Network Convergence: techUK's vision for a connected future

Exploring the Potential of Future Telecoms

techUK

10 St Bride Street
London EC4A 4AD
T +44 (0) 7331 2000

techUK.org | @techUK

Network Convergence: techUK's vision for a connected future

Introduction

The integration of terrestrial and non-terrestrial networks has the potential to provide comprehensive coverage across the entire UK. It also opens new opportunities for different markets, including greater collaboration with government initiatives. In the UK, for instance, the £1 billion Project Gigabit Programme alongside the Gigabit Broadband Voucher Scheme (GBVS) aims to deliver high-speed internet, either through fixed wireless access or optical connectivity to most households. However, achieving ubiquitous connectivity remains a challenge due to the costs of deploying physical infrastructure to distant areas and the continuing operation of the networks being commercially unviable for operators.

The telecommunications industry's move toward network convergence presents significant social and economic opportunities. Once seen as independent or even competitive with terrestrial systems, satellite networks could play a key role in complementing investment in terrestrial networks for mobile operators and reaching unexploited markets, extending coverage to extremely hard to reach areas. Furthermore, satellite backhaul is also adding resilience and reach for networks serving emergency services and remote locations to bridge the digital divide.

Beyond coverage, satellite networks offer scalability and efficiency, making them a compelling option in future connectivity solutions. To remain competitive, UK companies will have to promote strategic investments in core capabilities, requiring a collaborative approach to deployment between stakeholders in the telecommunications and space value chains.

This paper includes broad references to demand, growth, and the specific purposes that Network Convergence will serve. The paper compiles industry perspectives and actionable recommendations to guide efforts towards seamless convergence of terrestrial and non-terrestrial networks. The aim is to add the commercial aspects needed to deploy convergence in a context that highlights investment opportunities and the increasing demand for broader coverage. It emphasizes balancing standardization with practical deployment, clarifying the government's role, and ensuring equitable access for all.

techUK

10 St Bride Street
London EC4A 4AD
T +44 (0) 7331 2000

techUK.org | @techUK

Recommendations

Regulators and industry must work together to identify and address challenges in achieving seamless convergence between terrestrial and non-terrestrial networks

- **Integrating Network Technologies:** Identify compatibility between satellite and terrestrial networks, promoting a balancing of the requirements from international standards and practical deployments through available devices in which the network and satellite operators' technologies can evolve to allow for a variety of convergence scenarios.
- **Cooperation for Ecosystem Development:** Detail the interfaces that would allow mobile network operators and satellite operators to share information for monitoring network performance, and instructions or coordinated management of shared resources, while ensuring quality of service for different user tiers, accounting for international supply chains, investment and standards.
- **Mitigating Risks through Better Regulation:** Establish operational standards for the optimization of space assets is critical, focusing on more efficient capabilities and use of spectrum,[1] conducting thorough pre-deployment testing and developing industry-backed regulations that facilitates agreements between the satellite and the terrestrial network operators to avoid harmful interference, spearheading a European position on spectrum management in international forums.

[1] techUK. (2024). *Navigating the Final Frontier: A Recap of the Space Commercialisation Summit*.

10 St Bride Street
London EC4A 4AD
T +44 (0) 7331 2000

techUK.org | @techUK

Government must adopt a role in supporting development and ensuring the benefits of coverage and capacity from convergence are accessible to all

- **Investment and Funding:**[2] Guarantee financial support for research and development, while ensuring continuity of projects such as the Rural Connectivity Accelerator, through international funding agreements and launching industry-wide arrangements to further testing for the adoption of innovative technologies in communications systems, including AI, quantum, and PNT.
- **Set a Policy Direction:** Setting up a Public Sector Future Telecoms Taskforce to bring together DSIT teams across wireless, fixed, and space, and focused on how public services like the NHS, the police, or local authorities can utilise and subsidise connectivity from satellites and the services it supports by encouraging collaborative business structures with cross-industry stakeholders to share risks and attract institutional investors[3], considering the growth in dual use capabilities in space.
- **Public-Private Partnerships:** Foster mission-led partnerships between UKSA, Catapults, UKTIN, clusters, academia, and industry players to drive innovation in key demands and Government objectives, extending mobile coverage from non-terrestrial networks, and enhance connectivity in underserved communities in remote areas based on direct-to-device and the Internet of Things to address local needs such as healthcare, emergency services and disaster relief, transport, energy and NetZero, and agriculture.

[2] techUK. (2024). *Supercharging Investment in Space*. Hosted by techUK.
[3] techUK. (2024). *Telecoms Action Plan: A Policy Stocktake for the New Government*.

10 St Bride Street
London EC4A 4AD
T +44 (0) 7331 2000

techUK.org | @techUK

Opportunities from TN-NTN convergence

The satellite market is at an inflection point, driven by international investment and supply chains, a push for convergence, and rapid technological changes such as regenerative software technologies. Central to this transformation is the goal of building a network of networks, which will bring significant economic and social benefits worldwide, enabling truly ubiquitous connectivity for both people and businesses.

Closing the digital divide is primarily an economic challenge. Provision of full fibre gigabit capable infrastructure is a matter of cost with no technical limitations preventing its roll out to very hard to reach (VHTR) areas.

With the onset of low Earth orbit (LEO) satellite systems there is no technical or commercial reason why every premise cannot have access to ultrafast connectivity and have similar access to connectivity that those in more urban areas have. However, the key remaining barrier to satellite connectivity is affordability for the end user as typically broadband packages are more expensive.

