissioning a private network provides your organisation with a bespoke communications infrastructure tailored to your specific user needs. The network can provide ubiquitous and guaranteed connectivity indoors, outdoors, even underground. Having read this paper, you will be ready to move to the next step in deploying a new private network, or stand ready to upgrade existing IT/OT systems to include advanced communications technology.

In this section, we outline the key benefits of private networks for customers. Broadly, these benefits are available to all sizes of business and across all industry verticals to a certain degree: these are core benefits to the operation of your business, but also form part of the wider macro socio-economic opportunities that increased adoption of private networks can deliver for the UK, such as digitally transforming the way public services are delivered.

In general, the real benefits come not just from connectivity, but from increased access to data in near real-time, enabling faster actions and responses, and from increased automation, enabling process efficiency and elimination of errors. The details of how benefits will be realised depends on the specific industry sector and use cases, but the principles are similar for all.

Better connectivity provides more reliable data access which, in turn, improves decision making and automation.

Benefits of deploying an advanced private network

Flexibility: As bespoke communications infrastructure deployed specifically to meet your operational requirements, private networks offer enhanced customisability and agility for enterprise and the public sector.

Reliability: A private network can deliver robust, secure communications with consistent latency and speed. Especially in device-dense environments with data-heavy requirements, advanced technologies like 5G and Wi-Fi 6 can handle the high-performance demands of modern enterprise locations.

Security: Advanced private networks are inherently more secure than older connectivity solutions, with end-to-end security built-in from the ground up and on day one, ensuring that data remains secure and inaccessible to outside parties.

Performance: a key driver for the increased adoption of private networks today is the ability to support demanding applications and quality of service guarantees across a range of sectors.

Guaranteed coverage and capacity: even remote and hard-to-reach locations are guaranteed access to network performance at a high level. Separation from a public mobile network also offers increased network capacity for uninterrupted operations.

Deploying a new private network can enable a wider set of opportunities through digital transformation:

Increased productivity and efficiency: Private networks can unlock intelligence for enterprise through sensory networks. Capturing data in real time, an operational model of a factory enables predictive maintenance, identifying fixes to reduce downtime, and help reduce costs.

As well as predictive/smart maintenance, private networks can enable organisations to be more energy efficient through optimising operations.

Advanced applications: linking an advanced private network with cloud-based IT/OT infrastructure enables a number of digital applications and services to be unlocked. These include wide-area mobility for autonomous and remote-controlled operations, from smart manufacturing, the use of drones and autonomous vehicles, AI, machine vision, edge computing and augmented reality. Use cases include real-time automation and robotics, enhanced monitoring, sensory networks, and security of tracked assets (and secure tracking of assets).

Internet of Things: Because of the benefits of ubiquitous and secure 5G and Wi-Fi 6 in an enterprise private network, the possibility of deploying a new ecosystem of connected IoT devices is more viable for your business.

IoT technology enables manufacturers to increase the number of sensors fitted to equipment, collect more data, and measure more variables – vibration, temperature, pressure, humidity and more.

This data collection and analysis can enable necessary maintenance to be carried out in a scheduled way, reducing downtime and minimising the impact of repairs on a factory's performance[17]. IoT sensor technology can be used across multiple industry sectors. For healthcare, IoT can extend the reach of healthcare touchpoints for patients outside of traditional healthcare settings. Care in the community is delivered safely and remotely in the community through the use of remote patient monitoring devices, data gathering, wearables and fall sensors. IoT devices in your enterprise can be managed by an edge device management system, providing a single platform for monitoring and maintenance.

Safety: the mobility benefits of dedicated private networks mean increased worker safety, especially in challenging or hazardous environments. Ericsson points to the example of modernising Land Mobile Radio (LMR) networks with private mobile, which enables the 'collaborative worker' with video streaming for real-time sharing with teammates or remote experts and augmented reality to interpret the surrounding environment and equipment[18]. In remote or dangerous environments, such as ports, mines, and off-shore facilities, bespoke connectivity solutions designed to operate in hazardous locations ensure Mission Critical Push To Talk (MCPTT) radio and phone communication, help control bandwidth for worker communication and can integrate safety and maintenance apps into operational systems. Enhanced connectivity can also enable new technology to come online in these environments and scale: instead of a worker inspection, drones or robots can undertake tasks safely and remotely, empowered by AR inspections.

