Innovate UK
Global Expert Mission Report

UK - India Future Telecoms

May to June 2024

Contents

01. Executive Summary

Developing future networks has become a key priority for both the UK and India, with a strong focus on 5G, 6G, and diversifying telecom supply chains. Historically, both nations have adopted a collaborative approach in the telecom sector.

In collaboration with UKRI India and the Indian Department of Telecommunications (DoT), the online India Telecoms Global Expert Mission (GEM) explored the innovation landscape within 5G, Open-RAN, 6G, and quantum technologies in both countries. This mission brought together key government and R&D experts from the UK and India, facilitating the exchange of knowledge on present and future telecom priority areas. It provided insights into the challenges and opportunities in the two markets, and explored potential collaborations, development of partnerships, and grounds for long-term engagement through collaborative R&D and business innovation programmes.

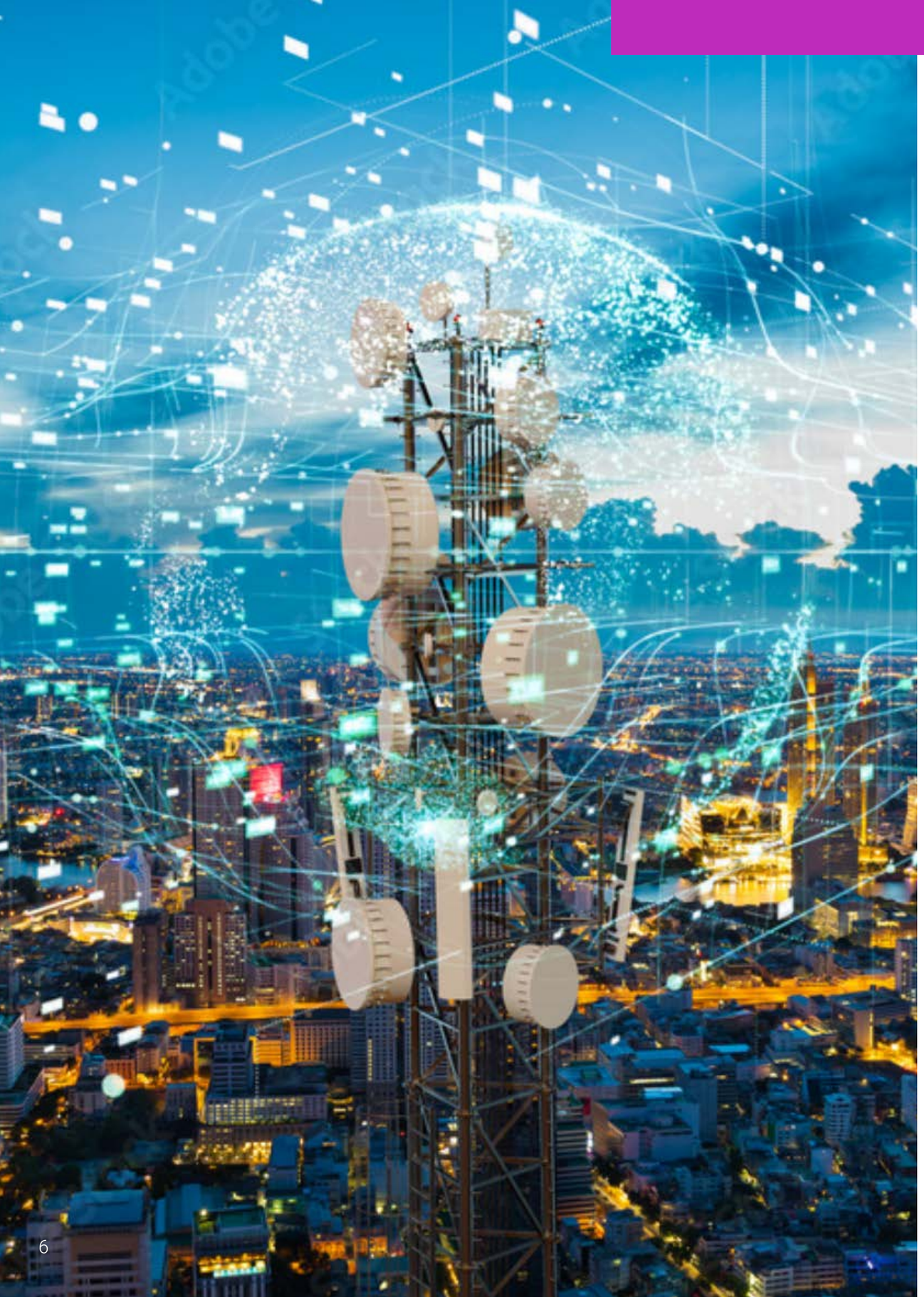
Examining the strengths, existing capabilities, and current policy trends, the mission pinpointed potential synergies between the UK and India. Collaborative efforts should focus on shared interest areas such as security, cloud-based solutions for Open-RAN development, AI applications in future networks, and non-terrestrial networks. Other cross-cutting areas providing room for partnership include enhanced network security, strengthening supply chains, and standard development.

Both countries demonstrate a strong interest in conducting joint trials and testing, particularly involving academics and labs, to facilitate the exchange of devices, knowledge, and physical resources.

However, several challenges must be addressed for successful and effective collaboration between the two countries. The GEM highlighted the need to strengthen the pipeline to commercialisation for 5G, Open-RAN, and quantum communication, ensuring that products and solutions can be brought to market. While promoting funding streams for 6G and quantum technologies is essential, academic research should also focus on higher Technology Readiness Levels. Additionally, the joint management of networks between labs presents further challenges that need to be tackled.