We have identified three primary drivers of change in this transformation. First, at the technology level, we are seeing accelerated efforts toward standardization and interoperability, along with the adoption of software-defined capabilities.

In this position paper, direct-to-device (D2D) is defined broadly to include both direct communication links to handsets, in line with 3GPP New Radio (NR) 5G standards, and NTN-based IoT connectivity. Non terrestrial networks (NTN) should be based on international standards as it will not deliver its full capability without a strong focus on the devices available.

Another important thread running through all of this is the rise of AI-enabled systems, which are not only enablers but critical components of delivering the full capabilities of these networks. These technologies will play a key role in advancing security and resilience. The combination of increased potential from drones, High Altitude Pseudo-Satellite (HAPS), and satellites offer wider coverage and stronger use cases (e.g., connected planes). Earth Observation and related applications continue to grow alongside the need for accuracy on the ground comes with more demand for communications and improved AI and PNT resilience.

Second, in terms of service, the emergence of new non-terrestrial network (NTN) operators, suppliers, and customers, unlocks new opportunities for organizations to build and operate their own networks. These international system architectures allow for greater possibilities in the way technology is applied to national terrestrial architectures. Hence, the network convergence element needs help to ensure the UK remains competitive against this context.

techUK

10 St Bride Street
London EC4A 4AD
T +44 (0) 7331 2000

techUK.org | **@techUK**

Third, in terms of business and consumer demand, the concept of direct-to-device (D2D) connectivity is a major driver. D2D means connecting not just mobile devices but also machines—such as cars, transportation systems, and Internet of Things (IoT) sensors. The expectation is that in the next few years, hundreds of millions of people and machines will be connected. For end users, this means devices that are always connected and machines that can seamlessly interact with one another, enabling connectivity everywhere.

As more systems come online, ensuring full integration across networks becomes critical. Without interoperability, supply chains could be disrupted, and consumers could be locked out of essential systems, undermining the potential of the network of networks. Finding solutions to these integration challenges is a key focus, and how systems will work together remains an open question, being tackled at several industry groups.

Connectivity through seamlessly alternation of signal from a base station on Earth or in orbit is a powerful development. Therefore, the immediate business opportunity from direct-to-device requires a rapid maturing of the sector to deliver value to end-consumers.

While it outlines that an emphasis in technological neutrality would be required, the economic dimension calls for a convergence implementation plan and competitive streams of funding that enable the completion of Gigabit or SRN coverage across the entire UK. Because it ought to be seamless, there are several components that need orchestration before delivering the capability without demanding an action from consumers.

In summary, network convergence requires the collective effort of the key operators and stakeholders in shaping the future of satellite communications, driving innovation, and ensuring that the UK remains at the forefront of this transformative sector.

Potential UK capabilities

The UK benefits from extensive terrestrial networks, with D2D expected to serve as a complementary solution, primarily addressing coverage gaps in remote "not-spot" areas. According to Ofcom's 2023 Connected Nations report,[4] 4G coverage in the UK reaches 93% of the countries' extension. This indicates that the market potential for D2D in the UK may be relatively modest compared to countries with larger areas lacking terrestrial network coverage. Notably, while D2D could address the 7% of the UK landmass without coverage, this area accounts for just 0.3% of the UK population.[5]

Satellite as a complementary source of connectivity to terrestrial services can provide another layer of resilience to ground infrastructure. Non-terrestrial networks can provide dynamicity, sustainability, add to the larger capacity, offering advances in latency, and

[4] Ofcom. (2024). *Connected Nations 2023*.
[5] Ofcom. (2024). Statement: Improving Mobile Connectivity from the Sky and Space.

controlled cost from terrestrial systems. Therefore, businesses and individuals in underserved communities outside the reach of fixed connectivity could benefit from D2D coverage as an alternative access to the telecommunications network.

Resiliency will become increasingly important for remote communities in the UK as well as vulnerable telecare users. Mobile communications are now seen by many UK residents as a primary means of communication, in particular those located in island communities in Scotland. The reliance on mobile networks is only likely to increase as 4G coverage improves and as the migration of landline customers from Public Switched Telephone Network (PSTN) to Voice over IP (VoIP) technology continues.

As end-users become more dependent on their broadband services, such as making outgoing calls to emergency services, the importance of resilience is increasingly critical to these communities as any prolonged mobile network outages can have grave consequences for those completely reliant on them. Therefore, satellite backup, as well as Radio Access Network (RAN) cell resilience, will start to become more essential.

Other difficulties associated with providing network in remote areas for users on the move involve existing natural barriers to the satellite signal. Nonetheless, ongoing projects demonstrating the value of direct-to-device in rural areas and manufacturing facilities through the convergence between satellite and other wireless technologies.

On the commercial side, the most immediate opportunities seem to align with the existing technology landscape. Leveraging direct-to-device connectivity in narrowband Internet of Things (NB-IoT) and NTN in mobile satellite services (MSS) bands appears to be the most natural fit. These technologies are within reach of existing standards and could be implemented smoothly, given their compatibility with current systems.

From a satellite operator point of view, one of the opportunities is scale. Satellite has been a niched ecosystem serving a small amount of, typically, expensive user devices. 5G NTN allows satellite services to access a wider and far more complex ecosystem.