Edge computing

Edge computing, while not new, is fast becoming seen as a key technology and an enabler of widescale innovation[19]. The benefits of edge computing are two-fold: accelerating innovation in key industries, and accelerating adoption on complementing emerging technologies.

Edge computing is a form of distributed computing that brings processing closer to the source of data, or in other words, putting IT resources nearer to where they get used. This form of distributed infrastructure allows you to deploy a new class of application, termed “Edge-Native Applications”. These applications need a raft of special features that classic or cloud architectures cannot provide in all locations, including low network latency and high bandwidth. Latency influences where the edge must be. Latency, the delay between transmitting and receiving data on a network, is highly sensitive to distance, so it follows that the nearer you can put processing power to its users, the lower the latency[20].

Examples of Edge-Native Applications include:

- Services which require rapid location tracking, e.g., semi-autonomous robotics in a factory environment, vehicle platooning
- Services which require very high bandwidths and low latency, e.g., Virtual Reality / Augmented Reality
- Services that require processing very large amounts of data in time-limited applications, e.g., high definition video analytics for quality control, security, transaction generations, etc.
- Services where highly confidential data must be processed within a secure zone to ensure total security of information

What to consider

Now that there is clear understanding of the key benefits that an enhanced private network can unlock for your business, the paper will now outline the key considerations to take into account as you build a business case. The aim is to help guide your thinking as you draft your request for proposal (RFP), define and set expectations, and confirm service level agreements (SLAs) and key performance indicators (KPIs) with your chosen private network supplier and/or service provider. Our aim is not to specify a technological solution for you, rather guide you in making your purchasing decision by expanding your understanding of what a private network can do, and how it can link with your wider business transformation.

Usage and coverage

Where your use case is primarily located will be an important factor in the design and technology choice of your private network. It could be indoor and localised, or wide area and largely outdoors. If there is a requirement for ubiquitous coverage both within a localised area and over a wide area, then the devices need to support this, either directly (e.g., with mobile capability which needs to hand off between local and national coverage), or by using multiple technologies and switching between Wi-Fi and mobile.

If you have coverage challenges where your organisation is based, private networks give you a vehicle to address them.

Indoor mobile coverage tends to be more challenging from a public network and is heavily dependent on the building construction which can lead to not-spots. Indoor boosters may provide a solution, making indoor coverage by mobile private networks no more challenging than Wi-Fi. If your enterprise already benefits from excellent mobile coverage, this may be a cost-effective option. If not, then a private network is likely to deliver coverage benefits.

Satellites can provide broadband coverage to even the most remote locations and offshore platforms.

Your private network provider will be able to provide expert help with spectrum access too – including which bands are available in your location.

Mobility

You will need a clear picture of how far the devices connected to your private network need to move: the scope may be entirely within the locale/campus, or they may need to roam further afield. Providers will be able to ensure company SIMs can be used on a private network as well as a public network, allowing users to take advantage of public mobile services while on the move. Identity is also an important consideration: how will the identity of devices be managed? Consider whether you expect to support devices with identities from third parties on your private network.

Deployment type

As discussed previously, there are several ways in which private network services can be deployed such as via a mobile network operator, via a specific telecommunications service provider, or perhaps in-house.

4G, 5G and Wi-Fi are some of the options in terms of technologies. The path chosen for how to deploy the private network then leads to a number of spectrum options:

- The mobile network operator option allows the operator's spectrum to be used;
- The telecommunication service provider will use 'shared access' spectrum such as 3.8-4.2 GHz which enables an organisation to apply for a licence to be able to use spectrum in your specific area of the UK[21].
- The Wi-Fi route will use licence-exempt spectrum such as 2.4, 5 and 6 GHz.

