Telecom Network 2030

Innovation Landscape and Opportunities

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1 Telecoms Innovation Powerhouse

Socialisation and connection are basic needs for humans to thrive as individuals and as a collective. While physical direct contact is mostly preferred, it may not be always possible. Telecommunication networks provide a means to communicate remotely, without the parties being in proximity. Today, telecom networks enable voice, video, and data transmission, facilitating human socialisation and information exchange for entertainment and work efficiency. Increasingly, they also support interactions with and among machines, such as computers, sensors, and robots.

Telecommunications are part of the national critical infrastructure, playing a vital role in our daily social and business life activities. Moreover, through the advancements of telecom technology, such as the evolution from 1G to 5G, telecom networks have evolved using internationally agreed standards to address the increasing digital demands within our lives and enhancing our national productivity.

As a country, the UK recognises the importance of technology advancement to our economic and social development. The Prime Minister announced the intention for the UK to be a science superpower by 2030, placing science, innovation, and technology at the heart of the governments vision, highlighting five priority technologies[1]. Telecoms is one of the priorities, together with Quantum technologies, Engineering biology, AI, and Semiconductors.

This paper discusses the telecom network innovation landscape and the opportunities that presented in the coming telecom technology evolution. The timeframe considered is to 2030. Every generation of network evolution, such as from 4G to 5G, took about 10 years, starting from defining the vision, detailing the requirements, carrying out research, to standardisation, planning, and implementation. Therefore, while looking the future, the innovation requirements from now to 2030 are also highlighted.

2 Major Drivers and Supplies of Future Telecom Innovation

The demands of advanced telecommunication networks are constantly evolving, from initial simple message communication to voice and now high-speed real-time data communication. The primary aim of advancing the telecom networks is to enhance our life-experience in 2030, while doing so assisting the developments of sustainable technologies that boost the growth of the economy.

[1] https://www.gov.uk/government/publications/uk-international-technology-strategy/the-uks-international-technology-strategy

Network evolution is a continuous process of innovation and improvement. It is driven by the changing market demands, technological advancements, societal and social trends. It is guided by the vision to create an intelligent, ubiquitous, secured, and sustainable network that can connect everyone and everything. There are many drivers of telecom evolution that can be catalogued as coming from consumer user, business, and society, as well as from environment conservation.

2.1 Consumer Driver

The development of communication networks and electronic consumer products are interrelated and create new opportunities for the future. Many electronic consumer products, both new and existing, depend on communication networks that can offer fast, reliable, secure, and low-latency data transmission. For example, new products such as 4K/8K TV, VR HMD, Apple Vision Pro, require high-speed and broadband video streaming capabilities to create the enhanced user experience.

Communication networks are constantly improving to meet these demands while also stimulating new product innovations. The latest wireless network for example can connect a large number of low-power products, which then enables the development of many new IoT devices, connecting such things as smart meters, home fridges, etc.

Future products, such as driverless car, require communication networks that can deliver even higher performance and near-real-time data exchange. Furthermore, the creation of the cyber world such as Metaverse and Digital Twin will need communication networks that can support seamless interaction between virtual and physical worlds.

2.2 Business/ Society Driver

5G ultra-low latency and reliable networks aim to serve consumers as well as businesses. Many initiatives are already in place to take advantage of these new 5G capabilities, including initiatives linked to the concepts of the Smart City, Smart Port, Smart Factory, etc.

By 2030, a new age of the digital economy will emerge, where everything that needs connection will be connected. Telecom networks in 2030 will be the main platforms and infrastructures for business communication, collaboration, and commerce, leading to high efficiency and high productivity. Moreover, telecom network 2030 will support government services, such as intelligent transport, crowd management, emergency, disaster, and crisis managements, and many others.

2.3 Environment Driver

The urgent requirement of environmental sustainability is becoming more recognized both within the industry and governments that regulate it. From the process of consumer device manufacture to the operation of radio antennae the telecom industry must consider its impact on the environment. Reducing the amount of carbon used in supply chains to the development and utilisation of energy efficient hardware are two examples where reduced carbon emissions are targeted. Moreover, utilisation of network technology has the responsibility to help other industries to achieve their Environmental, social, and corporate governance (ESG) and reduce their environmental impacts and carbon emissions.

2.4 Technology Innovation Supply

Technology evolution is accelerating all the times since industry evolution and as companies compete within a global marketplace. It is commonly recognised that technology is the only long-term solution to support the growth of a national economy. Telecom evolution can come from many areas, from the inventions of physical material such as hollow fibre, to radio frequency component, software radio, edge subsystem, platform, and to end-to-end orchestration system, integrating some other innovations in the fields such as AI, Quantum Computing, and Semiconductor.

2.5 Governance/ Policy/ Regulation

One of the main supplies of development towards a better and more sustainable society is government policy and regulation. They help encourage strategic innovation ensuring that the innovations are efficient, productive, and eco-friendly. As a driver of economic growth many countries and regions around the world have launched initiatives to become leaders in technologies to deliver the future of telecoms.