In that environment, satellite operators must consider devices availability, costs and international supply chains. D2D and IoT will not work without more attention to device available. Industry associations and third-party investors could offer advice or an observatory in his area for HMG to draw on. Devices may also need attention on a certification, interference, security and applications basis - some of this is necessary as international standards are not yet fully in place.

The opportunity for D2D is considerable across sectors and have expressive impact for innovations stemming from ubiquitous connectivity.[6] Particularly considering the potential from multi-orbit networks and HAPS to provide connectivity, network convergence between

[6] UKTIN Non-Terrestrial Networking Expert Working Group. (2024). *Future Capability Paper - Non-Terrestrial Networks.*

TN-NTN can enable mobile backhaul, Fixed Wireless Access (FWA), along with on demand coverage for land, air, and maritime.

Key technology drivers

By developing use cases across verticals, network convergence has the potential to create a significant positive impact on society. It can enhance safety services, enable more reliable telemetry in airplanes, and contribute to greater energy efficiency. It can further the resilience of energy networks and deliver Wi-Fi connectivity for users of rail services.[7] From a UK perspective, the immediate social benefit lies in making emergency services more widely accessible and ensuring citizens can always reach these services in critical situations.

As the boundaries blur between fixed and mobile satellite services, there is a real potential for new convergence models to emerge. The roll out of these new approaches will depend on the correct measures set by industry, facilitated by the Government and regulators, to address the key concerns in the sector.

1. Evaluate compatibility between satellite networks (SNOs) and terrestrial networks (MNOs), balancing the approach in standardization with practical deployment and commercial strategies.
2. Ensure that the actual network and technology stacks of MNOs and SNOs can evolve alongside systems security and regulation, including Radio Access Network (RAN), Core Network, transport Infrastructure, and Operations Support System and Business Support System (OSS/BSS).
3. Enable diverse scenarios for coexistence and convergence of satellite and terrestrial networks, implementing mechanisms for coordinated management of shared resources.
4. Define interfaces for seamless communication and information sharing between MNOs and SNOs, sharing data for monitoring network performance across satellite and terrestrial domains.
5. Ensure quality of service (QoS) standards for users across different tiers, considering user demand and available devices to maintain service quality during integration.

One notable initiative setting the example for overcoming barriers to service delivery is the UK's Shared Rural Network, which was launched to improve geographical coverage. This government-driven effort required substantial investment from Mobile Network Operators (MNOs), alongside public sponsorship to extend coverage in hard-to-reach areas.

[7] The Clarus Networks Group. (2024). *Now Offers Starlink for Trains*.

Equally relevant, the Open RAN Alliance, a collaborative effort between MNOs, highlights the importance of partnerships to advance innovation at the network level. The same collaborative approach is essential for convergence, requiring that government, MNOs, and satellite operators work together.

On the satellite side, an important initiative in this area is the Advanced Research in Telecommunications Systems (ARTES) programme, led by the European Space Agency (ESA) and the UK Space Agency. ARTES plays a key role in supporting the development of new satellite communication capabilities. The UK's subscription to ARTES provides a platform for national companies to contribute to innovative satellite communication services.

The program consists of three key elements to develop the use of space in Europe across industries. The advanced technology element includes early-stage technology development and definition studies, typically funded in full. Second, the core competitiveness element considers industry-led co-funded activities that support the development of next-generation satellite communications products and technologies. Lastly, the partnership projects element fosters collaboration between international stakeholders to drive innovation and achieve mutual benefits.

These initiatives involve joint development, testing, and deployment of technologies while aligning goals and responsibilities. For the UK, the success of convergence depends on strong partnerships to deliver advanced technologies, economies of scale, and consumer demand. In return, convergence can allow for a diversity of service and products across applications, enabling sectors to capture the benefits of the digital economy.

In recent years, the creativity and relatively low cost to create new services have led to the development of many new satellite-based initiatives. However, the cost to leverage technologies in mobile broadband and indoor connectivity can be significant, especially when it involves overhauling business processes and operational workflows.

Updating existing fixed or mobile infrastructure, migrating applications and services, and ensuring compatibility can transform the challenge from a simple capital expenditure into a broader issue. This encompasses both business concerns, such as ensuring compatibility and continuity, along with operational challenges, including service resilience and dependency on the new systems.

3GPP Release 17: A Catalyst for NTN and NG-RAN Integration

3GPP Release 17 is a significant milestone in the convergence of Non-Terrestrial Networks (NTNs) and Next-Generation Radio Access Networks (NG-RANs). This release introduces key features and standards that enable seamless integration between terrestrial and satellite networks:

techUK

10 St Bride Street
London EC4A 4AD
T +44 (0) 7331 2000

techUK.org | @techUK

- **NR-based Satellite Access** allows for direct connectivity between user devices and satellites, expanding coverage to remote and underserved areas.
- **NB-IoT and eMTC over NTN** enables low-power, wide-area IoT applications in areas with limited or no terrestrial network coverage.
- **Global Service Continuity** ensures seamless handover between terrestrial and satellite networks, providing uninterrupted connectivity for users.
- **Improved Positioning and Timing** enhances location-based services and enables precise timing synchronization.

3GPP Release 17 sets ambitious performance targets for non-terrestrial networks. These include minimizing latency for real-time applications, supporting high-speed data transmission, ensuring reliable connectivity in challenging environments, and optimizing spectrum usage and network resources to maximize capacity.