The wireless device ecosystem is global and depends on mass market global volume. Chipsets and the frequency bands that they support, along with the frequency bands that the device vendor chooses to enable in the device, are critical factors to consider. There is a large availability of chipsets and devices that supports mobile network operators' spectrum and Wi-Fi spectrum. The 'shared access' route (such as 3.8-4.2 GHz) is a new approach introduced by regulator Ofcom in the past few years and therefore the availability of devices that support this route is expected to increase. Our advice to enterprise customers is to consult with expert telecoms service providers and hardware vendors to see what devices and frequency bands are available.

Integration

Ensure you consider system and process integration with other OT/IT/cloud infrastructure, as well as identity management, security and compliance, service assurance and access control:

Management – how your private network is deployed and managed may depend on how mission-critical the application is, and how fast issues need to be resolved if they occur. It may be helpful to consider these scenarios:

- Self-managed private network – the private enterprise keeps complete control of the network build and digital capabilities. They can tune the network specifications and performance to exact requirements.
- Outsourced private network – the manufacturer requests a proposal for a managed private network based on its connectivity requirements. The service provider is responsible for the network build and is subject to exacting service levels. It might also help develop digital services or platforms to fully realise the benefits of private network capabilities.
- Semi-private network via network slicing – a mobile network operator uses network slicing to create a semi-private mobile network for the enterprise. There's flexibility in tuning the technical capabilities of the product to meet connectivity needs.

Wider context – the network will interact with your enterprise's organisation: what are the touch points, and what does this mean for data management and processing? It is important to understand how the use case drives connectivity from mobile devices into core operating systems, such as Enterprise Resource Planning, Operational Management systems and team communication channels. Interaction via a wide area public network will add latency: whereas a private network enables the computation to be closer to the devices and will reduce latency.

Skills

It's important to consider the skills you have within your organisation for the network deployment, and where you will need to rely on partners. Some enterprises may be comfortable with project managing the overall process and bringing in specific expertise as needed. Others may prefer to engage a system integrator or communications provider to take on overall responsibility for the deployment.

Data management

In deploying a private network, your organisation must also take a holistic approach to management of data, formed by your understanding of how your data will be transferred, stored, and managed. Furthermore, assessments should be undertaken to understand how sensitive the data gathered by the private network is, and whether there are specific data sovereignty requirements. Also, aim to understand in your approach to data management what further benefits your organisation can derive from the collection and processing of data.

The deployment of a Digital Twin might be beneficial, depending on your business type. A digital twin is a virtual model designed to accurately reflect a physical object. The object being studied — for example, a wind turbine — is outfitted with various sensors related to vital areas of functionality. These sensors produce data about different aspects of the physical object's performance, such as energy output, temperature, weather conditions and more. This data is then relayed to a processing system and applied to the digital copy[22].

Security needs

While there are different use cases for the development and deployment of private networks, they all require a strong approach to security. Cyberattacks take advantage of the breadth of endpoints, speed and traffic volume associated with wireless networks and organisations need to develop robust approaches to tackle the threats. Introducing advanced connectivity and many connected devices increases the opportunity for attack, which needs to be pro-actively defended against from day one. Security needs to be designed in from the start, not bolted on later.

Zero Trust is a strategic approach to cybersecurity that secures an organisation by eliminating implicit trust and continuously validating every stage of a digital interaction. Zero Trust removes implicit trust regardless of what the situation is, no matter who the user is, no matter where the user is, no matter what application they are trying to access.

Zero Trust specifically protects the security of sensitive data and critical applications by leveraging network segmentation, preventing lateral movement, providing Layer 7 threat prevention, and simplifying granular user-access controls. Where traditional security models operate under the assumption that everything inside an organisation's perimeter can be trusted, the Zero Trust model recognises that trust is a vulnerability.

Zero Trust: Benefits for Enterprises

Organisations are deploying a Zero Trust architecture to provide a strategic framework to guide the security approach and purchasing decisions. There are several benefits for enterprises:

- Building and enforcing more precise security policies that provide more granular control over which users can access the data and applications — now also possible for 5G traffic
- Defining identity as something broader than users to encompass all humans and machines that require access to protected assets
- Detecting and preventing threats in all transactions of data involving users and applications
- And most importantly, moving from a focus on securing the entire attack surface to securing at the point of an access request.

Zero Trust makes the idea of context and constant verification paramount – this inherently improves security.

