Future spectrum user demand in the UK

An independent study on macro trends, emerging use cases and technologies, and how these will shape the future spectrum utilisation landscape

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Contact

Scott McKenzie BE, MBA

Coleago Consulting Ltd

Tel: +44 7825 294 576

scott.mckenzie@coleago.com

Nick Fookes CFA, MSc

Coleago Consulting Ltd

Tel: +44 7710 350816

nick.fookes@coleago.com

Julian Garrett MIEE, BE

Coleago Consulting Ltd

Tel: +44 7391 498813

julian.garrett@coleago.com

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1. Executive summary

Radio spectrum is a finite national resource that underpins communications, broadcasting, transport, energy, emergency services and a growing range of industrial applications. Over the next 10 to 15 years demand for wireless connectivity is expected to broaden considerably as infrastructure becomes more connected, sensing becomes more widespread and autonomous and remotely operated systems move into routine use. The central policy challenge is therefore not simply whether more spectrum will be required but how users can obtain access to suitable spectrum, in the right locations and at the right time, while protecting existing services and maximising economic and social value.

This study considers the effect of emerging technologies and wider market trends on spectrum demand before examining a broad range of prospective use cases. Three were selected for more detailed analysis because they illustrate requirements that are likely to grow significantly but which are not necessarily well represented in conventional spectrum forecasts: agritech, telemetry and Distributed Energy Resource (DER) management as a rural portfolio, low altitude aerial platform communications and temporary drone enabled network extensions.

A consistent finding is that future spectrum demand cannot be understood through data traffic alone. Many emerging applications may generate relatively little traffic but still depend critically on coverage, availability, latency, resilience and security. The number of devices that can be connected simultaneously and the ability to obtain access when and where it is needed may be more important than the volume of data carried. Conventional measures based on population coverage and aggregate traffic will therefore need to be supplemented by measures of geographical and asset coverage, device density, concurrent use and service criticality.

Pressure is likely to remain particularly acute below 10 GHz, where spectrum combines useful propagation characteristics with sufficient capacity. The 400 MHz to 1 GHz range is already heavily contested and a continuing shortage of low frequency spectrum appears likely. The 3 to 6 GHz range is less pressured today but is expected to become increasingly important as mobile demand, industrial requirements and aerial platform communications grow. More intensive spectrum sharing is therefore likely to become a defining feature of the future spectrum landscape.

The detailed analysis also shows that emerging requirements will not all require the same solution. Routine monitoring and telemetry may be well suited to licence exempt or shared access while safety critical control may require protected access. Public mobile networks, private networks, satellite services, local networks and direct communications will increasingly need to operate as complementary parts of the connectivity landscape. In many cases the policy challenge is consequently one of providing more flexible access to existing spectrum rather than making substantial new allocations.

Our main conclusions and recommendations are:

- **Assess the demand and potential benefits of a future shared access product below 1 GHz.** Rural monitoring, agritech and Distributed Energy Resource applications need wide area coverage but generally generate relatively little traffic. Extending the Shared Access framework below 1 GHz would provide local licensed access to frequencies whose propagation characteristics are much better suited to these applications[1].
- **Review licence exempt arrangements below 1 GHz.** The permitted transmit power in the lower licence exempt block should be reviewed and consideration given to providing a network sub band. This could materially improve rural coverage for monitoring and control without requiring significant additional spectrum.
- **Measure machine demand differently.** Future demand from sensors and connected assets should be assessed by device numbers, reporting frequency and peak concurrent connections as well as data traffic. Without these measures a potentially significant source of future spectrum demand will remain largely invisible in conventional statistics.
- **Extend the measurement of mobile coverage to aerial users.** Growing use of drones for inspection, logistics, environmental monitoring and public safety will create a requirement for reliable connectivity at altitude. Ground

1 Note that one SPF stakeholder expressed doubt about the merits of extending the existing Shared Access framework, on the grounds that there has only been very light shared use of such bands above 1 GHz and that commercial licensed national networks can increasingly provide this kind of connectivity. However, the past is not necessarily indicative of future demand, and the evolving needs of diverse user groups in remote locations might not always be adequately met by commercial national network operators (for whom the business case for remote-rural deployment may be weak).

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level coverage cannot be assumed to provide equivalent aerial coverage and network availability and performance should increasingly be assessed with aerial users in mind.

- **Support Ofcom's proposed provision for drone communications while planning for a longer term solution.** The proposed access at 453 to 462.5 MHz and 5040 to 5060 MHz addresses an important emerging requirement, particularly for remote and rural operations. As the sector develops, suitable provision should be placed on a more permanent footing and aligned with international arrangements where possible.
- **Review airborne use of low band licence exempt spectrum.** Elevation materially changes the interference footprint of a transmitter. Existing power limits and access conditions have largely been designed around terrestrial use and should be reassessed as the number of airborne devices increases.
- **Create a standing authorisation for temporary aerial network extension.** The technology and spectrum needed to provide emergency coverage from a drone largely exist already. The principal barrier is the ability to use existing licensed spectrum lawfully and at very short notice from an aerial platform. Accredited operators should be able to activate temporary coverage under arrangements agreed in advance rather than seeking regulatory approval during an incident.
- **Build on existing infrastructure sharing precedents.** The arrangements used to share Emergency Services Network infrastructure with mobile operators under the Shared Rural Network provide a useful precedent. A similar national framework could support temporary aerial coverage, with technical, operational and regulatory safeguards agreed before an emergency occurs.

These findings point towards a broader conclusion. The economic and social value of spectrum cannot always be inferred from traffic volumes or commercial willingness to pay. Rural monitoring can support environmental, housing and infrastructure obligations. Better management of distributed energy resources can improve the efficiency and resilience of the electricity system. Aerial platforms can reduce the cost and risk of infrastructure inspection while temporary network extensions can strengthen emergency response and public safety. These wider benefits should therefore form part of future spectrum policy decisions.

The study does not conclude that emerging applications will require wholesale new spectrum allocations. In many cases the necessary frequencies, technologies and networks already exist. The more important issue is whether users can obtain appropriate access with the required coverage, reliability and protection and on terms that reflect the nature and value of the application. The priority should therefore be to improve the evidence base, develop more flexible forms of spectrum access and undertake practical trials before emerging demand reaches a scale at which existing access arrangements become a constraint.

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2. Introduction

2.1 Background

Radio spectrum is an essential input to the economy and to the delivery of public services across the United Kingdom. It supports mobile and fixed communications, broadcasting, transport, energy, defence, emergency services, scientific research and a growing range of industrial applications. As these activities become more connected, automated and data intensive, the availability of suitable spectrum and the conditions under which it can be accessed will have an increasing influence on productivity, innovation, resilience and public safety.

Future demand will not arise solely from the continued growth of familiar consumer services. Digital transformation is creating new requirements across sectors whose needs have not always been prominent in spectrum policy. Connected infrastructure, autonomous systems, distributed sensing, remote operations and advanced industrial processes may require combinations of coverage, capacity, speed, latency, reliability, security and availability that differ materially from those associated with conventional public mobile broadband. Demand may also be geographically concentrated, intermittent or safety critical, which means that aggregate traffic forecasts alone provide an incomplete basis for policy.

The technology landscape is changing at the same time. Developments in 5G Advanced, 6G, Wi-Fi, direct device communications, non-terrestrial networks and aerial platforms will broaden the range of technical options available to users. Greater use of spectrum sharing, local licensing and more flexible forms of access may also allow requirements to be met without permanent exclusive assignments. The central question is therefore not simply how much additional spectrum may be required; it is how connectivity needs can be met through an appropriate combination of technologies, networks, frequency bands and access models while protecting existing services and maximising value to the United Kingdom.

This report has been prepared for the UK Spectrum Policy Forum to provide an independent assessment of these issues over a 10-to-15-year period. It focuses on emerging and comparatively under-represented requirements rather than repeating analysis of sectors and services already examined extensively elsewhere. The study treats spectrum as a finite public resource and considers value in broad terms, including economic contribution, social benefit, national resilience and safety critical outcomes. This perspective is important because some uses of spectrum create material public value that may not be captured fully through conventional commercial measures.

2.2 Objectives

The principal objective of the study is to improve understanding of how emerging spectrum users and use cases may develop and what their connectivity needs could imply for future spectrum policy. The analysis is intended to help government, Ofcom and industry anticipate demand early enough to preserve options, encourage investment and avoid spectrum access becoming a constraint on beneficial innovation.

More specifically, the study seeks to identify the changes in the wider technology and service landscape that are most likely to influence demand, select three representative use cases for detailed analysis and develop plausible scenarios for their evolution. For each use case, it distinguishes the underlying need for connectivity from any resulting requirement for spectrum. It then considers the required service characteristics, the potential scale and location of demand, the technical means of delivery and whether existing allocations and access arrangements are likely to be sufficient.

The study also considers the implications for spectrum management. This includes the potential roles of exclusive, shared and local access, the scope for demand to be served by public, private or non-terrestrial networks and the circumstances in which dedicated spectrum may be justified. The aim is not to produce a single deterministic forecast or a detailed frequency plan. It is to establish a structured evidence base that highlights the most important uncertainties, identifies potential pressure points and supports proportionate decisions as technologies, markets and public policy priorities evolve.

2.3 Approach

The analysis combined a targeted review of published evidence with structured engagement across government, industry, public services and the technology community. The literature review considered relevant national strategies, regulatory material, sector studies and research on future communications technologies and applications. Stakeholder interviews were used to test the evidence, identify requirements that may not be visible in published forecasts and explore the practical barriers faced by current and prospective spectrum users. Where appropriate, discussions were conducted on a non-attributable basis to encourage candid contributions.

Evidence from these sources was brought together through a use case and scenario-based framework. Candidate use cases were assessed against their strategic relevance, potential economic and social value, dependence on wireless

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connectivity, uncertainty and the extent to which their spectrum needs appeared underrepresented in existing work. Three use cases were then selected to illustrate distinct patterns of future demand. A deliberate choice was made to focus on use cases that are likely to compete with others for access to frequencies within the 'sweet spot' range up to 10 GHz. These frequencies are in high demand because they combine favourable propagation characteristics with adequate quantities for capacity. While higher frequencies are more abundant, they have relatively shorter ranges, and many wide area applications will require spectrum in the lowest 1 or 2 GHz.

In brief, the three use cases that were selected for deeper analysis are:

- agritech, Telemetry and Distributed Energy Resource (DER) management, within the context of a 'rural portfolio' of accessible spectrum assets;
- low altitude aerial platform communications; and
- temporary drone-enabled network extensions.

The scenarios do not represent predictions. They provide a disciplined way to examine how adoption, service requirements, technology choices and deployment models could interact over the study period.

For each selected use case, the assessment begins with the expected development of demand and the principal factors that could accelerate or constrain adoption. It then translates service needs into connectivity characteristics, including coverage, capacity, speed, latency, reliability, security and availability. The analysis considers whether these requirements could be met through existing commercial networks, private networks, direct device links, satellite or aerial connectivity, fixed alternatives or a combination of platforms. Only after those options have been considered does the study assess the possible implications for spectrum bands, capacity and access models. Finally, the social and economic value associated with each of these three use cases is brought into focus.

This approach recognises the high degree of uncertainty inherent in a long-term assessment. Conclusions are therefore expressed as ranges, conditions and directional findings rather than as precise forecasts. The analysis also distinguishes between a technical requirement for wireless connectivity and a policy case for assigning additional spectrum. This distinction helps to avoid attributing every future connectivity need to spectrum scarcity and allows alternative solutions such as network investment, infrastructure sharing, improved spectral efficiency or more flexible access to be considered on their merits.

2.3.1 Social and economic impact assessment

The social and economic value associated with specific use cases may best be assessed across the following dimensions:

- impact on producer costs and/or revenues;
- GDP or GVA (gross value added) contributions enabled or facilitated by the use case;
- scope to extend the value of sunk investments or fixed (non-discretionary) public or private expenditure;
- value of resilience ('avoided losses/harm');
- human safety impact; and
- other societal gains such as for example environmental benefits, increased food security, animal welfare and consumer convenience.

Not all of the above are relevant to all of the three selected use cases that we consider in greater detail. In particular, producer cost savings feature prominently within the first two use cases, while incremental producer revenue opportunities do not. In some instances, cost savings are substantial, and if these are passed on to consumers, they may translate into consumer welfare gains.

GDP or GVA impact estimates should be read as the maximum 'addressable value pool' or, rather, as maximum 'value at risk' should the specific use case be hindered by spectrum insufficiency. This is not necessarily the same thing as value directly attributable to the use case, unless the relevant GVA source depends wholly on the use case for its existence.

In practical terms, it is often easier to obtain GVA statistics for a wider economic sector within which a given use case operates. This provides at least some overall sense of overall scale, and this may also be useful as a starting point for top-down analysis. For example, it would allow one to quantify the value of each 1% in extra efficiency that a use case may enable within this wider sector. This approach is taken in the DER monitoring use case.

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Some use cases may extend the scope of existing capabilities. This is potentially the case with drone-extended networks, which may allow emergency services to operate with greater effectiveness outside the current boundaries of the Emergency Services Network. In so doing, the use case extends the value of existing public safety expenditure.

The remaining sources of societal value, where applicable, are treated qualitatively within this report. Nonetheless, we have sought to include relevant statistics, where available, to indicate the scale of the issues at hand.

2.4 Organisation of this report

The remainder of the report is organised as follows.

Section 3 examines the relationship between technology and spectrum availability, considering both the dependence of technological development on access to spectrum and the impact of technological advances on spectral efficiency. It also considers how improvements in spectral efficiency affect overall spectrum demand

Section 4 provides an overview of the future spectrum usage landscape. It considers competing demands for spectrum from key existing and emerging user groups in the context of broader macro trends and examines technological and policy developments that may enable the increasingly intensive spectrum sharing likely to be required.

Section 5 categorises and describes key emerging and prospective future spectrum use cases. It then explains the process by which a long list of potential use cases was refined to select three for more detailed analysis, in accordance with the terms of reference for this study.

Sections 6 to 8 examine each of the three selected use cases in turn, considering expected demand, connectivity and spectrum requirements, relevant technologies, capacity constraints and potential spectrum access models. They also assess the potential economic benefits of each use case and its alignment with UK Government national strategies.

Section 9 sets out the study's key conclusions and identifies areas where further research or ongoing monitoring may be valuable. The annexes provide details of the stakeholder interviews undertaken and a glossary of technical terms and abbreviations.

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3. The role of technology in spectrum demand and supply

This study's terms of reference ask how current and emerging technologies depend on timely and reliable access to spectrum. The technologies specified include 5G-Advanced, 6G, Wi-Fi 7, Wi-Fi 8, artificial intelligence, virtualised radio access networks (vRAN), low-power wide-area (LPWA) technologies, software-defined wide-area networking (SD-WAN) and non-terrestrial networks (NTN).

It should be noted that NTN is not, strictly speaking, technology in the same sense as the other items on this list. Whereas 5G-Advanced, Wi-Fi 7/8, vRAN and LPWA describe air interfaces, protocols or network architectures, NTN describes a *deployment domain*: connectivity delivered from platforms in space or the stratosphere rather than from terrestrial infrastructure. An NTN link can, and increasingly does, incorporate several of the other listed technologies. For example, 5G New Radio delivered over a LEO constellation, or a vRAN-based architecture within a satellite ground segment, are both NTN implementations drawing on terrestrial-derived technologies and standards.

We therefore treat NTN in this section as an access platform whose spectrum dependency is best understood in relation to the terrestrial technologies it carries, but operating under materially different propagation, latency and interference conditions. Leaving aside the spectrum required for NTN platform monitoring and control, this distinction also explains why LEO Direct-to-Device (D2D), in particular, is treated primarily in this report as a means of extending coverage or providing resilience, rather than as a discrete source of spectrum demand in its own right[2].

3.1 Impact of spectrum access on technology deployment

Every technology on the above list ultimately requires access to radio spectrum to function, but the nature and extent of that dependency vary materially.

5G-Advanced and the emerging 6G standard depend on continued access to the mid-band 'sweet spot' discussed in Section 4. Their headline capacity gains are realised primarily through wider contiguous channels and higher-order MIMO, rather than solely through more efficient use of existing, narrower spectrum allocations.

From a performance perspective, contiguous mid-band channels of 100 MHz are considered optimal for 5G. Within the ongoing 6G study process, the current working assumption is for channels of 200 MHz. In principle, the Upper 6 GHz (U6) band could provide sufficient spectrum to accommodate 200 MHz channels for each of the UK's three MNOs. However, the UK's proposed hybrid mobile/Wi-Fi sharing framework for this band may constrain the extent to which U6 can be used optimally for 6G IMT deployment[3].

Wider contiguous channels provide benefits beyond improved performance and experienced data speeds. They can also generate significant deployment cost efficiencies, reducing total cost of ownership both per MHz deployed and per Mbps delivered to end users. In competitive markets, lower producer costs tend to be passed through to consumers, at least in part, through lower unit prices. Accordingly, wider contiguous channels could also drive additional consumer welfare benefits.

Wi-Fi 7 and Wi-Fi 8 depend on continued unlicensed access to the 5 GHz and 6 GHz bands, placing them in direct tension with mobile broadband's own claims on the Upper 6 GHz band.

LPWA technologies depend disproportionately on low-band spectrum (below 1 GHz), where coverage per unit of transmit power (not raw capacity) is the governing constraint, as discussed throughout the rural portfolio analysis in Section 6.

vRAN and SD-WAN are, by contrast, largely spectrum-agnostic in their own operation: they are network architecture and orchestration layers that determine how efficiently a given allocation of spectrum is used, rather than technologies that make an independent claim on bandwidth.

AI's dependency is similarly indirect: it is overwhelmingly a consumer of network capacity rather than a spectrum user with its own frequency requirement, save for the AI-controlled spectrum management applications discussed in section 4.3.

2 As argued in section 4, we see LEO D2D primarily as an extension of terrestrial IMT. Aside from the spectrum required for the D2D end-user payload, which is currently obtained from licenced MNOs in the UK, LEOs *do* of course still impose separate spectrum demands for command-and-control.

3 If a significant portion of 700 MHz in the U6 band is top-sliced for Wi-Fi priority (e.g., the lower 160 MHz or 320 MHz), or if indoor Wi-Fi sharing rules require strict guard bands and localized exclusions, it becomes mathematically impossible to fit three non-overlapping 200 MHz mobile channels into what remains. Channels that are less than 200 MHz wide will likely be suboptimal for 6G.

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NTN's payload dependency, for the reasons set out above, tracks whichever terrestrial-derived technology it is carrying, modified by the propagation and coordination requirements distinctive to satellite and high-altitude platforms.

The practical implication is that ‘dependency on spectrum’ is not a single, uniform relationship across this technology list. Some items (5G-Advanced, Wi-Fi 7/8, LPWA) are direct claimants on specific frequency ranges and are therefore exposed to the access constraints discussed in Section 4. Others (vRAN, SD-WAN, AI) depend on spectrum only indirectly, through the networks they orchestrate or the traffic they generate, and their significance for spectrum policy lies chiefly in the efficiency dimension addressed below.

3.2 Impact of spectrum efficiency on demand

Increases in spectral efficiency delivered by some of the above technologies also affect the amount of spectrum that particular applications may require.

Several of the listed technologies are best understood not as sources of additional spectrum demand, but as means of reducing the amount of spectrum that would otherwise be required to deliver a given level of service. In this sense, they can provide a genuine alternative to additional spectrum allocation, consistent with the distinction drawn in Section 2 between a connectivity need and a spectrum requirement.

5G-Advanced and 6G are expected to deliver further gains in spectral efficiency through enhanced massive MIMO and other multi-antenna techniques, continuing a trajectory in which massive MIMO has already demonstrated substantial improvements in capacity per unit of spectrum. A common industry rule of thumb is that each doubling of the MIMO order increases capacity per MHz by around 1.3 times. These gains do not eliminate the need for additional spectrum, but they increase the amount of traffic and the level of service that can be supported by a given allocation.

Wi-Fi 7 and Wi-Fi 8 improve spectral efficiency through higher-order modulation, multi-link operation and, in the case of Wi-Fi 8, coordinated multi-access-point transmission. The latter allows neighbouring access points to make more efficient use of available spectrum rather than simply competing for access to it, thereby reducing contention pressure in unlicensed bands.

vRAN disaggregates network functions from dedicated hardware, enabling more dynamic and efficient allocation of radio resources. This can improve utilisation of available network and spectrum resources and complements the AI-controlled spectrum management applications discussed in Section 4.3, which depend on software-defined infrastructure to act on their predictions.

AI, when deployed within spectrum management itself, is perhaps the clearest efficiency lever on the list. Interference prediction, dynamic spectrum allocation and digital-twin applications, also discussed in Section 4.3, are specifically intended to extract greater usable capacity from existing spectrum resources rather than generate demand for new allocations.

LPWA and SD-WAN contribute to efficiency less through improvements in spectral efficiency than through more efficient management of demand. LPWA’s narrowband, low-duty-cycle design allows large device populations to be served using only a small proportion of a carrier’s available capacity, while SD-WAN’s role is primarily to orchestrate traffic efficiently across available connectivity bearers.

These relationships are, however, highly use-case-specific: a technology that generates substantial spectrum demand in one deployment may reduce spectrum requirements in another.

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4. Future spectrum-usage landscape

Aggregate demand for spectrum within the 'sweet spot' below 10 GHz has been rising steadily and may be expected to increase sharply by the end of the next decade, driven by competing demands from a rapidly expanding range of wireless applications.

Yet, for the majority of use cases considered in this report, the amount of usable spectrum remains inherently finite. It will therefore not be possible to satisfy the spectrum requirements of all existing and prospective future users without substantially greater levels of spectrum sharing. More intensive sharing is consequently likely to become a defining feature of the future spectrum landscape.

To develop a forward-looking view of spectrum demand, we first consider the competing requirements of key existing spectrum user groups. Second, we examine the broader macro trends likely to shape future spectrum utilisation. Finally, we consider how technological and policy developments may enable greater sharing and coexistence between an increasingly diverse range of wireless applications.