The primary goal of the standards is to offer an open specification that facilitates services for consumers and connected devices, collectively referred to as the Internet of Things (IoT). Releases 18 and 19 aim to expand these specifications to include services tailored to the mobile broadband (MBB) terrestrial consumer market.

The role of MSS spectrum

The convergence of terrestrial and non-terrestrial networks has been an evolving concept long before the 3GPP's decision to standardize it. Nonetheless, New Radio (NR) specifications for 5G marked a pivotal moment for the industry, which began focusing on what we now know as satellite convergence.

Currently, various satellite systems compete for access to the Mobile Satellite Services (MSS) bands, which facilitate communication between mobile earth stations and satellites, supporting applications across land, maritime, and aeronautical domains.

MSS systems utilize non-geostationary (LEO and MEO) or geostationary satellites, primarily operating in the L-band and S-band. In the EU, the 2 GHz band (1980–2010 MHz and 2170–2200 MHz) is designated for MSS. Originally limited, MSS has expanded significantly and is expected to keep growing, providing connectivity in remote areas and supporting machine-to-machine (M2M) and IoT applications, helping meet the rising global demand for seamless communication.

A few players are counting on the use of MSS spectrum in conjunction with GEO provided services for global and quick service scalability. These allocations involve interference debates at the international level, which are driven by administrations of several countries at the International Telecommunication Union (ITU) conference and working groups. The upcoming World Radiocommunication Conference 2027 (WRC-27) will address three agenda

10 St Bride Street
London EC4A 4AD
T +44 (0) 7331 2000

techUK.org | @techUK

items (AI 1.12, AI 1.13, and AI 1.14) to evaluate the spectrum management challenges associated with D2D services.

Although the MSS ecosystem is mature, there is a growing interest in how to repurpose spectrum for other services in the future. Since the quality of service for end users heavily depends on spectrum availability, the stability of the frequency allocation, as well as effective and timely coordination of interference levels are crucial for success of operations.

Alternatively, satellite operators may utilize mobile spectrum (MS), which involves partnering with mobile network operators (MNOs) to access terrestrial mobile spectrum. This approach raises regulatory questions, as satellite services rely on MNO collaboration.

Ofcom's Local Access Licence framework allows third parties to use spectrum licensed to an MNO in areas where it is currently unused or not planned for use within three years. However, introducing D2D services or HAPS —particularly HIBs— into terrestrial mobile bands involves higher interference risks and technical complexities. Therefore, the use of a Local Access Licence would be contingent upon an agreement between the MNO and the satellite or HAPs operator, along with a coordination agreement.

Industry case studies

Rather than continuously overhauling systems to address the cost and operational challenges of network convergence, the sector should focus on optimizing existing resources, workflows, and business models. This approach should also allow for the seamless integration of new communication methods and technologies as they emerge.

Energy efficiency is another benefit from the evolution of networks toward convergence. Terrestrial and non-terrestrial network convergence would then enhance the system's overall energy efficiency through the optimal allocation of resources, such as transmission power, as well as enhancing efficiency within the entire system through improved data transmission. Hence, convergence could reduce communications system's total energy consumption while ensuring latency tolerance and maintaining quality of service.

Network convergence as a service has been used to improve the installed technology base of the East of England ambulance service, addressing cellular blackholes by including LEO services, and maintaining active data exchange between medical facilities and medical teams on the road at any time.[8] Even in areas of limited or no cellular coverage, the satellite service provides bandwidth to maintain operations, offering resilience and continuity when dealing with human lives. It has also shown that 15% of callouts could be dealt with onsite

---

[8] East of England NHS Ambulance Trust. *First to Pilot New Technology That Delivers "Unbreakable Connectivity"*.

instead of taking the patient back to the hospital – reducing logistics, costs and keeping customers confident.

Recent flooding in Valencia has shown the vulnerability of mobile networks. Once towers and power supplies are neutralised, they only have a limited life span. For broadcasting satellite services, the impact of the terrestrial streaming networks is already an opportunity to re-deploy satellites within the wider European and global context. Repurposing them as part of the convergence path would stimulate the evolution of national infrastructures both on the ground and in the sky.

Furthermore, lessons from Ukraine have shown that the way forward is "*a mesh-type arrangement of satellites, which provides greater resilience*".[9] Albeit the growth of LEO networks in recent years, geostationary orbits (GEO) is a fundamental piece of resilience in future satellite networks and will certainly play a critical role for network resilience, consumers, and governments. LEO network will be a complement to the GEO network with the aim to provide ubiquitous connectivity.

Another potential deployment could involve a mesh-type arrangement integrating satellite and terrestrial networks (fixed, Wi-Fi, and mobile) to maximize resilience. Network convergence plays a crucial role in eliminating the barriers created by separate underlying technologies, enabling immediate integration of satellite and terrestrial systems. This approach provides a significant competitive advantage over international partners.

Networking as a Service (NaaS) that is independent of the underlying infrastructure, is more attractive to both customer and service providers relying on communications regardless of the state of technology in particular countries or regions. This applies to a diverse and wide range of markets including defence, government, health care, drones, connected vehicles and rural communications.

ESA NG eCall - Migration to 4G, 5G and Satellite Networks

Calnex
Insight and Innovation

Since 2018, vehicles manufactured in Europe have been equipped with a system that automatically contacts the emergency services in the event of a serious accident, sending location and sensor information. The system was originally developed to operate over 2G and 3G networks. However, as telecom operators phase out legacy systems, a new generation of the service (called NG eCall), based on 4G and 5G mobile phone networks is being developed.

