UKTIN

Market Research Analysis

# Annual Report

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# Foreword

I have a lot of pleasure in contributing a foreword to this significant body of market research. One of the observations of the Telecoms Supply Chain Diversification Task Force in their report from 2021 was that the UK R&D&I ecosystem for telecoms was fragmented and difficult to navigate from the outside. This report goes a long way to solving this. While UKTIN offers other navigational tools, such as the Research Capability Discovery Service coming online mid-2024, and the Supplier Specialist Guidance Service which has been active since April 2023, this report ties a lot of the landscape together in a comprehensive way.

Not only does it offer a guide to what's going on in the UK on a technology-by-technology area, it illustrates this with numerous case-studies and quotations from ecosystem figures. And it connects all that with an international context into Europe, Asia, the US and beyond. It perfectly embodies the observation that for UK innovation to thrive, it must connect internationally. The UK finds itself the proud owner of an enviable global trading network. Whether you innovate in intellectual endeavour, practical product development, quality service provision, spinout start-up and scale up financing, or all of the above, I have no hesitation in recommending this report as your first guide and travel companion for UK telecoms innovation in 2024 and beyond.

**Dr Dritan Kaleshi**
**Director of 5G Technology and Digital Infrastructure, Digital Catapult**
**Head of UKTIN (interim)**

# What is UKTIN?

**Introduction to UKTIN**

The UK Telecoms Innovation Network (UKTIN) is an industry leading £11.6 million programme funded by the Department of Science, Innovation and Technology (DSIT). Co-led by Digital Catapult, Cambridge Wireless, the University of Bristol and WM5G, the programme seeks to provide vital resources and knowledge to the telecoms industry as they navigate the UK's telecoms R&D ecosystem.

With the mission of reshaping the UK's telecoms innovation ecosystem, UKTIN leverages the nation's world class strengths in technology, academia, and business, capitalising on emerging opportunities within the industry. It serves as the innovation hub for the UK telecoms sector, uniting industry players, government stakeholders, and academia to drive R&D investment, collaboration, and commercialisation. It also seeks to provide organisations with the necessary facilities and technical support to grow their businesses and to further develop their solutions and capabilities for open networks.

UKTIN has kickstarted its activities to enhance the potential for novel discoveries within the UK's telecoms supply chain by bringing together organisations engaged in R&D and innovative initiatives, fostering a collaborative environment for the advancement of telecoms. As an impartial, accessible, and inclusive forum, it offers the telecoms innovation ecosystem the ability to discover innovative ideas and concepts, understand present and future skills needs, identify funding routes available and match resources to relevant projects.

**Programme Objectives**

1. **Catalyse R&D&I investment in UK telecoms**
2. **Simplify the UK telecoms R&D&I and innovation landscape to accelerate market deployment**
3. **Forge connections between UK telecoms R&D&I stakeholders**

One of the primary objectives of UKTIN is to catalyse research and development's investment in the telecoms industry. Established in response to the government's 5G Supply Chain Diversification Strategy published in 2020, and building upon the recommendations of the Telecoms Diversification Taskforce, UKTIN aligns with the broader goal of positioning the UK favourably on the global stage to access and take part in telecoms R&D.

With widespread adoption of 5G estimated to gain up to "…£159 billion in productivity benefits by 2035", [1] the UK government's strategy highlights the commitment of up to "…£100 million spent in research and development" related to future telecoms [2]. Whilst this commitment is broadly welcomed by the UK telecoms community, findings from the Telecoms Diversification Taskforce indicate that UK telecoms R&D activity and funding are presently fragmented, particularly in the fields of research and testing. Given the vast and evolving nature of the telecoms R&D ecosystem, increasingly characterised by numerous suppliers and new entrants offering open interfaces and interoperable equipment, there is a perceived need for improved coordination and governance across the funding and activity realms of R&D initiatives.

In light of this, the UKTIN programme seeks to simplify the UK telecoms R&D and innovation landscape to broaden and accelerate market deployment. This involves facilitating knowledge sharing across the sector, fostering partnerships, and minimising unnecessary duplication. As a hub, UKTIN streamlines existing capabilities, effectively enabling the sector to identify and address gaps for accelerated research and innovation. This also includes easing the entry path for new suppliers into the UK's telecoms innovation landscape.

More information on programme membership and opportunities can be found here.

[1] UK Wireless Infrastructure Strategy, DSIT, 2023
[2] See 1, above

**The importance of telecoms innovation in the UK**

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"**Telecoms is the life blood of a digital economy. It enables us to connect, communicate and collaborate. It licences us to improve productivity and transform the way we work and live.**

**Innovation drives our ability to deliver connectivity further, faster and cheaper, underpinning the UK's ability to thrive in a competitive and dynamic world."**

**Paul Crane, CEO of Cambridge Wireless**

With telecoms constituting a vital part of the national critical infrastructure [3], it has become imperative to identify opportunities for boosting research and innovation to build UK capability for both current and future generations of telecoms technology [4]. Research, development and innovation serve as the cornerstone for creating new telecom solutions, providing a substantial competitive advantage for incumbent vendors, and fostering diversification within the industry.

The significance of telecoms innovation in the UK is twofold. First, it is being leveraged in the short term to accelerate the development and deployment of Open RAN and alternative deployment models in diversifying the supply chain. Secondly, it aims to identify opportunities for the UK to establish expertise and capability across the telecoms supply chain for long-term strategic research and innovation. The Telecoms Diversification Taskforce has emphasised dedication to both of these objectives, acknowledging that building UK capability to ensure the resilience of networks, both now and in the future, is a national priority [5]. By accelerating telecoms innovation, the UK seeks to re-establish itself as a key player in the global telecoms supply chain but also to develop secure networks, cultivating a robust skills and talent pipeline, and contributing substantially to advancements in technology and national prosperity.

Furthermore, the telecoms ecosystem is rapidly converging with other critical technologies such as AI, semiconductors, or IoT, presenting new opportunities for the sector. This convergence requires the UK to anticipate this shift and invest in infrastructure, talent, and regulatory frameworks to stay ahead of the innovation curve and remain competitive in the global market in these new cross-technology areas [6].

[3] Innovate UK. (2023). Telecom Network 2030: Innovation Landscape and Opportunities.
[4] DCMS. (2021). Telecoms Diversification Taskforce: Findings and Report.
[5] DCMS. (2021). Telecoms Diversification Taskforce: Findings and Report.
[6] DSIT. (2023). UK Science and Technology Framework.

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"In an era where innovation is currency, the strength of the UK hinges on its cutting-edge telecommunications, positioning it as a technological leader and driving force in the international arena.

Innovation in telecommunications serves as the backbone of the UK economy, propelling industries forward and connecting communities. As information flows seamlessly, it fosters economic growth, empowers businesses, and enriches societal progress, solidifying the foundation for a more interconnected and technologically advanced future."

**Jordan Williams, Project Manager at WM5G**

# Telecoms Innovation in Practice

**Telecoms Innovation in Practice**

The telecoms sector constitutes a diverse ecosystem, with over 1900 organisations distributed across the UK. Public and private organisations in telecoms collectively generated £31.8bn in revenue in 2022 [7], making a substantial impact to the UK economy and underscoring its pivotal role in the UK's technological advancement. The demand for data, both through fixed and mobile connections, is experiencing growing demand. In 2022, the average consumption per data user on mobile witnessed a notable 24% increase [8], fuelled by a rise in the adoption of faster broadband connections, demonstrating the pressing need to strengthen the deployment of telecom infrastructure. Similarly, global mobile network data traffic is expected to more than triple from 2023 to 2029 [9]. With this growing demand and increased need for resilience and new functionalities in telecoms, innovation in the sector has become a pressing need for industry and policymakers alike .

The UK Science and Technology Framework published by DSIT in March 2023 signposted the nation's ambition to become a 'science and technology superpower by 2030'. The Framework has set out 10 actions to achieve this goal, including building skills, strengthening existing infrastructure and investment levels to mature products, and promoting innovation. The International Technology Strategy published on the back of the Framework furthered the commitment to accelerate the development of advanced telecoms in the UK, with future telecoms being "a key aspect of its Critical National Infrastructure" [10]. The Framework also indicates the government's mission to put the UK at the forefront of global scientific and technological advancement.

[7] Ofcom. (2023). Communications Market Report 2023
[8] Ofcom. (2023). Communications Market Report 2023
[9] Ericsson. (2024). Mobile data traffic outlook.
[10] DSIT. (2023). The UK's International Technology Strategy

The efforts detailed in the strategy express an intention to enhance the UK's global competitiveness, foster innovation, and attract industry investment, as well as foreseeing international collaboration to take part in shaping the global ecosystem of future telecoms technology. With 5G and other future network technologies under development, the government aspires to guarantee the secure access of the country to global markets, while opening UK networks to diverse and international vendors. This approach aims to boost the UK's market share in global telecoms markets, while ensuring the security and resilience of the UK infrastructure [11].

However, DSIT has also recognised that in order to achieve this vast ambition, collaborative innovation should be galvanised, with industry, businesses, academia and private investors coming together. This unified approach is deemed essential to drive innovation, surmount existing challenges in telecom infrastructure, and advance the objectives of the 5G Supply Chain Diversification Strategy. Emphasising the importance of open interface models and interoperable standards to enhance network flexibility, the strategy underscores the critical need for a robust R&D ecosystem. This collaborative ecosystem, particularly focused on Open RAN, is seen as indispensable to accelerating and securing the development of telecom technologies and ensuring the UK's competitiveness in the global telecom market.

With the intention to create large R&D activities and innovation projects to establish UK vendors at the cutting edge of the telecoms market, the 5G Supply Chain Diversification Strategy has also highlighted the need for significant public and private investment towards development. This followed the announcement of a bundle of measures to accelerate the development and adoption of fixed and wireless networks, while guaranteeing substantial investment in the next generation of connectivity.

Moreover, DSIT's Wireless Infrastructure Strategy published in April 2023 outlines the UK's commitment to achieving nationwide Standalone 5G coverage (the implementation of 5G that does not depend on legacy 4G LTE infrastructure), in populated areas by 2030 and promoting innovative 5G services for both the private and the public sector. One such example is DSIT's intention to invest £40 million in the creation of ten 5G Innovation Regions, to facilitate private sector investment, encourage the adoption of advanced communication technologies in industrial sectors and places, while building skills at the local level [12]. A fund of £8 million has also been launched to promote satellite connectivity in remote areas [13].

[11] DSIT. (2023). UK Science and Technology Framework
[12] DSIT. (2023). Press release: £40 million fund launched to unlock 5G benefits across the UK
[13] DSIT. (2023). Press release: New investment boosts UK's digital connectivity

# A Race to the Top in Telecoms Innovation

## UK leadership and ambitions

The aforementioned Science and Technology Framework articulated the government's ambition to become a science superpower by 2030, with future telecoms identified as one of its five critical priority technologies. While government plans primarily focus on the telecoms sector at large, public investments are particularly being directed towards supporting businesses in advancing innovative solutions to market, as well as pushing further collaboration across the telecoms landscape.

The UK currently has a number of innovation programmes and R&D facilities dedicated to Open-RAN capabilities. With a strong base of innovative companies, and the rise of alternative network providers (130 to 150 small and large regional providers) [14], the UK aims to foster an environment conducive to innovation. This strategic initiative is paving the way for UK MNOs to deploy Open RAN technologies in UK mobile telecoms networks by 2025, while helping to establish the nation as a centre of excellence in this field [15]. Moreover, SONIC Labs' success as a primary hub for Open RAN activity affirms the commitment to setting the standards for telecoms supply chain diversification, while advocating for the adoption of open-interface solutions. By spearheading these efforts, the UK not only fosters innovation domestically but also makes substantial contributions to the global discourse on the evolution of telecoms, consolidating its position as an pioneering force in the domain of Open RAN.

[14] UKTIN Future Capability Paper – Security (2024)
[15] Digital Catapult. (2023). SONIC Labs Annual report.