For example, in Europe, there are the Europe's Digital Decade: digital targets for 2030[2] and the 6G Research and Innovation Programme[3]. In the US, there are the Next G Alliance[4], the NYU Wireless Industrial Affiliates Program[5], and cooperation in Advanced Wireless Communications with Finland[6]. UK have similar ambitions and aim to be a technology powerhouse, as defined in the Long-term Science and

[2] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/europe-fit-digital-age/europes-digital-decade-digital-targets-2030_en
[3] Europe launches the second phase of its 6G Research and Innovation Programme | Shaping Europe's digital future (europa.eu)
[4] https://www.nextgalliance.org/
[5] https://wireless.engineering.nyu.edu/industry-affiliates/
[6] https://www.state.gov/joint-statement-of-the-united-states-and-finland-on-cooperation-in-advanced-wireless-communications/

Technology Framework[7], the Wireless Infrastructure Strategy[8], and the International Technology Strategy[9].

3 Telecom Network 2030 Vision

Four core components make up the telecom network 2030 vision:

- Future Mobile and Fixed Infotainment
- AI and Data Network Economy
- Energised and Healthy Ageing Society
- Clean Growth

3.1 Future Mobile and Fixed Infotainment

Telecom network 2030 will provide seamless and immersive experiences that can enhance lives, offer entertainment, and facilitate access to information. It will keep user connected to the content, service, people, and machine that matter and benefit to the user. Moreover, telecom network 2030 will also enable users to interact seamlessly between the new virtual world and the physical world. Whether it is playing a cloud-based game on a device, watching a live concert in virtual reality, talking to a digital assistant on a driverless car, or socialising in the cyber world, the telecom network 2030 will support the future of mobile and fixed infotainment.

3.2 AI and Data Network Economy

Artificial intelligence and data are the key drivers of the digital economy. They enable creation of faster, smarter, and more efficient solutions for various challenges and opportunities. Telecom network 2030 will leverage AI and data to build an autonomous network that can be self-organized, self-optimized, and self-healing. In addition, it will also use AI and data to support connected IoT devices in transforming various industries and organisations, in the sectors such as manufacturing, agriculture, transportation, government services, and many more. Telecom network 2030 will harness the power of AI and data to create new value and improve business efficiency.

3.3 Energised and Healthy Ageing Society

The ageing society poses several challenges for the economy and society. It requires new ways of increasing productivity, enhancing well-being, and ensuring

[7] https://www.gov.uk/government/publications/uk-science-and-technology-framework/the-uk-science-and-technology-framework
[8] UK Wireless Infrastructure Strategy - GOV.UK (www.gov.uk)
[9] The UK's International Technology Strategy - GOV.UK (www.gov.uk)

quality of life. Telecom network 2030 will help to overcome these challenges by providing future telecom solutions that can boost productivity, efficiency, and innovation in various domains. It can also support for example leading-edge mobile and fixed health care solutions that can improve health outcomes, reduce costs, and increase access to care for the ageing population.

3.4 Clean Growth

Climate change is one of the most urgent issues facing humanity today. It requires collective action from all stakeholders to reduce greenhouse gas emissions and achieve green growth. The Telecom industry's Net Zero programme aims to take action to reduce the networks' carbon footprint and achieve net zero by 2030. Telecoms is also part of the ICT solutions that can empower industrial decarbonisation by enabling smart energy management, green transportation, etc. The aim is to reduce their environmental impact and contribute to clean growth.

3.5 Telecom Network 2030 Targets

Some of the Telecom Network 2030 targets are:

- Providing full mobility and broadband capabilities to support new Infotainments. Seamless experience between physical and virtual world
- 5G and 5.5G UK nation-wide coverage and new area coverages; Standalone 5G to all populated areas by 2030[10]
- Increasing IoT devices with Everything required connections get connected. Gigabit-broadband nationwide by 2030[11]
- Supporting new age of Intelligent Data Economy - smart manufacturing, transportation, public services, etc.
- Lift productivity to meet challenges of slow growth, ageing population, and rising energy costs
- Telecom Net Zero and ICT solutions can empower other industries to reduce carbon emission; ICT has the potential to hold global CO_2 emissions in 2030 at 2015 levels[12]

[10] https://www.gov.uk/government/publications/uk-wireless-infrastructure-strategy/uk-wireless-infrastructure-strategy
[11] https://www.gov.uk/government/publications/levelling-up-the-united-kingdom
[12] https://www.bt.com/bt-plc/assets/documents/digital-impact-and-sustainability/our-approach/our-policies-and-reports/ict-carbon-reduction-eu.pdf

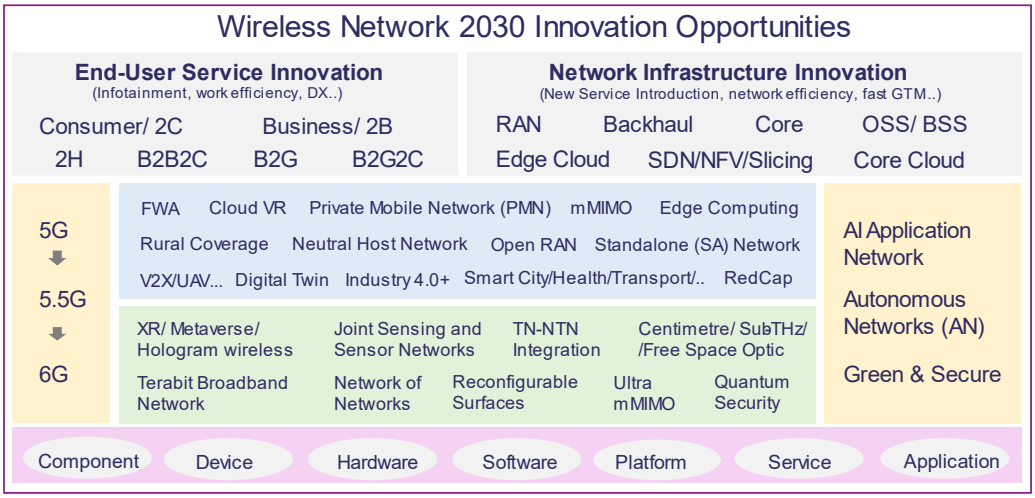
4 Telecom Network 2030 Innovation Opportunities

This section will explore the current and future trends of wireless and fixed network developments and examine the potential innovations in 6G networks through to 2030.