[9] Reuters. (2024, November 5). *Australia Scrapped Satellite Because New Tech Could Shoot It Out of the Sky*.

In this system, eCall messages consist of two parts. An automatically triggered message outlining location of the vehicle delivered on the basis that the driver or passengers may not be able to make a call themselves. However, if the occupants are able to speak, then a video or voice call can be made. With eCall, this is restricted to just voice with emergency services or vice versa.

The ESA ARTES NG E-call project is investigating how this might be augmented using, in particular, LEO and GEO satellite communications technology, which potentially could have a lot of positive features especially when in remote or rural areas where cellular services are not available.

A consortium led by Satellite Applications Catapult including Solutions, Oecon and Idneo won the ESA ARTES contract and has been providing technology to create a testbed for NG eCalls over the new hybrid (5G and satellite communications) environment. This technology will be used to validate whether the NG eCall system will be able to use either 5G or satellite networks depending on the available connections.

As part of this, Calnex Solutions has supplied its NE-ONE Enterprise Emulator which is able to implement the network conditions, including rapid changes of conditions (typically 100s of times a second), and also model the effects of things like the Doppler encountered as the LEO satellites move rapidly towards and away from the NG eCall system installed in the vehicle.

This capability is being utilized to identify and address the technical risks associated with deploying the NG eCall system within converged networks that integrate 5G and satellite communications. Car manufacturers are already pushing for changes to EV arrangements due to low demand but require clarity on the timeline for mandating NG eCall in all vehicles.

As the EU considers issuing a mandate for the use of satellite technology in emergency services, the UK faces an opportunity. With legacy network technologies being phased out, the early adoption of these cross-industry standards could accelerate the evolution of network convergence and unlock new business opportunities.

Hybrid Connections for Uncrewed Aircraft Systems

Uncrewed Aircraft Systems (UAS), driven by advancements in autonomy and artificial intelligence, are rapidly integrating into every facet of modern life. As regulations evolve and compliance frameworks mature, these technologies hold immense potential to enhance—or even replace—traditional methods of transportation, surveillance, and beyond-visual-line-of-sight (BVLOS) operations.

Projections suggest that the global drone economy could surpass $90 billion by the decade's end, as industries ranging from logistics and enterprise to emergency response and defence discover transformative applications. However, as the market expands, so must the infrastructure supporting it. This includes not only physical components like take-off and landing sites or air traffic management systems but also critical services such as cybersecurity, insurance, and fleet financing to ensure safe and efficient operations amidst growing traffic volumes and complexity.

UAVs leveraging regulated cellular networks operate on LTE/4G, utilizing frequencies below 6 GHz, or on 5G, which provides dramatically faster speeds. This makes 5G ideal for bandwidth-intensive tasks, such as streaming real-time HD footage during autonomous missions. Yet, even with advancements in telecommunications—from high-speed 5G to cost-effective low Earth orbit (LEO) satellite systems—no single network can meet the ever-growing demand for seamless, mobile connectivity.

The solution lies in hybrid networks. These systems combine multiple communication technologies, such as 3G, 4G, 5G, Wi-Fi, and satellite, to create a resilient, always-on connectivity solution. Smart networking dynamically selects the best available operator based on location, cost, or quality of service, allowing assets to maintain uninterrupted connections as they traverse different coverage zones.

This capability is further enhanced by software-defined network technology, which enables seamless integration of current and future connectivity services. For instance, innovative solutions like LiveWire Digital's RazorLink, embedded within Inmarsat's maritime-focused NexusWave, allow UAVs to agnostically switch between networks. This ensures optimal connectivity regardless of carrier, location, or operational needs—a previously untapped potential.

Hybrid connectivity empowers drones and other assets to transition effortlessly between networks, adapting to predefined criteria to ensure reliability and efficiency. Military applications, such as drone swarms or distributed systems, rely heavily on this robust connectivity. Without it, their full capabilities remain out of reach.

In the civilian sector, leveraging heterogeneous networks unlocks even greater possibilities. By enabling UAVs to perform a wide range of tasks safely, efficiently, and cost-effectively across industries, hybrid connectivity has the potential to revolutionize operations and drive innovation in ways that were previously unimaginable.

The potential intervention from the UK Government could capitalize on opportunities for the public sector, implementing centralized safety regulations under a single authority (such as the CAA), ensure robust support for AI, PNT, and drone demonstrators, and prioritize better integration across sectors. These steps would drive progress while maintaining safety and fostering innovation.

techUK

10 St Bride Street
London EC4A 4AD
T +44 (0) 7331 2000

techUK.org | @techUK

Implementation challenges

For the telecommunications industry, convergence is a wholesale business model and investment opportunity. Although there are more opportunities than risks, several stakeholders need to work together to develop services for consumers, beyond direct-to-device connectivity.

Non-terrestrial networks have always been interacting with terrestrial networks. In some instances, satellites have been used as a complete separate entity in competition to terrestrial networks. Later, satellite communications have been used to provide backhaul for remote mobile sites in very heard to reach areas, helping to extend mobile coverage and reduce cost for mobile operators.

From a space sector perspective, network convergence also adds complexity to a market that was based on satellite manufacturing, building a bespoke network, and providing user terminals across that network. Now the sector must deal with layers of agents and interests from chip manufacturers, handset and OEMs manufacturers, MNOs in the 5G NTN model (who own the customer), spectrum holders, and infrastructure investors.