A key recommendation put forth by the Taskforce is the establishment of a Digital Infrastructure Recommendations and Standards Alliance (DIRSA) [16]. UK-led and internationally focused, this initiative would plan to not only facilitate balanced government and industry participation but also serve as a platform for the UK to showcase its leadership in setting international standards for security and resilience in telecoms infrastructure. Its emphasis intends to ensure the security, resilience, openness, and interoperability of telecoms radio access equipment, while underscoring UK's commitment to shared progress and innovation. This ambition goes hand in hand with the objective of taking more of an active role in technology standards definition alongside key partners, ensuring that specifications and intellectual property generated from its pipeline of innovations go to inform standards development activities.

**"The growth and innovation opportunity in the telecoms sector is unparalleled and the UK currently has the potential to lead the revolution driving unprecedented efficiency, scalability, and service innovation. Ongoing research is focusing on topics ranging from self-optimising networks to personalised customer experiences. Continuous advancements across technologies, supporting collaboration between industry and academic stakeholders, and driving regulatory developments will ensure we lead and excel in this sector."**

**Dimitra Simeonidou, Co-Director of the Bristol Digital Futures Institute and Director of Smart Internet Lab, University of Bristol**

Recognising that its market represents a relatively small portion of the global demand for telecoms infrastructure, the government and actors of the UK's innovation ecosystem have stepped forward, expressing a keen interest in fostering partnerships with other nations [17].

R&D projects in collaboration with partners therefore play a pivotal role in supporting telecoms diversification, with the overarching goal of positioning the UK as a thought leader in this field. As such the UK innovation ecosystem welcomes collaboration with international companies, gaining and sharing skills, resources and best practice with their overseas counterparts. One such example of this is increased experimentation and investment in Open RAN in recent years, such as the European 5G Centre of Excellence. The centre was established in 2020 in Ruislip by Japanese manufacturer NEC's Open RAN Lab, and has engaged with several large European groups, including Telefonica, DT and Vodafone [18].

[16] DSIT. (2021). Government response to the Telecoms Diversification Taskforce.
[17] DSIT. (2021). Government response to the Telecoms Diversification Taskforce.
[18] Digital Catapult. (2023). SONIC Labs Annual report.

Beyond its commitment to future telecoms, there is UK ambition to carry out strategic investment in cross-sector technologies, including semiconductors, as outlined in the National Semiconductor strategy [19] to facilitate the widespread adoption of new materials and devices. To materialise this vision, the UK has allocated £1 billion for compound semiconductors, with specific use cases targeting advancements in future telecoms technologies [20]. Similarly, the UK has also underscored its intention to integrate AI technologies into strategic sectors such as telecoms [21]. Notably, the government has taken proactive steps towards AI standardisation by assuming leadership roles in ISO/IEC projects and actively engaging in the Industry Specification Group on Securing AI at the European Telecommunications Standards Institute (ETSI) [22].

Additionally, the National Quantum Strategy, published in 2023, signed the UK's commitment to invest £2.5bn into quantum technologies over the next decade. Recognising the significance of quantum technologies for communications, the government plans to invest £214m in research through the Quantum Research Hubs, leveraging EPSRC grants to explore innovations in the development and commercialisation of quantum technologies across communication, sensor and timing, enhanced imaging, and computing [23].

[19] DSIT. (2023). National Semiconductor Strategy.
[20] DSIT. (2023). Press release.
[21] DSIT. (2021). National AI Strategy.
[22] DSIT. (2023). A pro-innovation approach to AI regulation.
[23] DSIT (2023). National Quantum Strategy.

# UK Telecoms innovation - a Global Comparison

According to WIPO's Global Innovation Index (GII), Switzerland, Sweden, the United States, the United Kingdom and Singapore were the world's most innovative economies in 2023 [24]. In line with this positioning, the UK Government has pledged to elevate its R&D investment to £20 billion by 2024-25, aiming to increase its support to UK research institutions, universities, and businesses. This commitment is further underscored by the intention to widen investment to £22 billion by 2026-27 [25]. Among investment priorities, telecoms represent a significant focal point within public and private investment strategies pertaining to technology and innovation across numerous advanced economies.

[24] WIPO. (2023). Global Innovation Index 2023.
[25] DCMS. (2021). Press release.

## Japan

Japan holds a strong position in telecoms innovation, underpinned by its robust network infrastructure and active pursuit of 5G deployment. As one of the largest markets for telecoms, Japan witnessed a peak in its capital expenditure (Capex) investments in 2021, with continued growth anticipated from 2024 to 2028 as mobile operators intensify their investments in 5G deployments. Major telecom giants like NTT Docomo, KDDI, and SoftBank are heavily investing in infrastructure development and trials to deploy 5G services nationwide.

Recognising 5G as the linchpin for technological progress, Japan is directing R&D activities towards its role in facilitating advancements in other technologies such as autonomous vehicles or smart cities [26]. Institutions such as the NICT are also driving extensive research in advanced wireless technologies, IoT, AI, and network optimisation. The telecom landscape in Japan particularly focuses on O-RAN technologies, supported by a large ecosystem for telecom R&D, facilitated by collaboration between industry, government, and academia. Japan's pledge to international collaboration amplifies these innovation efforts, fostering knowledge exchange and standardisation activities.

[26] BusinessWire. (2023). Japan Telecoms Industry Report 2023-2028

## Singapore

Singapore stands as a vibrant hub for telecoms innovation, propelled by strategic initiatives such as the 5G Innovation Programme launched in 2019 and the Digital Connectivity Blueprint launched in 2023. Large telecom player Singtel initiated in 2022 the deployment of a 5G standalone network, covering over 95% of Singapore. Actively seeking partnerships with system integrators, app developers, IoT solution providers, and other ecosystem partners, Singtel aims to develop innovative 5G solutions tailored to enterprise customers [27]. Supporting this effort, the Singaporean government has allocated substantial R&D funding, totaling $18.7bn (£14.8bn) until 2025, to drive the development of transformative technologies.

The Infocomm Media Development Authority (IMDA), under the Ministry of Communications and Information, unlocked $22.4m (£17.8m) to fuel 5G adoption and commercialisation. Through accessible testbeds, businesses are working to develop and adopt innovative 5G solutions for various applications, including Industry 4.0, urban mobility, healthcare or augmented reality. Singapore is also looking to further explore future networks, with the establishment of a new 6G lab, dedicated to researching 6G alongside AI and holographic communications.

[27] U.S. International Trade Commission Singapore - Country Commercial Guide

## USA

The National Telecommunications and Information Administration (NTIA) and the Economic Development Administration (EDA) are opening federal funding programmes aimed at advancing the nation's broadband capabilities. Through these initiatives, the Department of Commerce is fostering public–private collaboration to revitalise its industry, creating jobs and reinforcing U.S. leadership in emerging technologies on the global stage. This leadership encompasses pioneering work spanning across quantum computing, AI, 5G, and 6G. The EDA's innovation and entrepreneurship grant programmes further support these objectives [28]. The Department of Commerce also actively engages in bilateral and multilateral partnerships to address shared goals, including R&D and innovation in telecoms.

The Public Wireless Supply Chain Innovation Fund, launched in 2023, is investing $1.5bn (£1.18bn) to drive wireless innovation, foster competition, and enhance supply chain resilience. The programme is in particular looking at expanding and improving testing and demonstrating the viability of new approaches to wireless, such as O-RAN networks. With an anticipated award of up to $140.5m (£110.7m), the initial tranche of grants will support a range of R&D and testing activities, including expanding industry-accepted testing and evaluation (T&E) initiatives [29].

[28] U.S. Economics Development Administration (n.d.). All Funding Opportunities.
[29] U.S. Department of Commerce. (2023). Press release.

## South Korea

South Korea has a mature telecoms ecosystem which is heavily dominated by three major firms (SK Telecom, LG, and the KT Corporation) and is a world leader in innovation. For example, the nation produced 25.9% of 5G patents in 2022–second behind China's 26.8% [30]. The South Korean government is seeking to catalyse further leadership in telecoms innovation as part of the K-New Deal and K-Network 2030 strategies. The K-Network 2030 Strategy has associated funding totalling roughly $500m (£395.6m) towards the objectives of becoming a market leader in 6G R&D; securing network infrastructure; and creating a competitive telecoms ecosystem.

Other notable research projects include the 6G Bridge, a partnership between ETRI (Electronics and Telecommunications Research Institute), South Korea's national knowledge and innovation centre, and the University of Oulu, which aims to develop an advanced system architecture for 6G. Nokia has also opened a 5G Open Lab in Seoul to showcase 5G private wireless network technologies and to encourage their adoption [31].

The Digital New Deal strategy is vastly larger and broader, with 81 trillion South Korean won (roughly £48bn) in associated funding between 2020 and 2025. Security, including around semiconductor production, is a primary concern and the government recently announced a semiconductor cluster plan involving $470bn of investment across private and public partners through 2047, or $20.5 billion annually for 23 years. The semiconductor industry is highly R&D intensive, and this capital spending will support future R&D activity in the sector.

[30] MSIT. (2023). MSIT Launches the K-Network 2030 Strategy.
[31] PWC. (2023). Perspectives from the Global Telecom Outlook 2023–2027.

## EU

Chip design and manufacture have emerged as a priority area in the EU's innovation approach, in line with global concerns around security and supply chain resilience. In 2023 €8.1bn (£6.9bn) in state aid was authorised for R&D related to these issues, which are planned to crowd in €13.7bn (£11.7bn) of private funding [32]. The European Commission also upgraded its target for semiconductor production, forecast at 20% by 2030.

The EU has a major research funding capability, with initiatives such as the European Smart Networks and Services Joint Undertaking aiming to facilitate research and innovation in 5 and 6G networks and services. The 6G Smart Networks and Services Industry Association further supports the EU's objective for 6G leadership, by bringing together a range of global telecoms and digital sector actors including operators, manufacturers, research institutes, SMEs, universities, and ICT associations.

Flagship research projects include Hexa-X and Hexa-X-2, led by Nokia Bell Labs in Finland, which explores new radio access technologies and high frequencies, high-resolution localisation, and sensing; AI-enabled air interfaces; governance for future networks; and 6G architectures that can enable network disaggregation and dynamic dependability.
The EU is also home to several notable telecoms companies including the main safe network infrastructure providers, Nokia and Ericsson. Nokia and Ericsson spent $4.5bn (£2.7bn) and SEK47.3bn (roughly £3.6bn) respectively on R&D according to their 2022 annual reports [33,34]; while Chinese network provider Huawei spent $23bn (£18bn) in 2022 [35].

[32] Telecoms. (2023). EU okays €8.1 billion worth of state aid for microelectronics R&D
[33] Nokia. (2022). Nokia in 2022.
[34] Ericsson. (2022). Ericsson Annual Report 2022.
[35] Huawei. (2022). 2022 Annual Report

## Finland

Since the Academy of Finland funded the 6G Flagship programme in 2018, Finland has developed particular strengths in 6G research and innovation, led by 6G research institutes at the University of Aalto, the University of Oulu, and VTT (Finland's national technology and innovation centre). The National Strategic Research and Innovation Agenda sets out three pillars: performance, sustainability, and security/trustworthiness. AI and Non Terrestrial Networks have been identified as key innovation areas for B5G (Beyond 5G) and 6G, with an expectation that B5G and 6G will make significant use of O-RAN technologies. In addition to the EU Hexa programmes, current major programmes include 6G Flagship and 6G Bridge, which seek to foster Finland's strategic leadership in 6G and strengthen collaboration across academia, the private sector, and international partners.

Finland is also home to Nokia and three Nokia Bell Labs locations. The Oulu lab has a particular focus on radio technologies, 5G standardisation, massive MIMO, and AI, and benefit from strong links to the University of Oulu and the 6G Flagship programme. Key players from across Finland's telecoms ecosystem come together through 6G Finland, strengthening their connections.

In addition to strong local collaborations, Finland has extremely strong regional partnerships with the other Nordic countries and the Baltic states, including between national governments. This partnership has resulted in joint ministerial declarations on 5G in the region and the use of digitalisation in government operations such as border controls. Finland also has strong international collaborations, such as the aforementioned link between ETRI and 6G Flagship.