Opportunities to foster collaboration should revolve around innovation partnerships, leveraging existing programmes, like the UKI-FTN and UKTIN, collaborative funding with testing and capability mapping, and providing business support to start-ups and scale ups prototyping devices.

Please note that ***this report was written during the pre-election period, so most sections are based on existing policies, with no speculation on the direction future policies may take.***



02. Acronyms

AI	Artificial Intelligence
DOT	Department of Telecommunications (India)
DSIT	Department for Science, Innovation and Technology
EPSRC	Engineering and Physical Sciences Research Council
GEM	Global Expert Mission
ITU	International Telecommunication Union
MoU	Memoranda of Understanding
NTN	Non-Terrestrial Networks
Open RAN	Open Radio Access Network
SIN	Science and Innovation Network
UKI – FNI	UK-India Future Networks Initiative
UKRI	UK Research and Innovation
UKTIN	UK Telecoms Innovation Network

03. Introduction

Innovate UK and the Global Expert Missions

Innovate UK supports business-led innovation and is part of UK Research and Innovation (**UKRI**). UKRI convenes, catalyses and invests in close collaboration with others to build a thriving, inclusive research and innovation system. To this end, Innovate UK helps businesses to identify the commercial potential in new technologies and turn them into new products and services that will generate economic growth and increase productivity. With a strong business focus, Innovate UK drives growth by working with companies to de-risk, enable and support innovation. Innovate UK Business Connect exists to connect innovators with new partners and new opportunities beyond their existing thinking – accelerating ambitious ideas into real-world solutions.

As innovation is increasingly a global endeavour and the ambition of UK businesses to become truly international enterprises is at its highest, Innovate UK established its Global Expert Mission (**GEM**) programme in 2017. Delivered by Innovate UK Business Connect, GEMs help further Innovate UK's global strategy by providing the evidence base for where it should invest and by providing the opportunities for UK businesses to build partnerships and collaborations with key economies.

Mission Overview and Objectives

Over the course of May and June 2024, Innovate UK, in collaboration with UKRI India and the Indian Department of Telecommunications (DoT), delivered a Global Expert Mission, bringing together key government and R&D experts from the UK and India. The GEM facilitated the exchange of knowledge, provided discussion opportunities, and generated a deep understanding of telecom priority areas for the UK and India. The GEM was delivered in an online format, comprising two separate workshops covering 5G and Open-RAN (Open Radio Access Network) during the first one, and 6G and quantum technologies on the second.

In recent years, UKRI has funded successful UK-India collaborative projects focused on AI, Open RAN, Remote Connectivity and Security, enabling a strong foundation of collaboration between the two countries. The GEM built on already existing collaborations between the UK and India, with the intention to explore new domains for potential future collaboration. This falls within the ambition to drive forward the commitments made in the **2030 Roadmap for India-UK Future Relations**, which seeks to strengthen the bond between the two countries in various areas, including telecoms, Artificial Intelligence (AI) and emerging technologies, interactive data systems and cyber resilience.

Mission scope

This Global Expert Mission focused on exploring the landscape and potential for collaboration within the selected topics in both countries. The objectives of the Mission were to:

- Gain an understanding of the innovation landscape in both countries, including related challenges and opportunities in the areas of 5G, Open RAN, future 6G and quantum telecommunications.
- Understand the market and priorities of the DoT and potential synergies with those of Innovate UK.
- Explore the potential for collaboration, development of partnerships and grounds for long-term engagement through collaborative R&D and business innovation programmes.
- To explore key geographical hubs to inform future Global Business Innovation Programmes (GBIPs).

04. Definitions

5G is the 5th generation of mobile communication technology, significantly surpassing previous generations in speed, reliability, low latency, increased capacity and innovative capabilities.[1] It is the first cellular network technology designed to provide Enhanced Mobile Broadband (eMBB), Massive Machine-Type Communications (mMTC), and Ultra-Reliable Low Latency Communications (URLLC). 5G enables a wide range of applications, from smart cities and connected ports to enhanced live entertainment experiences, remote collaboration, industrial training, and quality inspection.

Open-RAN is a way of building and operating mobile networks, which aims to make them more flexible, cost-effective, and innovative. Compared to traditional RAN (Radio Access Network) systems using proprietary hardware and software from a single vendor, O-RAN allows different companies to provide the hardware and software components. It uses standardised interfaces, meaning equipment from different vendors are interoperable and can work together. By enabling mobile networks to be built using a variety of different equipment suppliers, Open-RAN has the potential to drive innovation in telecoms and diversify the UK telecommunication supply chain. This interoperability between different vendor products foster competition and innovation, and allows for greater flexibility and potentially lower costs in network deployment and operation.

Quantum in the context of telecoms, refers to the use of quantum mechanics principles to enhance communication technologies. This involves leveraging quantum bits (qubits) for data transmission, instead of classical bits. Quantum technologies promise ultra-secure communication through quantum cryptography and significantly improved processing power with quantum computing. Applications in telecoms include quantum key distribution (QKD) for secure data exchange and potential advancements in network efficiency and capacity.[2]

6G, the sixth generation of mobile communication technology, aims to deliver even faster speeds, lower latency, and higher capacity than 5G. Much more efficient than 4G LTE or 5G, it will enable advanced applications like holographic communication and immersive extended reality (XR). 6G will also integrate artificial intelligence (AI) and machine learning (ML) for smarter network management and optimisation. It will focus on seamless global connectivity, including coverage in remote and rural areas, with enhanced security and energy efficiency being key features, supporting the growing demand for reliable and sustainable communication.