1. Spectrum management

Satellite spectrum allocation has traditionally fallen into two categories: mobile satellite spectrum and fixed satellite spectrum. In the case of mobile satellite, there has been a convergence story even within this allocation, where smaller, portable devices are used, typically equipped with low-power antennas. On the other hand, fixed satellite involves the use of larger parabolic dishes, traditionally pointed at GEO satellites, but more recently at LEO satellites.

Evolving the technology is a focus area to develop the right software and hardware to provide the required efficiency seen in terrestrial networks. Standards are a key component to achieve this degree of efficiency in the use of potential frequency bands.

In Release 17, 3GPP allocated almost 65 MHz of licensed spectrum, and in Release 18, this will increase to 80 MHz, though it still falls short of current needs. Looking ahead, the potential use of mmWave spectrum (beyond 15 GHz, such as 17, 20, and 28 GHz) with hundreds of MHz could help address capacity challenges.

Another emerging opportunity is the use of mobile spectrum for satellite services through establishing agreements with MNOs to access their licensed spectrum. From an efficiency perspective, this is beneficial, as it optimizes the use of available spectrum to deliver more services and connectivity. However, successful implementation requires close coordination between mobile and satellite operators to protect licensed terrestrial mobile network operators and their users from harmful interference.

Approaches to this include dedicating parts of the spectrum solely for satellite use or sharing spectrum by dividing it geographically in order to avoid interference with IMT bands. There are additional interference risks to consider, such as interference from adjacent users or other entities sharing the spectrum, such as Earth Observation (EO) satellites or offshore services.

Other significant barriers beyond interference will need to be developed and agreed upon. For example, another regulatory requirement than UK and European mobile operators must adhere to is lawful intercept as well as emergency calling requirements so end users can roam onto any available mobile network to make an emergency call. Some (or all) of these requirements will apply to satellite networks where they are being used to provide connectivity via D2D.

Similarly, GEO satellites will continue to play a crucial role in providing safety and critical services, and any LEO system will have to coexist within a GEO-dominant environment. In the L-band range (1-2 GHz), spectrum sharing and frequency reuse are particularly difficult due to the omnidirectional nature of many terminals, which struggle to view two satellites without causing interference. However, some systems can collaborate with other operators, making second-by-second decisions to mitigate conflicts.

These risks must be carefully managed to avoid degrading network performance, as rushing the process could worsen existing challenges. While international regulatory processes typically operate on four-year cycles to align global spectrum policies, some national regulatory bodies, such as the FCC, are pushing for faster authorizations to meet the growing demand for flexible and efficient spectrum use.

In this context, the UK has a unique opportunity to pioneer a regulatory approach rooted in testing and commercial deployments, shaping discussions in international forums. By capitalizing on the current 6G development cycle and its integration with non-terrestrial networks, the UK can drive innovation in network convergence. This effort would not only unlock new 5G use cases but also lay the groundwork for the adoption of future 6G standards.

2. Investment

The LEO satellite market is seeing increasing interest, particularly from players with large funding capacity. While the sector is still in its early stages, and it is difficult to predict winners, innovation and growth opportunities remain as satellite technology requires refreshing every five years. However, the market is heavily influenced by large, well-funded players such as SpaceX, whose dominance in broadband services (through their separate

Ku-band spacecraft constellation) makes competition challenging, especially for national security missions that rely on sole suppliers.

The UK needs to strategically think about its core capabilities—both technically and commercially—if it wants to play a significant role in this evolving market. Early investments must focus on enabling connectivity everywhere, which is crucial for maintaining competitiveness, within a multi-orbit approach and extracting value from space assets.

One key risk on the government's radar is the potential lack of investment, which could result in the UK being left behind if operators fail to see sufficient demand to justify providing these services.

The Satellite Applications Catapult's 'Size and Health of the UK Space Industry' Survey 2022 (covering 2020/21) reveals that the UK space industry's income has grown to £17.5 billion, up from £16.6 billion in 2019/20 (according to inflation-adjusted metrics). The sector contributes £7 billion in gross value added, directly employs 48,800 people, and supports 126,800 jobs across the supply chain.[10]

Additionally, as the economics of the satellite market shift, so do the power dynamics. New players, with access to large revenues from other business ventures, are entering the market, giving them different avenues for securing government contracts and capital. Competing purely on capital investment is increasingly difficult for smaller companies and established providers. Instead, these companies are focusing on technology and partnerships to deliver meaningful services, leveraging capabilities that new players lack.

Future systems and models, including those tied to infrastructure or chipset manufacturing, will require significant investment. The potential for growth is enormous, but the risks are equally high. Capturing the necessary investment is essential, especially as traditional satellite use cases (such as direct-to-device services) remain the foundation of future satellite development.

Therefore, the Government should promote collaboration across industry. It could also prospect international partners to develop specific R&D capabilities in the UK, attracting providers to the network convergence supply chain. These incentives would enhance the offering of solutions and products in the UK market, meanwhile enhancing the support from institutional investors.

Additionally, industry-wide barriers to investment include soaring energy costs, increasing interest rates, high business taxation, challenges posed by the post-Brexit business environment, stringent regulations, and a shortage of skilled workers. Addressing these challenges would enable the UK Government to create a more conducive environment for growth, fostering development across industries critical to advancing network convergence.

---

[10] Satellite Applications Catapult. *Our Impact*.