Resilience needs

A holistic approach to resilience is essential, and this will include an understanding of the operational need for availability and reliability. Different use cases will require different approaches to resilience, for example, some systems may require persistent connectivity across a wide area to function correctly. Resilience planning should help you ascertain what happens to the service during various failure scenarios, and whether satellite services could be required as back-up in the event of disruption to the terrestrial network. You may also need to consider what an unplanned outage could cost for your production line, as an example. It is important to consider whether there are health and safety implications of a technology failure.

The more demanding the resilience requirements, the more costly the network will be. Resilience can be added by having multiple elements to protect against failure of any one, but this adds to cost and complexity, so think very carefully about the actual needs and the time needed to recover from a failure.

Key success factors

By now, you should have a clearer picture of the benefits and opportunities for your business in deploying a private network. Some of the terminology and architectural terms may seem complex, and if you are a small enterprise or new to private networks, please don't feel daunted.

It might help to break your private network down into simple terms.

> What are your key user needs? Could you build scale within these use cases to make your business case more compelling?
>
> How long before you might need to upgrade and evolve the private network?
>
> How does the private network investment fit in with your wider business strategy? What other investments are planned?

Here is a list of some challenges to be mindful of, and how these can be mitigated as you embark on your private network project.

Building a strong business case:

Investing in advanced connectivity for your enterprise needs thorough planning and consideration. It's important to build a strong business case to help justify your investment. This will take time and preparation, especially if you are to replace an existing and satisfactory system or network.

You might need to think longer term, as it is unlikely that such an investment will pay back within a few months. You might need to think more broadly, how does a private network enable you to grow or drive efficiencies in ways which are not possible otherwise? The costs will depend on the type of network you build, and how wide the coverage is that you need. The benefits could be in terms of saved time (through direct data access, avoiding manual intervention), saved labour costs (by automating processes such as registering incoming goods, checking and monitoring services), and increased process efficiency (by eliminating manual steps through use of data and analytics).

It may also be helpful to think about the business case incrementally. The initial cost of acquiring / building a private network should be seen as a one-off investment. The benefits could be based around multiple use cases. Perhaps start by thinking about increased monitoring of what you do today and use that to drive automation deeper into the process, with the ultimate goal of eliminating any manual intervention. Sometimes you just need to start the journey knowing that the future is not completely understood, but enough is known to justify the initial cost. Further use cases will drive ever-increasing benefits, as the initial cost is already offset, and the running costs of a private network should be relatively small in the overall business case.

We also recommend considering the testing and interoperability needs for your business and its private network – this will be a key part of the process when approaching a provider.

It is also important to consider in your business case for investment your own staffing needs and how your internal teams will interact and engage with your private network service provider.

How it evolves:

How your private network evolves and iterates will be both a challenge and opportunity for your enterprise. Technological advances, and the wider availability of innovation in future years, will be developments to feel positive about today. It's vital, when building your business case, to have a clear understanding of what you want to achieve and for what period of time. Ideally you will have a vision of where you need to get to – for example, total automation of a production line (no human intervention). While it may not be clear at the outset how the vision can be achieved, changing technology is likely to deliver new options during the lifetime of the underlying network. This clear picture will enable you to mitigate your investment being stranded.

The moment of opportunity for enterprise

The growth of private 4G, 5G and recent advances in both Wi-Fi technology and satellite communications have seen a raft of innovative testbeds and proof-of-concepts for enhanced private networks for enterprise and the public sector. 2022 now presents a unique moment in time—or moment of flux—for the accelerated adoption of private networks. Adoption of enhanced private networks is real and accelerating, bolstered by a healthy and vibrant ecosystem of operators, suppliers, system integrators, and security experts. This ecosystem is spurring innovation for enterprise private networks, meeting unique user needs with bespoke deployments[23].

The increased adoption of private networks has also been driven by the need to modernise legacy network systems, such as PMR, as well as the need to bring added efficiencies with digitisation and automation[24].

It's not just the private sector that is set to benefit from the increased adoption of enhanced wireless connectivity, public services too can be improved and adapted thanks to private networks. A local school, large university campus, community care – all stand to benefit from advanced communications services.