4.1 Tensions between key existing spectrum user groups

IMT in particular has an insatiable appetite for bandwidth, driven by explosive growth in global mobile data traffic from 0.6 EB/month in 2012 to 33 EB/month just before the pandemic (a 55-fold increase)[4]. Global traffic doubled again during the pandemic, and it doubled again since to 2025, reaching a staggering 145 EB/month - or 17.5 GB per capita.

Growth in mobile data traffic may appear to be transitioning into an S-curve (logistic) pattern, certainly in the UK. However, while % growth rates have been declining in most markets, the size of *absolute* annual traffic increments is generally still increasing. There is also a school of thought according to which mobile-mediated AI traffic will drive a further upward inflection in growth. Omdia projects that by around 2031–32, Europe will reach a tipping point where cellular networks will carry more AI application traffic than non-AI traffic[5]. It forecasts a nearly 7x factor growth in total European mobile traffic between 2025 and 2033.

To accommodate the growth in traffic to date, mobile operators in the UK have been allocated a total of 1,130 MHz in bandwidth between 700 MHz and 3.8 GHz, most of which has been licenced on an exclusive basis for IMT. Spectrum assets within this range are among the most heavily contended across alternative users.

Much of the extra resources directed towards mobile in recent years have come at the expense of DTT broadcasters, who face persistent pressure with the ongoing decline of linear TV viewership. IMT continues to lay claims on DTT's remaining spectrum portfolio, with the 600 MHz band a prime target.

But the 600 MHz band is thin, and to meet anticipated future traffic demand, IMT is also pursuing higher mid-band assets including the Upper 6GHz band (over which Ofcom has recently made a decision[6]), the 4.5 GHz band (n79), and other resources above 6 GHz.

Beyond DTT, IMT's pursuit of bandwidth also creates tension with other spectrum users, such as PMSE (Programme Making and Special Events). In the UK, audio PMSE (wireless microphones, in-ear monitors) uses the same 470–694 MHz UHF band as DTT. It operates on a geographically interleaved basis in the gaps between DTT transmitters, with Channel 38 (606–614 MHz) reserved exclusively and nationally for PMSE use. This arrangement means that DTT is the "primary user" and PMSE the secondary – placing PMSE in a structurally more vulnerable position: BEIRG[7] (the British Entertainment Industry Radio Group) calculates that PMSE has lost 43% of its UHF spectrum over the past decade through the 800 MHz clearance in 2012 and the 700 MHz clearance completed in 2020, both reallocated to mobile broadband. A further reallocation of the 600 MHz band to IMT would, on BEIRG's estimate, strip out another 34% of what remains. The consequence, according to the industry, is that large-scale UK events (major concerts, festivals, sporting occasions) may

4 Ericsson Mobility Report, June 2026

5 Omdia, 'AI Network Traffic Report Update for Europe: Projected Cellular Growth will Stress Access Infrastructure', May 2025

6 Ofcom Statement, 20 July 2026: decision to implement a prioritised spectrum sharing framework in the Upper 6 GHz band comprisinga Wi-Fi priority portion in the lower 160 MHz of the band (6425–6585 MHz); and a mobile priority portion in the upper 540 MHz of the band (6585–7125 MHz).

7 British Entertainment Industry Radio Group, written evidence (CRF0017), House of Lords Communications and Digital Committee inquiry "A creative future", September 2022.

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be unable to secure sufficient interference-free spectrum for their production tools. Whether PMSE could mitigate this through sharing with a future IMT-600 remains a matter of heated debate.

Meanwhile, the public sector is still the largest spectrum landlords in the UK, albeit much of its holdings are shared across multiple users. It once held around half of all frequencies below 15 GHz, primarily for defence, aeronautical, maritime and emergency services use. Around two thirds of public sector holdings were assigned to the Ministry of Defence (MOD)[8]. There is a live, structural tension between the MoD, in particular, and the wider push for spectrum release for commercial use.

The 2010–2022 Public Sector Spectrum Release programme made 687 MHz of public-sector spectrum below 10 GHz available for civilian and commercial use. Some portions were released outright for exclusive licensed use, while others were made available subject to sharing arrangements. The 3.5 GHz band, now used for 5G, was among the spectrum released. This experience suggests that, up to 2022 at least, defence and other public-sector holdings represented a potential, albeit relatively slow-moving, source of additional spectrum for commercial users. Policy has since evolved, however, particularly following Russia's invasion of Ukraine in 2022, with a clear shift in emphasis from spectrum release targets towards demand-led sharing.

As the Government's Spectrum Statement of April 2023 notes, *"spectrum demand from MOD and its coalition partners is growing"* and *"advances in technology are also being adopted by potential adversaries, which will make available spectrum even more congested and contested. This demand is driven by the need for improved situational awareness, intelligence, drones, ever increasing data rates and target detection at greater distances, to name but a few."*

If AI drives substantially increased spectrum demand from IMT, it is reasonable to expect it also to contribute to growing bandwidth requirements for military applications, particularly as data-intensive sensing, intelligence and autonomous systems become more widely deployed. Rising MOD spectrum requirements do not, however, necessarily preclude shared civilian use of many bands in peacetime, across much of the UK's land area and for much of the time.

While relying on public mobile networks for much of their needs, UK Emergency Services are pursuing additional spectrum in their own right, notably to support direct device-to-device communications using the emerging Sidelink technology (currently being developed by Qualcomm[9]).

Transport and utilities form a further critical-communications user group with rising claims on sub-10 GHz spectrum. These are transitioning from legacy narrowband PMR systems to dedicated, private LTE-450 (and emerging 5G) networks. The evolving needs of modern smart grids within the context of Distributed Energy Resources (DER) are a prime driver. Electricity Distribution Network Operators (DNOs) in particular are seeking expanded, more clearly ring-fenced spectrum, as their data requirements is (or has) outgrown their narrow allocations at 450 MHz[10]. The original narrowband spectrum provisions for DNOs were engineered for a much simpler grid than the one now being built. Legacy SCADA telemetry is being overlaid with distribution automation, fault sensors, smart metering, and the real-time monitoring and control of a rapidly growing base of DERs (rooftop solar, batteries, EV chargers), all of which demand far more intensive, near-continuous two-way data exchange than the original licensed channels were sized for.

Overall spectrum demand is also rising across Fixed and Mobile Satellite Services (respectively FSS and MSS) categories. FSS underpins high-reliability, rain-resistant gateway/feeder links for GEO and NGSO systems, supporting rural connectivity, aviation, and maritime safety services. Its spectrum demand is ostensibly focused on expansion above 10 GHz (Ku-band, 10-17 GHz), with a more defensive posture in its existing lower bands[11]. MSS currently supports mobile satellite telephony, IoT and safety-of-life services through a range of spectrum assets that bring it into direct interaction with IMT. However, the resulting tensions appear to relate less to competing claims for the same spectrum than to coexistence challenges. These arise, for example, around 3.3–3.4 GHz, where there are competing primary allocations, at the edge of the L-band, and around the Upper 6 GHz band.

Similar coexistence challenges with fixed links in the 7–8 GHz range are also increasing as low-Earth orbit (LEO) satellite constellations proliferate to provide broadband connectivity and Direct-to-Device (D2D) services. Unlike geostationary satellites, links to LEO satellites are not geometrically static: the angle between a satellite and an Earth station changes

8 Sources: Ofcom Statement, 1 August 2008 and The Register, 'MOD spectrum under the spotlight', June 2008 (theregister.com), according to which the MOD held 35% of all spectrum under 15 GHz around 2008 (i.e. prior to subsequent releases).

9 Source: Coleago stakeholder interviews (under Chatham House rules).

10 See for example JRC response to Ofcom's June 2023 Call for Inputs.

11 As manifested by the industry's resistance to regulatory changes. See for example the ESOA/GVF Joint Consultation response to Ofcom's October 2016 consultation, 'Improving Consumer Access to Mobile Services at 3.6 to 3.8 GHz'.

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continuously as the satellite traverses the sky. This creates a more dynamic interference environment for terrestrial fixed links, a challenge that is likely to increase as the number and density of LEO constellations grow.

Whether LEO D2D itself generates a distinct claim on spectrum is debatable. Ofcom has not, to date, assigned dedicated spectrum resources for D2D in the UK, although existing satellite holdings at 2 GHz may potentially be repurposed for this purpose. Current LEO D2D services in the UK instead use existing licensed IMT spectrum to extend the coverage of terrestrial mobile networks.

D2D may therefore be better understood as an alternative platform for delivering IMT services - effectively, a network of 'base stations in the sky' - rather than as a distinct category of spectrum use. D2D operators could conceivably bid directly for licensed IMT spectrum in the future, potentially bringing them into competition with terrestrial mobile operators. We would, however, regard this as a form of new entry into the IMT market rather than as a competing spectrum claim from a distinct user group.

Finally, unlicensed spectrum/Wi-Fi is also subject to growing demand, with proponents warning of a potential spectrum crunch as traffic volumes increase and growing numbers of devices compete for capacity through individual Wi-Fi access points. This has also brought Wi-Fi[12]. into more direct competition with IMT for access to additional spectrum, most notably in the Upper 6 GHz band, as discussed above.

Exhibit 1: Spectrum demand trends across key existing user groups

User group	Spectrum demand	Basis of spectrum claim
IMT/mobile broadband	Rising	Traffic still growing in absolute terms; potential AI-driven inflection; near-universal consumer/economic dependency
DTT/broadcast	Declining (forced)	Viewing share falling steadily, but relied upon by more vulnerable user groups
PMSE	Broadly flat	Claim to retain existing spectrum; societal weight tied to cultural/creative-economy events rather than critical services
MOD	Rising	Post-2022 threat environment, drones, ISR needs (Intelligence, Surveillance, Reconnaissance) and AI-enabled systems are driving genuine new demand tied to national security
Emergency Services	Rising	Additional secure spectrum needed to support direct device-to-device communications
Utilities (SCADA/DER)	Rising	Small in bandwidth terms but critical for grid resilience and Net Zero transition
Satellite: FSS and LEO	Flat below 10 GHz (defensive rather than acquisitive posture)	Underpins high-reliability, rain-resistant gateway/feeder links supporting rural connectivity, aviation, and maritime safety services
Satellite: MSS	Rising	Currently supports mobile satellite phone, IoT, and safety-of-life services
Fixed links	Flat	Stable volume of links, but function (backhaul, critical infrastructure connectivity) remains foundational
Unlicensed/Wi-Fi	Rising	Carries the majority of mobile-device data traffic already (est. 70-80% of smartphone data via Wi-Fi) with double-digit annual growth

Source: Coleago, based on public literature

From this non-exhaustive set of 10 user-groups, we see six with clearly rising claims on spectrum, three with broadly flat demand (below 10 GHz), and just one with declining demand, whose decline is effectively thrust upon it.

12 WiFi Forward blog 'What Wi-Fi Exhaustion Means for Consumers – And How to Prevent It', June 2025.

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4.2 Further macro trends

In addition to some of the general trends identified above, the following developments will likely influence the future spectrum landscape by driving demand from existing, emerging and future use cases.

Proliferation of space assets

New pressures on sub-10 GHz spectrum are brought by the sheer growth in satellite numbers across multiple constellations - spanning Low-earth-orbit (LEO) systems for broadband and D2D connectivity today, and prospectively space-based data centres and orbital compute infrastructure in the future. Future LEO volumes ranging from hundreds of thousands to millions of units have been suggested.

Spectrum is needed for telemetry, tracking, and command (TT&C) of satellites, which traditionally relies on established VHF, UHF, and S-band allocations. These provide the necessary beamwidth for critical control functions. But with LEO constellations already scaling into the thousands of satellites, operators face growing contention for these narrow, congested bands and increasing need for coordination to avoid interference between fleets. Meanwhile, orbital compute and data storage infrastructure using continuous solar power to run AI training and Earth observation workloads, are moving from concept to concrete regulatory filings –with SpaceX, Starcloud, Google, and Blue Origin all pursuing their own constellations. These would add substantially to the demand for TT&C bandwidth.

As far as incremental service-related spectrum claims are concerned, LEOs are likely a mixed case. For D2D in the UK, these generally fall under IMT claims which have been discussed in the previous section (4.1). Broadband delivered from space might have a legitimate claim on incremental spectrum to meet rising demand for bandwidth, from rural customers in particular. However, this may in principle be provisioned with spectrum above 10 GHz (complementing existing Ku-band resources used for transmission to and from user CPEs). Ditto for LEO gateway/feeder links. While these so use 7-8 GHz (alongside Ka, Q and V-bands), expansion is highly likely to focus on resources above 10 GHz. Orbital compute, finally, will undoubtedly have large claims on spectrum for their service-related data traffic, but these are unlikely to touch on sub-10 GHz bands: in addition to X, Ku, Ka and V-bands, free-space optical (FSO)/laser links are being contemplated for high-capacity transmission.

Mass commercial deployment of UAVs

The proliferation of UAVs operating beyond visual line of sight (BVLOS) over the next 10–15 years is likely to place significant additional demands on spectrum below 10 GHz. Three distinct requirements can be identified. The first is for command, control, navigation and collision avoidance; the second is for air-to-ground transmission of data-intensive payloads, such as video feeds from UAVs used for infrastructure inspection; and the third is for the detection and tracking of UAVs themselves. The first two requirements, in particular, are likely to extend well beyond the licence-exempt 2.4 GHz and 5 GHz links commonly used for UAV control today.

Ofcom's July 2026 consultation[13] already proposes opening 453–462.5 MHz and part of the 5,030–5,091 MHz band for dedicated drone control links, alongside new drone-detection radar licences above 10 GHz, with the 16 GHz and 24 GHz bands identified as prime candidates for detecting and countering unauthorised activity near sensitive sites such as prisons and airports. However, significantly greater capacity may be required for UAV video transmission, especially for applications such as surveillance and critical infrastructure inspection.

The elevation at which UAVs operate will also create significant additional challenges for interference management and coexistence. Greater altitude increases line-of-sight range and therefore the geographic area over which UAV emissions may propagate and cause or receive interference, complicating coexistence with other spectrum users.

Concerns around GPS denial and around RF resilience

Growing dependence on satellite navigation across transport, telecommunications timing, finance and critical infrastructure has heightened concern about the vulnerability of GPS and other GNSS signals to jamming, spoofing and outright denial, whether as a result of hostile state activity, criminal action or unintentional interference. In the UK, these concerns have intensified following incidents of GPS jamming and spoofing affecting aviation and maritime navigation in regions adjacent to conflict zones. Critical national infrastructure, including power grids, mobile networks and financial systems, relies extensively on GNSS-derived timing signals, creating potential vulnerabilities where adequate resilience or backup systems are lacking. This may increase the case for alternative positioning, navigation and timing (PNT) infrastructure, some forms of which could require dedicated spectrum access.

13 Ofcom Consultation, 'Enabling drone innovation and security', July 2026.

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RF resilience is also rising up the policy agenda. Organisations, military authorities and governments are increasingly concerned about the vulnerability of conventional radio-frequency communications to interference, cyberattack and the physical destruction of supporting infrastructure. A range of technological strategies is being considered to improve resilience, although these lie beyond the scope of this report. Approaches based on redundancy, however, could create additional spectrum requirements and thereby add to the already rapidly growing pressure on available spectrum resources.

Growth in AI and edge computing

The convergence of artificial intelligence and edge computing is set to reshape sub-10 GHz spectrum demand over the next decade, shifting traffic patterns from centralised, latency-tolerant applications towards distributed, real-time processing at the network edge.

In the previous section, we discussed the projected impact of AI on mobile data traffic. Beyond public mobile networks, AI-edge convergence may, in some instances, require localised spectrum arrangements that bypass carrier infrastructure entirely. Industrial sites, warehouses and ports may increasingly deploy private networks to support AI-driven robotics, machine vision and predictive maintenance systems. These may require ultra-low latency and high reliability that public networks are unable to guarantee at scale.

Similarly, dense deployments of AI-enabled IoT sensors across smart buildings, agriculture and utilities may require direct device-to-device and device-to-edge-server communication, reducing dependence on mobile backhaul. Some of these applications may rely on existing unlicensed spectrum, but more critical applications may generate incremental claims on spectrum.

Autonomous vehicle-to-vehicle and vehicle-to-infrastructure (V2X) links, alongside drone-based inspection and delivery systems, could also emerge as significant non-mobile use cases, potentially requiring dedicated, safety-critical spectrum outside the public network ecosystem.

Rise in private mobile networks, telemonitoring, control and/or automation

Significant growth in Private Mobile Networks (PMNs) is anticipated across a wide range of sectors, overlapping to a large extent with increasing demand for remote monitoring and control across teleoperations. In the preceding section (4.1), we already highlighted transport, utilities and DER in particular. Other key sectors include, non-exhaustively:

- power generation outside the remit of DNOs:
  - consolidation of power plant control into centralised Remote Operations Centres, reducing on-site staffing needs;
  - offshore wind expansion, requiring long-range, high-resilience links for remote inspection and maintenance of hard-to-reach assets (similar requirements also apply to Oil and Gas extraction);
  - next-generation nuclear designs exploring remote, near-autonomous command-and-control from outside the site boundary;
- agriculture (agritech), including precision farming, livestock monitoring, and automated irrigation and crop management;
- autonomous vehicles and ground-based drones (e.g. for last-mile delivery), including navigation, vehicle telemetry and safety/collision avoidance;
- industrial automation and robotics, including remote monitoring, control, and optimisation of manufacturing processes, machinery, and production lines;
- construction and infrastructure, including remote operation of machinery, site monitoring, and automated asset inspection;
- retail and logistics, including warehouse automation, inventory monitoring, and remote operation of fulfilment systems;
- buildings and facilities management, including smart buildings, heating-ventilation-aircon (HVAC) automation, security systems, and energy optimisation in commercial and residential properties;
- Smart Cities, in relation to Resource Efficiency and Sustainability, Urban Mobility and Infrastructure, Public Safety and Health, and to Administrative Efficiency;
- healthcare and medical systems, including remote diagnostics, patient monitoring, and robotic-assisted procedures; and
- environmental monitoring, including air and water quality sensing, flood monitoring, and climate observation networks.

Not all of these will generate strong claims for additional spectrum. Smart Cities have strong and growing momentum in the UK, but smart city ecosystems are likely to rely largely on existing commercial mobile infrastructure, standard Wi-Fi and Ofcom's Shared Access frameworks. Buildings and facilities management is primarily an IoT and building automation story,

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for which unlicensed or lightly licensed spectrum may suffice. In retail and logistics, warehouse automation and inventory-tracking applications should be able to scale within existing enterprise Wi-Fi and private LTE networks. Sensors and IoT devices used for environmental monitoring do not generally require high bandwidth or low latency, so most should be able to rely on existing terrestrial and satellite networks. Within healthcare and medical systems, finally, niche incremental requirements for telesurgery or specialist remote procedures are more likely to be served by fibre/fixed broadband with 5G backup than through distinct spectrum allocations[14].

Industrial automation and robotics are potentially a mixed case, given their 'semi-critical' nature and the need for guaranteed low latencies. However, these requirements may be met through private campus networks using spectrum available under Ofcom's Shared Access or Local Access Licence frameworks. Shared Access provides dedicated, interference-protected spectrum in the 1800 MHz, 2.3 GHz, 3.8 - 4.2 GHz and/or 26 GHz bands (the latter currently indoor-only) within a defined geographic footprint, although industrial uptake to date appears to have been modest relative to the spectrum available.

Nevertheless, while uptake among SME industrial clusters started slowly, it is now increasing[15]. Instances could plausibly emerge within the next 10–15 years in which the capacity available through existing Shared/Local Access licences is insufficient to accommodate increased use of AI and edge computing within industrial settings. This could drive a legitimate claim for increased spectrum access.

Construction and infrastructure are a second mixed case. These applications are likely to sit more comfortably within existing public mobile footprints than industrial automation, since they are typically more latency-tolerant, aside from safety-critical teleoperation scenarios. In areas with strong 5G coverage, public mobile infrastructure should reasonably be able to meet these needs.

Where public mobile coverage is weak, as is common along rural infrastructure corridors, in quarries or at remote greenfield sites, there may be a case for temporary coverage solutions. These could include cell-on-wheels deployments, shared-access private networks or, in an emerging but still nascent capacity, drone-enabled pop-up networks to bridge the coverage gap for the duration of a project. The Shared Access framework, as well as Ofcom's new short-notice, short-duration 2.3 GHz licences, may be suitable for ground-based temporary networks. However, these explicitly prohibit airborne use, which would rule out drone-enabled pop-up solutions. New spectrum provisions would therefore be required for the latter.

Power generation (outside the remit of DNOs) is a third mixed case:

- The consolidation of power plant control into centralised Remote Operations Centers is likely to be met largely through existing infrastructure. Non-critical monitoring and control functions can typically rely on resilient fibre backbones for primary connectivity, with cellular or private LTE/5G as backup. Safety-critical protection and trip signalling, however, requires sub-10ms latencies, and will likely remain hardwired. Dedicated spectrum allocations are therefore unlikely to be necessary beyond what campus-style Local/Shared Access licences already provide for (non-critical) site-level operations.
- Offshore wind expansion, by contrast, advances a stronger claim for spectrum, albeit not necessarily below 10 GHz. Overall demand for bandwidth is likely to rise, as the density of assets requiring monitoring or control within any wind farm increases. Remote inspection and maintenance of turbines and substations, often tens of kilometres from shore, requires long-range, high-resilience links capable of supporting video feeds, drone-based inspection data, and condition-monitoring sensors in environments where terrestrial mobile coverage is mostly absent. Low latency and sufficient bandwidth are needed for real-time inspection and fault diagnosis. This points towards a case for dedicated maritime or point-to-point spectrum below 20 GHz, as rain attenuation becomes materially significant above that level.
- Next-generation nuclear designs, meanwhile, represent an emerging and more speculative category. Advanced modular reactors and other next-gen designs are exploring remote, near-autonomous command-and-control from outside the site boundary, which would require extremely high reliability and security guarantees. At this stage, most of these systems remain in design or early deployment phases, and while dedicated allocations seem necessary, firm spectrum demand might not crystallise within a 10 to 15-year horizon.