NOTE TO AUTHOR
Link to google doc below -
no public access

1 Verizon (2021). **A Journey to 5G report.**

2 Taken from **QTAP report**

05. The Innovation Landscape

Overview of Future Networks in the UK

5G

The UK is making a significant commitment to expanding and modernising its telecoms infrastructure, with a strong 5G rollout out of 92% of territory on non-standalone 5G. As part of the £1bn Shared Rural Network (SRN) agreement, an agreement between the UK government and the mobile industry announced in March 2020 to improve rural mobile coverage, the Government aims to achieve 95% mobile broadband coverage by 2025.[3]

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. The country is hoping that by the end of the decade, most of its territory will be covered by standalone 5G.[4]

One such example is DSIT's investment of £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. Around 2000 commercial mobile 5G standalone sites have already been deployed in 2023[5] and Virgin Media O2 announced that it had switched on its next generation 5G standalone network in 14 cities across the UK.

In addition, 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', 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 **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".

In 2020, the UK government's department for DCMS launched the Industrial 5G Testbeds and Trials (IG5TT) programme, to experiment and learn from early deployments of 5G technology within manufacturing and logistics on a variety of use cases. Similarly, the £70m funding for Future Telecoms through the UKRI Technology Missions Fund (**TMF**) supports the development of technologies that are crucial to future telecoms networks including 6G. In 2022, the EPSRC and Innovate UK established research hubs in key areas focusing on the development of technologies that will underpin a seamless, open and fully integrated network of networks.

UKRI International Collaboration

Through the £70m Technology Missions Fund, 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. 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.

3 NAO. (2024). **Press release.**
4 DSIT. (2023). **UK Wireless Infrastructure Strategy.**
5 Ofcom (2024). **Connected Nations 2023**

Open-RAN

Historically, the mobile network equipment market has been dominated by Nokia and Ericsson, a trend which was reinforced following the removal of Huawei from the UK list of vendors. With Ericsson poised to become the largest supplier of Open-RAN equipment, there is a strong push to promote Open-RAN as a tool for enhancing vendor diversity. This diversification is seen as critical for fostering innovation, reducing costs, and increasing competition in the market.

In early December 2020, the UK government released its **5G Supply Chain Diversification Strategy**, which focuses on three areas of activity to ensure the UK is "not reliant on any single vendor and begins to realise its long-term vision for a more open and innovative market". It was launched to accelerate new open network solutions for the UK, with a focus on Open RAN and the diversification of networks (integration piece and disintegrated networks). To deliver upon the UK's 5G Supply Chain Diversification Strategy, the **Open Networks Research and Development Fund**, a £250 million DSIT supported programme, has been created to support several R&D initiatives, including **SONIC Labs** and the **Future Open Networks Research Challenge** (FONRC).

The UK is seeing significant activity in the Open-RAN space, driven by major MNOs:

- Vodafone has committed to rolling out Open-RAN technology at 2,500 sites across England and Wales, with Samsung as the lead vendor for this extensive trial.
- Virgin Media O2 has selected Mavenir to lead its Open-RAN rollout after extensive trials, and Three has also started trialling an Open-RAN densification network in Glasgow, partnering with Mavenir.
- BT is working with Nokia to introduce its Open-RAN portfolio, specifically focusing on trialling RIC (RAN Intelligent Controller) applications and use cases.
- These operators are also exploring diversification trials in various areas, indicating a commitment to expanding their vendor base and enhancing their network capabilities.

Through the 5G Diversification Strategy, DSIT has provided thought leadership on **Open-RAN principles**, which have been adopted by the O-RAN Alliance and various governments worldwide. These principles revolve around building an open interface architecture, including open disaggregation, standard-based compliance and neutral testing of solutions against standards, implementation neutrality and demonstrated interoperability. By promoting these principles, the UK aims to drive innovation, reduce costs, and create a more competitive and resilient mobile equipment market.

The UK has also come up with new spectrum allocation policies, aiming to make licence fees more accessible to private users and involve a review of net neutrality. Global alignment with partners such as India, which has strong relationships with various countries, is also a priority to ensure a cohesive international approach to Open-RAN development and deployment.

6G

The **Wireless Infrastructure Strategy** has outlined a set of objectives to guide the industry toward the development of 6G and next-generation communications within the next 10-15 years. Given that 6G will be an evolution of 5G, much of the strategy reflects ongoing connectivity efforts while laying the groundwork for 6G.

As part of this, the 6G strategy builds on the momentum of 5G and includes priorities such as privacy values, ensuring an open internet, prioritising sustainability, and enhancing connectivity for remote areas. It highlights the constructive role of the UK government in ensuring that the 6G vision aligns with the needs of UK telecoms operators and in supporting 6G research in academia to meet these priorities.

Numerous research institutions are already active in this space, particularly through the TMF's Future Telecoms Mission.[6] Initiatives such as Network of Networks, Advanced Optical Networks, and Next Generation Wireless are spearheaded by leading institutions like the University of Bristol and Imperial College London. These efforts focus on higher Technology Readiness Levels (TRLs) and commercialising products and services to support smaller companies facing commercialisation challenges. The UK is also exploring the integration of AI into 6G networks for smarter, energy-efficient designs, predictive maintenance, and optimisation of network resources, aiming to enhance sustainability and reduce carbon footprints.