Through this guide, we are empowering prospective private network users as they begin their innovation journey, helping to increase their understanding of the benefits and opportunities of the advanced communications services available today.

The moment for transformation is now.

Case studies

Liverpool 5G

Liverpool 5G Create, part of the DCMS-funded 5G Testbeds and Trials Programme, brings public sector technologies to Liverpool's digitally deprived communities.

Liverpool 5G's network is one of the largest, independent, public-sector funded private 5G networks in Europe. It operates in an unlicensed spectrum, using existing council-owned fibre. This means project volunteers are offered free 5G connectivity, giving them access to life-changing technologies they'd otherwise miss out on.

The wireless 5G network Liverpool 5G is using was designed by BluWireless, using 5G mmWave technology.

It uses existing fibre to create a wireless mesh network, installed on streetlights, which allows internet service providers to use unlicensed spectrum band to provide gigabit connectivity to homes. The network's range has been extended, both geographically and technically. Data now transfers across multi-hops, so areas that had previously been harder-to-reach, have multi-gigabit access and backhaul network speeds without needing line-of-sight across the network.

This means the team can better navigate the dense, urban environment in the Liverpool neighbourhood.

Traffic paths can be rerouted if a signal is blocked by, for example, by a truck parking in front of a node.

The dynamic network supports life-changing health, social care, and education technologies: a medical grade device that monitors health conditions remotely; an app that teaches anxiety reduction for children; a remote GP triaging service; wound care management; and sensor technology.

One challenge for the team has been to ensure the 5G-supported technologies used in the project are useful, in a practical way, and easily adopted by care providers. Liverpool 5G is co-ordinated by Liverpool's eHealth Cluster, an organisation that acts as a technology mediator between the public sector and tech SMEs. This means technologies are designed with need and usability in mind. The eHealth Cluster developed an Adoption Readiness Level tool (ARL), to sit alongside technology readiness measurements.

Every 5G-supported technology used in the Liverpool 5G project has been measured against the ARL. This means they are guaranteed to be easier for health providers to integrate, leading to higher adoption rates, resulting in more measurable success outcomes for the project and real-life benefits for those using the technologies.

Liverpool 5G is developing a 'blueprint' for other public sector organisations, to help them develop affordable, socially focused 5G networks that disrupt digital exclusion. The innovative approach used by Liverpool 5G has already attracted attention elsewhere. The team lent expertise to a project examining how people with Multi-Drug Resistant Tuberculosis (MDR-TB) can be treated with 5G-supported care packages. A pilot funded in Peru, Mozambique and Nepal is taking know-how from the Liverpool 5G, to support this valuable new area of research[25].

Cellnex: Enabling business growth in Basingstoke

Cellnex UK is delivering a 5G private network in Basing View, Basingstoke's Central Business District, to turbo charge innovation and development.

Basingstoke Council's strategy is to create a comprehensive 5G ecosystem focused on commercialisation where businesses can access 5G connectivity to develop, trial, and bring new products, services, and applications to market. Cellnex UK is supporting this by deploying a 5G private network providing indoor and outdoor connectivity, working in partnership with the Enterprise M3 Local Enterprise Partnership and the University of Surrey 5G Innovation Centre.

Transforming business

Basing view is home to over 100 companies mainly from the professional and financial services, digital tech, cyber security and life sciences sectors. The private network will support these via enabling a range of commercial use cases and applications which leverage the high capacity, low latency, and end to end security features of 5G standalone technology.

Through its strong focus on commercialisation and business engagement, the network will also support start-ups and businesses, helping to develop and validate further 5G innovations and capabilities.

Enabling industry wide innovation

The project will enable deployment of a 5G Living Lab, where industry partners can showcase technology expertise and foster innovation by providing a range of use cases, including smart city and IoT applications, immersive retail and leisure, AR and VR, mobility and transport and digital health.