Autonomous vehicles are a fourth mixed case. They are unlikely to require distinct spectrum access for remote monitoring and control, which can be handled over existing terrestrial networks (with satellite backup) using standard IMT bands.

14 In a UK first, a remote prostatectomy was carried out from the UK on a patient in Gibraltar in March 2026. It involved a fibre link with 5G as a backup, albeit it also included a medical team on location as a further fallback. Source: E+T magazine, 6 March 2026.

15 Source: Coleago stakeholder interviews (under Chatham House rules)

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However, there remains an ongoing debate as to whether existing spectrum provisions for V2X will be sufficient to accommodate all peer-to-peer traffic as well as safety-critical broadcasts.

Agritech presents a stronger claim for dedicated spectrum access. Precision agriculture, for example, relies on a dense mesh of connected devices, including soil sensors, GPS-guided tractors, drones, autonomous robots and irrigation controllers. These need to communicate continuously across large, often remote areas where public mobile coverage may be weak or unavailable. Satellite may not always provide a suitable alternative, particularly where direct communication is required between drones and ground-based sensors.

Other applications in remote locations may also have legitimate claims on spectrum access where the bandwidth available from existing terrestrial and satellite networks is insufficient or unsuitable. These fall within our rural portfolio category, as discussed in Section 6.

4.3 Future spectrum demand

Taking both existing and anticipated long-term pressures on UK spectrum into account, we construct the indicative numerical 'heat map' shown in Exhibit 2 below. Current scores are given on a normalised scale of 1 to 10, where 10 represents the 'hottest' frequency range today. The uncapped future heat scores, reflecting our expectations over a 10 to 15-year horizon, are calibrated against this current 1 to 10 scale.

A degree of subjectivity is necessarily involved, not least because 'pressure on resources' and 'demand for spectrum' are somewhat fuzzy concepts in this context. For example, demand for spectrum on a shared, low-power basis does not create as much 'pressure' as demand for exclusive access. Furthermore, international harmonisation of spectrum uses, with the associated ecosystem constraints, means that not all resources within a given frequency range are equally fungible: only specific sub-ranges may come into contention for particular user groups.

Exhibit 2: Current and future pressure on spectrum by frequency range

Frequency range	Current heat score	Future heat score	Rationale for heat scores
Below 0.4 GHz	3	4	**Low-friction isolation** – Highly treaty-locked (VHF PMR, emergency services, military). Mild future pressure from narrow-band utility/agritech IoT at the margins, mostly offset by closure of Airwave TETRA network.
0.4 – 1 GHz	10	15	**Zero-sum gridlock** – IMT and DTT competing head-on for exclusive spectrum access, with heavy and rising mobile network congestion in low-bands underpinning claims for IMT-600. DTT/PMSE and mobile coverage needs remain structurally non-fungible, as higher bands cannot solve the coverage-depth problem, which compounds the problem. Pressure on DTT to give way to IMT will likely persist, plausibly beyond 600 MHz.
1 – 2 GHz	7	12	**Mounting pressure from UASs** – Global navigation satellite/aeronautical allocations stay fixed while traffic in core mobile 1.8 GHz anchors and L-band downlinks keep growing. Strong future pressure added by new safety-critical drone BVLOS links colliding with aviation bands. Strategic and commercial value of these mid bands for IMT further enhanced by satellite D2D re-use.
2 – 3 GHz	6	10	**Mass-market versus Enterprise contention** – High and rising consumer-device density in the 2.4 GHz unlicensed band, while 2.1/2.3/2.6 GHz bands support critical mobile capacity. Looking ahead, pressure escalates sharply as AI-driven, uplink-heavy traffic chokes existing IMT allocations, while new enterprise entrants compete for Ofcom Shared Access licenses to power private industrial 5G/6G automation.
3 – 6 GHz	9	17	**Key capacity anchors** – Currently the maximum-capacity resources for urban 5G and mid-band Wi-Fi. Surging mobile traffic will bear heavily on this 'sweet-spot' range by 2035, driving 3.6 GHz deployments across a widening footprint. Overall demand will be compounded by new WRC-allocated drone payload/diagnostic links (4.2-4.4 and 5.03-5.09 GHz), as well as by potentially high future Shared Access needs from industry.
6 – 7 GHz	8	14	**Colliding claims from WiFi and future mobile 6G** – High strategic friction following WRC-23 decisions, with the band a primary candidate as the future mobile 6G capacity layer. The UK's hybrid mobile/Wi-Fi sharing framework in the U6 band may need repeated, high-pressure renegotiations, within the context of rising consumer WiFi and AI-driven enterprise Wi-Fi 7/8 traffic on one hand, and surging AI-driven mobile 6G demand on the other.

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7 – 10 GHz	3	9	**Greenfield landgrab** – MOD/NATO fixed links, satellite gateways and maritime radionavigation currently dominate. Demand likely to rise sharply in the future, once an automated, tiered-access framework unlocks 6G cmWave capacity for commercial users alongside MOD/satellite incumbents.

Source: Coleago

Our overall assessment is that the 400 MHz - 1 GHz range is currently the hottest. Access to this scarce coverage resource is already heavily contested by IMT and DTT, adding mounting pressure on PMSE. Congestion levels for mobile networks (which hold roughly a third of bandwidth in this bucket) are highest across their sub-1 GHz holdings. High growth in overall mobile demand will also translate into surging demand for low-band, wide-area capacity. However, supply remains tightly constrained: demand from IMT could unlikely be met in full, even if all other users were to give way. While improvements in low-band MIMO antenna technologies may allow significant increases in capacity per MHz during the next 10 to 15 years, these proportional gains will unlikely ever match those that can be realized in higher bands. A perpetual shortfall in low-band spectrum seems likely.

By comparison, the 3 - 6 GHz bucket is less pressured today. Admittedly, the unlicenced 5 GHz WiFi band is heavily utilized, but the 3.5 GHz IMT band is less congested, and the shared 3.8 - 4.2 range even less so. Nevertheless, 3 - 6 GHz remains a ‘sweet spot’ (within the overall sub-10 GHz ‘sweet spot’), because it combines large amounts of contiguous bandwidth for individual use cases with decent propagation characteristics. For this reason, the 3.4-3.8 GHz range has already become the mobile 5G ‘workhorse’. Taken as a whole, we feel that the above justifies our assessment of this bucket as the second ‘hottest’ beneath 10 GHz today.

We anticipate that surging (AI-driven) mobile 5G demand, potentially high future shared and local access needs from industry and, in particular, the emerging payload and control requirements for the mass deployment of drones, will combine to make this the ‘hottest’ spectrum category over a 10 to 15-year horizon.

Our overall assessment is that the 400 MHz - 1 GHz range is currently the hottest. Access to this scarce coverage resource is already heavily contested by IMT and DTT, placing mounting pressure on PMSE. Congestion levels for mobile networks, which hold roughly a third of the bandwidth in this range, are highest across their sub-1 GHz holdings. Strong growth in overall mobile demand will also translate into surging demand for low-band, wide-area capacity. However, supply remains tightly constrained: demand from IMT would be unlikely to be met in full even if all other users were to give way. While improvements in low-band MIMO antenna technologies may enable significant increases in capacity per MHz over the next 10–15 years, these proportional gains are unlikely ever to match those achievable in higher bands. A persistent shortfall in low-band spectrum therefore seems likely.

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We anticipate that surging, potentially AI-driven, mobile 5G demand, high future shared and local access requirements from industry and, in particular, the emerging payload and control requirements associated with mass deployment of drones will combine to make 3 - 6 GHz the ‘hottest’ spectrum category over a 10 to 15-year horizon.

4.4 Developments towards intensive spectrum sharing

Intensive spectrum sharing will be needed to accommodate competing future demands for bandwidth below 10 GHz. Such sharing tends to be more challenging in lower bands, due to their wider propagation and higher potential for interference. Sharing and interference management will be further complicated by the surge in airborne devices and spectrum uses.

The remainder of this section examines current developments in this field, as well as what may be anticipated over a 10 to 15-year horizon.

4.4.1 Current and near-term developments

Geolocation databases and CBRS-type dynamic access frameworks

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The US Citizens Broadband Radio Service (CBRS) in the 3550 - 3700 MHz band remains the reference model for automated, tiered spectrum sharing: a Spectrum Access System (SAS) using a sensor network and centralised database to arbitrate access between incumbent naval radar, Priority Access Licence holders, and General Authorised Access users, with only one user permitted on a given channel at a time.

To date, this is the most advanced form of dynamic spectrum sharing between alternative spectrum users to have been implemented. It relies on geolocation database-controlled access, with a separate, specialised network of 'listening posts' that detects CBRS spectrum use (the Environmental Sensing Capability) and that is designed to protect US Navy aircraft carrier radars. It provides near-real time (pulse-scheduled) frequency management.

The UK has not adopted a direct CBRS equivalent, with Ofcom currently relying on administrative mechanisms under its Shared Access Licence (SAL) and Local Access Licence (LAL) framework. However, a 2023 Ofcom discussion paper on flexible and adaptive spectrum management explicitly did examine CBRS-style database-and-sensor architectures as a template for future UK dynamic spectrum access[16]. A 2024 UK Spectrum Policy Forum study also proposes 'automated Dynamic Spectrum tools" as one of four scenarios for opening up Ministry of Defence spectrum to civilian/commercial use, alongside a 'SMO' (Spectrum Management Organisation) model in which MOD itself would broker access[17].

Cognitive radio

Cognitive radio spans autonomous devices that sense their RF environment and adapt frequency, power, or modulation to exploit spectrum gaps, to enable spectrum utilization without impinging on higher tier users.

A move from research concept to live trials was envisaged in connection with the UK TV White Space (TVWS) framework trials (2013-2015). However, autonomous hardware sensing proved too unreliable at the time, due to the 'hidden-node problem'[18]. For this reason, pure spectrum sensing was replaced by centralized geolocation databases to protect broadcast incumbents during those trials.

Cognitive radio research continues to be pursued around cooperative and multi-sensor spectrum sensing, spectrum prediction (forecasting when a band will become free), and dynamic spectrum handover, techniques increasingly explored as inputs to AI-driven allocation systems rather than as freestanding technologies.

Smart antennas and interference-tolerant design

Advances in beamforming and massive MIMO are reducing the interference footprint of transmissions, which is loosening the "worst-case" assumptions that have traditionally driven conservative guard bands and exclusion zones. Adaptive digital beamforming can suppress sidelobes and null interference directions in real time, and multi-beam array antennas are increasingly designed with interference mitigation as a core function rather than an add-on. This matters for satellite/terrestrial coexistence in particular: recent robust transmit-beamforming designs for satellite-to-ground links use statistical channel knowledge to actively limit interference into terrestrial receivers, which could facilitate simultaneous, co-channel sharing.

AI-controlled spectrum management

AI is the area of rising policy interest within the context of spectrum sharing. Concrete use cases include use of machine learning to predict interference and feed optimisers for licence assessment, deep reinforcement learning for dynamic spectrum allocation, anomaly detection for compliance monitoring, and 'digital twins' of the radio environment to test sharing scenarios before deployment[19].

Near-term focus is likely to remain on hybrid systems, with AI-driven prediction layered on existing licensing and database structures, rather than AI replacing regulatory oversight outright.

Interference management policy

16 'Opportunities for dynamic or adaptive approaches to managing spectrum in the UK', March 2023.

17 'Exploring a new framework for defence spectrum sharing in the UK', LS Telecom report for UK SPF, July 2024. The remaining two scenarios include (1) maintaining the status quo and (2) extending the SAL framework.

18 The hidden-node problem (or hidden-terminal problem) is a fundamental physics and geometry limitation in wireless communications where a local device cannot "see" a primary transmitter, leading it to mistakenly assume a frequency band is empty.

19 For an in-depth discussion, see Smith Institute and Spectrivity report for UK SPF, 'Artificial Intelligence for Spectrum Management', February 2025.

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Ofcom is shifting policy emphasis from static, worst-case interference protection toward evidence-based, adaptive management. Its 2023 discussion paper (cited above) alludes in particular to spectrum management that is informed by real measurement rather than purely assumptions-based desktop modelling. 'Spectrum sandboxes' are also being explored as a means to enable better sharing and experimentation in specific frequency bands (such as 3.8-4.2 GHz), distinct from traditional innovation and trial licensing processes[20].

4.4.2 Longer-term direction of travel

Over the next 10 to 15 years, the overall direction of travel is likely to be towards automated, real-time sharing, with a shift from static, exclusion-zone-based licensing toward continuous, data-driven arbitration of access. In the UK, this would involve a transition from coordinated 'first-come-first-served' access (today's SAL/LAL model) to something closer to CBRS's real-time, database-brokered arbitration, particularly as sensor costs fall and coordination software matures.

AI moves from advisory to operational

In the near term (roughly 2026–2030), AI's role in UK spectrum management is likely to remain focused on decision-support: interference prediction feeding human licence assessment, anomaly detection flagging misuse, and digital twins used to test sharing scenarios before rollout. By the 2030s, as trust and explainability standards mature, a shift towards semi-autonomous control may be anticipated, in which reinforcement-learning systems dynamically reallocate frequency and power in near-real time across multiple co-existing networks. Human oversight will likely be retained for exception-handling and dispute resolution rather than for routine allocation.

Smart antennas absorb residual interference risk

As adaptive beamforming, massive MIMO, and (later) reconfigurable intelligent surfaces become standard rather than premium features, the 'worst-case interference' assumption underpinning today's guard bands and exclusion zones should erode further.

Sandbox trials already show that "*real-world environments can support more intensive sharing than theoretical models might predict*"[21]. Over 10 to 15 years, this evidence base may accumulate to the point where regulators can shrink protection margins with confidence, particularly for satellite/terrestrial co-channel sharing in the sub-10 GHz range. This is less a single breakthrough than a steady recalibration of risk appetite as measurement data replaces conservative modelling.

Cognitive radio complements database-driven models

Given the UK's earlier TVWS experience, as discussed above, where geolocation databases outperformed spectrum sensing for incumbent protection, cognitive radio is likely to evolve as a complementary strategy to manage coexistence rather than as a standalone solution.

We anticipate continued convergence between device-level adaptivity ('cognitive') and network-level arbitration ('database-driven dynamic access'), with pure autonomous sensing playing a supporting role for anomaly detection rather than primary access control.

Net trajectory

A plausible path over the 10-to-15-year horizon includes: (1) near-term consolidation of AI-assisted, database-driven sharing within existing SAL/LAL-style frameworks; (2) mid-term expansion of automated arbitration into previously protected government and defence bands; and (3) longer-term normalisation of real-time, multi-network co-channel sharing enabled by smart antennas and increasingly autonomous AI control, with human oversight narrowing to exception management.

The airborne and space-borne growth will likely prove to be the hardest test case for this trajectory, since satellite/terrestrial and UAV coexistence pushes both the AI prediction models and the beamforming interference budgets furthest from today's proven baseline.

20 Ofcom Spectrum Advisory Board, Annual Report 2022-2023.

21 Durham University-led study for DSIT, 'Spectrum Sandbox: WP1 Final Report', March 2025.

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5. Emerging and future use cases

Given the pace, breadth and creativity of innovation in the field, compiling an exhaustive list of emerging and prospective spectrum use cases would be an unrealistic undertaking. The following therefore covers the categories and use cases discussed during our stakeholder engagement and/or identified through our own literature research. These are broadly categorised in Section 5.1 below, although some use cases overlap, while others span more than one category.

In accordance with the terms of reference for this study, three of these use cases were selected for a 'deeper dive', covering future demand and expected connectivity and spectrum requirements. Section 5.2 sets out the basis for our final selection.

5.1 Key categories and use cases

Exhibit 3: Emerging and prospective future use cases

Category	Use cases
Space-Based Platforms, Assets & Networks	– Connectivity for orbital compute: satellite control and RF payload for service-related data transfer – Connectivity for space-based manufacturing (for example, crystals formed in low gravity environments): satellite control and automation) – IMT networks on the Moon supporting lunar missions, and eventually on Mars – Space-Based Solar Power (SBSP): satellite control and energy transfer to Earth via microwave or laser
High Altitude Platforms (HAPS)	– Stratospheric drones, blimps or balloons supporting terrestrial communications
Low Altitude Air-Ground-Air Communications	– Low altitude platforms for connectivity (tethered drones or aerostats) – Autonomous drones for asset monitoring – Autonomous drones for transportation and delivery
Airborne Detection Systems	– Airborne platforms for detection and/or control of drones: these platforms may conceivably range from tethered low flying drones, medium and high-altitude drones to stratospheric HAPS
Terrestrial Guidance	– Terrestrial guidance systems will be required if GPS is blocked or impaired. – Indoor positioning and navigation
Private Mobile Networks and Teleoperations	– Remote monitoring, telemetry, supervisory control and/or automation for critical infrastructure/operations (e.g. Power generation, Distributed Energy Resources, Transport, Oil & Gas) – Same for autonomous vehicles and ground-based drones/robots – Same for safety-critical operations (e.g. within Construction and Infrastructure) and for semi-critical operations (e.g. within Industrial Automation) – Non-critical private networks and teleoperations
Rural Portfolio	*A spectrum-access portfolio for rural/remote networks, to support critical as well as non-critical connectivity use cases such as:* – Monitoring, telemetry, supervisory control and automation for agritech, DER and other public, utility and private assets – Community wireless networks for public and local government and business use
Terrestrial device-to-device Communications	– device-to-device communications and connectivity tethering needs for ESN – device-to-device communications between autonomous vehicles (V2X) – device-to-device communications between ground-based drones/robots (over and above V2X), including connectivity tethering, when operating outside mobile and satellite coverage – Personal area networks – device-to-device SOS broadcast function
Pop-up and Nomadic Networks	– Temporary, localised licences issued instantly for PMSE, media and construction – Drone-enabled networks

Source: Coleago, based on literature research and stakeholder interviews

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Space-based platforms, assets and networks

Space is an arena in which seemingly eccentric proposals compete for spectrum resources. Many of the developments that are seen today, such as the D2D LEO boom, might have been deemed outlandish just a few years ago.

Large D2D satellite constellations are already a reality, and orbital compute is gaining traction as a prospect. These two alone would likely lay claim to substantial additional bandwidth, as discussed in section 4.2. But their focus would probably be on bands above 10 GHz - which is outside the scope of this study. The same is certain to be the case for prospective space-based manufacturing and solar power generation. Lunar 5G would not raise co-existence concerns with terrestrial IMT. On this basis, we have decided to exclude this category from further review within the present study.

High altitude platforms (HAPS)

Untethered high-altitude balloon initiatives, such as Google X's Project Loon, which were pursued around 2011, have so far proved unsuccessful. Loon wound down in January 2021; the business closed after failing to find a path to profitability, despite ostensible technical successes.

There may yet be a case for HAPS using solar-powered drones, or blimps, for communications or for (drone) detection use-cases. As pseudo satellites, they would have a latency edge over LEOs (roughly a quarter of a LEO's signal round-trip). Emerging AI-driven cognitive radio models could also allow HAPS platforms to automatically sense, share and reuse terrestrial mobile bands (like 2.1 GHz) or satellite Ka-bands dynamically, without causing ground interference.

In terms of D2D at least, LEOs seem to have all the momentum. For this reason, we have decided not to pursue this category and to focus instead on use cases closer to earth.

Low altitude air-ground-air communications

The anticipated mass deployment of drones for transportation and delivery, infrastructure inspection, agriculture support, and for surveillance is likely to add the greatest pressure on overall spectrum demand.

Commercial services, such as Amazon's parcel delivery drones in Darlington, increasingly rely on public mobile and satellite networks under Ofcom's UAS Operator Radio licence[22] to enable secure, long-range, beyond-line-of-sight communication. While this may be adequate for limited early-stage deployments, this solution is unlikely to scale to as volumes increase, particularly as drone traffic management systems require reliable, interference-free links. Accordingly, drones are likely to intensify competition for both dedicated licensed spectrum and shared/coordinated bands during the next 10 to 15 years. As already highlighted in section 4.2, the RF payload for video, in the case of surveillance and inspection drones, while less critical in nature, will likely create further challenges – as will interference management, on account of the drone's elevation.

Separately, we see potential for tethered low-altitude platforms to extend mobile coverage, albeit tethered drones seem a more likely implementation than aerostats, for the reasons outlined in Section 7 below. These should not generate any claim for dedicated spectrum, since their intent is to extend the reach of existing IMT bands. However, the systems' elevation could create significant interference issues, which raises interesting questions around how the IMT spectrum portfolio could best be 'shared' between ground-based and airborne delivery platforms.

Airborne detection systems

Drone detection is set to become an increasingly important function, due the anticipated proliferation of airborne assets on one hand, and the threats posed by malicious agents on the other. Airborne detection may involve:

- passive RF detectors and spectrum analysers, that listen to the bands where drones already communicate with controllers;
- passive radar, using emerging passive coherent location (PCL) systems that leverage ambient third-party transmissions (e.g. commercial FM radio, television, or cellular towers) to bounce off low-altitude drones without requiring any dedicated or new spectrum assignments; and
- active radar, which would be needed for example to detect hostile, autonomous drones that fly in radio silence.

22 Ofcom Statement: Spectrum for Unmanned Aircraft Systems (UAS), June 2022. This provision allows the use of send/receive radio equipment on drones operating in existing IMT bands, providing connectivity with terrestrial mobile and satellite D2D.

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Secure links would be required for control as well as to transmit detection data. This falls within the air-ground-air category discussed above. Active drone radar itself may fit existing spectrum. If it were to require dedicated bandwidth, this would likely involve higher frequency bands. As new spectrum claims under 10 GHz seem unlikely, and notwithstanding the high societal importance of this aspect, we decided to exclude it from further study within this report.