Lastly, the UK is heavily involved in international standards development. This includes foresight on key standardisation issues and direct government participation in developing IMT-2030 for 6G mobile technologies within the International Telecommunication Union (ITU), focusing on security and sustainability. The UK also actively participates in the 3rd Generation Partnership Project (**3GPP**), contributing to the core requirements for 6G, particularly in areas of security, trust, and sustainability, with an emphasis on total net energy use and gas transition.

6 **www.ukri.org/news/major-future-telecoms-research-boost-announced/**

Quantum communications

The UK is also leading research and initiatives in quantum technology. The **National Quantum Strategy** published last year outlined the UK's roadmap for quantum technology development until 2035, emphasising on building a strong pipeline of quantum innovations from research to commercialisation. The strategy also plans to invest to scale up quantum technologies, particularly photonics, which are critical for developing quantum communication systems and enhancing the overall telecom infrastructure. The aim is to push the maturity of quantum technologies further, including leveraging quantum cryptography for ultra-secure communication and exploring quantum computing for enhanced data processing capabilities.

Overview of Future Networks in India

5G

India has the second-largest telecommunications network in the world. The Indian telecom sector is characterised by strong competition with major players such as Bharti Airtel, Reliance Jio, and Vodafone Idea. The rollout of 4G networks has significantly improved connectivity, and there is growing anticipation for the implementation of 5G technology. Regulatory oversight and spectrum allocation and licensing in India are managed by the Department of Telecommunications (DoT) and the Telecom Regulatory Authority of India (TRAI), whereas in the UK these responsibilities are handled by Ofcom.

India has experienced a rapid 5G rollout, with 4G and 5G subscribers growing from 445m to 850m between 2018 and 2023. India is also active in standards development, working on globally approved standards for 5G.[7] The country has collaboratively developed 5Gi, a local 5G standard, to improve 5G coverage in rural and remote areas. To address the low coverage problem, Indian academia also proposed a 5G technology solution called LMLC (Low Mobility Large Cell configuration) to the 3GPP in 2020.

The Department of Telecommunications (DoT) participates in various 5G initiatives, such as the **5G High-Level Forum**, which evaluates and approves roadmaps and action plans for 5G, and the **Indigenous 5G Testbed**, which validates prototypes locally. The Government is particularly interested in the following areas:

- Open RAN
- Non-terrestrial communications
- Software defined networks
- AI in communications

India benefits from a vibrant startup ecosystem and promotes many 5G applications. The DoT launched a 5G hackathon aimed at shortlisting cutting-edge ideas focused on India that can be converted into workable 5G products and solutions. The **5G Vertical Engagement and Partnership Programme** has been offered to industry verticals with potential as testing and breeding grounds for innovative 5G use cases. The 5G Use Case Labs aims to expand the 5G ecosystem by building the competencies of 5G technologies and their use cases among students, the academic community, and start-ups. This initiative seeks to realise new opportunities, business models, and employment potential related to education, health, precision farming, and intelligent transport systems.

In addition, India facilitates policy interventions. For instance, it has eased clearances and wireless permissions for telecom towers. They conducted a successful spectrum allocation auction and implemented several spectrum reforms, such as zero spectrum usage charges, no mandatory upfront payments, and the ability to surrender spectrum after a minimum threshold period of 10 years.

7 economictimes.indiatimes.com/topic/5gi

Open-RAN

India is making significant strides in developing and deploying Open-RAN (O-RAN) capabilities, collaborating with multiple partners to foster a robust and diverse telecommunications ecosystem. By furthering these developments, India aims to create a self-reliant and competitive 5G ecosystem, enhancing its technological capabilities and contributing to the global telecommunications landscape.

The Centre for Development of Telematics (C-DOT), the R&D arm of the DoT, has set up a state-of-the-art 5G Open-RAN Lab in Delhi, equipped with both indoor and outdoor testing facilities. This lab is designed to offer comprehensive testing services, including functional, conformance, and interoperability testing of O-RAN systems. The primary aim is to facilitate the certification and badging of subsystems that conform to 3GPP and O-RAN Alliance standards. The lab is also used by start-ups to test their products and is deployed at several research agencies for internal use cases, data generation for AI/ML, and 5G testing and teaching.

Realising the benefits of O-RAN, several domestic companies that are not part of the O-RAN Alliance are also developing O-RAN compliant products and solutions. The Government, telecommunications service providers (TSPs), domestic companies (OEMs), and academic institutions are all part of the O-RAN Alliance. A key player in this ecosystem is C-DOT, which is developing various versions of 5G Radio Access Networks in the lower, mid, and high bands with the support of domestic Indian players.

India is also focused on developing and testing components of O-RAN solutions through its **Indigenous 5G Stack** initiative. This initiative aims to build an end-to-end indigenous system, encompassing network hardware, Layer 2 stack, and wireless technologies. Funded by the DoT, this effort includes developing core network elements, Baseband Units (BBUs), base stations, and Remote Radio Heads (RRHs).