3. Testing and performance

One of the significant challenges in achieving seamless performance and service level agreements in NTN-5G convergence lies in the complex nature of satellite networks. Factors such as propagation delays, space weather, atmospheric interference, and orbital mechanics can introduce latency and jitter into the network, potentially impacting real-time applications and user experience. Additionally, ensuring seamless handoffs between terrestrial and satellite networks is a complex task that requires precise timing and coordination.

Furthermore, the dynamic nature of satellite networks, with changing satellite positions and varying link qualities, can impair consistent performance. This requires sophisticated network management and optimization techniques to proactively address potential issues and ensure reliable service delivery.

To compound these challenges, the lack of comprehensive testing tools and methodologies specifically designed for NTN-5G integration can hinder the development and deployment of reliable networks. As a result, it becomes difficult to accurately assess network performance, identify potential bottlenecks, and optimize network configurations.

A major challenge in the successful integration of NTN and next generation Radio Access Network (NG-RAN) is the ability to thoroughly test convergence scenarios under realistic network conditions because replicating the complexities of real-world satellite and terrestrial networks can be challenging. Factors such as varying latency, packet loss, and interference can significantly impact network performance and require rigorous testing to ensure seamless integration and optimal operation. Overcoming this challenge is crucial for the widespread adoption of NTN-based 5G services.

To successfully implement the convergence of NTN and NG-RAN, rigorous testing is crucial. Simulating real-world network scenarios, allows engineers to test multiple cluster configurations, convergence strategies, and scaling scenarios under realistic network duress. By identifying and addressing potential issues early in the development process, organizations can reduce risks, optimize network performance, and accelerate time-to-market. High fidelity network emulators are being used across numerous convergence projects for adding realism to convergence testbeds.

By leveraging existing centres of excellence, alongside the supporting role of Catapults and the expertise of private organisations, Government could endorse the promotion of collaborative agreements with the private sector. Simultaneously, raising the visibility of clusters would help focus on the integration and testing of innovative technologies to satellite communications such as Positioning, Navigation, and Timing (PNT), artificial intelligence (AI), and quantum technologies. By bringing these advanced capabilities together across the UK it will facilitate convergence, foster innovation, and enhance collaborative opportunities from transformative fields of technology.

10 St Bride Street
London EC4A 4AD
T +44 (0) 7331 2000

techUK.org | @techUK

4. Cybersecurity and Data Sovereignty

The rise of satellite constellations, introduces significant cybersecurity and data sovereignty challenges, particularly given the fragmented global regulatory landscape. Establishing a cohesive global framework is essential to address issues such as data interception, regulatory compliance, and security risks in an environment where these networks are accessible from anywhere on the planet.

Currently, compliance relies on localized models where base stations and data centres adhere to national regulations, often involving secure agreements between satellite operators, mobile network operators (MNOs), and roaming partnerships on a country-by-country basis. However, this approach raises cybersecurity concerns, as securing these networks globally demands more robust, cooperative measures. As we progress toward creating a "cellular global network in the sky," lessons from terrestrial networks must guide efforts to mitigate heightened cybersecurity risks in satellite operations.

Data sovereignty adds another critical layer to this challenge. In Low Earth Orbit (LEO) satellite networks, which have smaller coverage footprints compared to Geostationary (GEO) satellites, traffic landing may be constrained by geopolitical or geographical considerations. Ensuring that internet traffic is not subject to foreign surveillance or manipulation is paramount for national security, privacy, and critical infrastructure protection. Alternatives such as optical inter-satellite links must be explored to minimize risks associated with traditional feeder links.

By prioritizing local data processing and routing through national data centres, countries can stimulate technological growth, create jobs, and reduce reliance on foreign technology providers, while enhancing network reliability and performance. Such an approach not only strengthens digital sovereignty but also ensures greater security and privacy in converged networks. Ultimately, addressing these interconnected challenges will require innovation, cooperation, and vigilance as satellite constellations continue to expand.

5. Skills and Space Sustainability

Scaling the space industry effectively requires addressing both skill development and sustainability challenges. Key to this is the adoption of open architectures that are complementary to other spacecraft and follow standardized approaches. This fosters competition, reduces reliance on monolithic systems requiring massive investments, and encourages smarter, more efficient solutions within an ecosystem-driven framework. Building skills around these innovations enables the space industry to tackle its challenges while preparing for future demands.

Collaboration between commercial and state actors is essential for creating diversity, fostering innovation, and cultivating the specialized skills needed to support a dynamic satellite and space sector. For the UK, investing in skills and capabilities is critical to securing a leadership role in the industry, rather than solely providing critical infrastructure services over the coming decades. Specialized funding initiatives for partnerships between industry and academia can accelerate these efforts, particularly through the integration of deep technologies like AI and ML in areas such as spectrum management, network convergence, and testbeds.

Sustainability, however, must be a central pillar of this development. The environmental footprint of space activities, including space debris and pollution from satellite re-entry, poses a significant threat to the long-term viability of space operations. Addressing this requires innovative solutions, such as deploying smaller, resource-efficient satellite constellations and adopting open architectures that enable shared access and minimize redundant infrastructure.

By embedding sustainability into the design of space systems and fostering cross-sector collaboration, the industry can ensure both the long-term health of the orbital environment and the development of a skilled workforce equipped to address these challenges. Together, skills development and sustainability represent interlinked imperatives for creating a resilient and forward-looking space and wider telecommunications ecosystem.