4.1 Wireless Network 2030 Innovation Landscape

Wireless network infrastructure is the foundation of the digital economy. In addition to mobility, it enables the delivery of high-quality, reliable, and secure connectivity to various devices, applications, and services. Network infrastructure is constantly innovating to meet the evolving needs and expectations of its users. It also evolves with the purposes of improving its own network efficiency, optimizing the resources, reducing the costs, and increasing the agility.

Future Wireless Innovation Landscape



Remark: the above is not a definitive list, but rather are potential areas of innovation

DX: Digital Transformation, GTM: Go-to-Market, FWA: Fixed Wireless Access, mMIMO: massive Multiple Input Multiple Output, RAN: Radio Access Network, OSS/BSS: Operations/Business Support System, SDN: Software Defined Network, NFV: Network Function Virtualization, V2X: Vehicle to Everything, RedCap: Reduced Capability, NTN: Non-Terrestrial Network (such as Satellite/ High Altitude Platforms HAPS)

There are two main sources of future telecom innovations:

- Network Infrastructure Equipment Innovations (enabling new capabilities, more efficiency, etc)
- End-User Service Innovations (enabling 2C Infotainment, 2B work efficiency, 2G digital transformation, etc)

Wireless network infrastructure consists of Radio Access Network (RAN), Transport (including Backhaul), Core network, and OSS/BSS. Innovations can be related to any of these infrastructure elements, as well as some of the latest technologies in Cloud Edge, SDN, NFV, Slicing, and Cloud Core.

5G is the first mobile system that aims to serve not only the general consumer market but, also business and organisation. The end-user service and application innovations cover all segments, including 2C, 2H, 2B, and 2G markets.

Wireless network evolution is a continuous process of research and standardisation. Mobile network has evolved from the 1G analogue voice network, 2G digital voice and SMS, 3G circuit and packet switches, to 4G data network, and 5G 2C and 2B data networks. Some of the key topics of 5G and 5.5G evolution include: FWA, Cloud VR, Private Mobile Network (PMN), massive MIMO, Edge Computing, Rural Coverage, Neutral Host Network, Open RAN, Standalone (SA) Network, V2X/ UAV, Digital Twin, Industry 4.0+, Smart City/ Heath/Transport/ Education/ Agriculture applications, and reduced capability (RedCap, also known as NR-Light).

6G research has been started. Some of the hot topics of 6G are: XR/ Metaverse/ Hologram wireless, Sensing and sensor networks, Terrestrial Network and Non-Terrestrial Network (TN-NTN) Integration, Terahertz/ mmWave, Free-space Optic, Terabit Broadband Network, Network of Networks, Reconfigurable Intelligent Surfaces, Ultra-massive MIMO, and Quantum Security Network.

Wireless network is in sync and converging with other technology advancements. For example, there is an increasing tendency of using AI for applications over networks and for an autonomous network. AI will be used in 5G and 5.5G networks and it is expected that 6G will widely incorporate the use of AI technology. Also, it is commonly accepted that all the infrastructure and application developments will have to fall under the green and secure framework. The networks will have to be power efficient themselves as well as have the capabilities to support other businesses and industries in their green credentials. Telecom networks also need to be inherently secured and continuously to be a major part of the critical infrastructure.

Potential areas of telecom innovation can come from but not limited to:

- Component (antenna, RF unit, beam-forming module, etc)
- Device (IoT, 5G Wifi router, etc)
- Hardware (MEC server, base station, etc)
- Software (Radio Intelligent Controller, device management, etc)
- Platform (cloud, edge, IoT, etc)
- Service (integration, design, data analysis, operation, etc)
- Application (smart city, port, education, health, etc)

4.2 6G Evolution and Innovation Opportunity

6G evolution is the next generation of wireless communication technology that will build on the achievements of 5G and provide extreme connectivity for various applications and services. 6G evolution will incorporate AI intelligence, tera networks, network of networks, green and secure technologies, as well as enhance

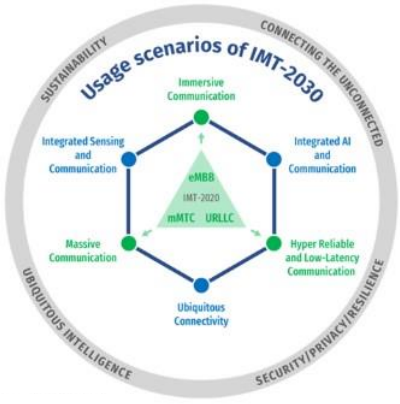
the existing 5G features of eMBB, mMTC, and uRLLC. Six Usage Scenarios are identified by ITU[13]:

- Immersive Communication (an extension of eMBB)
- Massive Communication (an extension of mMTC)
- HRLLC (Hyper Reliable & Low-Latency Communication – an extension of uRLLC)
- Ubiquitous Connectivity
- Integrated AI and Communication
- Integrated Sensing and Communication