Terrestrial guidance

Rising concerns around GPS denial and positioning resilience drive a need for alternative or complementary terrestrial positioning, navigation, and timing (PNT) solutions that do not depend solely on satellite signals – since a sustained GNSS outage could cascade across multiple sectors simultaneously. Terrestrial systems such as eLoran (enhanced long-range navigation), or new dedicated PNT services using sub-10 GHz spectrum are being explored as a sovereign backup capability, giving the UK an independent means of maintaining accurate positioning and timing if satellite signals are degraded or denied[23]. This shift represents a meaningful new category of spectrum demand, distinct from traditional communications use cases. It will likely require dedicated allocations designed for wide-area coverage, resilience, and interoperability with existing GNSS infrastructure.

Private mobile networks and teleoperations

There is considerable overlap between private mobile networks (PMNs) and teleoperations, and both are growing in prominence. PMNs can be delivered in several ways, including through network slices provided by existing mobile operators or through separate deployments using dedicated, shared or unlicensed spectrum. However, PMNs are too broad in scope to be treated as a distinct ‘use case’, whereas the monitoring, control and/or automation of teleoperations is more specific.

As argued in Section 4.2, the connectivity needs of a broad range of teleoperations should be adequately served by existing mobile infrastructure, or by dedicated networks using shared or unlicensed spectrum under existing provisions. Some applications may be considered mixed cases, with potential claims on additional spectrum either focused on frequencies above 10 GHz or less clearly justified in lower bands.

Agritech is one set of use cases that stands out, given its typically rural setting, where connectivity may be lacking. However, it may fit more naturally within our rural portfolio category, discussed below, which we also consider a more fruitful area for further investigation as part of this study.

Rural portfolio

A portfolio of spectrum assets that can be accessed for rural and remote use cases may be envisaged to support:

- the needs of for monitoring, telemetry, supervisory control and automation for agritech, DER and other public, utility and private assets, especially within a rural setting; and
- community wireless networks to provide connectivity to the public, local government and businesses.

The rural portfolio effectively brings together multiple community and industry stakeholder groups within a single, cross-sector rural infrastructure theme.

On the community networks side, important policy drivers include ‘levelling up’, digital inclusion and the provision of rural public services. The rural digital divide has proved a persistent challenge, attracting significant attention from local and regional authorities as well as central government. The Shared Rural Network programme is one example. Another is the DCMS Digital Connectivity Infrastructure Accelerator (DCIA) pilot programme, launched in February 2022 to promote and accelerate 5G deployment using public-sector real estate assets.

DCIA attracted significant participation from local and regional bodies with a strong rural focus. The authors of this report regularly heard public servants in these areas describe the difficulty of securing meaningful engagement from mobile network operators, even where local public-sector real estate assets were offered free of charge for digital infrastructure deployment.

Local initiatives to step in and deploy local infrastructure using spectrum under existing Shared Access or Local Access Licence provisions might appear to be a way forward. Neutral-host models have also been envisaged, however there

23 See for example Inside GNSS, ‘UK Commits £155 Million to eLoran, Timing and GNSS Monitoring in Major PNT Resilience Push’, November 2025.

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appears to be some resistance from MNOs to participate in such initiatives, and significant barriers to integration with national mobile networks and services persist[24].

On the industry and agriculture side, access to a rural portfolio may touch on important societal issues such as:

- the energy transition and Net Zero, within the context of distributed energy and its management;
- food security, within the context of agritech; and
- rural productivity.

A strong case may exist for additional spectrum access for DER and remote telemetry in rural UK settings, primarily to overcome lacking coverage from existing fixed and mobile infrastructures, and to avoid unduly hight fibre-backhaul costs that might otherwise be needed. The lack of suitable coverage also underpins the case for a rural portfolio supporting agritech as well as other industry use-cases within these settings. We expand on this in section 6.

Terrestrial device-to-device communications

A first application within this category includes direct device-to-device communications and connectivity tethering needs for emergency services within the context of ESN, using the emerging Sidelink technology, as alluded to earlier in this report. We see this critical use case as a strong candidate for dedicated spectrum provisions. Whether such bandwidth could be made available to other spectrum users on a secondary basis, subject to priority access for emergency responders, may be worth exploring.

A second application is direct device-to-device communications between autonomous vehicles under the V2X umbrella, including peer-to-peer data exchange without cellular routing, shared telemetry, as well as for rapid-response safety data exchange (requiring ultra-low latency). The latter is required for real-time collision avoidance and coordinated autonomous driving manoeuvres. The question, already raised earlier in this report, is whether sufficient spectrum is being made available for V2X.

Over and above V2X, provisions may be needed for device-to-device communications between ground-based drones and robots, including connectivity tethering, where clusters of drones straddle the edge of mobile and satellite coverage.

Personal Area Networks (PANs) are a further use case within the device-to-device category. These encompass short-range connections - typically within a few metres - between a person's devices. A PAN usually links devices such as smartphones, laptops, tablets, keyboards and mice, headsets, printers, connected wearables and/or smart home devices. Some items may be wired through USB connections, the remainder wireless, using Bluetooth, Near Field Communications (NFC), Zigbee and similar technologies. As PANs may carry increasing numbers of devices per person, including in future more sensors, tags and the like, local short-range capacity may become increasingly contended. This could underpin a case for increased allocations for unlicenced low power uses.

Finally, a device-to-device SOS broadcast function might be envisaged, using a sliver of low band spectrum. The idea is that outside mobile or satellite coverage, users in distress might activate the function from their smartphones. These would broadcast short SOS messages intermittently, containing SIM details, latest available geo-location, as well as the time the alert was first raised. These SOSs could be relayed automatically to emergency responders by nearby smartphones and other devices – either directly, if the latter are connected to wider networks, or on a 'store and transmit' basis as and when connectivity is re-established. As an added benefit, a single SOS relayed by multiple devices may help locate the emergency with greater precision via triangulation.

Similar SOS capabilities could also extend to ground-based drones and robots, if these find themselves stranded without direct network coverage. Search and rescue drones could also be sent to listen for SOS signals near the last known location of the stranded device - or indeed of the smartphone held by a missing person.

Pop-up and nomadic networks

Short notice, short duration licences can be obtained in the 2.3 GHz band in the UK, with a maximum duration of 14 days and a (non-guaranteed) three-day interval between application and grant[25]. This fast-track process is a major improvement in speed, flexibility, and cost compared to standard Shared Access Licences (SAL) and traditional PMSE pathways. Better

24 Source: Coleago stakeholder interviews (under Chatham House rules)

25 Ofcom Statement, 'Enabling short notice, short duration licences in the 2.3 GHz band', December 2025

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still would be instantly issued licences that could be used in a range of situations, across media and construction, for example, as well as PMSE.

Low-altitude tethered or untethered drones could conceivably be used to deliver the coverage of 'pop-up' networks under such licences.

5.2 Selected use cases for expanded research

The following longlist was drawn up from the categories and use cases recorded in Exhibit 3. We excluded space-based and HAPS platforms, as well as airborne detection, on the grounds that their bandwidth requirements are likely to be concentrated at frequencies above 10 GHz. Private mobile networks and teleoperations were also excluded, because some of the applications with greater potential dependence on new spectrum access are already reflected in the rural portfolio category.

Exhibit 4: Long list of categories and use cases for expanded research

Category	Use cases
Low Altitude Air-Ground-Air Communications	– Low altitude platforms for connectivity (tethered drones or aerostats) – Autonomous drones for asset monitoring – Autonomous drones for transportation and delivery
Terrestrial Guidance	– Terrestrial guidance systems will be required if GPS is blocked or impaired. – Indoor positioning and navigation
Rural Portfolio	A spectrum access portfolio for rural/remote networks, to support critical as well as non-critical connectivity use cases such as: – Monitoring, telemetry, supervisory control and automation for agritech, DER and other public, utility and private assets – Community wireless networks for public and local government and business use
Terrestrial device-to-device Communications	– device-to-device communications and connectivity tethering needs for ESN – device-to-device communications between autonomous vehicles (V2X) – device-to-device communications between ground-based drones/robots (over and above V2X), including connectivity tethering, when operating outside mobile and satellite coverage – Personal area networks – device-to-device SOS broadcast function
Pop-up and Nomadic Networks	– Temporary, localised licences issued instantly for PMSE, media and construction – Drone-enabled networks

Source: Coleago, based on literature research and stakeholder interviews

As per the terms of reference, the final selection of use cases for deeper analysis within this study would need to include two to three use cases:

- with high cross-sector relevance;
- that address under-represented and/or fragmented stakeholder groups; and
- with strong links to UK national strategies and/or critical national infrastructures (CNI).

'Under-represented' was taken to exclude potential spectrum use cases that were already being given ample attention by Ofcom. Because of the high proportion of use cases that fit these criteria, we also considered growth potential over a 10 to 15-year timescale, as well as the potential suitability for flexible, shared access.

Our next step was an evaluation at category level, as shown below.

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Exhibit 5: Category-level assessment

Categories → / Criteria ↓	Rural Portfolio	Terrestrial device-to-device	Low Altitude Air/Ground/Air comms	Terrestrial Guidance	Pop-up and Nomadic Networks
Cross-sector relevance	High	Medium	Medium–High	Medium	Medium–High
Under-represented / fragmented	High	Low	Fragmented but not under-represented	Low (likely prime future policy focus)	High
Link to national strategies & CNI	High	Medium–High	High	High	Medium
10–15 yr growth potential	High	High	High	Spectrum need unlikely to scale with demand	Medium–High
Suitability for flexible / shared access	High	Low with IMT, high with shorter-range V2X	Medium-High	Medium	High (under CBRS-type mechanism)
Comments:	Bundles agritech, distributed energy, utilities and community networks into a single cross-sector "rural infrastructure" theme	Clear public safety and resilience fit, but ESN emphasis counters 'under-representation'	Touches energy, transport, emergency response and inspection use cases	Critical in GPS-denied environments for transport and CNI, but more niche in terms of overall spectrum demand	PMSE, construction, events, temporary public-sector deployments; good for testing instant local licensing concepts
Coleago view of fit with criteria	#1	#4 (not under-represented)	#3	#5	#2

Source: Coleago

Terrestrial device-to-device and terrestrial guidance are both unquestionably important categories from a safety and resilience perspective, but these were excluded as a categories from our shortlist on the grounds that:

- Terrestrial device-to-device stakeholder groups (ESN, V2X) are well represented, with the main use cases already attracting significant attention from Ofcom;
- Terrestrial guidance appears to be more niche in terms of overall spectrum demand, with spectrum needs that seem unlikely to scale with demand for it.

This further distillation pass leaves us with the following short-list of use cases for further analysis:

Exhibit 6: Shortlist of use cases

Categories→	Rural Portfolio		Low Altitude Air/Ground/Air		Pop-up / Nomadic Networks	
Use cases → / Criteria ↓	Monitoring & Automation	Community Networks	Aerial platforms	Autonomous drones	Instant local licences	Drone-extended networks
Cross-sector relevance	High (spans agriculture, energy, utilities and other rural assets)	High (local government, SMEs, citizens in rural areas)	Medium–High (energy, transport, infra, emergency responders)	Medium–High (infrastructure operators across sectors)	Medium (construction, media/events, some public-sector)	Medium–High (emergency services, field engineers)
Under-represented / fragmented	High (many small/fragmented asset owners and solution providers)	Low (community and local authority initiatives)	Medium-Low (fragmented but powerful infra lobbies)	Medium–Low (fragmented but powerful infra lobbies)	High (lots of small, episodic users)	Medium–Low (fragmented but powerful infra and ESN lobbies)

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Policy / national strategy link	Strong food security, Net Zero, smart grids, rural productivity	Strong levelling-up, digital inclusion, rural public services	Strong resilience, disaster response, infra support	Strong infrastructure efficiency, safety, maintenance	Moderate infrastructure delivery, creative sectors	Strong resilience and continuity in hard-to-reach areas
10–15 yr demand signal	High long-term growth in sensing, robotics, automation	Medium/High steady expansion of rural broadband and local platforms	High growth in hybrid terrestrial/NTN and aerial platform use	High increasing automation of asset monitoring	Medium tied to construction and events cycles	Medium growth in remote infrastructure installations
Spectrum / access innovation potential	High strong case for rural sharing and local licences across sectors	High community-owned/ shared spectrum and local authority models	Very high combinations of terrestrial, airborne and NTN, dynamic corridors	High corridor or route-based licensing and situational access	Very high instant, time- and location-bound authorisation models	Very high ad-hoc extension of coverage using drones on demand
Comments:	Natural 'workhorse' rural portfolio use case; mixes low-rate telemetry with higher-rate automation traffic	Positions spectrum clearly as a rural public good; simple narrative for policymakers	Visually powerful and clearly future-looking; illustrates cross-domain coordination	Very intuitive CNI example; links spectrum to tangible cost and safety benefits	Clean, concrete example of dynamic licensing; episodic demand but rich for policy design	Strong for resilience narrative; bridges Pop-up and Air/Ground/Air concepts in one use case
Coleago view of fit with criteria	#1 under-represented, high growth	#6 underserved but not under-represented	#5 new area but category not under-reps.	#4 new area, high growth but not under-reps.	#2 under-represented, significant policy issues	#3 new use case, complex management issues

Source: Coleago

During our engagement with the UK SPF, there was some debate around our assessment of fit with the criteria articulated in the terms of reference for the study. In particular:

- There was stronger interest in aerial platforms, with one member remarking that "future connectivity requirements of drones and other aerial platforms are likely to be more interesting from a growth and innovation perspective; in addition to command-and-control, payloads such as CCTV and other monitoring payloads could demand high levels of bandwidth"[26].
- Views differed around Instant Access Local Licences and whether Ofcom's new 2.3 GHz short-notice, short-duration licences already addressed these adequately - but this use case was excluded on the basis that CBRS-style approaches had already been considered by Ofcom.

Following stakeholder discussions, the following use cases were agreed upon for further research. We expand upon these in the next sections.

26 Source: Coleago stakeholder engagement (under Chatham House rules)

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Exhibit 7: Selected use cases for further study

Category	Use Case
Rural Portfolio	(1) Monitoring, telemetry, supervisory control and automation for agritech, Distributed Energy Resources and other utility / private / public assets
Low Altitude Air/Ground/Air	(2) Aerial Platform communications and infrastructure support
Low Altitude Air/Ground/Air	(3) Temporary drone-enabled network extension for field comms (ESN, mountain rescue, field engineer communications)

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6. Use Case 1 – agritech, telemetry and distributed energy resource management

6.1 Expected demand

Demand for rural monitoring and automation in the United Kingdom is expected to grow substantially over the next 10 to 15 years. This demand will be driven by the need to improve agricultural productivity, manage increasingly complex infrastructure, support the transition to a decentralised energy system and strengthen the resilience of rural communities. The use case encompasses three related but distinct classes of demand: agritech, telemetry for rural infrastructure and distributed energy networks.

The number of connected devices is likely to increase significantly and there are broad estimates available for certain applications. Many users are small businesses, farms, local authorities and infrastructure operators whose requirements are fragmented and not recorded consistently. Furthermore, the volume of data generated by each device will vary widely. A soil sensor may transmit only a few messages each day, while an autonomous agricultural machine or remote inspection camera may require continuous connectivity and substantial uplink capacity.

Demand should therefore be assessed in terms of the number and geographical distribution of connected devices, the criticality of the applications and the service characteristics required rather than traffic volumes alone. Rural monitoring will generally require extensive coverage and reliable access across areas where the commercial case for conventional mobile infrastructure is weak. As applications progress from monitoring to control and automation, requirements for availability, latency, security and resilience will become increasingly important.

Agritech

Agricultural technology is expected to become an increasingly important source of rural connectivity demand going forward. UK agriculture faces persistent pressure to improve productivity, reduce its dependence on seasonal labour, use water and agricultural inputs more efficiently and adapt to changing climatic conditions. Digital technologies will help farmers address these challenges by enabling more precise management of crops, livestock, machinery and natural resources.

Initial demand will continue to arise from relatively simple monitoring applications. These will include soil moisture and nutrient sensors, local weather stations, crop condition monitoring, livestock tracking, animal health sensors, irrigation controls and the monitoring of fuel, feed and other farm supplies. Individual devices may generate very little traffic, but they could be deployed in large numbers across extensive and sparsely populated areas. Their principal communications requirements will be wide area coverage, low energy consumption, low equipment cost and the ability to operate unattended for long periods.

Over time, demand is expected to move beyond monitoring towards more active control and automation. Precision irrigation systems will combine soil, weather and crop data to determine when and where water should be applied. Variable rate equipment will adjust the application of seed, fertiliser and crop protection products in response to local conditions. Connected livestock systems will support earlier identification of disease or distress. These applications will require more frequent communications and greater assurance that messages are received accurately and within the required period.

Robotics and autonomous machinery are likely to create a more demanding connectivity requirement. Potential applications include autonomous tractors, robotic harvesting, mechanical weeding, automated feeding and livestock management. The Government is already supporting robotic harvesters, animal health monitoring and variable irrigation through its Farming Innovation Programme. More than 290 projects involving over 600 organisations had received support through the programme by April 2025, with over £150 million committed by government and a further £54 million secured from private investment[27]. This provides evidence of a developing innovation base, although commercial adoption remains at an early stage.

Autonomous equipment will require dependable command, control and positioning information. Some machines may operate largely independently and require connectivity only for supervision, software updates and the transfer of operating data. Others may require continuous remote oversight or interaction with other machines. Cameras, computer vision systems and remote diagnostics could generate substantial uplink traffic, particularly where data is processed away from the farm. Requirements may therefore range from very low-capacity sensor connections to higher capacity links supporting video, artificial intelligence and coordinated autonomous operations.

[27] https://defrafarming.blog.gov.uk/2025/04/22/fip-guidance-now-available-for-upcoming-funding-competitions/

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Agritech demand will vary considerably by agricultural activity. Arable farms may create demand across large open areas during planting, crop management and harvesting. Horticulture may require much greater device density and capacity within a smaller area, particularly where robotic harvesting and environmental controls are used. Livestock farming will place a premium on coverage across grazing land and inside agricultural buildings. Forestry will require exceptionally wide coverage but may generate less frequent traffic.

By 2036 to 2041, digital farming is likely to involve a mixture of public mobile networks, satellite connectivity, local wireless networks and private systems. No single technology or frequency band will meet all requirements. Lower frequency spectrum will be particularly valuable for wide area coverage and penetration into buildings, woodland and uneven terrain. Higher frequency spectrum may be used around farm buildings or in fields where autonomous machinery requires greater capacity. Local or shared spectrum access could allow farms, equipment suppliers and rural service providers to deploy coverage where public networks are unavailable or cannot provide the required service quality.

Rural telemetry

Rural telemetry covers the monitoring and control of assets outside the agricultural sector. It includes water infrastructure, flood defences, environmental sensors, transport assets, forestry, public buildings and other utility, private or public infrastructure. Demand is expected to grow steadily as organisations seek better information about widely dispersed assets and replace manual inspection with remote monitoring.

Water companies are likely to deploy more sensors across reservoirs, treatment facilities, pumping stations and distribution networks. These devices can identify leaks, monitor pressure and water quality and provide earlier warning of equipment failure. Environmental agencies and local authorities will require sensors for river levels, flood risk, air quality, soil conditions, wildfire detection and habitat management. Transport telemetry may include the monitoring of rural roads, bridges, rail infrastructure and traffic conditions. Landowners and public authorities may also use connected cameras and sensors to monitor access, waste, fire risks and environmental compliance.

Most telemetry applications will generate modest amounts of data. A device may send periodic measurements or report only when a defined threshold is reached. However, the aggregate number of devices could become substantial as the cost of sensors falls and asset owners seek more detailed and timely information. Demand will also become more varied. Routine measurements may be delay tolerant, while flood warnings, equipment alarms and safety related messages may need to be transmitted immediately. Video monitoring, acoustic analysis and remote inspection will require materially greater capacity than conventional sensor telemetry.

The business case will often depend on avoiding site visits, detecting problems earlier and managing assets more efficiently. Connectivity costs must therefore remain proportionate to the value of each device and the information it provides. Long battery life and simple installation will be particularly important where sensors are located underground, beside waterways or in other difficult locations. Devices may remain in service for 10 years or more, making long term technology availability and protection from premature network closure important considerations.

Coverage is likely to be the principal constraint. Rural telemetry assets are frequently located precisely where public mobile coverage is weakest. These locations include valleys, woodland, remote roads, agricultural land and underground chambers. Nominal population coverage is therefore a poor indicator of whether the needs of rural telemetry users can be met. The relevant measure is geographical and asset coverage, including the ability to communicate from difficult physical environments.

The market is likely to remain fragmented. Individual asset owners may require only a small number of connections in any one location, which may not justify dedicated infrastructure. There is consequently a strong case for shared rural connectivity platforms capable of serving agriculture, utilities, public services and environmental monitoring. Aggregating demand across these sectors could improve the economics of deployment and reduce unnecessary duplication. Shared access to suitable low frequency spectrum, combined with public mobile and satellite services, may be required to provide dependable coverage.

Distributed energy resource management

Distributed energy networks are likely to create the largest and most operationally critical increase in rural connectivity demand. The electricity system is moving from a model based principally on large generators and predictable flows towards one involving millions of distributed and controllable assets. These will include solar installations, wind generation, battery storage, electric vehicle chargers, heat pumps, flexible commercial loads and community energy systems.

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The scale of this transformation is already apparent. The Government's Clean Power 2030 Action Plan envisages 45 to 47 GW of solar capacity, 23 to 27 GW of battery capacity and 10 to 12 GW of consumer flexibility by 2030[28]. These figures relate to the end of the present decade, and capacity is expected to grow further through the 2030s as transport, heating and industrial activity become more dependent on electricity.

The National Energy System Operator expects annual electricity demand in Great Britain to rise from around 290 TWh today to as much as 785 TWh by 2050[29]. Its scenarios indicate that the remainder of the 2020s will be followed by substantial growth during the 2030s as low carbon heating, electric transport and other forms of electrification expand. The 2036 to 2041 period will therefore fall within a particularly important stage of the energy transition.