Harnessing the power of 5G

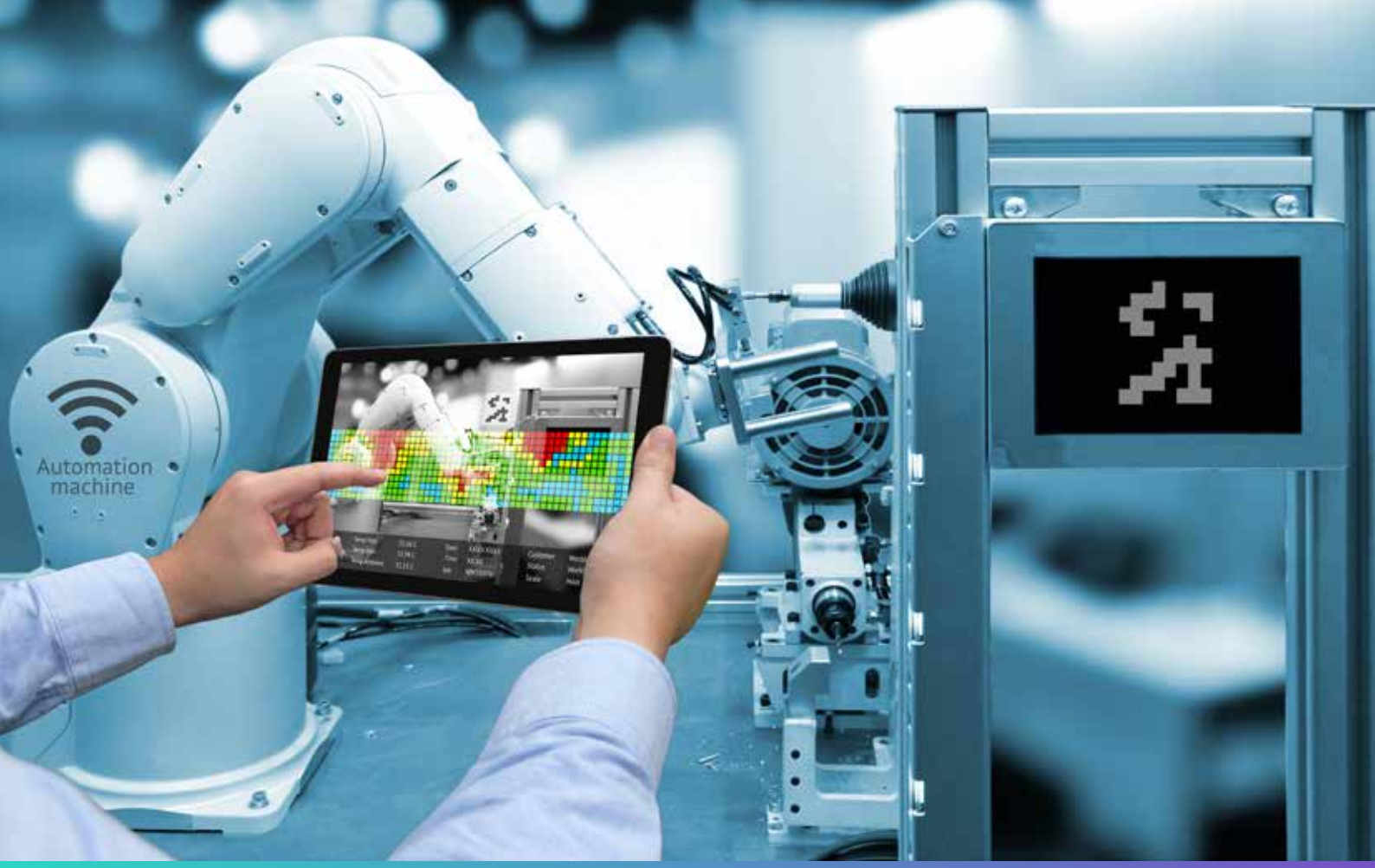
The ability of the Basing View 5G standalone private network to provide capacity scaled to the demanding business requirements is unparallel, especially when compared to other legacy technologies. In addition, it provides secure, seamless, and guaranteed voice and data coverage ensuring continuity of business-critical operations and is designed to meet demanding business requirements[26].

Verizon: Port of Southampton

Verizon is working with Associated British Ports (ABP) to transform the Port of Southampton into a Smart Port[27]. The project will allow the port to take full advantage of new technology applications and real-time analytics which will digitally transform its services in the future and bring new commercial opportunities.