And four design principles, applicable to all usage scenarios, are defined as:

- Sustainability
- Connecting the unconnected
- Ubiquitous intelligence
- Security/ privacy/ resilience

6G Evolution



Source: ITU IMT-2030 Framework (June 2023)

6G Connectivity*

- **High Data Rate:** peak downlink > 100Gbps, uplink > 10Gpbs
- **High Capacity:** 100x 5G
- **Gbps Coverage Everywhere,** 3D coverage' in the skies, space and underwater
- **Extreme Low Latency:** E2E < 1ms
- **High Reliability:** > 5 "9"
- **Always Secured** – Trust, Security and Resilience
- **Sensing Capability** & High Precision Positioning: 10 cm
- **Massive Connected Devices** (1-100m /km2)
- **Low Energy and Cost** – devices and infrastructure


Consumer


Business


Industry


Government

* Current proposals; to be defined by ITU IMT-2030 and 3GPP

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ITU and the wireless industry are in the process of defining the 6G requirements of IMT-2030. Below shows some of the key characteristics that are expected in 6G evolution:

- **High Data Rate:** The peak downlink data rate will exceed 100 Gbps, enabling ultra-fast transmission of large amounts of data. The uplink peak data will also be enhanced to larger than 10 Gbps.
- **High Capacity:** The network capacity will be 100 times higher than 5G, supporting massive data traffic and concurrent users.

[13] https://www.itu.int/en/ITU-R/study-groups/rsg5/rwp5d/imt-2030/Pages/default.aspx

- **Gbps Coverage Everywhere:** The network coverage will extend to three-dimensional spaces, including the skies, space, and underwater, ensuring seamless connectivity in any environment.
- **Extreme Low Latency:** The end-to-end latency will be less than 1ms, enabling real-time and interactive applications that require high responsiveness and accuracy.
- **High Reliability:** The network reliability will reach five nines (99.999%) or above, ensuring minimal errors and failures in critical scenarios.
- **Always Secured:** The network will provide trust, security, and resilience for all users and devices, protecting them from cyberattacks and privacy breaches.
- **Sensing Capability & High Precision Positioning:** The network will have the ability to sense the physical environment and provide high precision positioning for users and devices, in the resolution of 1 to 10cm, enabling new applications such as augmented reality and autonomous driving.
- **Massive Connected Devices:** The network will support up to 100 million connected devices per square kilometre, enabling the Internet of Things and smart city applications.
- **Low Energy and Cost:** The network and devices will consume low energy and cost, making them more sustainable and affordable.

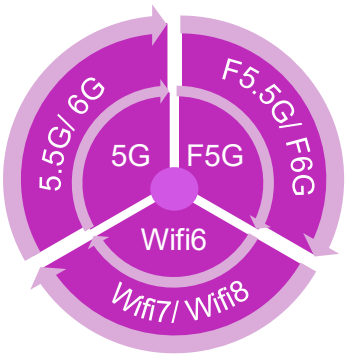
6G evolution will serve various sectors and domains, such as consumer, business, industry, and government, and enable new possibilities and opportunities for innovation and development.

4.3 Future Fixed Network Innovation Opportunity

Future fixed network innovations are the key to enabling a wide range of new applications and services that require high-speed, low-latency, secure, and reliable connectivity. It has the characteristic of deterministic experience that is more difficult to achieve in a mobile network. While 5G is moving on to 5.5G and 6G, the evolution of fixed network is also progressing from Fixed 5G (F5G) to F5.5G and F6G[14], whereas Wi-Fi is moving from wifi6, to wifi7 and wifi8[15]. These technologies aim to provide seamless and high-speed experiences for users across different domains and scenarios.

[14] https://www.etsi.org/images/files/ETSIWhitePapers/etsi_wp_41_FSG_ed1.pdf
[15] https://standards.ieee.org/beyond-standards/the-evolution-of-wi-fi-technology-and-standards/

Future Fixed Network Innovations



Application	Secure, Reliable, Deterministic, Intelligent Experience	
Cloud VR/AR/XR/ Desktop/ Metaverse Smart City Digital Twin Internet of Sensors Hologram ….	10s Gigabit Broadband for home/ organisation	• mmWave Wifi • High-density Wifi MIMO • Satellite LEO/ MEO Internet • FTTx (Everything and Everywhere)
	All-Optical Network	• All-optical processing/ switching • New hollow core fibre wavelengths and transceiver. Coherent Detection. • Flexible Optical Network carrier/ multiplexing/ channel
	Cloud Compute and Management	• Edge Compute/ Slicing/ Deterministic • Energy Efficiency Network • Integrated Power Computing • Autonomous (Intend based) Network • Network-based sensing systems

F5G: The Fifth Generation Fixed Network- Bringing Fibre to Everywhere and Everything (ETSI)

Some of the applications that can benefit from future fixed network innovations are Cloud VR/AR/XR/Desktop, wireless metaverse, smart city, digital twin, internet of sensors, hologram communication, and many more. These applications require high bandwidth, low latency, and high quality of service to deliver immersive and realistic experiences. For example, Cloud VR/AR/XR can enable users to access virtual or augmented reality content, without the need for expensive or bulky devices. Smart city can leverage the massive amount of data collected by sensors and cameras to improve urban planning, management, and services. Digital twins can create a virtual replica of physical objects or systems, allowing for remote monitoring, control, and optimization. The internet of sensors can connect billions of devices and sensors to the cloud, enabling new applications such as smart agriculture, environmental monitoring, and industrial automation. Hologram communication can enable users to interact with each other and object in 3D projection, creating a sense of presence and intimacy.