**UK and Global comparisons**

The territories considered above are all global leaders in different aspects of telecoms R&D, and there is a notable alignment across their current innovative and research efforts. 5G, 6G and using O-RAN to diversify the infrastructure market are common concerns, alongside a variety of approaches to semiconductor strategies. This points to the shared global context: everyone is responding to a changing risk landscape which has created a new need to diversify telecoms supply chains and telecoms networks. These innovation champions are also all looking to explore other technological advancements and applications that future wireless telecommunications can unlock, particularly in the areas of AI and IoT.

There are also significant commonalities in the approach taken to strengthening the sector in each country, such as efforts to bring academia and industry closer together, and to foster stronger international collaborations. This is similar to the approach taken in the UK, where the Catapult Network and projects including UKTIN and SONIC promote a diverse, deeply interconnected innovation ecosystem and effective international collaboration.

**Joint International Projects**

Alongside the increase in investment in R&D, the UK has also built relationships with a number of international peers in order to further strengthen cross border collaboration and to develop its position within international telecommunications innovation initiatives:

**Global Coalition on Telecommunications (GCOT)**

The UK has joined forces with leading nations to strengthen coordination on telecoms security, resilience and innovation as part of a new global coalition launched in October 2023, investing £70m through the UKRI Technology Missions Fund [36]. Together with Australia, Canada, Japan and the US, the UK plans to use the coalition to help ensure communications networks can remain resilient and adaptable when confronted with challenges. This will range from supply chain disruption to cyber attacks, strengthening the country's ability to stay connected at the most critical times.

The GCOT will also explore opportunities for closer coordination in areas such as research and development, information sharing and international outreach. Through these initiatives the coalition seeks to advance several shared objectives which include promoting growth opportunities for industry and enabling dialogue between policymakers, business, and academia.

[36] DSIT. (2023). Notice: Global Coalition on Telecommunications.

**UK–Republic of Korea Digital Partnership**

Launched in 2022, the UK–Republic of Korea Digital Partnership [37] provides a strategic framework for deepening digital cooperation between the Department for Science, Innovation and Technology of the UK (DSIT) and the Ministry of Science and ICT of the Republic of Korea (MSIT).

The initial focus of the Partnership will be the following 4 pillars:

1. Strengthening digital infrastructure;
    a. Collaborating to promote security, resilience, and interoperability within current and future telecoms networks, including in multilateral forums;
    b. Seeking shared opportunities to further technological innovation within the telecoms sector, such as developing research and development (R&D) collaboration in areas including, but not limited to, 5G, 6G, and future wireless technologies such as Open RAN;
    c. Facilitate cooperation and partnerships between the two countries' industry and academia.
2. Fostering technological innovation;
    a. Exploring opportunities for collaboration on interoperability and AI skills development;
    b. Promoting agile approaches to AI governance, based on clear evidence and multi-stakeholder engagement;
    c. Deepening collaboration in multilateral forums, notably the Global Partnership on AI (GPAI), the OECD, UNESCO, and facilitate coordination among like-minded international partners;
    d. Promoting information-sharing and dialogue to more effectively identify and address harms arising from the application of artificial intelligence systems.
3. Reinforcing multi-stakeholder forums and approaches; and
4. Improving baseline cyber security and securing critical technologies

[37] DSIT. (2023). Notice: UK-Republic of Korea Digital Partnership

**UK–India Future Networks Initiative (UKI–FNI)**

The UK–India Future Networks Initiative (UKI–FNI) [38] is an initial £1.4million project led by the University of East Anglia (UEA) and has been funded by the UK Government to explore innovations in the supply chain for hardware and software systems that provide access, connectivity and services for future digital networks.

The UKI–FNI project, collaborating with scientists and engineers in India, will also develop a joint vision and research strategy roadmap for the future of 5G and 6G and integration with Optical networks.

The project explores the technical requirements for future integrated digital networks and the establishment of an experimental testbed connecting India and the UK to test innovative solutions. The project aims to identify opportunities for increased competitiveness and choice of vendors that design, manufacture and deploy systems such as antennae, transmission and switching equipment at base stations, as well as the integration components that support backhaul transport and associated network management control systems.

**UK – Singapore Memorandum of Understanding**

Singapore's Ministry of Communications and Information (MCI) and the Smart Nation and Digital Government Office (SNDGO), and the United Kingdom (UK)'s Department for Science, Innovation and Technology (DSIT) have signed two memorandum of understanding (MoU) agreements to deepen research and regulatory cooperation on the use of data and emerging technologies.

Both the MoUs build on the February 2022 UK–Singapore Digital Economy Agreement, and the 2020 UK–Singapore Free Trade Agreement. In particular, the MoU on emerging technologies commits to:

- Share both countries' experiences of building new telecommunications infrastructure, like 5G networks, to Improve future connectivity as digital communications technology accelerates
- Promote more business partnerships on artificial intelligence (AI)
- Identify 'trustworthy' use of AI which can be replicated
- Align technical standards for use of AI
- New research between the UK National Health Service and Singapore's National AI Office to understand how AI can improve health services and support for patients.

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[38] UKI–FNI (n.d.). Press release.

**UK and France Collaboration on AI**

The UK and France have announced new funding initiatives and partnerships aimed at advancing global AI safety [39].

This includes a commitment to £800,000 in new funding towards joint research efforts both the UK and France are already involved in, such as Horizon Europe, to unlock more UK–France joint bids for grants to support cutting-edge R&D. A landmark partnership between the UK's AI Safety Institute and France's Inria was also unveiled, signifying a shared commitment to the responsible development of AI technology.

The collaboration between the UK and France underscores their shared commitment to advancing scientific research and innovation, with a focus on emerging technologies such as AI and quantum.

[39] DSIT. (2024). Press release.

# UK Ecosystem

**UK Telecoms Facilities**

DSIT and other Government departments have launched several initiatives in telecoms R&D&I and related areas in recent years, in parallel with UKTIN's studies. The UK hosts numerous telecom facilities, encompassing universities, businesses, and various research and public institutions. These facilities are dedicated to testing and developing solutions related to advanced networks, aiming to enhance their capabilities. Among these, a few notable examples include:

SONIC Labs

SONIC (SmartRAN Open Network Interoperability Centre) Labs is a commercially-neutral, collaborative, environment for testing interoperability and integration of open, disaggregated and software-centric network solutions and multi-vendor architectures. The world-leading £20 million joint programme between Digital Catapult and Ofcom looks to accelerate the introduction of open network products, starting with Open RAN.

It has been designed to offer network vendors, operators and integration companies:

- A place for collaborative, peer-assisted, integration and interoperability testing of products and solutions at a pre-commercial development stage, addressing the challenges of multi-vendor end-to-end solutions
- A technical platform. A commercially-neutral, multi-tenancy open network testbed providing real world indoor and outdoor scale environments, including test and measurement capabilities

A programme focuses on helping vendors accelerate technology development and early stage integration work, with targeted innovation and acceleration activities.

## UK Telecoms Lab (UKTL)

The UK Telecoms Lab (UKTL) is the telecoms security lab, established by the Department for Science, Innovation and Technology (DSIT) and operated by the National Physical Laboratory. This state of the art national facility, located in the West Midlands technology hub in Metropolitan Borough of Solihull, will provide test and evaluation capability to enhance confidence in the resilience and security of telecoms systems deployed in the UK.

UKTL has been established to support the UK government's security and diversification policy and help drive UK supply chain diversification ambitions. UKTL will engage with industry to ensure that its activities remain relevant as networks and the technology that underpins them evolve.

The UKTL works with National Cyber Security Centre (NCSC), Ofcom, UKTIN and SONIC Labs.

## Smart Internet Lab

The Smart Internet Lab facilities at the University of Bristol provide open network testbeds for research and experimentation, in one of the most well known centres of excellence in telecommunications research in the UK. These renowned facilities foster a diverse range of innovative activities, from network experimentation, wireless research, to photonic fabrication and large-scale research testbeds. With a team of 200 experts specialising in 5G radio/wireless, optical communications, and network challenges, the lab is dedicated to advancing end-to-end network design and optimisation.

## 5G/6G innovation centre

Located at the University of Surrey, the 5G/6G centre brings together leading academics and industry partners to define and develop 5G/6G infrastructure. The testbed offers 5G infrastructure including 4G and 5G core network, mobile edge computing and access network, satellite systems Wi-Fi, and LoRA. SMEs use the testbed to test different aspects of 5G technologies such as 5G applications, cyber security on 5G technology and 5G network slicing. The centre is particularly looking at:

- Indoors and outdoors environment coverage, including dense urban centres and sparse rural locations
- 5GIC 4G and 5G RAN coverage
- E2E network slicing architecture
- Core network

### ESA 5G/6G Hub

The 5G/6G Hub – based at European Space Agency's (ESA) European Centre for Space Applications and Telecommunications (ECSAT) at Harwell in the UK – is a place for collaboration and innovation, where industry will take advantage of the immense potential of converged satellite and terrestrial telecommunications networks to create advanced applications that benefit society and the environment. Benefiting from the support of the UK Space Agency (UKSA) the Hub fits into the UK Government's 5G and 6G strategy.

While initially focused on 5G, as the connectivity transformation continues, a further generation, 6G, will become part of the Hub and provide even greater capacity. Developed with information technology company CGI, the 5G/6G Hub enables three types of activities, through the provision of a private 5G network with SatCom connectivity in a business-driven facility designed to engage the wider community.

### Wider Resource

In 2022, the EPSRC and Innovate UK established research hubs in key areas such as network of networks, wireless and wired systems and spectrum, and cloud computing. Funded through UKRI £70 million Technology Missions Fund (TMF), the Future Telecoms Research Hubs closely work together to ensure that research activities are complementary, enabling a coordinated approach [40]. Current ongoing hub projects include the following:

- TITAN, a platform driving the foundations of a network of networks, led by University of Cambridge.
- HASC, looking at all-spectrum connectivity, led by University of Oxford
- CHEDDAR, a communications hub to empower distributed cloud computing applications, led by Imperial College London
- JOINER, a national accelerator programme on 6G, running until March 2025 and led by the University of Bristol. JOINER brings together academic institutes, research labs, and industrial partners across the UK in a joint open infrastructure for networks research, providing a collaborative experimental environment.

[40] UKRI (2024). Press release.

A number of other R&D initiatives have been funded by the DSIT in its commitment to developing telecommunications innovation, including:

- The Open Networks R&D Fund is a £250 million diversification-focused fund which aims to further the ambitious plans set out in the 5G Supply Chain Diversification Strategy. Projects and competitions under this fund include:
  - Open Networks Ecosystem (ONE) competition, offering up to £80 million of funding to tackle key barriers to the adoption of open mobile networks.
  - The Future Ran Competition (FRANC), a £30 million fund for initiatives developing new solutions to accelerate Open RAN deployment
  - The Future Open Networks Research Challenge (FONRC), a £25 million fund aimed at connecting UK academics with international RAN providers to work collaboratively.
  - Flexi-DAS – a £3 million project under the The UK & Republic of Korea (ROK) Open RAN R&D collaboration competition to develop a next generation Distributed Antenna System (DAS) using cutting edge technologies such as world's first use of Reconfigurable Intelligent Surfaces (RIS).
  - NeutrORAN, led by Japanese supplier NEC and with £1.6 million government funding, developed a testbed in North Wales for multiple vendors and mobile operators to come together to test Open RAN neutral host in a live outdoor rural environment.

**"Reflecting on the strengths, and in many cases world leading, of the UK telecommunication systems research and innovation capabilities, it is extremely encouraging to see the UK government investing significantly to underpin the UK future capabilities in this space. Most of the interventions are focusing on strengthening in particular the research translation capabilities in the UK – how to take forward commercially the excellent output of the UK telecommunication ecosystem. "**

**Director of 5G Technology and Digital Infrastructure, Digital Catapult
Head of UKTIN (interim)**

# UKTIN Activities

**The story so far**

As an integral component of its core operations, the UK Telecoms Innovation Network (UKTIN) programme is organised into six distinct streams of work, all of which commenced during the first year of the programme. These six strands serve diverse purposes, but collectively aim to enrich the understanding of the telecoms innovation ecosystem and industry, while promoting collaboration among stakeholders.