6G and Quantum

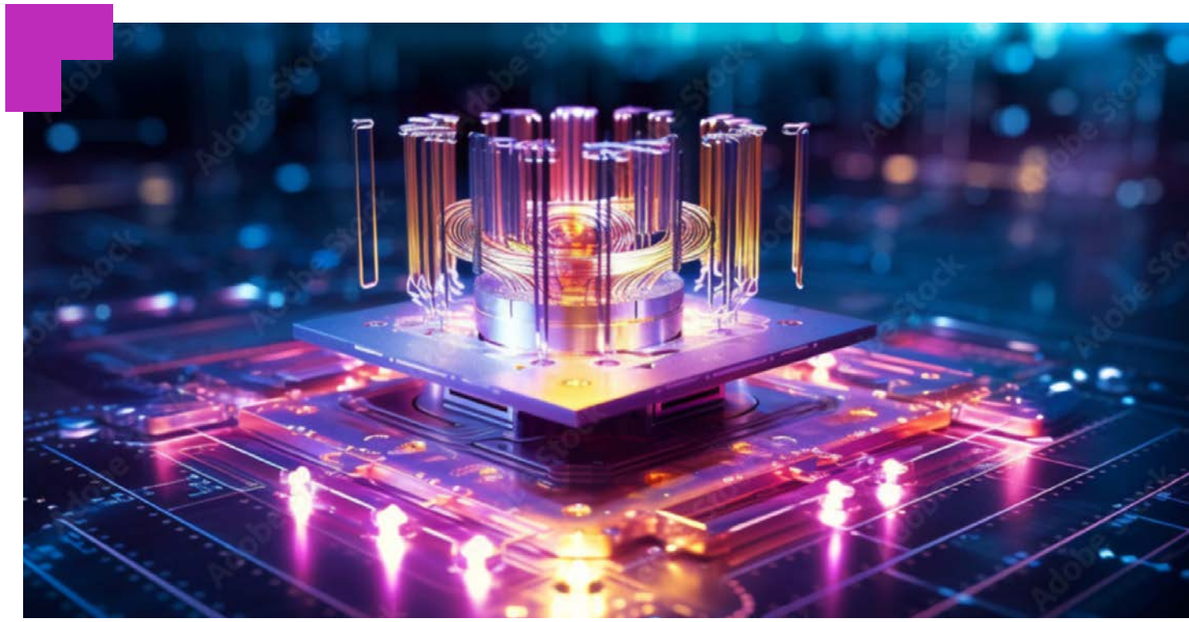
India's efforts in developing O-RAN and 5G technologies are also paving the way for the future, making the country 6G ready. In 2023, India released the "**Bharat 6G Vision**," which sets an ambitious goal to become a pioneering force in the design, development, and deployment of 6G technology by the year 2030. This vision underscores India's commitment to being a front-line contributor in the next generation of telecommunications innovations, ensuring the country remains at the forefront of global technology advancements.

The Bharat 6G Vision is built on principles of affordability, sustainability, and ubiquity, aiming to make 6G networks accessible not only within India but also globally. India's Bharat 6G Vision, complemented by the Bharat 6G Alliance, is instrumental in facilitating cooperation and development of 6G technology. This alliance has signed a Memorandum of Understanding (MoU) with the NextGAlliance of the USA and the 6G SNS AI initiative of the EU, fostering international collaboration and innovation.

Key elements of this vision include:

- Ensuring that 6G technology is cost-effective and accessible to a wide range of users.
- Prioritising energy-efficient and environmentally friendly network designs.
- Achieving widespread coverage, including remote and rural areas.

Current projects include the THz testbed conducted by SAMEER, which focuses on advanced communication techniques using Orbital Angular Momentum (OAM). India is also enhancing optical networks to support the high data rates and low latency required for 6G. The country is actively seeking proposals for innovative 6G applications, such as Edge AI-empowered networks, holographic communications, augmented reality (AR) multisensory applications, blockchain for spectrum sharing, and metaverse applications. Besides, the **Telecom Technology Development Fund (TTDF)** supports other innovative projects, exploring advancements in radio interface technologies, including Non-Orthogonal Multiple Access (NOMA); Enhanced Massive MIMO (E-MIMO); Successive Interference Cancellation (SIC) technology.



6G standardisation efforts

Under the special agenda of the International Telecommunication Union (ITU), India is actively participating in setting 6G technology global standards. The Telecommunication Engineering Centre (TEC), the technical arm of the DoT, is dedicated to formulating standards for the telecoms, broadcasting, and other ICT sectors. By setting these standards, TEC aims to foster interoperability, enhance communication efficiency, and ensure the robustness of emerging technologies. India's 6G standardisation efforts emphasise several emerging trends and technological enablers, such as AI-native air interface, integrated sensing and communication (ISAC), device-to-device wireless communication, or antenna-on-chip and antenna on package.

Quantum communications

India is focusing on several advanced technologies to implement 6G, including cell-free communication, AI, blockchain, and quantum technologies. As such India is making significant advancements in quantum technologies within the telecom sector, primarily focusing on integrating quantum capabilities into 6G systems. The country is developing quantum-enabled 6G systems to establish Quantum Non-Terrestrial Networks (Quantum NTN) and offering Quantum-As-a-Service to enhance communication security and efficiency. Additionally, initiatives are underway to create end-to-end quantum-secure 5G networks.

06. Collaboration Opportunities

Opportunities for UK-India collaboration on 5G and Open-RAN

Existing collaborations

The UK and India have a strong history of collaboration in telecoms, involving both academic institutions and industries. The EPSRC **UK-India Future Networks Initiative** (UKI-FNI) is a key platform facilitating these collaborations, led by the University of East Anglia in collaboration with the Universities of Surrey, Southampton, University College London, and supported by BT. It covers a wide range of topics including optical networks, security, 5G, 6G, and the physical layer of telecommunications. The programme has recently reinforced its commitment to advancing telecommunications technology through a series of collaborative efforts.