Some of the major innovation topics of Fixed Network 2030 include:

- 10s Gigabit Broadband for home and organisation
  - mmWave Wifi
  - High-density Wifi MIMO
  - Satellite LEO/ MEO Internet
  - FTTx (Fibre To The Everything and Everywhere)

- All-Optical Network
  - All-optical processing/ switching
  - New hollow core fibre wavelengths and transceiver. Coherent Detection.
  - Flexible Optical Network carrier/ multiplexing/ channel

- Cloud Compute and Management
  - Edge Compute/ Slicing/ Deterministic
  - Energy Efficiency Network
  - Integrated Power Computing
  - Autonomous (Intend based) Network
  - Network-based sensing systems

5 Accelerating Future Telecom Innovation

To create and be recognised as a future telecom technology powerhouse, the UK would benefit from accelerating the pace of developments in both the infrastructure and the application. There is strength in the UK academic base which can support industry in specific development opportunities. In this section, we will analyse the strengths, weaknesses, opportunities, and threats (SWOT) of UK in these two areas and discuss how to develop the telecom infrastructure equipment industry and how to energise the application developments.

5.1 Developing a UK Telecom Network Infrastructure Industry

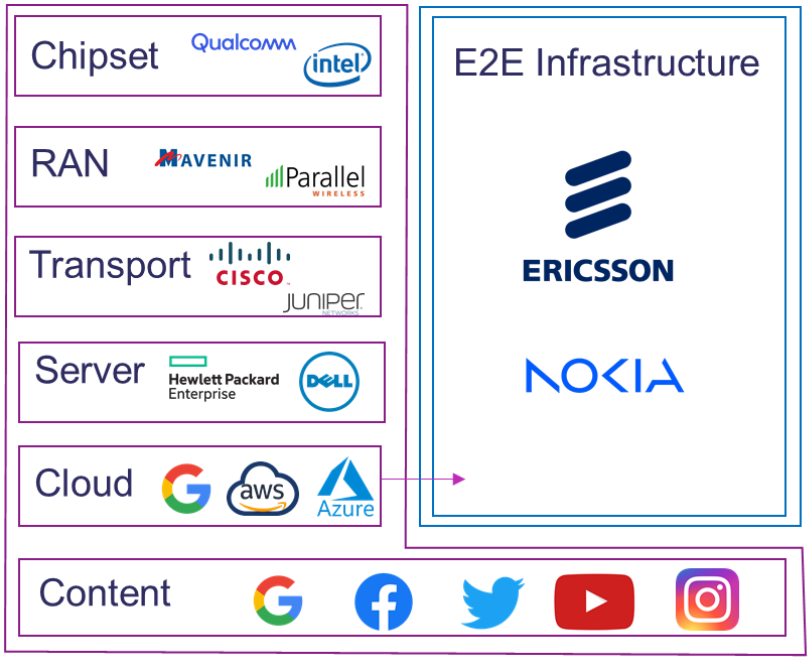
The global telecom network equipment market is expected to grow rapidly from £1 trillion in 2020 to £2.4 trillion by 2030[16]. The UK has strengths in this market, such as leading academic research, leading telecom operators, well established telecom labs, and favourable finance and regulation. However, the UK might face some challenges in fostering the telecom equipment industry, such as debatably lacking a major native telecom infrastructure vendor headquartered in the country and arguably not having the necessary supply chain eco-system in the UK, for such things as communication chipset, router, computer, and cloud servers, being made in UK.

To address the lack of a large-scale UK infrastructure provider, an opportunity exists in the diversification of the network and support for new innovators into the supply chain. To support this, the UK has set out its future telecom innovation strategy and is looking to seizing the opportunities presented by the open network initiatives, the UK supply chain diversification strategy, along with the technical opportunities within the upcoming 5.5G, 6G, and non-terrestrial communications evolutions.

With a strong research base, the UK is well positioned to create innovation that can be exploited to grow new infrastructure providers for the telecom networks of the future. This is well supported by UK government yet presents an opportunity for the innovation to be accelerated so that it can grow and scale up in its early stages. Highlighting the key technological areas where the UK can develop an early competitive edge and leadership is essential.

[16] https://www.ericsson.com/assets/local/5g/the-5g-for-business-a-2030-compass-report-2019.pdf

Research efforts of 6G and Telecom Network 2030 are already taken places in North America, Europe, China, Korea, and Japan, aiming to be the leaders in creating 6G applications and services, as well as the technologies that will set the global standards. Meanwhile, each region or country has its own strengths and advantages in different aspects of the 5G/5.5G ecosystem. Below investigates particularly the situations in United States and Europe.



Some of the major mobile telecom infrastructure providers in US and Europe (representative only, size of the logo does not reflect the market size or importance)

The US has a strong presence in the radio chip industry, with companies such as Qualcomm, Intel, Xilinx, and Nvidia leading the market. The US also dominates the server computing industry, with companies such as Dell, HPE, and Compaq providing high-performance solutions. Moreover, the US is home to the major cloud infrastructure providers, such as AWS, Microsoft Azure, and Google Cloud, who offer scalable and reliable platforms for 5G/5.5G applications and services. These cloud hyperscalers are also increasingly getting into the telecom infrastructure markets, leveraging their scales and finances, starting from core and edge clouds and to the whole end-to-end infrastructure.