Distributed assets will need to exchange data with suppliers, aggregators, distribution network operators and system operators. Communications will support metering, forecasting, fault detection, voltage management, demand response and participation in flexibility markets. Larger assets may require continuous monitoring and direct control, while smaller consumer devices may respond automatically to prices or instructions provided through an aggregator.

The number of communicating energy devices is likely to reach many tens of millions. There were already 41 million smart and advanced meters in homes and smaller business premises across Great Britain at the end of 2025. The Government intends for nearly all consumers to have working smart meters by 2030, and the communications system is expected to move to 4G before the closure of 2G and 3G networks by the end of 2033.

Traffic generated by each energy asset may remain modest, but the communications service will become more critical. Network operators will require accurate and timely information to understand local generation and consumption, manage two-way power flows and maintain voltage and frequency within acceptable limits. Flexibility markets will depend on the ability to coordinate large numbers of relatively small assets. A communications failure affecting a single domestic battery may have little consequence, but concurrent failures across thousands of devices could affect network operation.

Coverage, resilience and security will therefore be more important than raw capacity. Many renewable generation and storage sites are in rural areas where public mobile coverage may be incomplete or dependent on a small number of sites. Energy operators may require multiple communications routes or the ability to use alternative networks during an outage. Cyber security, device authentication and protection against interference will also be essential because distributed energy assets may influence the operation of critical national infrastructure.

Overall, distributed energy networks are likely to move rural connectivity from a largely administrative and monitoring function towards an integral part of electricity system operation. This will increase demand for reliable wide area coverage, predictable service quality and resilient access to spectrum. Public mobile networks will remain important, but dedicated utility systems, private networks, satellite links and shared rural platforms may also be required where commercial services cannot meet operational needs.

6.2 Expected connectivity and spectrum requirements

The rural portfolio covers a broad range of applications with different connectivity requirements. To assess how demand may develop over the next 10 to 15 years, the analysis considers three main areas:

- Agritech, comprising livestock monitoring and precision farming;
- Telemetry, comprising environmental monitoring and local authority and utility asset monitoring; and
- Distributed energy resource management.

Each area has different requirements in terms of coverage, capacity, latency, availability, mobility, resilience and security. They also differ in the number and type of devices likely to be connected and in the consequences if communications are unavailable. For each area, we therefore examine the principal drivers of connectivity demand, the likely scale and geographical distribution of connected devices and the characteristics of the communications service required.

The analysis then considers the technologies and spectrum that could meet these requirements over the next 15 years. These include public and private mobile networks, licence exempt technologies, satellite connectivity, potential new spectrum access arrangements and future mobile technologies. Importantly, increasing connectivity demand does not

[28] https://www.gov.uk/government/publications/clean-power-2030-action-plan/clean-power-2030-action-plan-a-new-era-of-clean-electricity-main-report

[29] https://www.neso.energy/news/bold-and-sustained-action-clean-energy-imperative-now-and-beyond-2030

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necessarily translate into a requirement for additional spectrum. In many cases demand may be met using existing spectrum if appropriate technology, coverage and access arrangements are available.

Having assessed the three areas separately, we identify the common requirements across the rural portfolio. These include the importance of low frequency spectrum for rural coverage, the potential role of shared and licence-exempt access, the contribution of mobile and satellite networks and the circumstances in which protected spectrum access may be required. This provides the basis for assessing whether current arrangements are likely to remain adequate over the next 10 to 15 years and where further policy or regulatory action may be warranted.

6.2.1 Agritech

Agritech can be divided into two main areas with significantly different connectivity and spectrum requirements: livestock monitoring and precision farming. Livestock monitoring is characterised by very large numbers of low power devices transmitting small amounts of data across extensive rural areas. Precision farming combines large numbers of fixed sensors with a much smaller number of connected agricultural machines which have greater capacity, availability and reliability requirements.

Livestock monitoring

Livestock monitoring covers the use of animal borne devices to monitor location, movement, health and reproductive status, together with fixed sensors monitoring pasture conditions, water supplies, gates and weather conditions. The individual connectivity requirement is very small, typically consisting of a few bytes transmitted periodically. However, this needs to be multiplied across potentially millions of devices which must be inexpensive, physically small and capable of operating for several years from a battery.

The principal requirement is therefore coverage rather than capacity. Devices need to operate across grazing land and other rural areas where conventional mobile coverage may be weakest. Lower frequencies are particularly attractive because they provide greater coverage for a given transmission power. Frequencies below 1 GHz, and potentially below 500 MHz where suitable spectrum is available, are therefore likely to be most appropriate.

Existing connectivity solutions only partly address this requirement. Public mobile networks can provide coverage in many rural locations but do not necessarily cover the whole farm and conventional subscription models can become expensive when applied to very large numbers of low value devices. Satellite connectivity is less suitable for small animal borne devices because of antenna, power and equipment constraints. Local low power networks such as LoRa can provide a cost-effective alternative but require sufficient network infrastructure to provide coverage across the area concerned.

The likely long-term solution is therefore a combination of technologies rather than reliance on a single network. Low power local networks could provide the primary connection across a farm or wider rural area, with cellular networks providing wider connectivity and backhaul where appropriate. The two should be regarded as complementary rather than competing technologies.

The spectrum requirement itself is modest. Livestock monitoring generates little traffic, has limited latency requirements and can generally tolerate occasional delays. Shared or licence exempt spectrum is therefore appropriate and there is little justification for dedicated protected spectrum. The more important issue over the next 15 years will be ensuring that suitable low frequency spectrum and affordable network arrangements are available to provide reliable rural coverage.

Exhibit 8: Livestock monitoring connectivity and technology requirements

Category	Requirement	Comment
Expected number of devices (nationally)	2 - 4 million by 2036–41	Livestock monitoring dominates by number. Around 33 million cattle and sheep are kept outdoors rather than housed, and at 5–7% take-up that gives roughly 2 million animal-borne devices. Sensors on crops, soil, water and farm buildings, and connected machinery, make up the rest.
Highest concentration of devices	1,000–10,000 per square kilometre in the most intensive locations	Devices are thinly spread across grazing and arable land. Concentrations occur only in glasshouses and intensive units, where many sensors sit within a small area.
Coverage type	National rural coverage, delivered locally or regionally	What matters is covering land and assets rather than population. Devices sit where animals graze and machinery works, which is exactly where the

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		commercial case for building conventional mobile coverage is weakest.
Indoor or outdoor coverage	Both, focus is on outdoor	Grazing land and open fields outdoors; barns, milking parlours, grain stores and equipment sheds indoors, where getting a signal through the structure matters more than distance.
Mobility	High	Animal-borne devices move continuously around a holding, and machinery moves across the fields being worked. Neither travels fast, so handing a device between transmitters is straightforward.
Bandwidth	0.001–10 Mbit/s typically; above 20 Mbit/s where live video is used	Animal and environmental sensors sit at the very bottom of this range. Each device sends the equivalent of a few tens of megabytes per month at most — location, movement, temperature and activity readings. Even several million devices generate a negligible volume of data nationally
Latency	<60 seconds	Nothing in animal or environmental monitoring must arrive by a particular moment; response times are measured in minutes. Machinery guidance and any future remote operation set the tighter figure.
Availability	Medium for monitoring	As herds move, periods of lost measurements due to low coverage are periodic in nature. On the network side, best effort availability is satisfactory
Can existing infrastructure be used?	In general - no	Satellite cannot reach a device this small, this power-limited and this close to the ground. Mobile networks may reach farmyards and roads but not reliably across grazing land, and the monthly charge per device is significant at scale. The gap is commercial as much as technical.
If separate network what frequency ranges will be required	Sub 1GHz/as low as possible to increase coverage	Lower frequencies cover far more ground for the same transmit power. Since each device must be cheap and run for years on a small battery, the amount of ground covered per unit of power is what determines whether the whole use case is affordable.
If separate network can frequency resources be shared?	Yes, this is a necessity due the scarcity of spectrum blocks	Traffic is occasional, tolerant of delay and tolerant of competition for the airwaves. Nothing in this use case requires protected access.

Source: Coleago

The principal conclusions for livestock monitoring are therefore:

- low frequency spectrum is important, ideally below 1 GHz and potentially below 500 MHz, to maximise rural coverage and battery life;
- aggregate capacity requirements are very low despite potentially millions of connected devices;
- latency requirements are modest, with most applications able to tolerate delays measured in minutes;
- shared or licence exempt spectrum should generally be sufficient;
- cellular and local low power networks are likely to be complementary; and
- the principal challenge is achieving affordable coverage across agricultural land rather than providing additional capacity.

Precision farming

Precision farming has a different connectivity profile. It includes fixed sensors monitoring soil, crops, weather and environmental conditions, alongside connected agricultural machinery such as tractors, combines, sprayers and planters. Fixed sensors have requirements similar to those used for livestock monitoring, but agricultural machinery can accommodate larger antennas, higher power consumption and more sophisticated communications equipment.

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The majority of devices will continue to be relatively simple sensors generating small amounts of data. However, a much smaller number of connected machines will account for most of the traffic. These machines increasingly depend on precision guidance, telemetry, remote diagnostics and software updates. Over the next 15 years, greater automation and supervised autonomous operation could add live video, remote intervention and direct communications between machines.

Coverage remains important because machinery operates across the whole farm rather than only close to farm buildings and roads. However, unlike animal-borne devices, agricultural machinery can make effective use of satellite connectivity. Non-terrestrial networks are already being incorporated into agricultural machinery and are likely to become increasingly important as a means of filling gaps in terrestrial coverage. Fixed sensors are less suited to this approach because of their much lower value, power and capacity requirements.

The spectrum requirement is consequently more varied than for livestock monitoring. Fixed sensing will favour low-frequency spectrum below 1 GHz, where coverage and power efficiency remain the priorities. Connected and increasingly autonomous machinery may also require access to spectrum between 1 and 6 GHz where greater capacity is needed. Satellite connectivity can provide wide-area coverage, while local private networks or direct device-to-device communications could support autonomous machinery operating within a farm.

Availability will also become more important. A missed soil measurement is unlikely to have significant consequences, whereas loss of connectivity to machinery during a short planting or harvest period could be costly. Future autonomous or remotely supervised machinery could require still higher levels of reliability and protection. Shared spectrum should therefore remain suitable for routine sensing, while machinery control, guidance and autonomous operation may require more protected forms of access.

Exhibit 9: Precision connectivity and technology requirements

Category	Requirement	Comment
Expected number of devices (nationally)	~3 million by 2036–41	Two populations of very different size. Fixed sensing dominates by count: across roughly 6 million hectares of cropland, sensing at one device per 5–10 hectares gives under a million, and finer resolution takes it to several million. Connected machinery adds a few hundred thousand units at most, but each carries far more traffic than a soil probe
Highest concentration of devices	20–100 per square kilometre in open fields; several thousand under glass; machinery negligible by count	Open-field sensing is thin, a probe representing a management zone rather than a plant. Protected cropping concentrates sensing and control into a very small footprint and produces the highest densities in agriculture. Machinery is sparse — a handful of vehicles across a large holding — but each is a heavy user.
Coverage type	National, concentrated in arable and horticultural areas	Cropland is generally flatter and more evenly distributed than grazing land, so coverage obligations are simpler than for livestock. The requirement is nevertheless broadly spread - both sensing and machinery work away from the roads and buildings where coverage is strongest.
Indoor or outdoor coverage	Both, but focus is on outdoor	Open fields and working machinery outdoors. Glasshouses, polytunnels, grain stores and machinery sheds indoors, where signals must pass through structures, dense foliage and metal framing.
Mobility	High	The sensing base is fixed for a season or longer. Machinery moves continuously across the worked area during operations, at working speed rather than road speed.
Bandwidth	0.001–10 Mbit/s typically; above 20 Mbit/s where live video is used	Soil, moisture and weather readings are a few bytes every few minutes. Machinery is an order of magnitude apart: operating data, field records, remote diagnostics, and — as supervised driverless working arrives — live video for oversight. Almost all the traffic in this use case comes from a very small proportion of the devices.

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Latency		Soil and weather readings have no deadline. Environmental control is measured in seconds. Machinery guidance and any remote oversight of driverless working set the tightest requirement in agriculture, though still undemanding by wider standards.
Availability	Medium for sensing; medium for protected cropping and for machinery during working windows – current technology must be able to perform offline.	A missed soil reading is inconsequential. Failure of glasshouse control on a hot day can destroy a crop within hours. Loss of connectivity to machinery during a short sowing or harvest window is expensive out of all proportion — so the requirement is concentrated into a few weeks of the year.
Can existing infrastructure be used?	Partly, dependent on access model	Machinery is already served commercially by satellite, following manufacturer retrofit programmes from 2024, because a powered vehicle can carry the equipment and the aerial. Fixed sensing is not: mid-field coverage is unreliable, and a per-device monthly charge does not survive multiplication by thousands of sensors. The gap is at the low-cost end of the use case, not the high-value end.
If separate network what frequency ranges will be required	Below 1 GHz for sensing; 1–6 GHz where machinery needs capacity	Below 1 GHz for sensing; 1–6 GHz where machinery needs capacity
If separate network can frequency resources be shared?	Yes, for sensing; not for control or guidance	Sensor traffic tolerates competition for the airwaves. Environmental control, machinery guidance and any driverless operation need protected access, because failure carries crop loss or a safety consequence.

Source: Coleago

The principal conclusions for precision farming are therefore:

- low frequency spectrum will remain important for large scale fixed sensing and rural coverage;
- connected machinery will generate substantially more traffic than fixed agricultural sensors;
- satellite connectivity is likely to play an increasing role in providing coverage to agricultural machinery;
- local private networks and device to device communications could become more important as agricultural machinery becomes increasingly autonomous;
- capacity requirements will remain modest for most applications, but live video and remote supervision could create higher localised demand; and
- shared spectrum should be sufficient for routine sensing, but more reliable and protected access may be required for machinery control, guidance and autonomous operation.

Overall, agritech is unlikely to create a significant national capacity requirement. Its importance for spectrum policy arises instead from the need to connect large numbers of devices and increasingly sophisticated machinery across rural areas where the economics of conventional network deployment are weakest. The principal challenge over the next 15 years will therefore be to combine low-frequency terrestrial coverage, local networks, cellular connectivity and satellite services in a way that provides affordable and reliable connectivity across the entire agricultural environment.

6.2.2 Telemetry - environmental and local authority asset and utility monitoring

This use case covers a diverse range of telemetry applications, including environmental monitoring, water and utility infrastructure, connected street lighting, social housing sensors, telecare and alarm systems. Despite their different purposes, these applications have remarkably similar connectivity requirements. The common requirement is to connect potentially very large numbers of inexpensive devices that transmit small amounts of data, are often battery-powered and may remain in service for 10 years or more.

The principal challenge is therefore coverage and penetration rather than capacity. Many devices are located precisely where communications are difficult. Environmental and utility sensors may be positioned beside rivers, in valleys, along remote infrastructure routes or below road level. Other devices are located inside buildings, basements, plant rooms,

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stairwells and equipment cabinets. In many cases, the ability of a signal to penetrate a structure is as important as its ability to cover distance.

The number of connected devices could increase substantially over the next 15 years, potentially reaching 10 to 25 million nationally. However, each device will generally transmit only small and infrequent messages. Even with millions of connections, the aggregate volume of traffic will remain very small compared with consumer mobile traffic. The important network constraint is therefore likely to be the number of devices that can be supported and the frequency with which they communicate, rather than the total volume of data carried.

Unlike agritech, most of these devices are fixed. This simplifies the connectivity requirement because mobility and handover between network sites are not significant issues. However, the large proportion of devices located indoors, underground or in other difficult physical environments place greater emphasis on signal penetration. This points strongly towards the use of spectrum below 1 GHz, where propagation characteristics are better suited to both wide-area coverage and penetration into buildings and below-ground locations.

Most telemetry applications have modest latency and availability requirements. A delayed environmental or asset reading will generally have little immediate consequence. There are, however, important exceptions. Utility monitoring may need to continue during power outages and other periods when public communications networks are themselves under stress. Alarm and telecare applications also require more frequent confirmation that connections remain operational. These applications therefore require higher levels of availability than routine environmental monitoring.

Exhibit 10: Telemetry connectivity and technology requirements

Category	Requirement	Comment
Expected number of devices (nationally)	~ 10–25 million by 2036–41	Composed of: connected streetlighting rising from around 2 million nodes today to 4–6 million as central control becomes standard on replacement; social housing environmental sensing as the largest single component, at three to five sensors across a proportion of roughly 4 million social homes in England; personal alarm and telecare users at around 2 million, all requiring migration; monitored alarm connections at 1–2 million
Highest concentration of devices	Thousands to tens of thousands per square kilometre in dense housing; a few hundred per square kilometre in urban street furniture; very thin elsewhere.	Most of the estate is dispersed across the country, but the housing component concentrates into exactly the areas where coverage is already strongest, so the density peak and the coverage problem do not coincide.
Coverage type	National, including rural and hard-to-reach locations.	Environmental and utility assets sit on riverbanks, in valleys and along network routes chosen by topography rather than population. Housing and street furniture are urban.
Indoor or outdoor coverage	Both, and the indoor requirement is the defining characteristic.	A large share of this estate sits in stairwells, voids, plant rooms, basements, roadside chambers and below ground level. Getting a signal through the structure, rather than across distance, is what sets the requirement for much of it.
Mobility	None	Every device is fixed for its working life, typically 10 years or more. This removes the handover problem entirely and permits fixed aerials and, where accessible, mains or solar power.
Bandwidth	Below 0.01 Mbit/s per device	A few tens of megabytes a month at most. Even at 25 million devices the national total is negligible against consumer traffic. Bandwidth is not the constraint anywhere in this use case.
Latency	Generally none, with two specific exceptions	Storm overflow discharge information carries a statutory one-hour publication deadline from the start and end of each discharge, which imposes an end-to-end requirement absent elsewhere. Alarm signalling

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		requires proof that a connection is still alive within ninety seconds to a few minutes under safety standards
Availability	Medium for most monitoring; high for utility networks and alarm signalling.	The distinguishing requirement in this use case is continued operation during power cuts, when public mobile networks themselves degrade — which is precisely when utility monitoring and alarm signalling matter most.
Can existing infrastructure be used?	Partly, and less than for agriculture	Mobile networks reach most of this estate geographically, but two gaps remain – alarm monitoring was nearly free on the PSTN, but mobile subscription will push OPEX up. For rural devices the networks of whatever type will need expansion
If separate network what frequency ranges will be required	Below 1 GHz	Wide-area coverage economics demand it for dispersed, battery-powered devices. Independently, the indoor and below-ground share of the estate demands it for penetration
If separate network can frequency resources be shared?	Yes	The technology requires frequency sharing due to its constrained nature (very small block of spectrum).

Source: Coleago

Existing infrastructure can meet some, but not all, of these requirements. Public mobile networks already cover much of the country, but coverage may remain inadequate at remote assets and within or below buildings. Conventional mobile subscription models may also be uneconomic when applied to millions of low-value connections. The closure of the PSTN and retirement of earlier generations of mobile technology will further increase the importance of finding sustainable alternatives for existing telemetry and alarm services.

Low-power networks such as LoRa provide a cost-effective solution for many telemetry applications and are likely to remain important over the next 15 years. Their suitability will depend on sufficient network infrastructure being deployed to accommodate the growth in connected devices. Public mobile networks, particularly narrowband cellular technologies, can provide a complementary solution where greater coverage, availability or managed service quality is required. As with agritech, the likely outcome is therefore a combination of technologies rather than a single network solution.

The principal conclusions for telemetry are:

- device numbers could increase substantially, potentially reaching 10 to 25 million nationally over the next 15 years;
- aggregate capacity requirements will remain very low because individual devices transmit only small amounts of data;
- coverage and signal penetration are considerably more important than bandwidth;
- spectrum below 1 GHz is particularly well suited to the requirement because devices are widely dispersed and many are located indoors, underground or in other difficult environments;
- most applications can tolerate shared spectrum and relatively modest latency and availability;
- utility monitoring, alarms and telecare have higher availability requirements, particularly during power outages and other periods of network disruption;
- public mobile and low power networks are likely to provide complementary solutions; and
- commercial arrangements will need to support very large numbers of low value connections without conventional per device costs becoming prohibitive.

Over the next 15 years, demand is likely to be driven by three developments in particular. First, the closure of the PSTN and retirement of older mobile technologies will require a substantial existing estate of telemetry and alarm connections to migrate to new platforms. Second, statutory requirements will increase the deployment of environmental, housing and utility monitoring, making some of this growth more predictable than demand driven purely by commercial adoption. Third, continuing pressure to reduce operating costs is likely to encourage utilities and local authorities to replace manual inspection with permanent remote monitoring.

Overall, telemetry is unlikely to create a material requirement for additional spectrum capacity. Its significance arises from the scale of the device population and the difficulty of providing affordable and dependable connectivity to devices across a wide range of environments. The principal spectrum challenge is therefore to ensure access to suitable low-frequency

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spectrum and network arrangements capable of supporting millions of low-bandwidth connections economically over long periods.

6.2.3 Distributed energy resource management

Distributed energy resource management has more demanding connectivity requirements than the monitoring applications considered above. It covers the monitoring and control of distributed generation, battery storage and other flexible energy assets connected to the electricity system. The number of connected assets is expected to increase significantly over the next 15 years as the electricity system becomes more decentralised and increasingly dependent on the active management of generation, storage and demand.

Unlike conventional telemetry, communications are required in both directions. Data must be collected from distributed assets, but instructions must also be sent to them to increase, reduce or stop generation, storage or consumption. The amount of data involved remains relatively small, but the reliability, latency and security requirements are considerably greater. A failure of conventional monitoring may result in missing information. A failure of Distributed Energy Resource Management communications can leave an asset uncontrollable and potentially affect the operation of the electricity system.

Coverage will be a particular issue. Many distributed energy assets will be located in rural areas where land and grid connections are available, rather than where communications networks provide their strongest coverage. Solar farms, wind generation, battery storage and other installations may therefore be situated towards the edge of existing mobile networks. Control equipment may also be located inside substations, cabinets, inverter housings and plant rooms. The requirement is consequently for both wide-area coverage and good penetration into buildings and equipment enclosures.