**Ecosystem and Marketing**

The UKTIN marketing and events programme is designed to inform and connect the telecoms ecosystem, and through the adoption agenda, the demand-side of the market.

A rich events programme delivers a blend of technical, consultation and hero content from participation at third party events to hosting round tables through to large scale conferences. This programme, including preparing for events such as MWC 2024, plays a critical role in highlighting telecoms innovation happening across the UK, connecting and convening the ecosystem and driving towards UKTIN's broader mission.

More information on events from UKTIN and the wider telecoms ecosystem can be found [here](#).

**Supplier Specialist Guidance Service**

The Supplier Specialist Guidance Service (SSGS) was established in January 2023. It performs the role of a concierge to the UK's telecom ecosystem, guiding partners, network members and prospective organisations to the relevant resource or contact. The SSGS activities revolve around four main pillars:

- A Signposting Service monitoring external requests and guiding claimants to the right service. Over the course of last year, the signposting service engaged with more than 340 contacts. As the SSGS operates primarily as a commercial entity, it has developed a Customer Relationship Management (CRM), acting as a cornerstone tool for managing leads, facilitating follow-ups, and ensuring a continuous influx of new opportunities.

- A Business Support Service delivering support in requests from companies. The service facilitates networking between companies, and expedites connection with testbeds, facilities, and research centres. It has already delivered over 220 services, including identifying opportunities for international companies. On another note, the SSGs provided matchmaking support to 13 out of the 19 consortia projects part of DSIT ONE Competition. The SSGS also organised an investment event in October 2023 at the Digital Catapult offices in London with over 40 attendees to raise the profile of the telecoms sector as an investable asset class. Another investment event is planned in March in Bristol.

- A Funding Call Support helping UKTIN member organisations to navigate grant funding opportunities available and to provide guidance for grants funding applications. The service curated and advertised over 40 opportunities within the network.

- An International Advisory Support reaching out to international companies to attract them into the UKTIN network. The service also gathers insights on compliance, standards and needs that are relevant to international companies interested in collaborating, investing, or partnering with the UK telecoms ecosystem. In its first year, the support service developed a paper for its international strategy to engage with companies of interest for DBT and DSIT.

**Systems Future Capabilities**

The objectives of the UKTIN Telecommunications Systems Future Capabilities activity are to advise DSIT about the strategic steps to take towards developing UK research, development and innovation (R&D&I) activity over the coming years in two respects: (i) providing a critical mass of open and representative input on the UK Future Telecommunication Systems R&D&I capability development plans and roadmaps; and (ii) building and maintaining a UK telecommunication community consultative structure that provides a continuous, open, representative and impartial input into the UK Government for the development of UK telecommunication systems capabilities.

The Systems Future Capabilities activity oversees the establishment of UKTIN Expert Working Groups (EWGs), whose aim is to recommend actions and interventions for the UK telecoms innovation ecosystem and provide thought leadership. The purpose of the EWGs is to bring together collective expertise in specialist areas to explore the opportunities, gaps and challenges in the UK telecommunications ecosystem, establishing where the UK can advance R&D&I looking towards 2030 and beyond. This will focus particularly on the telecoms supply chain and how to support and extend diversification activity in open networks with a common goal of supporting a coherent, end-to-end, telecoms R&D&I capability development activity in the UK.

The EWGs are currently producing a series of reports for publication, from Spring 2024 onwards, providing an overall UK-centric view of the telecoms systems capabilities, market status (strengths, weaknesses and gaps, opportunities and threats), skills and R&D&I topics (emerging and over the horizon), across a number of key systems technologies, including:

- Wireless Networking Technologies
- Artificial Intelligence
- Non-Terrestrial Networks
- Security
- Network Management
- Semiconductors
- Core Networking Technologies
- Optical Communications and Photonics
- Standards

**SME Workouts**

Telecoms is a complex and competitive market with challenges in supporting the transition of early-stage technologies into commercial products due to investment, access to information and the lack of a strong sector network. The UKTIN workshops, expert mentoring and online support platform will support early-stage companies to navigate the UK telecoms sector and bridge gaps between investment, incubation and acceleration. These vital resources are helping to understand the sector's investment and SME landscape, and turn these into opportunities that will accelerate growth, helping the UK to develop a more competitive and dynamic market.

In addition to the workshops and online platform, UKTIN is working with Pitchbook to produce an investment report which will examine the key trends in deal making and early-stage venture investment that pinpoint emerging technologies at the nexus of UK telecoms and connectivity. The team will collate and refine datasets to explore the most active players, top deals, financing metrics and more, the report provides an overview of the flows of capital across the space and which emerging segments are attracting the most investment. The aim is to produce an accurate picture of the trends and patterns over time, and where the gaps are for early-stage growth companies under a broader definition of telecoms, which is appropriate for the nature of the market.

The programme is learning more about the challenges that SMEs within the telecoms sectors face and providing practical solutions to help businesses overcome these, as well as welcome new and diverse talent into the sector. For example, from underrepresented groups and inspiring younger generations toward careers in telecoms.

## ◉ Discover more: UKTIN Publications and Insights

UKTIN Reports and White Papers provide insights for the future development of the telecoms industry.

The Market Insights Reports offer a summary of the current landscape within the telecoms industry. Meanwhile, Future Capability White Papers provide insights into the potential future of the UK telecom ecosystem.
These publications can be accessed by clicking on the links provided below.

### Market Insights Reports
Market Research Insights Report – Artificial Intelligence Published February 2024

### Future Capability White Papers
Non-Terrestrial Networks
prepared by the UKTIN NTN Working Group and published April 2024
Security
prepared by the UKTIN Security Expert Working Group and published March 2024
Wireless Networking
prepared by the UKTIN Wireless Networking Expert Working Group and published February 2024

**Skills**

The primary objective of this activity is to enhance awareness of the sector's current and future employment opportunities. It seeks to elevate the profile of telecoms to attract a more diverse talent pool and address the skills gap in the sector. Many activities conducted in the first year of the programme were centred around gathering knowledge to gain a comprehensive understanding of the sector's labour market challenges. These efforts were aimed at informing strategies to attract talent within the sector and to increase engagement in training programmes and career pathways.

This activity produced an internal ecosystem mapping report titled 'Skills, Workforce and Employment Barriers to UK Telecoms Innovation' intended to be informative for programme partners. This report combines data from surveys and secondary research to assess the current state of entrepreneurship, training, and employment in the telecoms sector. It highlights several challenges, including the lack of clear career pathways, limited employment opportunities, and the need for investment in digital inclusion and top-level skills.

In 2023, the UKTIN Talent Advisory Group was established, comprising over 100 members, to facilitate collaboration among organisations in telecoms, training, and employment. This group aims to develop and disseminate insights to inform a programme of activities, fostering the development of skills, knowledge, and connections to attract and retain talent within the sector.

Furthermore, a Talent Hub has been made available on the UKTIN website, providing essential information about career pathways and high-demand roles. Additionally, it has actively engaged with the educational sector, with over 3,000 individuals, attending career fairs to maintain a continuous presence and raise awareness about telecoms job opportunities.

**Adoption**

The UKTIN adoption programme provides a vertical industry and place-based focus to the adoption of advanced communication technologies, supporting the DSIT £40m 5G Innovation Region programme (5GIR) which was set out in the Wireless Infrastructure strategy along with other associated initiatives.

The aim is to drive economic growth and accelerate commercial investment in 5G and other advanced wireless technologies by aggregating and demonstrating demand.

The UKTIN programme aims to bring together prospective end customers, telecoms services providers, equipment vendors and system integrators. Proving the existence of a market and of competitive solutions for the prospective customers, by virtue of the experience of the existing end customers. The focus is on four vertical market segments; health and social care, transport and logistics, manufacturing and agriculture as well as engaging on the regional agenda.

Work has included:

- The recruitment of 4 industry led Adoption Working Groups - playing a critical role in bringing together the demand and supply sides of the ecosystem. Experts are leading on the development of adoption toolkits to provide practical guidance for prospects covering use case challenges and solutions, business case insights along with benefits and lessons learned;
- The creation of a Regional Working Group that brings places and industry together to identify the strategic considerations for adopting advanced wireless technologies. It provides independent advice, helping UKTIN to offer guidance and create practical tools to benefit all places. This includes the development of an annual Market Engagement report to summarise the learnings and experience captured. All ten 5GIR projects are represented in the Regional Working Group, along with a broad membership drawn from across the UK;
- UKTIN Clusters a large and growing open forum for all regions and nations, focused on disseminating key insights, tools, guidance and regional capabilities to enable inter-place collaboration, the sharing of best practice, and advance the immediate adoption of advanced connectivity throughout the UK;
- Marketing operations, including the creation of extensive resource hubs on the UKTIN site by application area, targeted media campaigns to raise demand-side awareness, an events programme, as well as support for DSIT to help deliver the 5GIR comms plans - disseminating the key lessons emerging throughout the UK.

The key aim is to reduce duplication, risks and costs and to share best practice.

"

**"Our job at UKTIN's adoption arm involves bridging the chasm that lies between test beds and trials, and the tangible real-life effects that advanced connectivity can have on citizens, public services and industry. We're guided by pragmatism, and by learning directly from people who've been there, done it and seen the impacts. The barriers here are only partially about the technology itself, of course, indeed that can sometimes be the most straightforward element! There is the need to develop complex business cases that stack use-cases justifying the capex on infrastructure. There is the challenge of cultural inertia and institutional silos, the problems of sourcing funding and suppliers, as well as the complexities of procurement, and the practical issues of deployment and sustainability at scale. The role of an innovation network is invaluable in disseminating best practice and fostering partnerships and relationship that otherwise simply would not happen."**

**Robert Driver – UKTIN Senior Advisor and Adoption Programme Lead**

# Wider UK ecosystem

UKTIN is looking across the ecosystem, aiming through the EWGs to reduce fragmentation and develop a strategic approach that coordinates different technology areas of telecoms R&D&I. This section delves into the eight EWG's areas of focus that underpin telecom networks. It offers insights into the state of the UK innovation ecosystem around these technology areas, exploring trending and emerging research fields and applications. It also describes UKTIN's initiative on standards through the ninth EWG.

## AI

AI has seen significant consideration in 5G and beyond. Despite the widespread willingness to adopt AI in telecommunications, the industry's AI maturity may be perceived to be lagging, with the majority of the Communication Service Providers (CSPs) categorising their AI deployments as still in the basic stages of development, primarily focused on pattern identification, prediction, and simple automation of IT tasks [41].

Some fundamental challenges on AI deployment, such as availability and cleanliness of data, scalability, transparency and explainability of the ML models, still remain and currently hinder the widespread AI deployments in telecom networks. AI integration into the legacy network is another compelling challenge to achieve full autonomous network service management, top to bottom and end to end.

The UKTIN AI Expert Working Group has recently released its Artificial Intelligence Future Capability Paper [42]. This paper is a result of comprehensive analysis conducted on the role AI plays in telecommunications, through the EWG's understanding of the status quo and emerging trends and technologies.

[41] RCRWireless. (2023). Telcos have lowest satisfaction with their AI deployments: Survey
[42] UKTIN. (2024). Artificial Intelligence Future Capability Paper

One recommendation from the EWG is to establish a cohesive 'Open6G' testbed that facilitates the seamless integration and assessment of multivendor interoperability solutions for native AI network elements and testbeds. This testbed would serve as a comprehensive platform for evaluating the compatibility and effectiveness of various AI-driven components from different vendors, ensuring a unified and efficient operational environment for the next generation of integrated communication, computing, and sensing networks.

## Case Study: CENTRIC'S AI-based Air Interface

Funded by the Horizon Europe Programme, CENTRIC [43] is a co-funded R&D&I European project that proposes leveraging AI techniques through a top-down, modular approach to wireless connectivity that puts the users' communication needs and environmental constraints at the centre of the network stack design.