The initiative has backed four pilot projects aimed at tackling the technical, engineering, and business challenges associated with designing and building future telecommunications infrastructure. These projects focus on developing innovative solutions in hardware, software, and protocols to integrate high-speed mobile systems with metro and core optical communications networks. Research and innovation have been at the forefront of these efforts, utilising a testbed that connects India and the UK, facilitating the testing of cutting-edge solutions. The UKI-FNI aims to expand its activities into a larger-scale project over the next four to five years, further strengthening this international collaboration.

Several ongoing research and innovation initiatives further highlight the strong collaborative relationship between the UK and India to advance the development of future networks. UKRI has funded several successful collaborative projects focusing on key areas such as Artificial Intelligence, Open RAN, remote connectivity, and security, underscoring both nations' commitment to pushing the boundaries of telecommunications technology. Another example is C-DOT in India and UK partners have explored new business models for 5G, particularly leveraging cloud technology and the concept of **Network-as-a-Service** (NaaS). This exploration is intended to drive innovation in network deployment and management, offering more flexible and scalable solutions.

Common interests and strengths

India and the UK share numerous common interests in the advancement of 5G and 6G technologies, particularly in areas such as system integration and specialised technologies like MIMO (Multiple Input Multiple Output), the RIC (RAN Intelligent Controller), XApps leveraging AI, Non-Terrestrial Networks (NTN), and cloud computing. Both countries are also committed to fostering a disaggregated Open RAN vendor ecosystem, with an emphasis on UK supply chain diversification and promoting Indian indigenous OEMs in the UK and EU markets. They both seek to develop cloud-based solutions for network orchestration and automation, which are pivotal for the adoption of **Open RAN**.

UK-India lab collaborations

Strengthening these connections between labs in both countries can play a crucial role in these collaborative efforts, notably by enabling mutual recognition of the testbeds. These facilities should work on exchanging devices and utilising legacy solutions already present in the following labs:

- The **SONIC Labs**, with a focus on interoperability
- **UK Telecoms Lab** with a focus on security
- **UK Telecoms Innovation Network**, bringing together industry, government stakeholders involved in telecoms
- Indian labs, including the **100 5G Use Case Lab**, the **Indigenous 5G Testbed**, and the C-DOT **Open RAN Test Bed**.

Strengthening supply chains

With the aim of both countries to strengthen their domestic industry bases, the UK and India should promote the entry of Indian indigenous OEMs into the UK and EU markets. Collaboration between the two countries could also participate in enabling better 5G connectivity in remote and rural areas.

Joint trials and research

India and the UK can work on developing large-scale use cases to demonstrate the usefulness of next-generation networks across a range of 5G applications. Joint trials, test cases and research can include a broad spectrum of activities including:

- NTN prototyping and use into 5G networks
- Cloud-based solutions
- IoT deployments
- 5G NBIoT use cases

Collaboration may also explore opportunities for captive **private small-scale deployments** and 5G private networks, where the UK can leverage its expertise in neutral hosts, network convergence, and RIC/App development and capitalise on device and technology sharing. **Open RAN joint pilots** can also be conducted in both countries' telecom networks, with joint research focusing on Open RAN ecosystem interoperability and security requirements.

Cross-cutting collaboration areas

Education and upskilling

Collaboration should focus on addressing **the skills deficit in the UK** while fostering educational and professional development in both countries. This involves creating studentships enabling knowledge exchange and upskilling of future engineers and scientists. It is essential for the next generation of professionals to gain direct exposure to operational environments in both India and the UK. To this end, the UK-India Future Networks Initiative (UKI-FNI) supports 3–6 month secondments for PhD students, backed by strong industrial support, allowing them to understand how future systems can be managed at the control layer. Additionally, UKI-FNI is planning to develop a robust skills pipeline for next-generation network engineers to manage future networks effectively.

Security

Security remains a critical area of collaboration, essential for creating a resilient and trustworthy telecommunications infrastructure to support the advanced needs of 5G and 6G networks.

Emphasis on emerging technologies such as blockchain and quantum cryptography can enhance security. Key collaborative areas include blockchain-based solutions and tokenisation for identity management, untrusted infrastructure sharing, and device management to ensure secure transactions.

Addressing security implications in Open RAN deployments is also crucial, with efforts directed toward developing robust security frameworks to safeguard networks against emerging threats. Additionally, threat analysis could be looked into, involving identifying unexpected security and resilience threats arising from the diversification of 5G-6G hardware and software. Within this context, the Digital Security by Design (DSbD) programme highlights the importance of memory-safe hardware to prevent security vulnerabilities, representing another potential area for future collaboration.

Softwarisation

The softwarisation of network technologies is another critical area of collaboration focus. This involves transforming traditional hardware-based network functions into software-based solutions to increase flexibility, scalability, and efficiency.

By focusing on software-defined networks (SDN), to enhance network management and control for more responsive and agile network operations, the UK and India can aim to create more efficient and versatile network infrastructures. One key initiative is the **DSIT Flex 5G Project** which investigates the softwarisation of 5G technologies, including MIMO and O-RAN, to enable more dynamic and adaptable network solutions.

Opportunities for UK-India collaboration on 6G and quantum technologies

The UK Telecoms Innovation Network (UKTIN) programme established eight Expert Working Groups to focus on areas such as NTN, AI, and wireless technologies. These groups have produced technical roadmaps which highlight the necessity for intellectual partnerships in telecoms, acknowledging that the UK alone cannot advance future telecoms without international cooperation.