In contrast, the EU excels in the end-to-end telecom infrastructure equipment industry, with companies such as Ericsson and Nokia providing comprehensive solutions for 5G/5.5G networks. The EU has also been active in promoting open network and diversified supply chain strategies, as well as supporting research and innovation projects through initiatives such as Horizon Europe.

The UK stands out in academic research, including telecom, software, and AI. Further, the UK has some of the world's leading universities and research institutes in these fields, such as Cambridge University, Imperial College London, and Alan Turing Institute. The UK also hosts some of the largest telecom operators in the world, such as Vodafone Group and BT Group, who are conducting leading product and solution research for future telecom technologies.

Thus, UK has a great opportunity to develop future network infrastructure equipment industry harnessing academic research strengths coupled to operational experience of large telecom networks. To develop the telecom infrastructure providers in UK, the following approaches can be considered:

- **Leverage on academic research in telecom and software**. The UK has a strong academic research base in telecom and software, which can provide with cutting-edge knowledge and innovation to help harness scientific innovation in the domain. There are many large opportunities for the UK to foster collaboration around telecom technologies through innovation among universities, industry, and government, to support the transfer of research outcomes to the market.

- **Learn from experience of large telecom operators**. The UK has some of the largest and most advanced telecom operators in the world, which can offer valuable insights and best practices on how to design, build, manage, and operate network infrastructure. Through leveraging experience to integrate innovative infrastructure equipment solutions into the market, UK organisations can address the challenges and needs of telecom operators worldwide.

By developing its own telecom network infrastructure industry, the UK can create competitive advantage, ensure national security, and encourage economic growth, while contribute to the global telecom sector.

5.2 Energising Telecom Network Application Development

5G and beyond have the potential to enable revolutionary applications that can benefit individuals, businesses, and governments. However, the advantages of 5G are not yet fully realised by consumers or businesses.

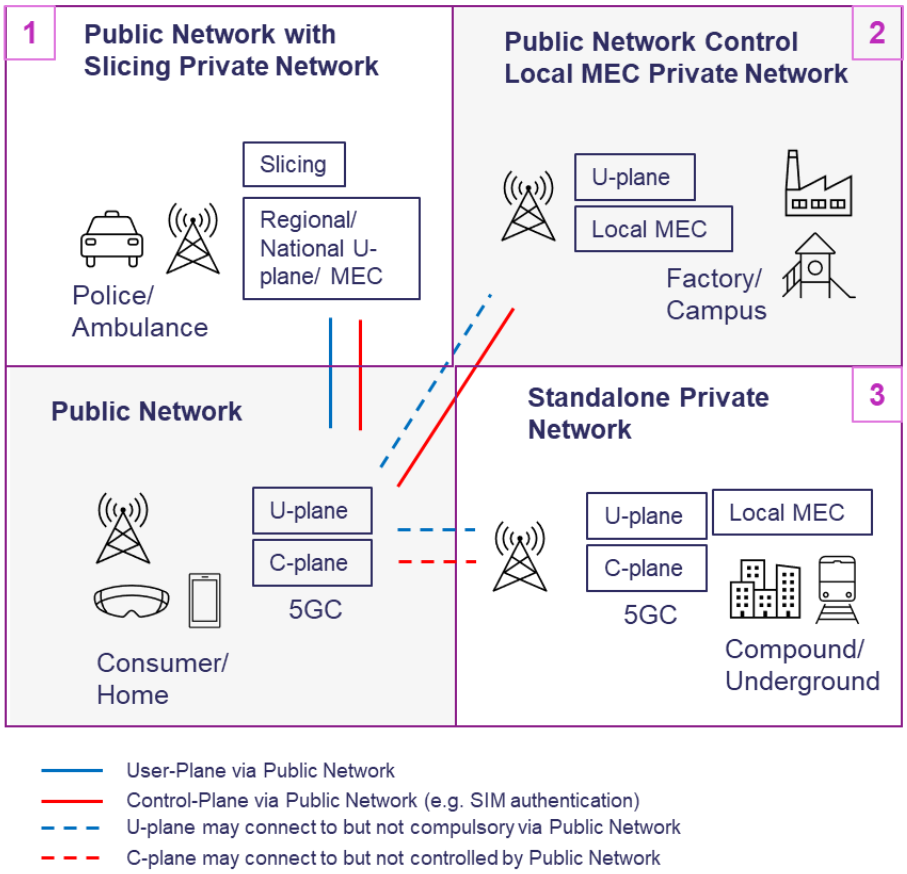
The UK has some strengths in harnessing the opportunities of 5G, such as an open society that allows for a variety of applications, and a strong venture capital market for tech companies ($14.9B in 2020)[17]. The UK also leads Europe in AI investment and has well-established 5G Testbeds & Trials, in addition to a large software industry with a pool of skilled software and AI engineers. However, the UK, in fact the whole industry, also faces some challenges, such as a lack of standardised methods and application blueprints of deploying 5G in various industrial sectors.