Lower-frequency spectrum, particularly below 1 GHz, is likely to be important because of its coverage and penetration characteristics. Existing public mobile networks and fixed broadband can support many domestic and commercial assets today, but their availability is generally designed around consumer requirements. As the number and importance of controllable distributed assets grow, this may no longer provide sufficient resilience for the more critical elements of the electricity system.

The key distinction is between monitoring and control. Routine monitoring can tolerate occasional delays or interruptions and can therefore use shared spectrum, public networks or other best-effort connectivity. Control functions have much more demanding requirements. Instructions may need to reach assets within seconds, connectivity must remain available during network or power disruption, and communications must be secure against interference or malicious attack.

These requirements mean that licence-exempt spectrum is unlikely to be suitable for critical control functions. The absence of interference protection and guaranteed availability makes it difficult to rely upon where communications form part of the operational control of the electricity system. Protected access is therefore likely to be required for the most critical applications, although this does not necessarily imply dedicated spectrum. Appropriate protection could potentially be provided through licensed mobile networks, private networks or shared-access arrangements offering sufficient quality of service and priority.

Exhibit 11: Distributed energy resources connectivity and technology requirements

Category	Requirement	Comment
Expected number of devices (nationally)	~ 0.5-2 million connections by 2036-41	Consisting of distribution-connected generation and storage sites, and rural assets lying beyond reliable broadband.
Highest concentration of devices	Low – 10’s per square mile	Field-scale generation, storage and rural premises are dispersed by their nature - solar farms and wind sites are sited by land availability and grid connection, not by population.
Coverage type	National	National, with the requirement concentrated where the network's edges are. Distribution networks extend furthest exactly where population is thinnest, so the connectivity gap and the generation sites coincide.
Indoor or outdoor coverage	Both.	Control equipment sits in cabinets, inverter housings, substations and plant rooms as often as in the open, so penetrating enclosures matters as much as covering distance.

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Mobility	None	Installations are fixed for their operating life, typically decades, which allows fixed aerials and permanent siting.
Bandwidth	Average 0.01 Mbit/s per device but can burst upwards	Traffic is balanced in both directions. Unlike the rest of the portfolio, where devices almost only send, instructions travelling out carry as much data as readings coming back. Volume is small; the symmetry is the distinguishing feature.
Latency	Seconds	Instructions to increase, reduce or stop generation operate on cycles measured in seconds, and delayed response can affect the stability of the electricity system. Modest by wider standards, but a step change from the minutes tolerated everywhere else in this study.
Availability	Very high, including during power outages	A failed connection here does not merely leave equipment unmonitored; it leaves it uncontrollable - turning a communications failure into an operational one at exactly the moment the network is under stress.
Can existing infrastructure be used?	Partly, and less than it appears.	Domestic assets in covered areas are adequately served by home broadband and public mobile today. Rural generation sites are not, and everything currently in use offers only consumer-grade reliability, which is probably sufficient at present scale but would not be at the scale expected over fifteen years
If separate network what frequency ranges will be required	Below 1 GHz	The coverage and penetration arguments are the same as elsewhere in this use case; what differs is that free-to-use spectrum is disqualified - limits on transmission time, absence of protection from interference and best-effort availability each rule it out independently.
If separate network can frequency resources be shared?	Yes, for monitoring.	Sensor traffic tolerates competition for the airwaves. Environmental control, machinery guidance and any driverless operation need protected access, because failure carries crop loss or a safety consequence.

Source: Coleago

The principal conclusions for Distributed Energy Resource Management are therefore:

- the volume of data generated will remain relatively small and additional capacity is unlikely to be the principal spectrum requirement;
- connectivity will increasingly support control as well as monitoring, making communications more operationally important;
- national coverage will be required, including rural locations where many generation and storage assets are situated;
- spectrum below 1 GHz is likely to be particularly valuable because of its coverage and penetration characteristics;
- latency requirements for control will be measured in seconds rather than the minutes that are acceptable for most telemetry applications;
- very high availability will be required for critical control functions, including during power outages and other periods of network stress;
- security will become increasingly important as large numbers of distributed assets become remotely controllable; and
- shared or best effort connectivity should remain suitable for routine monitoring, but critical control functions are likely to require protected access.

Overall, distributed energy resource management does not create a large requirement for additional spectrum capacity. The more important issue is whether sufficiently reliable, secure and widely available connectivity can be provided to a rapidly growing population of distributed assets. The challenge over the next 15 years will therefore be to develop an

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access model that combines the coverage advantages of low frequency spectrum with the protection, resilience and quality of service required for electricity system control.

6.2.4 Technology requirements

The three areas considered above have different applications and levels of criticality, but they share a number of important connectivity and spectrum requirements. Taken together, six common conclusions emerge for the rural portfolio.

Low-frequency spectrum is fundamental to achieving coverage economically. All three areas benefit from access to lower frequencies. For livestock, environmental monitoring and other dispersed battery-powered devices, the principal advantage is the greater coverage that can be achieved for a given transmission power. For local authority and utility applications, better penetration into buildings, basements, plant rooms and other difficult locations reinforces the same conclusion. Most monitoring applications therefore favour spectrum below 1 GHz, with the lowest practical frequencies offering the greatest coverage benefits. Precision farming machinery may additionally require mid-band spectrum where greater capacity is needed, together with satellite connectivity for coverage beyond terrestrial networks. None of the applications considered requires high-band spectrum.

Licence-exempt spectrum can support many monitoring applications, but existing arrangements may constrain wide-area networks. Current licence-exempt spectrum provides sufficient capacity for the small amounts of data generated by most monitoring devices. The more important constraints are permitted transmission power and duty cycles. These can limit the area covered by each network site and therefore affect the economics of providing widespread rural connectivity. There would be merit in reviewing whether existing licence-exempt provisions remain appropriate for the much larger populations of rural and fixed monitoring devices expected over the next 15 years. In particular, the case for higher-power, network-capable access at lower frequencies warrants further investigation.

Networks need to be designed specifically for large numbers of low-bandwidth devices. Most devices within the rural portfolio will transmit small amounts of data periodically rather than maintain continuous high-capacity connections. Conventional cellular protocols can be inefficient for this type of traffic because establishing and closing a connection may consume more network resource than transmitting the data itself. Technologies designed for large-scale machine communications are therefore important. The objective should be to support very large numbers of connections efficiently rather than to provide additional bandwidth.

The requirement for licensed spectrum capacity is relatively small. Even if the number of connected devices grows substantially, aggregate traffic from monitoring applications will remain modest. Existing narrowband cellular technologies can support very large numbers of devices using a small amount of spectrum. The principal requirement is therefore unlikely to be a new spectrum allocation. A more important issue is ensuring widespread rural deployment of appropriate narrowband capabilities and making them available on commercial terms that are viable for millions of low-value connections.

Satellite connectivity will have an important but selective role. The suitability of satellite varies significantly according to the type of device. It is already a practical solution for powered agricultural machinery that can accommodate the necessary antennas and communications equipment. It could also provide secondary or resilience connectivity for some fixed outdoor assets. It is much less suitable as the primary connection for small animal-borne devices or sensors located indoors, underground or in other locations without a clear view of the sky. The development of direct-to-device satellite services should therefore be monitored, but satellite should be regarded as complementary to terrestrial connectivity rather than as a general solution for the rural portfolio.

Security and resilience requirements depend on the consequences of communications failure. Routine monitoring can generally rely on standard network security and shared connectivity, provided appropriate measures are taken to protect devices, credentials and backhaul. The requirements become substantially more demanding where communications are used to control infrastructure. Distributed Energy Resource Management is the clearest example. Where communications support the operation of critical national infrastructure, higher standards of security, availability and resilience will be required, and appropriate national cyber security requirements should apply.

Overall, the rural portfolio is unlikely to create a major requirement for additional spectrum capacity. The more significant challenge is providing affordable, reliable and secure connectivity across large geographical areas and to very large numbers of devices. This points towards greater use of low-frequency spectrum, more effective sharing, widespread deployment of narrowband machine connectivity and a combination of terrestrial, local and satellite networks.

The policy issue is therefore less about identifying a large new spectrum allocation and more about ensuring that existing and future spectrum can be accessed and used in ways that reflect these requirements. In particular, there is a case for reviewing low-frequency licence-exempt and shared-access arrangements, encouraging rural deployment of machine

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connectivity and ensuring that more protected forms of access remain available where communications move from monitoring assets to controlling them.

6.2.5 Capacity constraints

The rural portfolio is unlikely to create a significant capacity requirement when measured in terms of data traffic. Ofcom's Connected Nations 2025 reports that 27.7 million active machine connections on UK mobile networks generate around 2 PB of data per month, representing less than 1% of total mobile traffic. Even assuming around 20 MB per device per month for the applications considered in this study, the rural portfolio would account for only a small proportion of future mobile data traffic.

The more important capacity issue is the number of devices using the network and the way in which they communicate. Many applications could involve millions of devices, each transmitting only a few bytes or kilobytes at a time. The constraint is therefore not the amount of information being carried but the number of devices that the network must support and the frequency with which they establish connections.

This distinction matters because a short message can create substantially more network activity than its data volume suggests. Each time a device communicates, the network may need to establish a connection, authenticate the device, exchange the message and then release the connection. If millions of devices communicate frequently, this signalling activity can place a significant load on the network even though the actual volume of data transmitted remains very small.

The former Redcare alarm service illustrates the issue. Connections were checked every eight seconds, creating a very large number of communications exchanges despite carrying little actual information. Migrating this type of application directly onto a mobile network without changing the way devices communicate could therefore consume disproportionate network resources relative to the amount of data carried.

The key finding is that capacity planning for machine connectivity needs to consider how devices use the network as well as how much data they transmit. Device numbers, reporting frequency and signalling behaviour are consequently more useful measures of future demand than megabytes or gigabytes of traffic. Technologies and protocols designed specifically for large scale machine communications will be important in reducing unnecessary signalling overhead.

A further consideration is that demand may not be evenly distributed over time. Environmental, drainage, flood and utility monitoring can all become more active during severe weather. Large numbers of devices may therefore communicate simultaneously at precisely the time when public mobile networks and electricity supplies are also under greater stress. Networks should consequently be assessed against the likely coincident peak rather than average traffic levels.

Licence-exempt spectrum introduces a different constraint. Duty cycle restrictions limit how long individual devices can transmit. This is unlikely to present a problem for sensors that send short, infrequent reports without requiring a response. It becomes more relevant for applications requiring frequent two-way communications, particularly where longer range requires lower transmission speeds and therefore longer use of the radio channel.

Overall, spectrum capacity is unlikely to be the principal constraint for the rural portfolio. Even very large numbers of devices can generate relatively little aggregate traffic. The more important questions are how many devices can be supported simultaneously, how frequently they communicate, how efficiently the network handles each communication and whether large numbers of devices are likely to communicate at the same time. Spectrum sufficiency for this portfolio should therefore be assessed primarily in terms of device density, signalling behaviour and peak concurrent demand rather than aggregate data traffic.

6.2.6 Access models

The rural portfolio can be served through a combination of public mobile networks, private networks, licence exempt networks and satellite connectivity. Each has an important role, but each also has limitations. The principal challenge is therefore not identifying a new technology but developing access arrangements that provide affordable and reliable connectivity across rural areas and support the very large number of low value connections expected over the next 15 years.

Public mobile networks provide the most immediate wide area solution, particularly as Shared Rural Network coverage expands. Their principal limitation for mass telemetry is likely to be cost rather than technical capability. Current per device subscription charges become expensive when multiplied across millions of low value sensors. Public mobile networks are therefore most likely to meet the requirements of the rural portfolio if narrowband connectivity is deployed widely across rural areas and made available on wholesale terms appropriate for mass telemetry. This could allow organisations or

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intermediaries to aggregate large numbers of devices rather than requiring each connection to support the economics of a conventional mobile subscription.

Private networks using shared access spectrum are better suited to geographically concentrated or higher value applications. Examples include autonomous agricultural machinery operating across a large farm and critical elements of utility infrastructure. Private networks allow the user greater control over coverage, availability and quality of service. However, the current Shared Access framework does not provide spectrum below 1 GHz, while much of the rural portfolio benefits strongly from low frequencies for wide area coverage and penetration. Extending shared access arrangements below 1 GHz therefore represents an important opportunity to address the gap between the requirements identified in this study and the spectrum currently available for private networks.

Licence-exempt networks provide a low-cost solution for many monitoring applications. Equipment is relatively inexpensive and additional devices do not incur individual subscription charges. This makes the model particularly attractive to local authorities, utilities, farms and other organisations deploying large numbers of sensors within an area where they can provide their own network coverage. The limitations arise primarily from restrictions on transmission power and duty cycles, together with the absence of interference protection or guaranteed availability. Licence exempt networks are therefore well suited to routine monitoring but less appropriate for safety critical applications or functions involving the control of important infrastructure.

Satellite connectivity provides an important complementary solution where terrestrial coverage is unavailable. It is particularly well suited to powered agricultural machinery and some fixed outdoor assets capable of accommodating the necessary communications equipment and antenna. Developments in direct to device satellite connectivity may progressively expand the range of devices that can be served. However, satellite remains less suitable for small battery powered devices and sensors located indoors, underground or in other difficult environments. It should therefore be regarded principally as a means of filling terrestrial coverage gaps rather than as the primary connectivity solution for mass rural monitoring.

The appropriate access model will consequently vary according to the application. Routine monitoring can generally use lower cost shared or licence exempt connectivity. Applications requiring greater reliability can use public mobile or private networks, while critical control functions may require protected access and guaranteed service levels. Satellite can provide additional coverage and resilience where terrestrial networks cannot meet the requirement.

The main gap is at the intersection of low frequency coverage, low cost and managed access. Licence-exempt networks provide low-cost connectivity but with limited power and no protection from interference. Public mobile networks provide managed wide area service but may be too expensive for millions of low value devices. Private networks provide greater control but currently lack access to spectrum below 1 GHz under the Shared Access framework.

Closing this gap does not necessarily require new technology or significant new spectrum allocations. A combination of wider rural narrowband mobile deployment, wholesale pricing for mass telemetry, improved licence-exempt provision and shared access below 1 GHz could address much of the requirement. There would therefore be value in reviewing the existing access framework as a whole to determine whether it provides an appropriate combination of coverage, affordability, reliability and protection for the large-scale rural connectivity requirements expected over the next 15 years.

6.3 Alignment with national strategies and policies

The rural portfolio's distinguishing feature, in policy terms, is that its demand is created by government but is largely absent from spectrum policy. Section 82 of the Environment Act 2021 mandates continuous water-quality monitoring on a statutory timetable running to 2035; Awaab's Law sets hazard response timeframes from October 2025 for which continuous sensing is the only economic compliance route; lead local flood authority duties under the Flood and Water Management Act 2010 drive drainage and watercourse monitoring; net zero policy and the distribution system operator transition generate the controllable-asset population underlying distributed energy resource management; and the PSTN closure on 31 January 2027 forces the migration of a legacy telemetry and alarm estate on a government-mandated deadline. Each of these is a firm commitment with a date attached. None of them was framed as a spectrum requirement, and none appears as demand in the evidence base on which rural spectrum policy is formed.

The connectivity strategies, meanwhile, are described in human terms. The Wireless Infrastructure Strategy's headline ambition is standalone 5G coverage of all populated areas by 2030, alongside targets expressed in premises and landmass; the Shared Rural Network defines its obligations by a 2 Mbps downlink and an uninterrupted 90-second voice call, verified by road-based drive testing. These are appropriate metrics for programmes designed to serve people, and this report does not suggest otherwise. The consequence, however, is that the machine-type demand described above benefits from these programmes only incidentally, and its progress is not measured by them.

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Two live policy processes offer the alignment route. Ofcom's Call for Input on spectrum to support utilities sector transformation remains open, and the draft Statement of Strategic Priorities of February 2026 commits government to setting out the needs of the utilities and transport sectors by the end of 2026 - the natural vehicle for the licensed low-band provision this portfolio requires, provided any resulting arrangement is designed as a multi-tenant rural asset rather than a single-sector allocation. Alongside it, the sharing agenda set out in Ofcom's spectrum management strategy and the Statement of Strategic Priorities aligns directly with this report's access-model conclusions, with one gap: the current Shared Access framework offers nothing below 1 GHz, which is where every fixed-monitoring requirement in this portfolio resolves.

A third alignment point sits within Ofcom's own framework for equipment that needs no licence, rather than in a formal process. Of the two blocks available below 1 GHz, only the upper provides a small higher-power sub-band for network equipment; the lower has no equivalent, so it's better propagation cannot be used to build a network. Ofcom's recent licence-exempt releases, including the liberalisation of fixed network devices, already move in the direction this portfolio requires, and extending that work to the asymmetry between the two low-band blocks would need no new spectrum. The relevance to alignment is that a substantial proportion of the demand described in this report will be met by licence-exempt networks whatever licensed provision emerges from the utilities process, so the two routes need to develop together rather than separately.

6.4 Social and economic impact

Our approach has been to identify the value pools that connectivity enables within each rural portfolio sub-use case, ranging from producer cost savings to Gross Value Added (GVA).

Agritech

The clearest producer-side evidence comes from precision farming trials. Cranfield University's review of UK precision agriculture found that variable-rate nitrogen application delivers an average benefit of £22 per hectare over uniform application, while yield gains on responsive land ranged from £57 to £74 per hectare. Applied illustratively across the roughly 6 million hectares of UK arable land, and allowing for only the 20–30% of land area typically identified as agronomically "responsive" to variable treatment, this points to a plausible national value pool in the low hundreds of millions of pounds per year from variable-rate input management and yield optimisation alone[30]. There may also be further irrigation and machinery-diagnostics gains, which we do not attempt to quantity.

A second, GDP-related indicator is market growth: the UK precision farming market is valued at around $477 million in 2025 and is projected to reach $976 million by 2030, a 10.8% CAGR[31]. This sits within a UK agriculture sector that already contributes £14.5 billion in GVA directly to the economy, or 0.56% of the total, according to DEFRA (2024). A large proportion of this value is created ion areas with inadequate mobile coverage: a recent NFU membership survey indicates that only 22% of UK farmers report a reliable mobile signal across their entire farm[32].

Beyond yield and input efficiency, agritech connectivity has a labour-substitution dimension with real economic weight. UK agriculture faces structural labour shortages across skill levels, which have been linked to tens of millions of pounds in wasted food output in a single year[33]. Autonomous machinery, remote livestock monitoring and reduced reliance on manual inspection-rounds directly offset this constraint. This could yield producer savings that are arguably more impactful for UK farm viability over the next 10–15 years than input-efficiency gains alone.

Livestock monitoring carries a distinct, harder-to-monetise value: earlier detection of disease, distress or difficult births, and better management of flocks during adverse weather would bring genuine animal welfare benefits and would promote UK food security. Reducing preventable animal loss and supporting farmer wellbeing by reducing the need to physically check remote or difficult terrain sits closer to the societal side of the ledger than to conventional cost-benefit accounting. This is likely a material driver of adoption in its own right.

30 See Godwin *et al*, 'An Economic Analysis of the Potential for Precision Farming in UK Cereal Production', Biosystems Engineering Vol 84, April 2003.

31 Source: Markets and Markets, 'UK Precision Farming Market (2025-2030)', June 2026

32 Source: NFUonline.com, 'Rural connectivity still falling short as farmers call for urgent action', 18 July 2025

33 NFU evidence submitted to the Business and Trade Committee's inquiry on Post-pandemic economic growth: UK labour markets, July 2022

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Cost efficiencies, if reflected in retail prices, would also drive consumer welfare benefits.A lower-bound for total quantifiable value-at-stake would be in the order of $1 billion per annum by 2030 and plausibly in excess of $2 billion by 2040. Even modest productivity gains attributable to a rural portfolio could represent a meaningful and growing economic contributions. But these may be overshadowed by the unquantified social benefits, including promoting rural and agricultural community sustainability.

Other rural telemetry (environmental and utility asset monitoring)

This sub-use case differs from agritech in that a large share of demand is created by statutory obligations (See section 6.3) rather than a discretionary business case. Its economic impact is therefore best framed primarily in terms of cost-avoidance and compliance risk-reduction.

On the utility side, the value case for remote assets telemonitoring rests on replacing costly manual inspection cycles with permanent sensing.

On the environmental side, flood prevention provides a compelling example. Flooding causes average annual direct damages in England estimated at around £2.3 billion, with wider one-off events costing £1.6–3.2 billion in a single year, and knock-on effects including an estimated £290 million in lost output annually from workers unable to reach flooded workplaces[34]. Better real-time monitoring of rivers, drainage and flood defences cannot eliminate risk nor damage, but faster detection and earlier warning may plausibly reduce the losses at the margin – notably by giving time to secure or move valuable assets.

The strongest justification for this sub-use case, however, is societal rather than economic. Awaab's Law exists because inadequate monitoring of a housing hazard contributed to a child's death. Statutory water-quality and flood-duty timetables exist for public health and safety reasons, not for commercial return. Accordingly, connectivity that enables compliance with these duties carries a safety and public-health value that conventional cost-benefit metrics fail to capture.

Distributed energy resources (DER) management

DER connectivity has the most directly quantifiable and largest UK value pool of the three rural portfolio sub-use cases. On the producer side, flexibility in electricity markets is projected to deliver over £3bn in savings by 2028 through avoiding or deferring network reinforcements, reducing connection charges and increasing the use of low-carbon energy sources[35].

The Government's Smart Systems and Flexibility Plan estimates that energy flexibility could save consumers up to £10 billion per year by 2050 and reduce total net-zero transition costs by as much as £70 billion[36]. According to the Green Alliance, a smarter, flexibility-focused strategy for the electricity market could be nearly 20% cheaper than the current approach. It would generate £8 billion in annual savings while also producing up to two-thirds less carbon emissions by 2030[37]. The Carbon Trust's central estimate for a fully flexible GB energy system is £9.6–16.7 billion per year in net savings by 2050[38].