Delivered in partnership with Nokia, Verizon's private 5G platform provides one of the UK's busiest ports with a secure, low-latency private network connection and deeper customisation. It enables data communications to be consolidated onto a single network, reducing previous complexity as well as helping to improve the reliability and security of terminal communications.

The deployment does not only address the immediate problem of loss of onsite data communications as a result of poor Wi-Fi connectivity, but also helps the enablement of new service advancements including asset tracking, autonomous guided vehicles, workflow management, predictive maintenance and safety monitoring by utilising new technologies such as real-time analytics, IoT and Machine Learning.



5G-ENCODE: 5G for manufacturing

5G-ENCODE is a £9 million collaborative project aiming to develop clear business cases and value propositions for 5G applications in manufacturing. The project is partially funded by DCMS as part of its 5G Testbeds and Trials Programme. It is run by a consortium of leading organisations led by Zeetta Networks including National Composites Centre, Mativision, Plataine, Solvay, Toshiba, Telefonica, Siemens, Accedian and the University of Bristol's Smart Internet Lab. Deployment partners Druid Software and Airspan provide key technology components.

5G-ENCODE aims to prove the commercial benefit of 5G technology to enable three specific industrial use cases: augmented reality and virtual reality to support design, manufacturing and training; monitoring and tracking time sensitive assets; and wireless real-time in-process monitoring and analytics.

The first phase of the industrial private network, using 4G, was used to establish a baseline for existing mobile technologies, against which results from the private 5G network can be benchmarked.

The results of phase one will be revealed at a phase two launch event at the NCC in October 2021.

Key to the success of 5G-ENCODE's use cases has been the deployment of network slicing and splicing technology developed by leading 5G-ENCODE consortium partner Zeetta Networks. Within any manufacturing environment there are multiple tools and machines all requiring different levels of connectivity with varying degrees of latency and throughput. Slicing and splicing technology enables operators to create multiple virtual networks that can be customised according to specific services and traffic levels needed. The network can therefore be optimised to meet the needs of different processes to improve efficiency, performance and business output.

The technology enables seamless delivery of applications across a number of separate private 5G, 4G or Wi-Fi domains that communicate via a public 5G or other transport networks. Through Zeetta Networks' multi-domain orchestrator platform, engineers can automate the splicing and dicing of the network resources, to provide users and machines with the exact level of connectivity to optimise performance at any time. Any leftover capacity can be directed elsewhere, making the factory far more efficient and productive.

As part of the phase two network deployment, Zeetta and partners have created a new network slice by stitching together slices from one transport network and two separate private networks: one located at NCC HQ and the other at another facility at NCCI located several miles away from the first location[28].

Mettis Aerospace

Laying the foundation for enhancing processes, reducing variability and increasing productivity with Wi-Fi 6

Manufacturers work in incredibly complex environments, none more so than Redditch based Mettis Aerospace who designs, manufactures and assembles precision forged and machined components for the aerospace industry. Mettis Aerospace has been at the forefront of metallurgical innovation for over 80 years and their vision is not only to be the best at what they deliver but to continually set new standards in the industry by investing and innovating.

That means embracing the opportunities with the shift to 'industry 4.0', driving the networking of existing machinery and systems and adopting big data processing to enhance Mettis' manufacturing processes, reducing variability and increasing productivity.

The foundational building block of such innovation is the communications network that is able to provide high performance, reliable connectivity and consistent coverage across the factory floor. In Mettis' case, that means its 27-acre facility in the West Midlands, over 3000 assets, such as machines, devices and computers and an environment that

can rightfully be described as “hostile” to Radio Frequency engineering. Using metal presses that weigh in excess of 40-tonnes, product in various stages of manufacture that are stored in hoppers that are effectively “metalized walls” from an RF perspective, together with the graphite grease that is used as a lubricant throughout the forging process. Mettis’ factory can be characterized as one of the most challenging of environments to wirelessly network, with radio waves being reflected and diffracted in all directions.