10 St Bride Street
London EC4A 4AD
T +44 (0) 7331 2000

techUK.org | @techUK

Conclusion

This position paper seeks to gather input from techUK members and stakeholders to shape key recommendations for the rollout of network convergence. As the satellite industry becomes increasingly vital, a proactive approach to these technologies is essential. Collaboration between the satellite sector and traditional telecommunications providers will enhance coverage and connectivity, supporting the UK's economic and societal goals.

Strengthening commercial partnerships will be a crucial step in advancing this convergence. As satellite and terrestrial network convergence advances, industry collaboration with regulators such as Ofcom is crucial to unlocking the full potential of 5G, 6G, and IoT technologies, while ensuring seamless, resilient connectivity for both urban and remote areas. Additionally, ensuring a balance between adopting new solutions and maintaining support for existing workflows is crucial to enabling businesses to transition smoothly and sustain the efficiency of their physical and automated operations.

The launch of the Regulatory Innovation Office (RIO) marks a significant step toward fostering a pro-innovation regulatory environment to accelerate the deployment of emerging technologies in the UK. RIO aims to reduce regulatory barriers, streamline approvals, and drive investment in cutting-edge fields such as AI, autonomous vehicles, space, and healthcare technologies. By ensuring its efforts remain targeted and relevant, RIO has the potential to unlock barriers to satellite communications and convergence.[11]

Achieving the goals of the UK Industrial Strategy will likely require greater focus on coverage and network convergence. To remain internationally competitive, the UK would benefit from a comprehensive Convergence Plan to attract investment and keep pace with other countries. This is not solely about improving data speeds but ensuring equitable access and reliable delivery to those who need it most—not just in homes and offices, but also across the sea, in connected vehicles and transport systems, and in rural areas.

The UK’s leadership in space and telecom sectors will depend on streamlined regulation, sustainable practices, and fostering industry-government partnerships to drive innovation, economic growth, and global competitiveness. This approach will position the UK at the forefront of next-generation connectivity solutions, ensuring its infrastructure underpins future social and economic development.

[11] techUK. (2024). *Regulate to Innovate: Response to the Launch of the Regulatory Innovation Office (RIO)*.

10 St Bride Street
London EC4A 4AD
T +44 (0) 7331 2000

techUK.org | @techUK

Bibliography

1. techUK. (2024). *Navigating the Final Frontier: A Recap of the Space Commercialisation Summit*. Retrieved from https://www.techuk.org/resource/event-round-up-techuk-space-commercialisation-and-tech-summit.html.
2. techUK. (2024). *Supercharging Investment in Space*. Hosted by techUK. Retrieved from https://www.techuk.org/resource/event-round-up-supercharging-investment-in-space.html.
3. techUK. (2024). *Telecoms Action Plan: A Policy Stocktake for the New Government*. Retrieved from https://www.techuk.org/resource/telecoms-action-plan-a-techuk-policy-stocktake-for-the-new-government.html#:~:text=The%20Telecoms%20Action%20Plan%20%E2%80%93%20formed,policymakers%20can%20enact%20after%205.
4. Ofcom. (2024). *Connected Nations 2023*. Retrieved from https://www.ofcom.org.uk/phones-and-broadband/coverage-and-speeds/connected-nations-2023/
5. Ofcom. (2024). *Statement: Improving Mobile Connectivity from the Sky and Space*. Retrieved from https://www.ofcom.org.uk/spectrum/space-and-satellites/improving-mobile-connectivity-from-the-sky-and-space/
6. UKTIN Non-Terrestrial Networking Expert Working Group. (2024). Future Capability Paper - Non-Terrestrial Networks. Retrieved from https://uktin.net/whats-happening/resources/future-capability-paper-non-terrestrial-networks
7. The Clarus Networks Group. (2024). *Now Offers Starlink for Trains*. Retrieved from https://www.clarus-networks.com/2024/11/13/the-clarus-networks-group-now-offers-starlink-for-trains/
8. East of England NHS Ambulance Trust. (n.d.). *First to Pilot New Technology That Delivers "Unbreakable Connectivity"*. Retrieved from https://excelerate-group.com/east-of-england-first-nhs-ambulance-trust-to-pilot-new-technology-that-delivers-unbreakable-connectivity/#:~:text=East%20of%20England%20first%20NHS,delivers%20'unbreakable%20connectivity'%20%2D%20Excelerate
9. Reuters. (2024, November 5). *Australia Scrapped Satellite Because New Tech Could Shoot It Out of the Sky*. Retrieved from https://www.reuters.com/business/aerospace-defense/australia-scrapped-satellite-because-new-tech-could-shoot-it-out-sky-says-2024-11-05/
10. Satellite Applications Catapult. (n.d.). *Our Impact*. Retrieved from https://sa.catapult.org.uk/about-us/our-impact/#:~:text=The%20latest%20'Size%20and%20Health,48%2C800%20employed%20in%20the%20industry.
11. techUK. (2024). *Regulate to Innovate: Response to the Launch of the Regulatory Innovation Office (RIO)*. Retrieved from https://www.techuk.org/resource/regulate-to-innovate-techuk-s-response-to-the-launch-of-the-regulatory-innovation-office-rio.html

techUK
FOR WHAT COMES NEXT

linkedin.com/company/techuk

youtube.com/user/techUKViews

@techuk.bsky.social

info@techuk.org

Image credits | iStock by Getty Images