[17] https://dealroom.co/blog/tech-nation-report-2021-the-future-uk-tech-built

One of the challenges of developing and deploying innovative applications over 5G and beyond is the business model and the barriers to fast adoption. Different stakeholders, such as network operators, vendors, integrators, and verticals, may have different incentives and expectations from the network. For examples:

- Operators may not find it attractive to only charge for traffic, if they need to invest in network infrastructure and maintenance
- Vendors may not find it overwhelming to only provide a small network, with a handful of radio base stations and local infrastructure solutions.
- Integrators may not find it appealing to provide customisation services, as they need to deal with complex and diverse requirements from different verticals.
- Verticals may not be willing to adopt the network solutions, as they may face large initial investment and possible high total cost of ownership (TCO), as well as potential operation disruption with not so clear benefits

However, it is well understood that the use of latest telecom network technology can increase long-term productivity, competitiveness, security, and agility of business and facilitate digital transformation of the society as whole. Therefore, there is a rationale to foster innovation of the application developments over 5G and 5.5G network. To be able to consider fully the areas of application development, we first will discuss the business models of different architecture options of the 5G and 5.5G private mobile network.



Private Mobile Network Deployment Options with service examples (Much simplified sample architecture and examples are for illustration only)

1. **Private network over public network with slicing**: This model uses network slicing to create virtual networks over a shared public network infrastructure. This can offer readily available wide-area coverage, scalability, and reliability to the users as well as is a relative low-cost solution. For example, this model can be used for public services such as police or ambulance, of which slicing will ensure high priority, low latency, and high security for the user. These blue light services need wide area coverage that is already provided by the public mobile network. Moreover, network slicing can guarantee the quality of service and security that they require. This solution also has the advantage of using the licensed radio spectrum of the public mobile network operator.

2. **Private network with public network control and local MEC**: This model uses Multi-access Edge Computing (MEC) to create local private networks that are controlled by a public network operator. This can offer more proximity, bandwidth, and intelligence for local applications or services, as well as high local data security. For example, this model can be used for smart manufacturing or smart campus, which require high data rate, low latency, local real-time processing, and local data security.

3. **Standalone private network**: This model uses a dedicated network infrastructure that is owned and operated by a private entity. This can offer more autonomy, security, and optimisation for isolated applications or services. For example, this model can be used for large oil and gas field plant or underground mining site, which require high availability, reliability, safety, and security of data. Although it is called a standalone network, some of the facilities, such as a radio base station can be share-used with the public network. By doing so, this will allow private user to seamlessly access to public network services, as well as enable public user to use and share some cost of the equipment in the private network. Furthermore, in this case, network slicing can be implemented to ensure there is no compromise of either the service quality or network data security to the private network user.

There are potential innovations in the following three areas of application development:

1. **Public services**. Mobile application developments for the local authority can improve the efficiency and quality of public services, such as ambulance, fire, and police. For example, 5G technology can be used to enable real-time communication and data transmission between emergency vehicles and control centres, to allow remote diagnosis and treatment of patients. These blue light services need wide area coverage that is already provided by the public mobile network. Moreover, network slicing can guarantee the quality of service and security that they require. This solution also has the advantage of using the licensed radio spectrum of the public mobile network operator.

2. **Neutral host network**. In this case, application developments can enable for example vehicle-to-infrastructure (V2I) communication, such as smart traffic management, road safety, and environmental monitoring. The neutral host network model, where a single network infrastructure is shared by multiple operators and service providers, can reduce costs, increase coverage, and allow interoperability.

3. **Private network industrial blueprints**. Mobile applications can be developed that can enhance the productivity and performance of industrial sectors, such as manufacturing, mining, and logistics. The concept of standardisation into a fixed menu of use case applications for different vertical businesses should be promoted. These application templates facilitate easier deployment and allow enterprises in various industry to choose the most suitable standard applications for their needs.