These figures represent the addressable value pool that dependable, low-latency, secure telemetry and control connectivity facilitates or enables. Each 1% of extra efficiency that would be attributable to a rural portfolio would be worth on the order of £100 million per year over the next 10 to 15 years.

Finally, DER connectivity carries a resilience dimension that is best expressed through the Value of Lost Load (VoLL) rather than conventional GDP accounting. Recent UK estimates put VoLL at around £23,000–23,600 per MWh, with earlier regulatory work placing weighted average VoLL at roughly £16,900 per MWh. These figures illustrate the scale of potential economic harm that closer DER monitoring and control could prevent during periods of grid stress.

During winter cold spells and especially for medically dependent households, there is also an important safety dimension in preventing outages.

34 Source: Paul Bates CBE FRS, Professor of Hydrology at University of Bristol, Linked-In post, 16 April 2026

35 'DSO Flexibility Markets Transforming GB's Grid Economics', Blake Clough Consulting, October 2025

36 Source: Explanatory Notes (HL Bill 39–EN 58/3). Department for Business, Energy and Industrial Strategy, presented to the House of Lords on 6 July 2022.

37 Green Alliance Policy Insight, October 2016.

38 Carbon Trust, May 2021.

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7. Use Case 2 - Aerial platform communications

7.1 Expected demand

Demand for aerial platform communications in the United Kingdom is expected to grow substantially over the next 10 to 15 years, as drones and other low altitude platforms move from specialist applications towards routine commercial and public service operations. The principal sources of demand will include infrastructure inspection, environmental monitoring, emergency response, surveillance, logistics and the use of aerial platforms to provide communications or sensing coverage over a defined area. Although there is no sufficiently robust evidence to produce a precise forecast of traffic or spectrum demand, the direction of change is clear. There will be more platforms operating for longer periods, over greater distances and with increasingly sophisticated communications payloads.

The Government's Future of Flight Action Plan envisages routine drone operations beyond the pilot's visual line of sight and the creation of a sustainable commercial ecosystem for emerging aviation technologies. Earlier government analysis indicated that the UK could have as many as 76,000 commercial drones operating by 2030, although this estimate covers the wider drone market and should not be interpreted as a forecast for aerial communications platforms alone. The Government has also cited estimates that drones and advanced air mobility could contribute up to £103 billion to the UK economy over the next 25 years[39]. These projections are necessarily uncertain but demonstrate the expected scale of development across the sector.

This use case focuses principally on static drones, tethered aerostats and other low altitude platforms operating within or close to the current general height limit of 120 metres above the surface. Higher altitude platforms could eventually play an important role, but their development is subject to more complex aviation, technical and commercial constraints. Low altitude platforms are more likely to be deployed at scale within the study period because they can be launched locally, positioned over a defined area and integrated more readily with existing terrestrial networks.

Growth in platform applications

Infrastructure inspection is likely to be one of the most important drivers of demand. Electricity network operators, renewable energy businesses, water companies, transport authorities and telecommunications providers are already using drones to inspect assets that are difficult, dangerous or expensive to reach. Applications include the inspection of electricity lines, wind turbines, pipelines, railways, bridges, mobile towers and flood defences. By the 2030s, a growing proportion of these inspections is likely to be undertaken autonomously or under remote supervision.

The transition from occasional manually controlled flights to routine autonomous operations will change the communications requirement. A drone operating within sight of its pilot may depend principally on a short-range radio link. A platform undertaking a long-distance inspection or operating without a pilot nearby will require continuous command, control and telemetry connectivity across its entire route. Network coverage will therefore need to be assessed in terms of altitude, flight corridors and operational areas rather than conventional coverage experienced by users at ground level.

Environmental and land management applications are also expected to expand. Aerial platforms can monitor coastlines, rivers, forests, agricultural land and protected habitats. They can carry cameras, thermal sensors, radar, air quality equipment and other instruments. Climate change is likely to increase demand for monitoring related to flooding, coastal erosion, wildfire risk, drought and ecological change. These missions may take place in remote areas where terrestrial communications infrastructure is limited, which could increase reliance on satellite services or purpose-built local networks.

Emergency services will make greater use of aerial platforms for incident assessment, search and rescue, traffic management and public safety. A drone can reach an incident before personnel arrive and provide live imagery to an operations centre. Police, fire and rescue services may also use persistent platforms to monitor an area during a major incident. Demand will be intermittent but highly time critical. The communications service must therefore be available when required rather than merely providing a high average level of performance.

Logistics services will experience a large uptake. These are conventional mid-lift drones, but due to the expected volume of delivery vehicles, these will add appreciably to network demand. Operating as a hub-and spoke arrangement, autonomous drones will conduct rapid delivery from their base of operation and will need to be able to operate in BVLOS, implying 4G/5G connectivity, and other like the other use cases, have high mobility and developed collision avoidance capabilities.

[39] https://www.gov.uk/government/news/nearly-50-million-government-backing-to-power-up-drone-and-flying-taxi-tech-and-crack-down-on-illegal-drones

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Tethered drones and aerostats are likely to develop as a distinct class of platform. A physical tether can provide continuous power, allowing the platform to remain airborne for much longer than a battery powered drone. It can also provide a secure communications or fibre connection to the ground. Such platforms may support persistent surveillance, environmental sensing, event monitoring or temporary communications infrastructure. Their ability to remain in a stable position for hours or days could make them particularly valuable where a permanent tower is unavailable, impractical or not economically justified.

Communications generated by aerial platforms

Communications demand will consist of several different traffic types. Command-and-control messages will usually require relatively little capacity but very high reliability, security and availability. These messages allow an operator or automated control system to manage the flight, monitor the condition of the platform and intervene if necessary. Loss of the control link triggers required, pre-defined behaviour rather than an immediate safety failure. The availability requirement reflects that the mitigation ends the flight and commits the aircraft to an autonomous manoeuvre through shared airspace, that the operator loses the ability to respond if anything else goes wrong, and that authorisation for higher-risk operations depends on demonstrating a correspondingly reliable link.

Telemetry will include the location, altitude, speed, direction, battery condition and technical status of the platform. Individual messages will be small but may need to be transmitted frequently. Platforms may also be required to broadcast their position to other airspace users and traffic management systems. Ofcom and the Civil Aviation Authority made 978 MHz available for airborne transmissions from unmanned aircraft in March 2025 to support electronic conspicuity and longer distance operations[40]. The introduction of digital identification, detect and avoid systems and uncrewed traffic management will add further communications requirements as the number of simultaneous operations increases.

Payload communications are likely to generate substantially more traffic. High-definition video, thermal imaging, radar and detailed infrastructure surveys can create large volumes of uplink data. Some processing may take place on the platform, allowing only selected information or alerts to be transmitted. However, live monitoring and remote decision making will continue to require high-capacity connections. The growing use of artificial intelligence may increase both local processing and the demand to transfer data to remote systems for analysis, storage and integration with other sources.

The resulting traffic will be strongly weighted towards the uplink. Public mobile networks have traditionally been planned around greater consumer demand in the downlink than the uplink. Concentrations of drones transmitting video from an incident, industrial site or major event could therefore create local capacity constraints even where total network traffic appears manageable. Antenna systems designed to serve users at ground level may also provide inconsistent coverage to platforms operating above the normal clutter of buildings and vegetation.

Expected pattern of demand

Demand is likely to be geographically uneven and operationally diverse. Some applications will follow predictable corridors such as electricity lines, railways, roads and pipelines. Others will be concentrated around industrial facilities, construction sites, ports or renewable energy installations. Emergency and environmental applications may arise with little warning in locations where communications demand is normally low.

The number of active platforms at any one time will remain much smaller than the number of terrestrial mobile devices. However, each advanced platform may require several simultaneous communications functions, including command-and-control, telemetry, electronic conspicuity and payload transmission. The value and safety implications of these connections may also be much greater than their traffic volume would suggest.

Demand is expected to accelerate as regulation enables routine operations beyond visual line of sight. The Civil Aviation Authority introduced the UK Specific Operations Risk Assessment process in 2025 to provide a more consistent and scalable route for authorising complex drone operations[41]. Government policy has also supported the development of detect and avoid technology, digital traffic management and operating frameworks for commercial services. These measures should reduce barriers to deployment during the late 2020s and establish the basis for broader adoption during the 2030s.

Implications for future connectivity demand

[40] https://www.caa.co.uk/commercial-industry/airspace/communication-navigation-and-surveillance/spectrum/ofcom-caa-joint-statement-on-use-of-978-mhz-for-uas-and-change-in-audio-pmse-access/

[41] https://www.caa.co.uk/newsroom/news/uk-civil-aviation-authority-launches-uk-sora-a-digital-risk-assessment-system-for-unmanned-aircraft-systems/

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No single communications technology is likely to satisfy all aerial platform requirements. Short range licence exempt links will remain suitable for local operations. Public mobile networks could support many commercial applications, provided that airborne coverage, uplink capacity and interference are managed effectively. Private mobile networks may be appropriate around industrial sites and critical infrastructure. Satellite connectivity could provide coverage over remote areas or serve as a resilient secondary connection. Aviation specific spectrum will remain important for safety functions such as electronic conspicuity.

By the 2030s, demand is therefore likely to favour integrated communications systems that can move between terrestrial, private and satellite networks while maintaining the required service quality. Operators will require predictable access along flight routes and within operating areas rather than broad population coverage alone. There may also be a need for local, temporary or dynamically coordinated spectrum access where several platforms are deployed together.

Overall, aerial platform communications are expected to represent a high growth but comparatively specialised source of spectrum demand. Aggregate traffic may remain modest compared with consumer mobile broadband, but the combination of high uplink requirements, extensive coverage, operational reliability and aviation safety will make the use case important for spectrum policy. The principal challenge will be to ensure that suitable connectivity is available wherever aerial platforms operate without creating harmful interference or requiring inefficient permanent assignments for demand that may be localised and intermittent.

7.2 Expected connectivity and spectrum requirements

Aerial platforms have a distinctive connectivity requirement because they can perform two different roles. They can consume connectivity, where communications are required to control the aircraft and transmit data from it, or they can provide connectivity, where the platform carries communications equipment and acts as a temporary elevated network site. These two roles have different requirements and should be considered separately.

Where the aerial platform is consuming connectivity, two principal links are required. The first is the command-and-control link, which carries relatively little data but becomes safety-critical when the aircraft operates beyond visual line-of-sight. This requires very high availability, low latency and secure, authenticated communications. The second is the payload link, which carries information collected by the platform. Its requirements vary considerably, from small amounts of telemetry or sensor data to high-definition live video requiring tens of Mbit/s.

Where the platform provides connectivity, it can act as a rapidly deployable elevated network site. A tethered drone, for example, can carry a small cell or other communications equipment above buildings, vegetation and terrain, with power and potentially backhaul provided through the tether. This can provide temporary coverage over a much larger area than equivalent equipment located at ground level and could support applications such as agricultural operations, major events, emergency response and temporary coverage following network failure.

Altitude is therefore both an advantage and a challenge. Raising a transmitter above surrounding obstacles can greatly extend its coverage, but the same signal may also be received over a much wider area than originally intended. Spectrum and power arrangements designed for terrestrial equipment cannot necessarily be applied directly to airborne transmitters without increasing the risk of interference. Aerial connectivity therefore requires specific consideration of platform height, transmission power, antenna characteristics and coordination with terrestrial networks.

The principal requirement for platforms consuming connectivity is consequently reliable and protected communications engineered for operation at altitude. Licence-exempt spectrum may remain appropriate for short-range operations within visual line of sight, but routine operations beyond visual line of sight will require more dependable connectivity. Public mobile networks, dedicated aviation spectrum and satellite services could all contribute, depending on the application and location.

For platforms providing connectivity, elevation can solve a temporary coverage problem but does not provide permanent connectivity. A sensor or other device on the ground cannot rely on an aerial platform being present whenever it needs to communicate. Aerial networks are therefore best suited to temporary or periodic requirements such as harvest operations, infrastructure inspection, major incidents, flood response or planned engineering work. They complement rather than replace the permanent terrestrial connectivity considered in the rural portfolio.

Exhibit 12: Aerial platform communications connectivity and technology requirements

Category	Requirement	Comment
Expected number of devices (nationally)	150,000–300,000 connections by 2036–41; low thousands to tens of	Government analysis suggests around 76,000 commercial drones by 2030, covering the wider market rather than communications platforms alone.

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	thousands airborne concurrently at peak	Extending that trajectory gives a fleet in the low hundreds of thousands within the study period. Fleet size is the wrong dimensioning number, however: platforms only need spectrum while flying, so concurrent operations is the figure that matters, and it is one to two orders of magnitude smaller. Each active platform may need several simultaneous links — control, position reporting, and payload — so connections exceed platforms.
Highest concentration of devices	1–100 concurrent platforms per square kilometre in hotspots	Most airspace carries almost nothing. Concentrations occur in delivery corridors, around large industrial and construction sites, at major events, and above significant incidents where several agencies operate simultaneously. These are precisely the locations where terrestrial networks are already busiest.
Coverage type	National	The distinguishing requirement in this study: coverage must exist at altitude, not merely on the ground beneath. Predictable demand follows linear infrastructure — power lines, railways, pipelines, roads — while emergency and environmental use arises without warning in places where demand is normally negligible.
Indoor or outdoor coverage	Outdoor only	Indoor drones are for experimental purposes are therefore not suitable for this study – very low numbers and likely proprietary technologies
Mobility	Very high	Platforms move quickly, change altitude, and cross between transmitter coverage areas far more rapidly than ground users. Handling that movement reliably, rather than merely providing signal, is the harder part of the requirement.
Bandwidth	A few kbit/s for control; up to 10–50 Mbit/s for live imagery; strongly weighted toward the uplink	Control and position messages are very small but frequent. Imagery dominates the total, and unlike consumer use the traffic runs predominantly from the platform to the network — the opposite of what mobile networks are planned around. On-platform processing will reduce this over the period, sending findings rather than continuous video.
Latency	Below a second for control; relaxed for most payload traffic	The control link is safety-related once the operator loses sight of the aircraft, and position reporting must be timely enough for other airspace users to act on. Inspection imagery has no deadline unless someone is watching live and directing the aircraft from it.
Availability	Very high for control; medium for payload	Loss of the control link is an aviation safety event, not an inconvenience, and this is the strictest availability requirement anywhere in the study. Payload interruption merely postpones the mission. Demand is intermittent but time-critical: the service must be there when required, which is a different thing from performing well on average.
Can existing infrastructure be used?	Partly, and less than it appears.	Mobile network antenna point downward at ground-level users, so coverage above the rooftops is incidental rather than designed. Satellite works well for range and resilience where the platform can carry the equipment. Dedicated aviation spectrum already exists for position reporting following the 978 MHz release in March 2025. The gap is not geographic reach but deliberate engineering for altitude.
If separate network what frequency ranges will be required	Below 1 GHz	The coverage and penetration arguments are the same as elsewhere in this use case; what differs is that free-to-use spectrum is disqualified — limits on transmission time, absence of protection from

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		interference and best-effort availability each rule it out independently.
If separate network can frequency resources be shared?	Yes for monitoring.	Sensor traffic tolerates competition for the airwaves. Environmental control, machinery guidance and any driverless operation need protected access, because failure carries crop loss or a safety consequence.

Source: Coleago

Overall, aerial platforms are unlikely to create a major national capacity requirement. The more important issue is ensuring that reliable connectivity is available at altitude and that airborne transmissions can coexist with terrestrial networks without causing unacceptable interference. Spectrum demand will also be highly localised and intermittent, making the number of concurrent platforms and their geographic concentration more relevant than the total number of drones in operation. One SPF stakeholder remarked that the 2600 MHz mobile band is currently not authorised for Drones use in the UK due to concerns around compatibility with ATC radars but would be a good source of additional capacity (including mobile uplink) if compatibility concerns can be revisited and resolved[42].

The policy challenge over the next 15 years is therefore likely to be less about identifying a large new spectrum allocation and more about developing appropriate access arrangements for different aerial functions. Command-and-control will require highly reliable and protected connectivity, while payload communications can make greater use of existing mobile, satellite and shared networks. Where aerial platforms themselves provide connectivity, suitable arrangements will also be required to enable temporary airborne transmission without creating interference across the much wider area visible from altitude.

7.2.1 Technology requirements

Aerial platforms require different technologies for command-and-control, payload communications and the provision of connectivity to users on the ground.

For command-and-control, the priority is a highly reliable and secure connection to the aircraft. Public mobile networks could provide this using 3GPP capabilities designed for aerial devices, but networks need to be specifically engineered for users at altitude. Good mobile coverage on the ground does not necessarily mean that reliable coverage exists above it[43]. Dedicated UAS spectrum, including the UK provision at 978 MHz, can provide an alternative for safety-related communications, while satellite can extend coverage into remote areas and provide additional resilience. Conventional licence-exempt spectrum at 2.4 GHz and 5.8 GHz remains appropriate for shorter-range operations within visual line of sight.

For payload communications, requirements vary according to the application. Simple telemetry and sensor data require very little capacity and can use licence-exempt or other low-capacity connections. Live imagery requires considerably more bandwidth and is better suited to mobile or satellite networks. Over the next 15 years, greater processing of data on the platform should reduce this requirement as drones increasingly transmit relevant information and detections rather than continuous raw video.

Where the aerial platform is providing connectivity, it effectively becomes a temporary elevated network site. The principal advantage is the large coverage area created by altitude. However, the communications technology must be capable of exploiting this additional range. Some cellular technologies have technical limits on cell radius which may prevent them from using the full coverage available from an elevated platform. Low-power wide-area technologies may provide greater flexibility for some applications.

Within this context, one UK SPF stakeholder observed that the CAA has introduced a Remote-ID policy[44] that has spectrum implications.

42 The ECC Decision (22)07 includes this band but suggests tightened out of band emission levels.

43 One UK SPF stakeholder commented that 3D modelling of mobile coverage will be important for MNOs in particular.

44 Remote ID (RID) | UK Civil Aviation Authority.

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Overall, no single technology will meet all aerial connectivity requirements. Public mobile networks, dedicated aviation spectrum, satellite and licence-exempt technologies are likely to have complementary roles, with the appropriate solution determined principally by the required coverage, capacity and level of reliability.

7.2.2 Capacity constraints

Aerial platforms are unlikely to create a significant capacity requirement when measured by total data traffic. Command-and-control requires only a few kbit/s, and most telemetry applications also generate very little data. Live videos require substantially more capacity, but these applications are likely to represent only a proportion of aerial operations, and greater processing on the platform should reduce their bandwidth requirements over time.

The more important constraint is the number of platforms operating simultaneously within the same area. Delivery services, infrastructure inspection and emergency operations could result in significant numbers of drones using the same airspace at the same time. Each may require separate command-and-control, position reporting and payload connections. Future unmanned traffic management systems will create an additional communications requirement.

Altitude also creates a particular interference challenge. An aerial platform can receive signals from, and transmit signals towards, many more network sites and other radio users than a device at ground level. As altitude increases, radio coverage improves, but the potential for interference also increases. The amount of usable capacity may therefore be constrained by interference before it is constrained by the volume of traffic.

The appropriate measure of future demand is consequently not the total number of drones or the amount of data they generate. It is the peak number of simultaneous operations within a given area of airspace, and the number of communications links each operation requires. This is particularly important for future beyond visual line of sight operations, where every platform will require a dependable connection throughout its flight.

7.2.3 Access models

Four main spectrum access models are likely to support aerial platform communications over the next 15 years.

Licence-exempt spectrum is currently widely used for command-and-control and payload communications, particularly at 2.4 GHz and 5.8 GHz. It is well suited to relatively short-range operations within visual line of sight. However, because it provides no protection from interference or guarantees of availability, it is unlikely to provide a sufficient basis for large scale safety critical beyond visual line of sight operations.

Public mobile networks could provide a scalable solution for both command-and-control and payload communications. The UK UAS Operator Radio Licence provides a route for authorised airborne use of mobile spectrum. However, the effectiveness of this model will depend on mobile operators engineering their networks to provide reliable coverage at altitude. Existing terrestrial coverage should not be assumed to provide an equivalent aerial service.

Dedicated aviation spectrum is likely to become increasingly important as beyond visual line of sight operations grow. The availability of 978 MHz spectrum provides an initial UK example of dedicated provision for aerial applications. As the number and concentration of commercial operations increases, further protected spectrum may be required for safety critical command-and-control and position reporting.

Satellite connectivity can provide coverage in remote areas and an additional layer of resilience where terrestrial networks are unavailable. Its role is likely to increase as satellite technology and direct to device services develop, although cost and equipment requirements will continue to determine which applications can use it economically.

Where an aerial platform is itself providing connectivity, the access requirement is different. The platform needs permission to use the spectrum of the service being extended and to transmit that spectrum from the air. This can already be achieved through cooperation with an existing licensee for applications such as temporary event coverage or planned operations. In future, shared access or local licensing arrangements could provide a more flexible route for temporary and geographically limited aerial networks.

Overall, the appropriate access model depends primarily on the criticality of the communications link. Licence-exempt spectrum can continue to support lower risk operations, public mobile and satellite networks can provide wider coverage and capacity and dedicated or otherwise protected spectrum is likely to become increasingly important for safety critical command-and-control as routine beyond visual line of sight operations develop.

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7.3 Alignment with national strategies and policies

Aerial platforms are unusual within this study in requiring two regulators to move in step. Spectrum authorisation rests with Ofcom, while the operating envelope, including altitude, beyond visual line of sight approval and operator authorisation, rests with the Civil Aviation Authority. Demand in this use case is therefore gated by aviation policy rather than by spectrum availability, and no amount of spectrum provision will generate demand ahead of the authorisations that permit flight.

On the spectrum side, alignment is already good and improving. Ofcom created the UAS Operator Radio Licence in January 2023, authorising airborne use of mobile and satellite terminals that the licence-exempt regime could not support, a direct enabler of beyond visual line of sight operation. In March 2025, Ofcom and the CAA jointly made 978 MHz available for airborne transmission from unmanned aircraft, the first UK instance of dedicated spectrum provision for this sector and, notably, an example of the two regulators acting together. Both measures anticipate the trajectory this report describes, and the study's recommendations build in that direction rather than departing from it.