CENTRIC's AI-based Air Interface develops methods to automatically establish connectivity solutions that dynamically adapt to the continuously changing telecommunications landscape, caused by emerging and demanding new applications and use cases. The results of CENTRIC will be validated and demonstrated in laboratory prototypes. Its breakthroughs will enable future 6G use cases, such as self-driving vehicles, the internet of nano bio-things, or multi-sensory holographic communications.

[43] CENTRIC. (n.d.). Homepage

## Wireless

Given the existing strengths in UK wireless R&D&I, a crucial aspect is to focus on adoption of UK innovations into the marketplace. The limited number of large-scale end-to-end vendors for public mobile networks – none of which is UK-based – means channels for UK innovators to be heard in international markets are seriously restricted, and the incentives for UK operators to adopt locally born innovations are slim.

With the challenges of adoption, the Future Capability Paper for Wireless Networking [44] (written by the Wireless Expert Working Group) suggests potential remedies such as operators adopting UK technologies into their commercial networks with routes via private, local and short range wireless networks for special applications and IoT, which are already more diverse and may offer faster and less restricted opportunities for adoption.

- In partnership with Cisco and the Scotland 5G Centre, the University of Strathclyde is developing a pioneering private 5G Cloud Core network. This endeavour, supported by a £4 million investment from the Scottish Government's S5GConnect programme, aims to accelerate R&D efforts in 5G technology [45].

- The Institute for Communications Systems at the University of Surrey focuses on the design of air interfaces for future wireless networks, with a primary focus on 5G+ and 6G technologies. Their objectives span diverse areas including ubiquitous coverage, massive connectivity, ultra-low latencies, high-speed data transmissions, geolocation, green energy, and service multiplexing [46].

- Project REASON, led by the University of Bristol, brings together an ecosystem representing the entire telecommunication R&D supply chain, including three major mobile network equipment vendors - Ericsson, Samsung and Nokia.
  - REASON will develop a roadmap for open 6G networks, which will set the framework for new developments across the entire technology stack. The project will provide novel solutions to effectively integrate multi-technology access networks and to advance their performance in line with the emerging 6G KPIs. New concepts will be proposed to support unprecedented network densification. Smart technologies will be developed that aim to use multi-technology access networks to extract sensing information and support 6G use cases.

[44] UKTIN. (2024). Future Capability Paper - Wireless Networking.
[45] Glasgow City of Science and Innovation. (2023). Press release.
[46] University of Surrey. (n.d.). Institute for Communication Systems: Research.

**Case Study: England's Connected Heartland (ECH)**

As part of the DSIT 5G Innovation Region Competition [47], Oxfordshire County Council was one of the successful winners, receiving £3.8 million for their England's Connected Heartland (ECH) project [48], which aims to extend the reach of advanced wireless connectivity by way of enabling wider adoption of the technology as a means of improving business productivity, further innovation, and improving public service delivery.

ECH will deploy resources from each of the participating authorities (Oxfordshire, Berkshire, Buckinghamshire, Bedfordshire, Cambridgeshire) to develop joint opportunities with the wireless telecoms supply chain and the sectors to create an Advanced Wireless ecosystem.

As part of ECH Oxfordshire County Council have started plans to build a private 5G network that covers the entire Harwell Science and Innovation Campus. Among the 194 companies on the site, several are active in telecoms, especially NTN, including the Satellite Applications Catapult, the UK base of the European Space Agency, and Thales Alenia Space UK.

[47] DSIT. (2023). Notice: 5G Innovation Regions: successful regions - Oxfordshire County Council
[48] England's Economic Heartland. (n.d.). Homepage.

**Non Terrestrial Networks**

The Non-Terrestrial Networking (NTN) Expert Working Group focuses on a broad range of non-terrestrial network architectures and applications. Across the telecoms landscape, the group will explore themes around satellite systems (GEO, MEO and LEO), medium to high-altitude systems (including HAPS and UAS), integration and convergence, and user equipment.

Telecom advancements and non terrestrial networks have historically played a critical role in commercial sectors such as maritime and aviation, areas in which the UK holds a strong heritage. While terrestrial infrastructure has traditionally dominated developments to meet the demand for mobility and ubiquitous coverage, the market is currently undergoing a significant transformation. This shift is aimed at unifying terrestrial and non-terrestrial sectors, fostering cross-sector, seamless, and ubiquitous coverage network architectures. Non-terrestrial technologies, including satellites, are now becoming integral components of telecoms networks. This change highlights the substantial evolution of the market, with increased investment, and a growing focus on the convergence of non-terrestrial and terrestrial sectors, leading to the creation of a more unified and comprehensive network infrastructure.

Although the UK demonstrates excellence in areas underpinning NTN, this sector has only recently gained significant priority in the development of future communication networks, making it a prime area for growth opportunities. In light of this, the Future Capability Paper for NTN proposes a series of recommendations, primarily directed towards the UK Government, regulators, and industry stakeholders.

The paper notably suggested that the UK industry should collaborate with standardisation bodies to ensure that E2E management plane capabilities (including TN-NTN boundary continuity) are incorporated into future standardisation activities. Besides,establishing an NTN Centre of Excellence to facilitate knowledge sharing between academia and industry was advocated. Lastly,it was recommended that Ofcom actively participates in future international discussions to identify suitable frequency bands and develop appropriate technical conditions for NTN, supporting their broader harmonisation.

The GSMA estimates that globally, 400 million people are still not covered by a mobile broadband network according to their latest State of mobile internet connectivity report [49]. At UK level, Ofcom's connected nations report 2023 states that with reference to 4G coverage "The proportion of UK landmass covered by at least one Mobile Network Operator (MNO) is now 93%" [50].

[49] GSMA, The State of Mobile Internet Connectivity 2023
[50] Ofcom, Connected Nations 2023 Report

The Government aims to achieve 95% coverage by 2025 as part of the Shared Rural Network (SRN) agreement, an agreement between the UK government and the mobile industry announced in March 2020 to improve rural mobile coverage [51]. The UK Government has conducted several projects to begin addressing this challenge through its 'Very Hard to Reach' premises: alpha trials [52], one of which involved a partnership with OneWeb and BT to deliver 4G connectivity to Lundy Island off the coast of Devon.

## Case Study: BT & OneWeb Remote 4G Trial

Eutelsat OneWeb (OneWeb having become a subsidiary of Eutelsat in 2023) is a global communications company that aims to provide high-speed, low-latency broadband connectivity worldwide through its constellation of over 630 Low-Earth Orbit (LEO) satellites. These satellites aim to deliver broadband access to remote areas that currently lack connectivity, providing 100Mbps+ and low latency (<100ms [53]). Eutelsat OneWeb's network aims to enable improved communications and expanded opportunities for businesses, governments, and communities in hard-to-reach places across the globe. BT announced a partnership with Eutelsat OneWeb in 2021 aligned to their network ambition "For 5G connectivity to be available anywhere in the UK by 2028" [54]
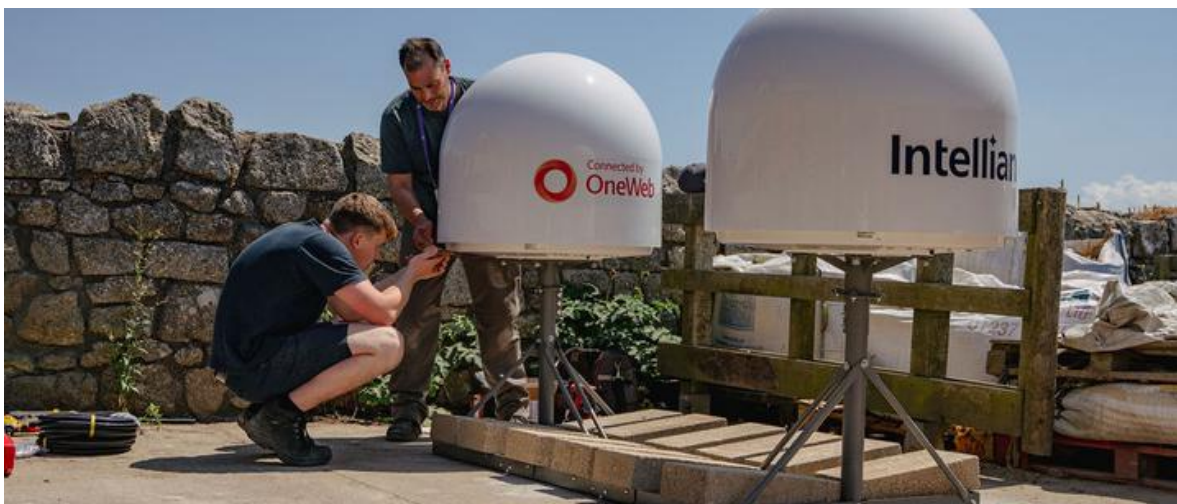


Figure 1: Image credit: BT. Intellian dual parabolic terminal which was installed on Lundy Island.

[51] About the Share Rural Network
[52] Gov.uk Notice, Very Hard to Reach premises: alpha trial case studies, February 2024
[53] ISP Review Article by Mark Jackson, OneWeb LEO Satellite Test Delivers 195Mbps Broadband Speed
[54} BT Network Vision & Policy

**Case Study: BT & OneWeb Remote 4G Trial – continued**

The demonstration on Lundy was the first in-field example of the partnership delivering benefits to a remote location in the UK. The island is home to 28 permanent residents and was designated the UK's first Marine Conservation Zone in 2010, it's also a Site of Special Scientific interest (SSSI) with three endemic species and over 21,000 seabirds.

In providing network connectivity to the island, benefits can be realised including payment systems in the local tavern and shop and support to local conservation efforts. Connectivity is delivered through an Intellian dual parabolic terminal which was installed on the island, this is an outdoor antenna system which connects to Eutelsat OneWeb's constellation in LEO. The connection travels from User Terminal (UT) to Satellite Network Portal (SNP) via the LEO satellites, where it is backhauled their Wide Area Network to handover to one of BT's points of presence (PoP) in London. From the PoP, traffic is routed back into the internet or delivered into BT's 21C core network.
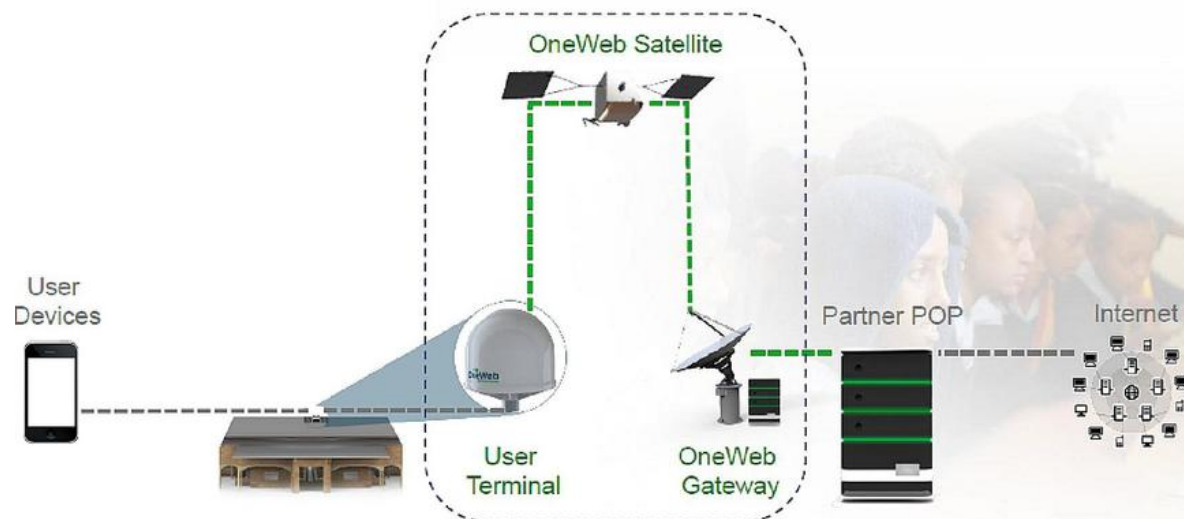


Figure 2: OneWeb System architecture (image credit: OneWeb)

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"Digital connectivity is a necessity in modern society, and the limitations in reach and resilience of terrestrial mobile networks are now being recognised as an enduring characteristic, constrained by infrastructure capital and operational costs.