Joint efforts in 6G

Academic research and testbeds

Academic research should work towards promoting the exchange of information on programmes in areas of shared interest, leveraging ongoing work at universities in both countries, and building on existing relationships to quickly add value. One such example is the **JOINER** programme, 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.

Key activities could cover:

- Identifying current and future 6G research and innovation testbeds and similarities between the two countries.
- Promoting joint research, proof of concepts (PoC), and pilot projects on 6G technologies within the two countries.
- Establishing Memoranda of Understanding (MoUs) between universities working in the 6G domain, supported by both governments.

Collaboration should put forward values such as trust, resilience, and security to create a secure and trusted telecommunications infrastructure.

Solving technical challenges

Both countries are focusing on a bundle of technologies, including Terahertz (THz) communication, optical networks, and precise timing technologies, necessary for the development of 6G. The UK and India should be looking at establishing a strategy on whether to put the effort on a single one for collaboration or to consider them as a group of technologies.[8]

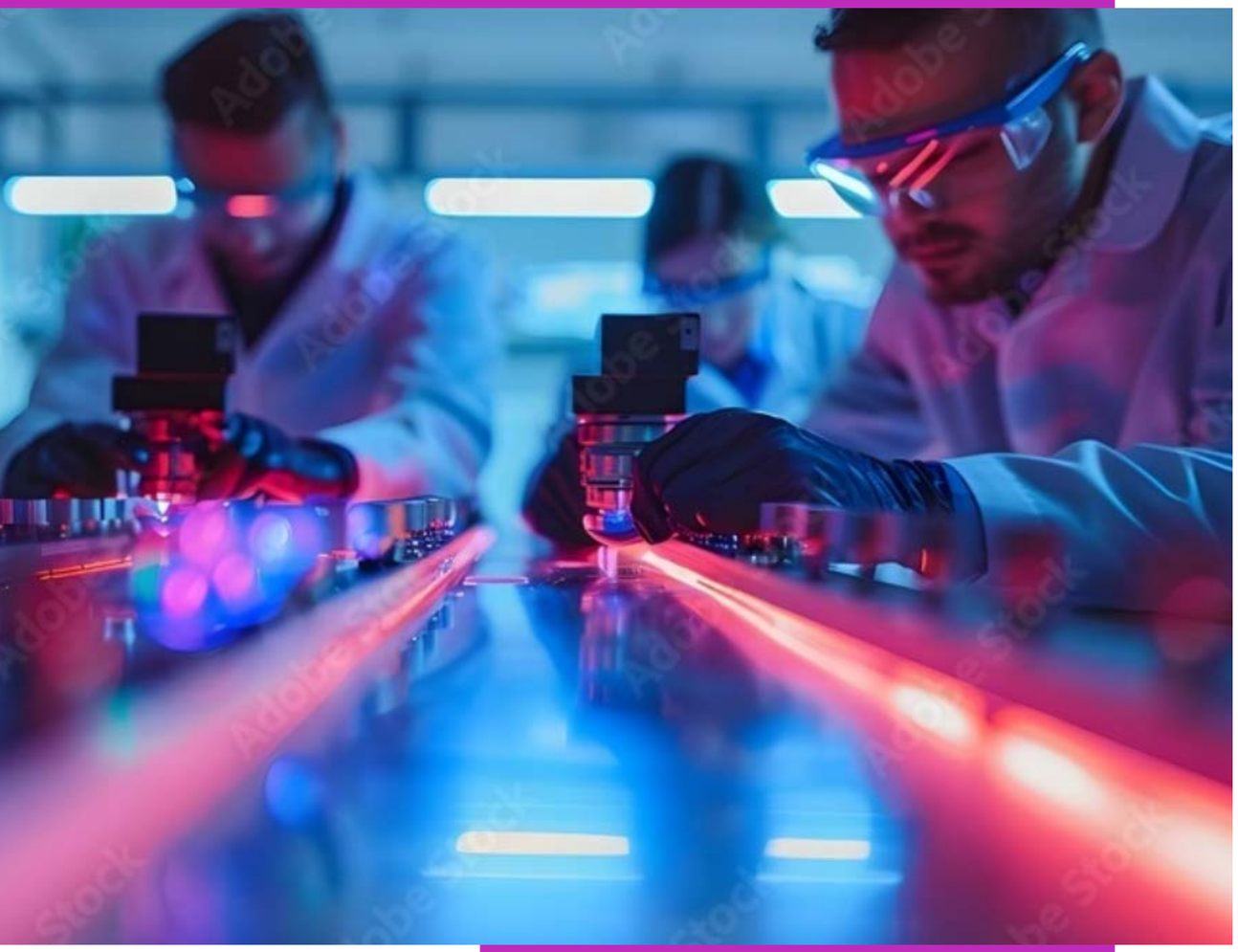
Several other challenges have been identified, including:

- Energy consumption, and addressing the high energy demands of advanced telecommunications technologies.
- Ensuring robust security measures to protect against cyber threats
- AI applications into 6G networks
- The convergence of terrestrial and non-terrestrial networks
- Managing bandwidth limitations and varying compute capabilities at different edge nodes (LEO, GEO, MEO, HAPS, BS) and addressing latency issues at different edge nodes.
- Linking core networks to base stations versus non-terrestrial nodes
- Utilising hyperspectral payloads available on satellites

6G standardisation efforts

With India and the UK both actively participating in 6G standardisation efforts, building working groups to foster research and development (R&D) and standards development should be a priority to ensure the alignment of technological advancements with global standards.