Recognising the extreme environment made mobile technologies challenging to deploy and operate effectively, Mettis turned to WiFi6 and the first deployment of its kind to showcase Wi-Fi 6 supporting Industrial Enterprise IoT use-cases. The WiFi6 network is able to support real-time 4k video streaming applications used to help monitor the accurate operations of the manipulator arm used in Mettis’ Draw-Down Press. Benefiting from the new functionality delivered with WiFi6 enabled speeds of 700 Mbps using 80 MHz channels to be achieved while simultaneously supporting low latency applications with end-to-end latency below 6 ms. These figures prove that Wi-Fi 6 infrastructure can operate well in the presence of interference and noise in a complex and challenging factory environment.

Industrial augmented reality (AR) is an integral part of Industry 4.0 concepts, enabling workers to access digital information and overlay that information with the physical world. With the wireless networking capabilities delivered with Wi-Fi 6, Mettis is able to showcase the benefits of augmented (mixed) reality software in enhancing current maintenance processes. Now the maintenance team is able to perform “walk-by” machine monitoring, using Wi-Fi enabled tablets alongside the traditional forging machinery to get an instant reading of the real-time pressure and performance of the machine. This capability is set to speed fault-finding and diagnosis, aid preventative maintenance and minimize machine downtime.

“The Wi-Fi 6 infrastructure has exceeded our expectations in terms of performance, reliable connectivity and consistent coverage across the target area,” said Dave Green, Head of IT, Mettis Aerospace. “We are seeing immediate benefits in terms of the data we’re now able to collect and use. Moving forward, we will be able to vastly increase the data we collect from devices across our business, enhancing our manufacturing processes, reducing variability and increasing productivity.”

Acknowledgements

techUK is grateful to members of the Communications Infrastructure and Services Programme for their contribution to this document, and other industry stakeholders, with special thanks to the speakers at our Private Network workshops in 2021 for sharing their insights:

Nanda Menon	Athonet	https://athonet.com
Simon Watts	Avanti Communications	https://www.avantiplc.com
Andrew Conway	BAI Communications	https://www.baicommunications.com
Roberta de Lima	BAI Communications	https://www.baicommunications.com
Jonathan Freeman	Cellnex UK	https://www.cellnextelecom.co.uk/
Mick Goulding	Cellnex UK	https://www.cellnextelecom.co.uk/
Alan Nunn	CGI	https://www.cgi.com/en
Mark Grayson	Cisco	https://www.cisco.com/c/en_uk/index.html
Stephen Speirs	Cisco	https://www.cisco.com/c/en_uk/index.html
Tadhg Kenny	Druid Software	https://www.druidsoftware.com/
Jennifer Manner	Echostar	https://www.echostar.com/
Con Kennedy	Ericsson	https://www.ericsson.com/en
Mike Kennett	Freshwave	https://freshwavegroup.com/
Peter Couch	JRC	https://jrc.co.uk/
Sarabjit Singh	Keysight Technologies	https://www.keysight.com/gb/en/home.html

Ann Williams	Liverpool 5G	https://liverpool5g.org.uk/
Rosemary Kay	Liverpool 5G	https://liverpool5g.org.uk/
Dave Green	Mettis Group Ltd	https://www.mettisgroup.com/
Gareth Alston	OneWeb	https://oneweb.net/
Carla Baker	Palo Alto Networks	https://www.paloaltonetworks.com/
Piotr Linke	Palo Alto Networks	https://www.paloaltonetworks.com/
Jennifer Miranda	PwC	https://www.pwc.co.uk/
Stuart Cooke	Samsung	https://www.samsung.com/uk/business/
Areeb Bhaila	Strategy&, part of the PwC Network	https://www.strategyand.pwc.com/
Adrien Sella	Verizon	https://www.verizon.com/business/en-gb/
Gemma Whiteley	Verizon	https://www.verizon.com/business/en-gb/
Elisa Elschner	Vodafone	https://www.vodafone.co.uk/business
Paul Rosbotham	Vodafone	https://www.vodafone.co.uk/business
Tiago Rodrigues	Wireless Broadband Alliance	https://wballiance.com/
Vassilis Seferidis	Zeetta Networks	https://zeetta.com/

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