Non-terrestrial network technologies are increasingly viable as flexible complementary systems, enabled by new wireless, semiconductor and digital technologies and dramatic reduction in costs to achieve scale satellite systems. The UK has a strong heritage in space systems and is well placed to lead in this global revolution in future telecommunications services"

**Paul Febvre – CTO, Satellite Applications Catapult**

**Security**

Security, like Network Management or AI, is a cross-cutting consideration and enabling function critical to the wider telecoms' ecosystem. Telecoms security is notably evolving to become an integrated aspect of IT, network, and platform security. This shift underscores the prominent role security plays in driving advancements within the UK's telecoms sector. According to industry insights, investments should be further directed towards enhancing security capabilities, with a concerted effort to implement and apply existing technological best practices and tools to mitigate vulnerabilities. Skills in security risk assessment and security practice are in particularly short supply, even more so than other telecoms sectors.

As such, the Security EWG stated in its Future Capability Paper: Security that current priority in telecoms security is to enhance security outcomes and reduce barriers to the implementation of proven existing mitigation measures. For future initiatives, a move towards more innovation at higher TRL levels is crucial in order to facilitate the adoption of these solutions. Additionally, setting security standards has become an outstanding feature of new research initiatives.

Exploration is underway in logistics and supply chain use cases to implement innovative structures such as decentralised identity services within web 3.0. The technologies at the core of these advancements, including distributed ledgers and privacy-preserving techniques, could potentially find practical applications in managing telecoms supply chains, subscriber authentication, and device identity management.

Many universities are also working to address security challenges, but also to prepare for future security threats in telecoms and the skills needed to address the challenges of security. Some examples include:

**Case Study: University of Bristol – Secure Wireless Agile Networks (SWAN)**

The Secure Wireless Agile Networks (SWAN) is a programme jointly funded by the EPSRC, Toshiba Europe Ltd alongside other industry partners & GCHQ, with the University of Bristol through 2019 Prosperity Partnership awards that will will focus on the creation of Secure Wireless Agile Networks that are resilient to both cyber-attacks and accidental or induced failures [55].

In a five-year joint research programme, the Partnership will work to identify vulnerabilities in RF interfaces, allowing for the development of techniques that can be used to detect and mitigate against the effects of cyber-attacks.

SWAN aims to create enabling technology for radios that can truly be software defined and secure by design down to the basic levels of system functionality, such as operating frequency bands, modulation, and multiple-access protocols, as well as the surrounding frameworks needed to make resilient and secure systems.

The EPSRC Centre for Doctoral Training in Cyber Security, hosted at the University of Bristol and University of Bath has launched a 4-year unique interdisciplinary PhD programme providing an immersive challenge-led training approach [56]. The programme provides a hands-on experience of realistic large-scale infrastructures in the state-of-the-art critical infrastructure and Internet of Things testbed at Bristol, becoming familiar with major programmes of research on human aspects of security and privacy in Bath, and enhanced learning with masterclasses, innovation challenges, sandpits and placements/internships at industry partners and international research centres.

[55] University of Bristol. (n.d.). SWAN: Secure Wireless Agile Networks.
[56] University of Bristol. (n.d.).EPSRC Centre for Doctoral Training in Cyber Security

**University of Surrey**

The University of Surrey have established a Security Testbed [57] which is used to test performance and feasibility of cyber security and privacy technologies for connected and autonomous vehicles (CAV), intelligent transport systems (ITS) and related 5G/6G connectivity.

The University is also investigating mobile network security [58]. The scope of this research covers security and privacy for 5G+ and 6G services that is aided by next generation AI and a network of networks comprising short range, wide area and satellite networks, including major verticals such as vehicle and transport communications (V2X) and 5G/6G-based 'internet of things'. The work covers scalable and light weight authentication and access control and uses techniques such as blockchain technology and quantum safe cryptography.

**Case Study – Project BEACON-5G (Coventry University)[59]**

Project BEACON-5G is developing an end-to-end 5G system, aligned with Open RAN framework and principles, with reconfigurability, security, trustworthiness, and service architecture agility. The broader vision is to realise a high-performance 5G system with built-in capabilities of openness, security, and trustworthiness, that can be rapidly reconfigured and optimised for operation in diverse industry-centric and consumer-centric applications in dense urban local/private as well as in public/carrier environments.

The key innovations of the project are being demonstrated via a product-grade 5G system operating in real-world environments and versatile use-cases, with a particular focus on interoperability and cyber security.

The goal of building a high-performance, robust, versatile, and resilient 5G system based on general-purpose hardware, third-party RAN and core components, and open-interface solutions is not possible without solving a significant number of challenges. This project provides various technological innovations toward some of the main functional priority areas identified by DSIT, thereby playing a key role in achieving the goals of the UK Government's 5G supply chain diversification strategy.

[57] University of Surrey (n.d.). Security Testbed.
[58] University of Surrey (n.d.). Mobile Network Security.
[59] UKTIN. (n.d.). BEACON-5G.

**Optical**

Optical communications (OC) have been playing a pivotal role in meeting the changing demands of present and future networks. The UK is at the forefront of this transformative shift, with a solid expertise in photonics and electronic technologies, and differentiated Photonic Integrated Circuit (PIC) design and packaging capabilities.

Substantial investments in optical communications and photonics research underline the UK's commitment to advancing optical technologies. The UK has built world-class research capabilities in this area, with infrastructure to support research prototyping, facilitate experimentation, and explore emerging materials for new applications. Additionally, optical communications is attracting talent and fostering innovation, whilst providing extensive training opportunities at PhD level, nurturing the next generation of researchers in optical communications. Direct training of post-doctoral researchers and associated doctoral students is a priority, with ongoing projects focused on key areas such as optical communications, optical devices and subsystems, and optoelectronic devices and circuits. Universities such as UCL, University of Cambridge, St Andrews, Strathclyde and Heriot-Watt Universities are hosting Centres for Doctoral Training (CDTs) to provide training in electronic and photonic systems, applied photonics or photonic imaging, sensing and analysis.

A robust body of research, case studies, and practical implementations are also stemming from both academic and industrial sectors:

- The UK has embarked on a series of EPSRC grants and actively supports EU projects in the optical communications domain. Strong collaboration between academia and industry is fostered by long-standing partnerships, facilitated by government initiatives such as the UKRI Research Projects (EPSRC) and Innovate UK programmes. These initiatives, including Programme Grants, Prosperity Partnerships, and collaborative R&D projects, aim to translate research findings into industrial applications. Private partners for these grants include large industrial companies including ADVA, Airbus, BT, Cisco, Ericsson, Huawei, Microsoft, Nokia Verizon, and Xtera.

**Case Study: The National Dark Fibre Facility (NDFF)**

Established by the EPSRC in 2014, the NDFF stands as a cornerstone of research into cutting-edge communication technologies [60]. Its main goal is to provide researchers with the infrastructure necessary to develop the fundamental technologies underpinning future networks. At the heart of the facility is Aurora2, a dedicated fibre network linking four university sites: UCL, Bristol, Cambridge, and Southampton. This network promotes collaboration among leading UK academic institutions, but also ensures seamless connectivity to European and worldwide research networks via telecommunications facilities in London.

The facility also includes state-of-the-art equipment designed to support quantum-secured networking, sensing, experiments with novel spectrum use, and intelligent network management. This enables the development of capabilities such as L-Band operation, optical links extension, and reconfigurable optical networks. The lab works with UK photonics and electronics.

Silicon Photonics is recognised as a key technology in tackling challenges in opticals. Its manufacturing processes are among the most controlled and best understood semiconductor processes in use today, making it a promising avenue for advancements in optical telecoms solutions. While some manufacturing challenges persist, particularly in the field of integrated photonics, significant progress is being made:

- As the UK provides flexible multi-project offerings and robust support systems for start-ups, the landscape is witnessing the emergence of small Silicon Photonics (SiPh) companies, contributing to the diversification and dynamism of the sector. For instance, TechOptics has emerged as a key player in providing cutting-edge fibre-optic communication products and expertise. Specialising in the defence, naval systems, aerospace, and energy generation sectors, TechOptics offers a range of customisable fibre-optic cable assemblies and tailored solutions to meet the diverse needs of modern communication infrastructure.

[60] The National Dark Fibre Facility. (n.d.). Homepage

## Core Network Technologies

Core network technologies cover the wide range of IT and telecommunications technology elements assembled to create networks that ultimately form a telecoms network that provides services to users, namely consumers and private and public enterprises [61].

Core networks must transport large amounts of data efficiently and correctly to the right destination on behalf of processes in the application layer, fulfilling diverse purposes and being distributed as cooperating components across many locations. The number of such disaggregated application components is growing rapidly and the amount of data that they generate is growing even more rapidly.

The Core Network Technologies EWG examines how physical media can be built into deployable networks making use of the data-links they provide, with off-the-shelf standard commercial, optical, copper or wireless solutions generally used. This configuration requires efficient transport layer protocols to carry the application data end-to-end between the applications' processes across a network layer that ensures delivery to the right place.

The R&D landscape is however more dynamic at the network and transport layers, driven by the evolving demands placed on the Internet. Internet technology is increasingly employed as a foundation for mass services, and critical infrastructure. Hence, the internet technology has become a synergy of the best of high-performance modern information, computing, and telecommunication technologies with the internet's scalability at all levels and resilience. For example, the original Internet was a flat collection of internetworked premises, campus, regional, national and transnational networks integrated by a global connectivity fabric. Nowadays Core Network Technologies must facilitate the creation and stable life of an unlimited number of internets, distributed across the world as well as local or private. They may be isolated or interconnected, or overlaid or underlaid above/below/within one another as circumstances demand.

On this journey, original internet design principles are being stretched, resulting sometimes in the loss of certain capabilities. Inefficiencies in some functions and protocols persist but are being addressed, as evidenced in the MP-TCP case study below. R&D and innovation in all aspects of Internet technologies and applications is global and extremely active, including towards standardisation in the IETF, both from academia and industry.

[61] Insights taken from the Core Network Technologies White paper, currently being reviewed for publication.

**Case Study: Multipath TCP (MP-TCP)**

The Transmission Control Protocol (TCP) sender adjusts its transmission rate when it fails to receive acknowledgments from the receiver, often indicating congestion-related delays in data delivery. This has spurred numerous research endeavours, in particular among PhD students dedicated to enhancing TCP, refining congestion algorithms, and exploring alternative reliable-delivery protocols. The QUIC protocol for instance is currently being standardised by the IETF, initiated by Google.

In the realm of Internet connectivity, hosts frequently maintain multiple IP connections, known as "multi-homing," resulting in multiple routes between senders and receivers. Multipath TCP (MP-TCP) capitalises on this by splitting data across these routes, aiming to bolster throughput and improve overall performance. For example, smartphones typically maintain two active IP connections (one to a cellular 4G/5G MNO service and another to WiFi). Both Apple and Samsung have integrated MP-TCP into their phone products, allowing faster downloads and uploads.

In response to these challenges, the UK is deploying a robust R&D effort. Alongside large-scale collaborative projects, such as the hubs described below, various universities including Aberdeen, St Andrews, UCL, Glasgow, Cambridge, QMUL, Imperial College London, and Sussex, among others, are actively engaged in research on these topics. Furthermore, many of these institutions play a role in contributing to telecoms standards and Internet standardisation efforts, ensuring the continued evolution and enhancement of core network technologies.

UKRI has awarded £6M to three consortia to establish long-lived communications hubs. The funded projects are:

- TITAN, a consortium of 17 universities leading research in critical segments of future communication networks and supported by four associate partners. The consortium aims to establish an open and productive platform for research collaboration and engagement across a large number of academic and industrial partners [62].