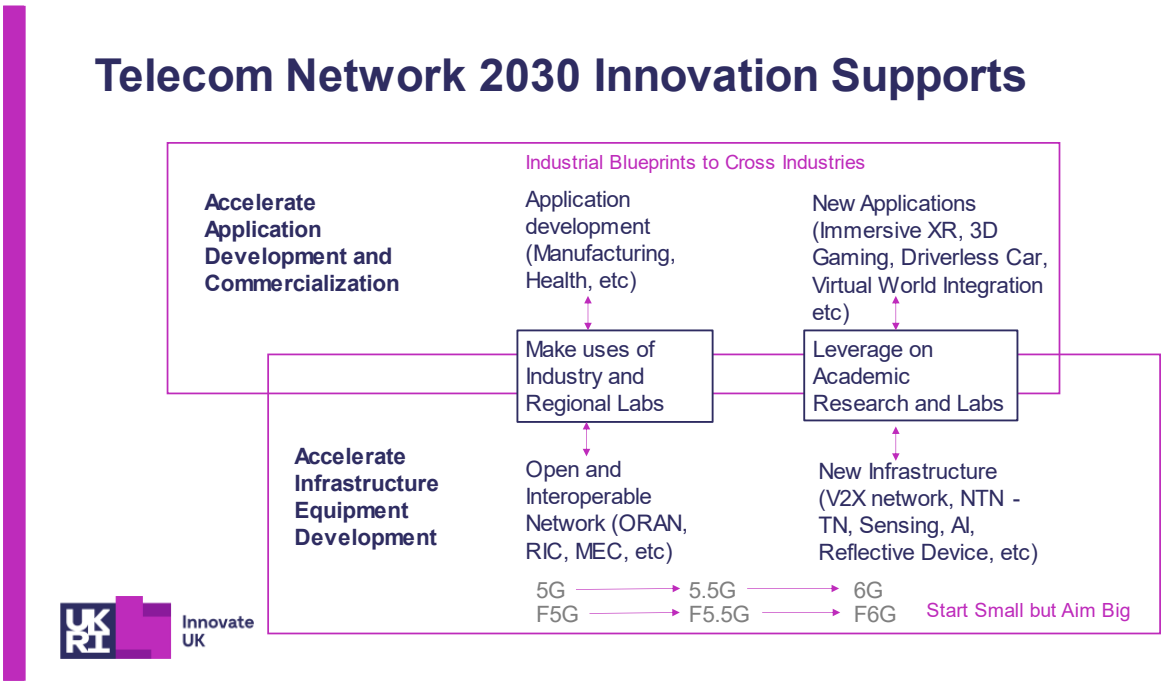
6 Network 2030 Innovation Supports

6.1 Facilitating UK Telecom Network 2030 Innovation

To achieve the vision of Telecom Network 2030, both the development and commercialisation of innovative applications and services as well as the development of advanced infrastructure equipment are important.

Innovate UK, as part of UK Research and Innovation (UKRI), together with Engineering and Physical Sciences Research Council (EPSRC), Catapults, local and regional governments, industrial organisations, and universities have already established several industry and academic telecom labs across the country, which provide supports to the deployment and testing of open and interoperable network technologies, such as ORAN, RIC, MEC, etc. These labs can also support the application development for various domains, such as manufacturing, health care, etc.

In addition, though Department for Science, Innovation and Technology's (DSIT's) Future Telecoms programme, EPSRC and Innovate UK will support the establishment of academic research hubs across the country, which can foster new infrastructure equipment development, such as V2X network, NTN-TN, sensing network, AI, reflective device, etc. These hubs can also enable new applications and services, such as immersive XR, 3D gaming, driverless car, virtual world integration, etc.



As part of delivery of the Future Telecoms programme, Innovate UK, will run several funding challenge competitions, based on well-established methods, to support future telecom innovative projects by companies.

Furthermore, Innovate UK is working with the Celtic-Next programme[18], which is part of the EUREKA Cluster[19], in internationally collaborative R&D projects focusing on next-generation communications for the digital society. Successful project proposal

[18] https://www.celticnext.eu/about-celtic-next/
[19] https://www.celticnext.eu/eureka-clusters-programme/

to Celtic-Next will get a Label. The label can then be used, to indicate that the project has been technically assessed by Celtic-Next, in the application of Innovate UK funding challenges.

6.2 Innovation Support Framework

To foster innovation, the following areas are important across the UK:

1. **Lab Facilities**: Continue to consolidate and grow testbed and trial lab facilities that can support innovative projects, for new future telecom infrastructure development, interoperability test, and telecom application development and integration.

2. **Vertical Industry Application Blueprints**: identify key target verticals, such as healthcare, education, manufacturing, and entertainment, which can benefit from 5G and other telecom technologies, and deliver a blueprint application solution to each target vertical. Application could be first developed as a standard best practice for a specific industry, but it should also have the market potentials to apply to other industries – cross market is a big opportunity.

3. **Open Network Infrastructure Equipment Development**: Continued promotion of 5G/5.5.5G development, with a focus on open network and diversified supply chain strategies. Access for innovators to get entry to the UK open telecom infrastructure ecosystem is important. New infrastructure development can start with pilot projects and trials but needs to have a clear vision and roadmap for large-scale deployment and adoption.

4. **6G/F6G research**: Development of a 6G ecosystem, encouraging cross domain technology convergence and leveraging on the UK's excellent research capabilities, industry-university collaboration programs, and standardisation efforts.

As the UK's innovation agency, Innovate UK's mission is to help UK businesses grow through the development and commercialisation of new products, processes, and services, supported by an outstanding innovation ecosystem that is agile, inclusive, and easy to navigate. Innovate UK will continue to inspire, involve, and invest to support innovation.

List of Abbreviation

Abbreviation	Definition
AI	Artificial Intelligence
AR	Augmented Reality
BSS	Business Support System
DSIT	Department for Science, Innovation and Technology
eMBB	Enhanced Mobile Broadband
EPSRC	Engineering and Physical Sciences Research Council
ESG	Environmental, Social, and corporate Governance
FTTx	Fibre To The “x” (Home, room, etc)
FWA	Fixed Wireless Access
HMD	Head Mounted Device
HRLLC	Hyper Reliable and Low-Latency Communications
ICT	Information and Communications Technology
IMT	International Mobile Telecommunications
ITU	International Telecommunication Union
LEO	Low Earth Orbit
MEO	Medium Earth Orbit
MIMO	Multiple-Input and Multiple-Output
mMTC	Massive Machine Type Communication
NFV	Network Functions Virtualization
NHS	National Health Service
NR	5G New Radio
NTN	Non-Terrestrial Network
ORAN	Open Radio Access Network
OSS	Operation Support System
PMN	Private Mobile Network
RAN	Radio Access Network
RedCap	Reduced Capability, also known as NR-Light
RF	Radio Frequency
RIC	RAN Intelligent Controller
SA	Standalone (5G architecture)
SDN	Software Defined Network
SMS	Short Message Service
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TCO	Total Cost of Ownership
TN	Terrestrial Network
UAV	Unmanned Aerial Vehicle
UKRI	UK Research and Innovation
uRLLC	Ultra-Reliable Low Latency Communications
VR	Virtual Reality
XR	Extended Reality