8 THz communications, joint communications and sensing, artificial intelligence and machine learning, reconfigurable intelligent surfaces, photonics and visible light communications.



Key areas for Quantum communication collaboration

The intersection of quantum technologies and telecoms, particularly within the context of 6G, presents a unique opportunity for innovation and collaboration. Both the UK and India recognise the potential of this synergy and are exploring joint funding opportunities and collaborative projects to leverage their respective strengths in these domains.

As such, there is a concerted effort to secure joint funding for advanced communications projects that support the integration of quantum technologies with 6G networks. Collaboration should aim to explore how quantum technologies can be a cornerstone for the future of 6G, enhancing the capabilities and security of next-generation networks. With many future telecom projects funded in the UK already overlapping with quantum technologies, this makes room a strong foundation for further collaboration.

Academic research

Academic institutions in both countries are advancing quantum research. Memoranda of Understanding (MoUs) between universities will formalise collaborations, enabling joint research projects and funding opportunities in advanced communications fields. Specific areas of focus could include quantum teleportation research, quantum-assisted telecom technologies, and joint testings.

Pilots and joint testing projects

Indian companies have made significant strides in developing quantum communication products and solutions. These innovations provide a fertile ground for pilot projects and joint testing initiatives. By making testbeds and facilities available to collaborators, both countries can benefit from shared resources such as sources, memory, fibre, detectors, and telescopes. A significant milestone in the collaboration would be the setup of a quantum network demonstration for space-based quantum networks. This involves agreeing on protocols and coordinating the use of ground receiver telescopes, showcasing the practical applications of quantum communications in a real-world setting.

Besides, great prospects for **developing components** such as entanglement photon sources, quantum memories, and detectors exist. Demonstrations of these components in free-space quantum networks, including space-to-ground communications, represent new opportunities for both countries. Additionally, exploring the potential of quantum satellites and quantum sensing technologies can further expand the scope of collaboration in this space.

Solving challenges in quantum information transport

Yet, the commercialisation of quantum technologies requires overcoming challenges in quantum information transport, particularly the attenuation in transmission channels. Developing new mechanisms for laser beam transport is essential, as the existing fibre optic backbone poses limitations. Collaborative efforts could focus on innovative solutions to these challenges, ensuring that quantum communications can be effectively integrated into future telecom infrastructures.

Security enhancements through the QKD

Quantum Key Distribution (QKD) is a critical technology for enhancing communication security. By implementing QKD and exploring entanglement distribution, the UK and India could participate to develop robust security frameworks to prevent eavesdropping and interference. What's more, moving beyond basic QKD to develop quantum memories and quantum repeaters is essential for extending the range and robustness of quantum networks, necessitating deep collaborative research and development efforts.

WGs to foster R&D and standards development

The UK's **National Quantum Strategy** has emphasised the importance of international collaboration, particularly in setting standards and developing satellite applications. Establishing working groups focused on standards development in quantum telecommunications could enhance coordination between the UK and India. This collaboration would ensure that both nations actively contribute to and benefit from advancements in quantum standards development.

07. Potential Barriers to collaboration

Challenges for 5G-related collaboration

- One of the primary challenges in 5G collaborations is securing sufficient **funding support for industry** partners. Organisations require long-term financial backing to mitigate the risks associated with their involvement in collaborative projects. Without this, the development and deployment of new technologies could be significantly hindered.
- Successfully **transitioning research outputs into commercial markets** remains a significant hurdle. Ensuring that innovative solutions developed through collaborations can be effectively brought to market requires strategic planning and support from the conception of collaborative projects.
- Keeping technological advancements in sync with the **3GPP's regular updates and releases** is essential.

Challenges for Open-RAN collaboration

- Understanding the impact and relevance of **technical standards** related to security, scalability, and resilience is critical for successful Open RAN collaborations. Ensuring both nations adhere to and influence these standards can facilitate easier integration and interoperability of technologies.

Challenges for 6G-related collaboration

- While there is considerable long-term research support through programmes like Horizon Europe, the UK is being **less integrated in 6G and quantum funding streams**. This presents an opportunity for establishing global collaborations outside of Europe to secure the necessary financial resources.

Challenges for quantum communications collaboration

- Combining quantum technologies with classical optical transmission systems presents both technical and operational challenges.
- **Jointly controlling and managing quantum networks** to supply end-to-end secure keys involves sophisticated coordination and technology sharing. Ensuring seamless collaboration in this domain requires establishing clear protocols and robust management frameworks.

08. Conclusion

From an innovation and R&D perspective, the GEM underscored the strong appetite and willingness for UK-India bilateral collaboration. While the UK and India have a history of successful partnerships, including joint labs focused on 5G and Open-RAN, there is significant potential for further collaboration to accelerate the development of future network technologies and strengthen both markets.

Research conducted as part of this GEM revealed mutual interests in key technology areas and applications within future telecoms. Both countries are extensively investing in research and funding to diversify and strengthen their telecom supply chains, particularly by creating open and interoperable 5G networks. They are also committed to setting and developing standards in 5G, 6G, O-RAN, and quantum technologies to foster interoperability, enhance communication efficiency, and ensure the robustness of emerging technologies globally.

Emphasis is placed on improving the security of devices and networks, leveraging new technologies such as Quantum Key Distribution (QKD) and the softwarisation of networks. Recurring themes for collaboration include the use of Artificial Intelligence in communication applications, developing Non-Terrestrial Networks (NTN) to improve service quality, resilience, and coverage, and better assessing security risks and threats to telecoms.

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10. Annex – List of UK Participants

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