[62] UPSRC. (2023). TITAN: Details of Grant

- The HASC hub brings together research teams from eight universities. They bring leading expertise in a wide range of wired and wireless technologies, in order to address the challenge of providing high-speed, low-latency access to internet services for future fixed and mobile users [63].
- CHEDDAR [64] is a communications hub for empowering distributed cloud computing applications to drive research and networking across the UK academic community. The CHEDDAR hub aims to:
  - Inform the design of new communication surfaces that cater to emerging computing capabilities (neuromorphic, quantum, molecular), key infrastructures (energy grids and transport), and emerging end-user applications (swarm autonomy, air-service on demand).
  - Create integrated design of hierarchical connected human-machine systems that promote secure learning and knowledge distribution, resilient capabilities, sustainable operations, trust, and equality, diversity and inclusion-aware accessibility.

**Case Study: The University of Bristol's Smart Internet Lab**

This lab has been at the forefront of research since 2014 to achieve end-to-end multi-technology network convergence [65]. Their ground breaking work resulted in two pivotal innovations now embedded to 5G networks: technology-agnostic optical-wireless architectures for converged networks, and agile autonomous end-to-end service provision through Network Function Virtualisation and Orchestration. Furthermore, their research has been recognised and adopted by international standards bodies such as 3GPP, furthering their impact on the global telecoms landscape.

However, few UK companies are developing products in the core network domain, with limited activity in end-to-end integration or specialisation in specific technology groups like overlay/underlay technology. This is primarily due to uncertainty surrounding their return on investment, given the wide range of products that are already available on the market. Another reason is that the UK no longer has any large telecoms vendors to create demand for UK manufactured innovations and supply to UK operators with most Intellectual Property being held overseas.

[63] University of Oxford. (2023). HASC: Future Communications Hub in All-Spectrum Connectivity
[64] UPSRC. (2023). CHEDDAR: Details of Grant
[65] UoB. (n.d.). Smart Internet Labs.

The limited industrial core networking research in the UK is bound to BT and the domestic presence of large off-shore multinationals, many a residue from historic acquisitions of UK innovator companies. However system integrators, such as UK-based company Freshwave, possess the potential to introduce significant innovations as most telecoms R&D projects involve system integration to a major degree.

## Semiconductors

Semiconductors are a foundational component of digital products, and a key area of challenge for secure digital supply chains in a volatile geopolitical and trade context. Although the UK has major strengths in chip design, it lacks a native large-scale chip manufacturer, and significant capital cost barriers to the creation of new production capacity mean that the UK is dependent on importing chips manufactured abroad. This increases the risk that chips may be tampered with during their fabrication.

"
**"Semiconductors play a critical role in telecom infrastructure, from capturing images and data to encoding, encryption, transmission, reception, decryption and presenting data to the user. As we explore new ways of working and visualising the world, semiconductors will play an increasingly important role in telecom networks, ensuring that data is sent and received efficiently and securely."**

**Rupert Baines, co-chair of the UKTIN Semiconductor EWG**

Secure 5G, a project funded by DSIT and undertaken by a team involving the Compound Semiconductors Catapult, Lime Microsystems, Slipstream Engineering, and Arqit, addressed this problem by building a flexible platform using ORAN technologies in programmable radio modules that will enable companies to roll out and maintain their own quantum-safe private networks, including targeted applications for the Internet of Things (IoT), Industry 4.0, and mobile edge computing. The project leveraged wideband PA technologies for its software-defined radios, allowing frequency switching at software definable levels, and used a general-purpose processor plus commodity Linux operating system platform, integrating quantum safe cryptography which provides a solution for MPN deployment in a variety of geographic contexts.

The ORAN nature of the Secure 5G project means that network operators would be less reliant on a few vendors who offer integrated solutions, increasing the resilience of their supply chains should issues emerge with any one supplier in the O-RAN system. Improving energy efficiency was a key aim for the project, as energy usage presents a key constraint to the increased adoption of wideband technologies.

**Case Study: The ORanGaN project**

ORanGaN [66], also supported by DSIT and conducted by INEX Microtechnology with Custom Interconnect and the CSA Catapult, aims to create a new sovereign supply chain for the development of UK radio frequency gallium nitride (GaN) products for use in 5G communications. As there are currently no commercial RF-GAN devices fully developed and manufactured in the UK, this will increase the security of UK manufacturing supply chains and enhance the UK's 5G infrastructure and resilience.

The ORanGaN project is developing new manufacturing processes and packaging solutions for the creation of 5G components including monolithic microwave integrated circuit chips (MMIC), which are used in power amplifiers. Power amplifiers boost signals before their transition from a base station to smartphones and computers, and RF power amplifiers are a significant growth market – estimated to grow to $9 billion by 2025, with devices built using GaN compound semiconductors occupying $2.5-2.7 billion of this market. The ORanGaN project could support the UK's competitiveness in a vital technical area and economic opportunity.

"

**"Increasing data usage and energy consumption coupled with security challenges present significant threats to the network that require new semiconductor and compound semiconductor innovations and more resilient supply chains. As a world leader in research and innovation, the UK is well positioned to lead and commercialise these innovations, helping to create advanced telecom services and next-generation networks."**

**Andy Sellars, co-chair of the Semiconductor EWG**

[66] UKTIN. (n.d.). ORanGaN.

**Network Management**

Maintaining, administering, and monitoring networks is a significant cost area which is expected to grow as networks become more complex and could act as a bottleneck for the application of other emerging technologies. There are many drivers of these new complexities, such as the Internet of Things requiring networks to connect vastly more devices than previously, resulting in networks operating at a much larger scale than previously. Other drivers of complexity include the increasing uptake of ORAN technologies, as the heterogeneity of network components results in increased complexity of supplier and other stakeholder relationships.

While historic applied R&D projects have paid little attention to network manageability, the increasing complexity of future networks architectures, growing demands for better customer experiences, and cost and skills pressures call for a better consideration of this matter. New initiatives are trying to address this through AI automation, CEM digital twins, and open, trusted APIs in future R&D projects.

The UK government has provided funding for projects relating to network management through a series of competitions such the Future Open Networks Research Challenge which allocated nearly £29 million in 2022, including a £12 million award to the REASON project. REASON (Realising Enabling Architecture and Solutions for Open Networks) will develop advanced solutions for network-edge and wide automation using AI techniques. The initiative will also provide end-to-end service optimisation through cognitive orchestration tools to enable edge-to-edge and domain-domain functionalities for a wide range of use cases.

With £12 million in funding from DSIT, REASON project partners, led by the University of Bristol, represent the entire telecoms R&D supply chain including Nokia, Ericsson, and Samsung. This breadth of collaboration will enable the project to meet its aims of developing multi-technology access networks which can efficiently extract sensing information, support the development of 6G use cases, and strengthen collaboration between several key actors in the UK telecoms ecosystem.

**Case Study: The Reality Emulator**

The Reality Emulator project, also led by the Bristol Digital Futures Institute, addresses this issue by offering the world's first large-scale, interdisciplinary, reconfigurable digital twin to offer emulation using real-time data monitoring and analysis. This will allow potential adopters to emulate their network in a range of situations, testing it in simulation. This offers adopters greater confidence about the technologies in question, reducing the risk of adoption and thereby spurring greater uptake of new technologies. The Reality Emulator is being built and piloted in 2023-24.

As an enormous range of new technologies and use-cases related to network management emerge there could be a barrier to their adoption if potential adopters are deterred by the risk that the technology will not meet their requirements. Although the Reality Emulator is intended to explore immersive systems and eXtended Reality, it can connect to external services and devices, including network infrastructure. It could be used to investigate large scale network management applications as an advanced XR immersive system using its monitoring and analytic capabilities to identify design and deployment issues as well as reducing adoption barriers.

## Standards

The Standards expert working group is part of the second wave of EWGs, and as such has only been meeting since Autumn 2023. This EWG is unique in the degree to which its work cuts across that of other EWGs, and there are no 'solutions providers' providing product-based solutions to highlight. Despite this difference to other UKTIN areas, and the early-stage of the Standards EWG's work, there are some important system failures that have been identified already.

Standards and Intellectual Property play an essential role in facilitating global market participation and access and ensuring that value is preserved. While UK-based experts make globally significant contributions to the development of 5G standards-essential patents, there are no UK-headquartered companies that hold ownership of these patents: the UK produces breakthroughs but it does not own them. The Standards working group is, therefore, considering how UK patenting could be better supported through different options including strengthening connections between standards organisations, SMEs, and academia. Considerations in these areas, combined with potentially identifying forums through which the UK can effectively collaborate with international standards organisations, could address key weaknesses in UK telecoms standards.

Whilst there has been a particular focus on 5G standards in recent years, the 6G standards and specification processes are currently in development. 3GPP organisational partners: ARIB, ATIS, CCSA, ETSI, TSDSI, TTA and TTC announced that 3GPP will develop the next generation of global communications specifications [67]. Based on its success over several technology generations — from 3G to 5G — 3GPP is uniquely positioned to develop the standard for the sixth generation of mobile systems or "6G".

The International Telecommunication Union (ITU) has also published a framework for the development of standards and radio interface technologies for the sixth generation of mobile systems [68]. The details of the 6G framework are contained in the "IMT-2030 Framework" approved by the ITU Radiocommunication Assembly (RA-23). ITU's Radiocommunication Sector (ITU-R) will now focus on defining technical requirements, the submission process, and the evaluation criteria for potential 6G radio interface technologies.

Further information on the key telecom trends and digital technologies, as well as an interactive map of telecoms expertise across the UK can be found on the UKTIN website

[67] 3GPP News Article, 3GPP Commits to Develop 6G Specifications
[68] ITU Press Release, ITU advances the development of IMT-2030 for 6G mobile technologies

# Recurring Themes in EWG Areas

A number of recurring themes have been identified as occurring through multiple Expert Working Groups, based on a comparative analysis of draft white paper materials and analysis produced by UKTIN. The frequency of which these themes between EWGs occur may shed insight on various particularities within the UK telecoms and innovation ecosystems.

### Skills in telecoms

Skills have emerged as a vital issue across the working groups. While people working in UK telecoms are regarded as highly skilled, with a particularly deep talent pool in academia, relevant engineering disciplines, and in the clusters around Bristol and Cambridge, the Wireless EWG notes that there are not enough of them and there is an insufficient pipeline of new domestic talent and training to support the expansion of the industry and replace an ageing telecoms workforce. The ongoing shortage of skilled and experienced UK workers because of factors such as retirement, results in a sufficient lack of the human capital needed to drive business growth and innovation and certain gaps in coverage and essential development. This will require the industry to recruit internationally to meet its skill needs.

The EWGs have consistently identified that the industry is perceived as less exciting and attractive than others, particularly in relation to AI skills. Furthermore, higher salaries offered in other sectors make telecoms a less attractive destination to emerging talent and hamper staff retention: the Wireless EWG indicates that 25,000 skilled workers have left telecoms in the last 15 years with a large proportion of them heading to other sectors such as IT and energy networks.

The EWGs have identified two major opportunities around skills: attracting more women and people from lower socioeconomic backgrounds into the sector, and educating greater numbers of undergraduates to meet the sector's emerging skills demands. The Semiconductors working group observed that in 2022 there were 3245 undergraduates enrolled on Electronic and Electrical Engineering courses, of which only 335 were women, in comparison to over 7000 total undergraduates enrolled on Mechanical Engineering courses. The Security EWG has identified improving diversity as the most significant opportunity for addressing skills gaps in the security sector, with women currently representing 17% of the workforce in security roles compared to 48% of the total UK workforce.

Many organisations in telecoms have recognised an opportunity to close skill gaps by expanding recruitment of currently underrepresented groups. To address the lack of women in the sector, a group of major telecoms organisations including BT, Three, and GCHQ came together with Ofcom in 2023 to sign the Women in Tech pledge. They committed to increase senior representation of women in technology-based roles over the next three years, invest in attracting and retaining women, share good practice, and publish information on the impact of these initiatives [69]. This could be a useful data source for other organisations looking to improve their workforce's social diversity and recruit more women to address skills shortages. There are also multiple initiatives and resources to improve female representation in the tech workforce, such as Tech UK's Women in Tech campaign [70]. While a range of activities have been undertaken by government and industry to attract more women into the sector and technology roles generally, from policies such as improved maternity leave to increased female representation in senior tech roles, progress has been slow in absolute-terms and this remains an area of weakness in the UK tech labour market. As the undergraduate enrolment numbers indicate, there is an issue further up the skills pipeline, before university.

The restricted availability of degree-level undergraduate courses in electronics is related to the significant costs they involve and the availability of teaching staff. The expansion of degree-apprenticeships offers an alternative route for skills development to traditional university-based tuition, and in 2022 several UK telecoms organisations such as Sky provided these opportunities [71].

[69] Ofcom. (2023). Press release.
[70] TechUK. (2023). Women in Tech: March 2023
[71] Education and Skills Funding Agency. (2022). Guidance: Higher and degree apprenticeships.

The Network Management EWG also notes the time required for the development of specialist network management skills and that there are opportunities for university curriculums to increase their inclusion of network management content. There is a roughly ten-year period required to develop specialist network management skills, so addressing this challenge will require a long-term skills plan with consistent commitment.

## AI

AI is increasingly recognised as vital to the future of the telecom sector, as emphasised by multiple EWGs. While the UK nurtures global leadership in AI talent, with institutions like the Alan Turing Institute and DeepMind underscoring the nation's AI capabilities, skill shortages persist as demand for AI expertise surpasses supply. However, there is a disconnect between this talent pool and the telecoms sector.

The adoption of AI and intent-based networks could lead to a rebalancing of the skills mix needed by the sector, potentially reducing the need for traditional roles like customer service or network technicians while elevating demand for AI skills. Despite this, competition for AI talent across sectors remains fierce, with telecoms facing challenges in attracting individuals with requisite expertise compared to other industries. Consequently, the AI EWG has explored strategies for Telcos to upskill their workforce, examining timelines and drawing insights from international successes, particularly in India.

Furthermore, data is essential in advancing AI within telecom networks. Notable efforts towards standardisation and the development of data framework requirements have been spearheaded by organisations such as ITU, TMF, NGMN, and 3GPP. However, the existence of multiple standards and organisations addressing data issues highlights the fragmentation within the telecom industry. Persistent practical challenges associated with data management remain, reflecting the ongoing complexity in leveraging data for AI-driven advancements within the sector.

## Businesses and spin-outs

The expert working groups have identified real areas of strength in the UK's start-up support systems, but weaknesses in transitioning start-ups and spin-outs into scaled-up firms. As the sector is dominated by hyperscalers, a lack of major firms could mean that the UK becomes more marginal in the telecoms industry.

Many funding opportunities for UK firms make small awards, in the context of the tech sector, and only give awards to a small fraction of applicants. For example, Innovate UK's Smart Grants fund up to £350k and 3.5% of applicants received an award. Internationally, competitor regions such as the EU and the US are offering larger direct funding. Furthermore, as firms grow larger the business support and incentives landscape shifts towards tax deductions such as R&D Tax Relief. However, tech scale-ups are likely to operate at a loss and rely on fundraising, making these reliefs less useful to them. This creates a gap in the UK business support system for scale-ups and medium-sized businesses.

**International perspective**

International considerations underscore multiple working groups concerns, particularly concerning the security of supply chains addressed by the Semiconductors and Security EWGs, as well as the promotion of effective standards. Geopolitical tensions and uncertainty have heightened the need to secure supply chains against potential disruption. There has been a particular need to strengthen the resilience of the telecoms supply chain following the UK government's decision to ban high-risk vendors from core 5G infrastructure, and this need has expressed itself in several areas which are explored by the working groups.

The telecoms market's concentration and the prevalence of vertically integrated vendors selling proprietary systems magnify the impact of supply chain disruptions. Diversifying the industry through technologies like O-RAN presents a potential solution, enabling the development of multiple supply lines to mitigate the impact of disruptions. The UK government's 5G Supply Chain Diversification Strategy outlines ambitions in this regard, with initiatives such as SONIC supporting their implementation [72].

Despite possessing an outstanding research base, challenges persist, such as those arising from the UK's disrupted participation in the Horizon Europe programme. For instance, the UK's absence as a collaborator in the initial six NTN research projects within the current Horizon and SNS JU portfolio highlights such challenges. The AI working group acknowledges the UK's robust AI skills base but notes a reliance on international hyperscalers for product ownership, posing potential vulnerabilities.

[72]  DSIT (ex-DCMS). (2020). 5G Supply Chain Diversification Strategy

**Energy and resource consumption**

Energy and resource consumption underlie several issues across the working groups. The huge expansion of connectivity and network scale has meant that energy usage has increased. The National Grid forecasts that data centres' energy consumption will increase from roughly 5TWh in 2020 to up to 22TWh in 2030, representing 6% of the UK's total energy consumption [73]. In the context of the government's net-zero ambition and energy price volatility, there is a public and market need to reduce energy consumption.

Significant challenges including high energy consumption impose substantial power management constraints. Aerial platforms, as highlighted by the NTN EWG,, can offer a flexible solution, and have gained importance for providing widespread wireless connectivity during emergencies or temporary events, as well as relaying services for mobile devices. Their on-demand deployment capability enhances energy efficiency compared to the continuous operation of fixed terrestrial infrastructure, presenting a promising avenue for addressing energy consumption concerns.

Technical improvements in chip design, such as ORanGaN chips mentioned previously, could increase the energy efficiency of networks. Other developments such as AI-enhanced network optimisation could also drive net-efficiencies. Despite these opportunities around energy consumption, the resource use of the telecoms industry is inherently difficult to address. The semiconductors EWG indicate that there is limited scope for reusing chips, and limited customer appetite for using old equipment: the business model for key telecoms components is to innovate new products that incur new resource burdens in manufacture.

**Standards**

Standards emerge as a recurring theme, particularly in relation to AI. Given AI's pivotal role in shaping the sector's future capabilities, the rapid development of AI-specific standards and regulations presents an opportunity to establish effective and recognisable frameworks that consider international movements like the EU AI Act.

AI standards are currently fragmented, leading to confusion and barriers to SMEs' understanding of this complex landscape. Initiatives such as the Alan Turing Instititue's AI Standards Hub are facilitating improved understanding of the standards landscape and bringing stakeholders from across the ecosystem together to develop effective standards. However, EU and US standards are likely to exert significant influence in the UK market. Furthermore, the UK market lacks sufficient scale to wield influence over standards definition for core technologies, underscoring the importance of aligning with broader international standards frameworks.

[73]  National Grid ESO. (2022). Data Centres report.

**Supply chain resilience and diversification**

The semiconductor industry has disaggregated in recent decades, with specialised companies managing specific segments of the supply chain. In this context, UK companies shifted towards chip design with leaders like ARM becoming global design leaders propelling the emergence of a substantial semiconductor cluster around Cambridge.

The availability of domestic chip manufacturers recurs across multiple working groups as a weakness and constricting factor for the scaling, security, and adoption of several innovation areas such as NTNs. The US and EU have mobilised significant public capital investment, $52.7 and €43bn respectively, to drive domestic chip manufacturing, onshore digital supply chains, and invest in skills. In comparison the UK could not support a fully end-to-end supply chain and has not released comparable public investment to spur domestic manufacturing capability and capacity. While domestic chip production is unlikely to develop at scale in the UK based on current trends, collaboration with a multiplicity of trading partners could ensure a supply chain that is resilient to shocks in any one geography.

However, this emphasis on design led to the loss of domestic manufacturing capability, now dominated by East Asia and the USA, leaving the UK vulnerable to supply chain disruptions amid heightened geopolitical uncertainties. The substantial capital costs associated with re-establishing manufacturing domestically present significant barriers. Nevertheless, the development of diversified supply chains across friendly nations offers a mitigating strategy against these risks, with the UK Government's Semiconductors strategy delineating a roadmap to address these challenges.

With the growing dominance of a few international players and hyperscalers, such as Nokia or Ericson, companies have little incentive to expand their business in a market the size of the UK, rather than being acquired. Consequently, vendors often relocate their development capabilities away from the UK. Even though the UK has a rich history in radio frequency, the drive for supply chain diversification is a real opportunity to restore radio frequency capability, but faces challenges in skills, international competition, the cost of market entry and the lack of a major domestic system integrator.

Overall, the recurring themes across the EWGs indicates that the UK telecoms innovation ecosystem has significant strengths in its depth of expertise and the presence of world leading academic institutions. However, exploring these themes also shows that the UK risks becoming marginalised in several areas. In semiconductors and skills the UK is experiencing security and supply-chain risks due to long-term declines in domestic capability as a result of offshoring of manufacturing and software development to East Asia and UK-founded or headquartered business leaving the market - the Wireless and Semiconductors EWGs observe that the Financial Crisis saw their sectors consolidate away from UK companies. While the USA and EU are responding to these challenges with significant public funding to galvanise the rebuilding of their domestic capabilities, the UK is likely to be reliant on international partners in many areas of telecoms.

# Next steps for UK Telecoms Innovation

The global market for telecoms network equipment is expected to grow rapidly from £1 trillion in 2020 to £2.4 trillion by 2030 [74]. The UK will capitalise more on academic strengths, well established telecom labs, leading telecom operators to meet the future needs resulting from this market growth.

To firmly establish itself as a leading force in the telecom landscape, the UK will seek to step up its efforts to accelerate advancements across network infrastructure and applications [75]. The UK telecoms innovation ecosystem is expected to drive innovation in wireless network infrastructure, covering Radio Access Network (RAN), Transport, Core network, and OSS/BSS components. While leveraging academic research in telecom and software domains is a pivotal strategy, gleaning insights from the operational expertise of major telecom operators will inform the design, construction, management, and operation of network infrastructure. Through a variety of R&D initiatives, ecosystem insights suggest that emphasis will be also placed on data networks and AI, as well as providing comprehensive mobility and broadband capabilities.

Lastly, insights from industry experts suggest that the UK is seeking to advance progress in telecom technology through the involvement of domestic experts in standards development at both national and international levels. Sustained efforts to diversify the network landscape and foster support for emerging innovators within the supply chain will be instrumental in realising the UK's vision as a telecom technology powerhouse.

[74]  DSIT. (2023). The UK's International Technology Strategy
[75] Innovate UK. (2023). Telecom Network 2030: Innovation Landscape and Opportunities.

UKTIN was launched as a front door to the Telecoms sector. The programme has made significant progress to date with the imminent launch of the Research Capability Discovery Service providing a way of navigating and mapping the sector with easy access to a number of stakeholders. Similarly, UKTIN has been honoured to work with the ecosystem in developing and delivering an innovation framework for translational research ensuring they are well equipped to answer some of the challenges in the sector. The establishment of UK Telecoms Innovation Network (UKTIN) is a pivotal step towards harnessing both public and private investments in R&D, strategically aligning with governmental objectives. Positioned as a catalyst for future innovation, UKTIN is fostering a culture of collaboration and knowledge exchange across sectors, forging strategic partnerships to streamline efforts. As such UKTIN plays a proactive role in engaging and supporting organisations involved in open networks R&D initiatives, ensuring their alignment with governmental R&D ambitions while helping to inform future policy decisions [76].

Looking forward, the UKTIN programme will seek to continue this trajectory of de-risking and de-mystifying new technology, fostering and enabling new R&D to take place in the sector, and working alongside key players in delivering this innovation. In the upcoming year, the programme aims to expand its international outreach by actively participating in global congresses such as MWC25 and aligning its activities with additional funding opportunities under Horizon Europe.

◉ **Get involved**
Turning innovative ideas into tangible, commercial outcomes is tough, particularly in a complex market like telecoms. Click here to find out more, or speak to a member of the UKTIN about how we can support your commercialisation endeavours at specialistguidance@uktin.net

[76]  DSIT. (2022). UK Telecoms Innovation Network Competition.