Two areas warrant continued attention as the sector matures. The first is the licence-exempt position: airborne permission in IR 2030 is stated provision by provision and attaches to the device category rather than the band, so as low-altitude operation becomes routine, a consolidated statement of where airborne use is permitted would assist deployers and give Ofcom a basis on which to review whether the current arrangement remains appropriate. The second is the engineering of terrestrial networks for aerial users. The government's ambition for standalone 5G in all populated areas is expressed, correctly, in terms of ground-level service; aerial users of those same networks experience coverage that is incidental rather than designed. As unmanned traffic management and dense operations arrive, whether the mobile layer is deliberately engineered for altitude becomes a policy question rather than purely a commercial one.

7.4 Social and economic impact

In contrast with traditional IoT, where the value of connectivity is dispersed across millions of lower value devices, aerial platforms concentrate high value across fewer connections.

High-value UAS flights are enabled by command-and-control links whose failure carry safety consequences that are disproportionate to their traffic volumes. The economic case therefore rests less on aggregate connectivity spend and more on what each reliable link displaces: a manual inspection, a helicopter sortie, a delayed emergency response – all set against a growing GDP contribution from the drone sector itself.

Producer cost savings

The clearest and best-evidenced value pool is inspection substitution. PwC estimates that UK businesses could realise up to £22 billion in net cost savings by 2030 through drone adoption across construction, utilities, transport, and public safety[45]. This includes between 30 and 60% savings from drone-enabled asset monitoring, depending on a range of factors including nature of teleoperations and hazard levels. Specific examples cited include:

- 35% savings for BVLOS powerline monitoring versus VLOS; and
- 30-50% savings for wind-turbines and solar assets, based on industry reporting, versus rope-access and other ground-based methods.

These direct producer cost savings include avoided labour, equipment, and downtime, and they depend entirely on the reliability of the command-and-control and payload links that are associated with this use case.

GDP-related impact

Drones and advanced air mobility could contribute up to £103 billion to the UK economy over the next 25 years, as highlighted in section 7.1 above. PwC's central estimate is that drones could already add up to £45 billion to UK GDP by 2030, supporting around 650,000 associated jobs.

These figures span the whole commercial drone economy rather than aerial-platform communications specifically, but they point towards a very large addressable value pool from this use case. Crucially, connectivity reliability is one of the principal adoption constraints between current deployment and that potential. It seems likely that incremental spectrum access may be needed to unlock this full value.

Societal and safety value

45 PwC, 'Skies Without Limits v2.0', July 2022.

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Beyond cost savings and GDP creation, the overall use case promotes human safety. Search and rescue is the clearest example. The UK Maritime and Coastguard Agency helicopters already respond to an average of seven missions a day, saving more than 1,600 people annually[46]. Because drones can reach difficult terrain faster and operate over longer periods, they can act as an invaluable search and rescue complement to crewed aircraft, boats and land-vehicles. Improvements in aerial platform connectivity may translate into faster search coverage and, plausibly, additional lives saved on land as well as at sea.

Limiting inspection-related work at height on pylons, turbines, and towers, through the use of drones, leads to direct risk reduction. The human safety benefit alone ought to be a far more important consideration than the contingent cost of workplace injury or death that this use case may help avoid.

46 AirMedandRescue.com, 10 February 2020.

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8. Use case 3 - Temporary drone-enabled network extensions

8.1 Expected demand

Demand for temporary drone enabled network extension in the United Kingdom is expected to grow materially over the next 10 to 15 years as emergency services, infrastructure operators and field personnel become increasingly dependent on broadband communications. A drone or tethered aerial platform equipped with mobile network equipment could provide temporary coverage where terrestrial service is unavailable, has been damaged or lacks sufficient capacity. The platform could operate as an aerial base station, a relay between users and a distant terrestrial site or a connection between local users and a satellite network.

This use case differs from the broader aerial platform communications use case because its primary purpose is to provide connectivity to people and equipment on the ground. The drone will have its own command, control and telemetry requirements, but the principal source of traffic will be the users served by the temporary network. These may include police officers, firefighters, ambulance personnel, mountain rescue teams, utility engineers and other workers operating in remote or disrupted environments.

It is not currently possible to produce a reliable quantitative forecast of demand. Deployments will be driven by incidents, weather conditions, infrastructure failures and operational needs that cannot be predicted precisely. Nevertheless, demand is likely to increase because the number of users and applications dependent on mobile connectivity will grow, while complete and resilient terrestrial coverage across every part of the United Kingdom is unlikely to be economically or technically achievable.

Emergency services communications

The Emergency Services Network (ESN) will be the principal communications platform for the police, fire and ambulance services in Great Britain. It is designed to provide secure voice, video and data services over a 4G network and will eventually replace Airwave. More than 300,000 frontline emergency service personnel are expected to depend on ESN, using handheld devices and equipment installed in approximately 45,000 vehicles, more than 90 aircraft and around 200 control rooms. The planned network includes 20,840 new or upgraded sites, of which 292 Extended Area Service sites are intended to improve coverage in some of the most remote parts of Great Britain[47].

Although ESN will provide extensive geographical coverage, terrestrial infrastructure cannot remove every localised gap. Mountains, valleys, forests, tunnels and isolated coastal areas can prevent or weaken radio signals. Coverage may also be lost when storms, flooding, fire or power failures damage network infrastructure. At a major incident, the terrestrial network may remain operational but become congested as emergency personnel, members of the public and the media generate unusually high traffic.

Temporary aerial coverage could address these situations by establishing a radio footprint above obstructions and providing a direct line of sight to users across the affected area. A platform positioned at up to 120 metres could cover a materially larger area than a portable terrestrial base station at ground level. It could also be moved as the incident develops or positioned where ground access is unsafe.

Demand is likely to be intermittent but operationally critical. Most emergency incidents will not require aerial network extension because existing ESN or commercial coverage will be sufficient. However, when aerial coverage is required, it may need to be established within minutes and operate continuously for several hours or days. The value of the service will therefore depend less on average utilisation and more on its availability, speed of deployment and ability to support communications when other networks are impaired.

By the 2030s, emergency services are likely to use considerably more data than they do today. Mission critical voice and group communications will remain essential, but users will also exchange live video, high resolution images, building plans, medical information and location data. Drones and body worn cameras may transmit video to incident commanders. Firefighters may use sensors to monitor temperature, air quality and their physical condition. Ambulance teams could transmit diagnostic information to hospitals, while police officers may require immediate access to databases and live surveillance feeds.

These applications will increase peak capacity requirements, particularly in the uplink. They will also require low latency and predictable performance. A temporary aerial network must therefore provide more than basic coverage. It must

[47] https://www.gov.uk/government/publications/the-emergency-services-mobile-communications-programme/emergency-services-network

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preserve service priority, security and quality across voice, video and data applications. It may also need to support direct communications between users when the connection to the wider ESN is unavailable.

Mountain rescue and remote area operations

Mountain rescue provides a particularly strong example of the potential demand. Incidents frequently occur in locations where terrain obstructs terrestrial signals and where rescue teams are dispersed across a wide area. Voice communications may be possible only from certain points, while broadband connectivity may be unavailable altogether. Poor weather can further restrict coverage and make the installation of temporary ground equipment difficult.

An aerial platform could provide a local communications cell above a valley, hillside or search area. Rescue personnel could use standard handheld devices rather than carrying specialist equipment for each possible network. The platform could also connect search drones, cameras, location beacons and environmental sensors. Where no suitable terrestrial backhaul is available, the aerial platform or its ground station could connect through satellite.

Future demand will extend beyond voice communications. Search teams are likely to make greater use of live mapping, shared location information, thermal imagery and automated analysis of drone video. Medical teams may need to consult specialists remotely or transmit information about a casualty before evacuation. These applications could improve coordination and reduce the time required to locate and treat people, but they will depend on reliable broadband connectivity.

The number of mountain rescue incidents is unlikely by itself to create large aggregate traffic volumes. However, the social and safety value of the service will be high. Demand should therefore be assessed in terms of the number of locations and operational circumstances in which connectivity might be required rather than the annual volume of transmitted data.

Similar requirements will arise in coastal rescue, wildfire response and operations on remote islands. Climate change may increase the frequency or severity of floods, fires and storms, creating more occasions on which terrestrial networks are damaged or inaccessible. Aerial network extension could become part of a standard package of deployable communications equipment maintained by national or regional emergency organisations.

Field engineers and infrastructure operators

Demand from field engineers is expected to become more regular than demand from emergency services, although individual deployments may be less urgent. Electricity, water, rail, telecommunications and other infrastructure operators manage assets in rural and remote locations where mobile coverage is inconsistent. Engineers increasingly require access to digital work systems, asset records, live sensor data and remote technical support while on site.

By the 2030s, field operations are likely to depend more heavily on video collaboration, augmented reality, digital twins and remotely operated equipment. An engineer may need to transmit high resolution images to a specialist, download technical models or interact with an automated inspection system. Multiple contractors and autonomous machines may also require connectivity during construction, maintenance or repair work.

Temporary aerial coverage could be used during planned activity at sites where permanent infrastructure is not justified. Examples include the construction or maintenance of electricity transmission lines, wind farms, reservoirs, pipelines and remote railway infrastructure. A tethered drone could remain in position throughout the working day and receive continuous power from the ground. A free flying platform might be more appropriate where teams move along a route or across a large site.

The market for these services may be larger and more predictable than the emergency response market because deployments can be scheduled. Infrastructure operators could reserve equipment and spectrum access in advance, while specialist providers could serve several industries using a common platform. Demand may also be aggregated with monitoring and automation requirements at the same site, improving the commercial case for deployment.

Connectivity and spectrum implications

A temporary aerial network will require at least three communications links. The first is the access connection between the aerial base station and users on the ground. The second is backhaul from the platform or its ground station to ESN, a commercial mobile core or another operational network. The third supports command, control and telemetry for the aerial platform itself. These links may use different technologies and frequency bands.

The access link will generally need to use spectrum and technical standards supported by existing user devices. Emergency personnel cannot be expected to replace or reconfigure equipment during an incident. Integration with ESN and commercial mobile networks will therefore be important. Backhaul could be provided through a distant terrestrial site, fixed wireless link, fibre connection or satellite system depending on location and circumstances.

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Low frequency mobile spectrum would offer a relatively wide coverage area and good propagation around terrain and vegetation. Mid band spectrum could provide greater capacity but would cover a smaller area and may require more precise positioning. The appropriate combination will depend on the size of the incident area, the number of users and the applications being supported.

Airborne transmitters can be visible to terrestrial sites over a much wider area than ground-based equipment. This creates a risk of interference and means that conventional local licensing assumptions may not always be appropriate. Power levels, antenna direction and platform height will need to be coordinated carefully. Multiple aerial networks may also need to operate simultaneously during a large incident involving several agencies.

A key policy requirement will be the ability to obtain spectrum access immediately. A licensing process that takes days or weeks would have little value during an emergency. By the 2030s, operators may require advance authorisation that permits defined equipment to be activated in specified circumstances. A dynamic system could assign frequencies according to location, altitude, duration and existing use. Emergency services may require priority access, while planned field engineering deployments could use a more conventional reservation process.

Overall demand for temporary drone enabled network extension will remain episodic and geographically dispersed, but it is likely to become an important component of national communications resilience. The strongest case will arise where terrestrial coverage cannot provide the reliability, capacity or geographical reach required for operationally critical activity. The policy challenge will be to make suitable spectrum and network interfaces available at short notice without reserving substantial capacity permanently for platforms that may be used only occasionally.

8.2 Expected connectivity and requirements

This use case differs fundamentally from Use Case 2. In Use Case 2, the aerial platform is itself the user of connectivity. Here, the platform becomes part of the communications infrastructure, providing temporary network coverage to people and equipment on the ground.

The principal applications are emergency services operating outside existing coverage, mountain rescue in remote terrain and utility or field engineering teams working where public networks are unavailable, congested or have been damaged. In each case, an aerial platform can be deployed temporarily above the affected area to provide coverage that would otherwise require permanent terrestrial infrastructure.

The connectivity requirement is determined primarily by the users on the ground rather than by the aerial platform. Emergency personnel, rescue teams and field engineers need to be able to use their normal handsets and other communications equipment without modification. The aerial platform must therefore support the networks and spectrum already used by those devices. The principal requirement is consequently not for new spectrum, but for a mechanism that allows existing spectrum to be used temporarily from an aerial platform at the location where coverage is required.

Three communications links are needed. The first is the access link between the aerial platform and users on the ground. This should use the spectrum and technology already supported by their devices, with lower frequencies generally preferred because they provide the widest coverage from a single elevated platform. The second is backhaul, connecting the aerial platform to the wider communications network. This could use a terrestrial point-to-point connection where surviving infrastructure is available, or satellite where it is not. The third is the command-and-control link for the aerial platform itself, although this is less demanding than in Use Case 2 because the platform will normally remain in a fixed position and be operated locally.

This capability would complement rather than replace permanent terrestrial networks. The Emergency Services Network and commercial mobile networks will continue to provide the principal communications infrastructure, but complete permanent coverage of every remote location is unlikely to be economically practical. Mountainous areas, remote valleys and other sparsely populated locations are among the most expensive places to serve with fixed infrastructure. A deployable aerial network provides an alternative by creating coverage only when and where it is required.

The same principle applies when existing coverage has failed rather than never existed. Severe weather, flooding, fire or other incidents can damage terrestrial networks or interrupt their power and backhaul. Utility engineers may therefore need reliable communications precisely when the public networks on which they normally depend are least available. A tethered aerial platform with an independent power supply and satellite backhaul could continue to operate in these circumstances.

The most important requirement is therefore rapid availability. An emergency communications capability has little value if spectrum authorisation must be obtained after an incident has occurred. The platform may need to be operational within minutes or hours of deployment. This effectively rules out an access model based on obtaining a new licence for each incident and points instead towards some form of standing or pre-authorised arrangement.

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Availability and resilience are also particularly important. A system that is deployed only occasionally must nevertheless work reliably whenever it is required, including during the severe weather, power failures or network disruption that may have created the need for it. This makes independent power and resilient backhaul important parts of the overall solution. Over time, direct handset-to-handset communications using the aerial platform as a relay could provide an additional capability where connection to the wider network is unavailable.

Overall, this use case does not create a significant requirement for new spectrum or new communications technology. The necessary spectrum, devices and network technologies largely exist. The principal gap is the ability to integrate these components and obtain immediate, temporary and lawful access to the required spectrum from an aerial platform. The policy challenge is therefore primarily one of access and authorisation rather than spectrum availability.

Exhibit 13: Temporary drone-enabled network extensions connectivity and technology requirements

Category	Requirement	Comment
Expected number of devices (nationally)	1,000–5,000 deployable platforms by 2036–41; typically, tens deployed at any one time, rising to low hundreds during a severe weather event	The platforms themselves are a national capability held by emergency services, mountain rescue teams, utility operators and specialist providers, and the fleet is small. The users served — single digit deployments at minor/moderate incidents, 10-100 at a major one.
Highest concentration of devices	1–10 platforms over a single incident area	Normally one aerial cell serves an incident. Several may operate together where multiple agencies attend a large or extended event, which is also the circumstance in which they are most likely to interfere with one another. (e.g. one for coverage, one for remote viewing, one for area risk scanning etc)
Coverage type	Local and regional incident coverage, deployable anywhere nationally	This is a capability rather than a coverage obligation. The requirement is not that anywhere is covered but that coverage can be created anywhere within minutes to hours, most often in terrain that permanent infrastructure has been unable to serve economically.
Indoor or outdoor coverage	Both	The platform is always outdoors. Indoor required for some users.
Mobility	Both static and high mobility scenarios are possible	This inverts the previous use case. A tethered platform holds position for hours or days, while the personnel it serves move continuously on foot and in vehicles across the incident area. The mobility situation is reserved for wide area scanning.
Bandwidth	10–50 Mbit/s aggregate per platform, strongly weighted toward the uplink	Tens of concurrent users, historically voice-dominated but increasingly carrying live video from the scene, body-worn cameras, imagery, mapping and casualty information. Traffic runs predominantly from the incident outward, which is the opposite of the direction public networks are planned around.
Latency	Below a second for voice and priority messaging	Mission-critical voice standards apply unchanged: the aerial layer must not degrade the service the ground devices expect. Imagery and file transfer are less demanding.
Availability	The highest in the study	Two things must be available: the link, and the capability itself. A deployable service used a few times a year must nonetheless work on the day, in conditions that have already defeated the permanent network — and must continue working when local power and backhaul are gone, which is what the tether's generator feed and the satellite link exist to provide.
Can existing infrastructure be used?	Not as currently deployed	The equipment, standards and spectrum all exist — the platform deliberately carries the service the ground

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		devices already use, and there is no new technology requirement. What does not exist is A) the full integration of the parts and B) authorisation to transmit from the air, at an unplanned location, within minutes. That is the entire gap, and it is administrative rather than technical.
If separate network what frequency ranges will be required	The carried service's own band for the access link, favouring low frequencies; satellite or a point-to-point link for backhaul	No new spectrum is required for the access layer, because using the ground users' existing band is a condition of the concept working at all. Low frequencies give the widest coverage from a single platform over difficult terrain. Backhaul is the separate requirement, and satellite is the only option that survives the loss of local infrastructure.
If separate network can frequency resources be shared?	Yes, sharing is the model	The access layer operates within a licensee's existing rights rather than on spectrum of its own, so the arrangement is inherently shared. The requirement is for that sharing to be agreed in advance, with priority for emergency use, rather than negotiated when an incident is already underway.

Source: Coleago

8.2.1 Technology requirements

The most practical platform for this use case is a tethered drone operating as a temporary communications site. Unlike the aerial platforms considered in Use Case 2, it would normally remain in a fixed position above the incident area for several hours or potentially several days. A tether is therefore important because it can provide continuous power and a data connection, overcoming the limited endurance of a battery-powered drone.

The platform could operate either as a small cell connected to the wider network through satellite backhaul or as a relay extending coverage from a surviving terrestrial network site. The appropriate configuration would depend on the circumstances. Satellites become particularly important where terrestrial infrastructure, power or backhaul has been lost.

The access link between the platform and users on the ground should use the communications service and spectrum already supported by their devices. For emergency services, this is likely to mean low-band 4G or 5G supporting mission-critical voice and data services. Utility field crews could use their normal mobile or operational communications service, while VHF relay may remain appropriate for some mountain rescue and other specialist users. The objective is for personnel on the ground to continue using their existing equipment without needing to change devices or communications procedures.

Over time, device-to-device relay technology could simplify the aerial equipment required. 3GPP sidelink capabilities provide a potential means for the platform to relay communications between devices without carrying a complete mobile base station. This could reduce the weight, power consumption and complexity of the aerial payload.

8.2.2 Capacity constraints

Individual deployments are unlikely to require large amounts of capacity. A typical incident may involve only tens of users, with communications initially dominated by voice and messaging. Increasing use of body worn cameras, drone imagery, live mapping and other operational information will increase data traffic, particularly in the uplink direction, but the overall requirement should remain relatively modest.

The principal capacity constraint is more likely to be backhaul than the connection between the aerial platform and users on the ground. All traffic from the temporary aerial cell must pass through a satellite or terrestrial point to point connection. Live video and other high bandwidth uplink applications are likely to place the greatest demand on this connection.

A second constraint is interference. Because the platform operates at altitude, its transmissions can travel well beyond the immediate incident area. The aerial cell therefore needs to be coordinated with any surrounding mobile infrastructure that remains operational. This is particularly important where the temporary network is deployed because the public network is congested rather than completely unavailable.

The third consideration is simultaneous demand at national level. Most incidents will require only one or a small number of platforms. However, severe storms, flooding or other major events could create simultaneous demand from emergency services, rescue organisations and utility operators across several locations. Capacity planning should therefore consider

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the number of deployments that may be required at the same time rather than simply the requirements of an individual incident.

Overall, spectrum capacity is unlikely to be the main constraint. The more important issues are providing sufficient backhaul, managing interference with surrounding networks and ensuring that enough platforms and pre-authorised spectrum arrangements are available to meet peak simultaneous demand.

8.2.3 Access models

The most important requirement for this use case is that spectrum access must be agreed before an incident occurs. A temporary aerial network may need to be operational within minutes or hours. A licensing or authorisation process that takes days would therefore make the capability ineffective when it is most needed.

This is particularly important during major incidents. Public mobile networks may be congested even where they have not been physically damaged, and several emergency services and infrastructure operators may arrive in the same area within a short period. The spectrum arrangements must therefore allow an accredited aerial network to be activated immediately under clearly defined conditions.

Three potential access models could provide this capability.

Host licensee access would allow the aerial platform to operate under the existing spectrum rights of the service it is extending. For example, an aerial cell supporting the Emergency Services Network could use the spectrum associated with that service under an agreement covering temporary airborne deployment. Similar arrangements could be established with utilities or mobile operators. This is likely to be the most straightforward approach and should ideally be agreed at programme level rather than for individual incidents.

Standing emergency authorisation could provide a second route. Accredited organisations or specialist providers could be authorised in advance to operate defined aerial communications equipment under specified emergency conditions. The authorisation would remain dormant until required and could then be activated immediately. Appropriate restrictions could ensure that the temporary network serves authorised users and operates only within the necessary geographical area and period.

Device-to-device relay could provide a further option as the technology develops. An aerial platform could relay communications directly between authorised devices using existing or potentially dedicated spectrum. This could reduce dependence on terrestrial infrastructure and provide a useful additional capability where connection to the wider network is unavailable.

Satellite would provide backhaul under existing commercial spectrum arrangements and would not normally require a separate access model for the temporary network. Licence exempt spectrum is unlikely to have a significant role in the mission critical communications path because it cannot provide the required protection from interference or guarantee of availability.

Overall, the principal barrier is not a shortage of spectrum. These deployments will often take place where existing terrestrial coverage is absent, damaged or congested and the required spectrum is already assigned to the services being extended. The gap is the absence of a simple mechanism that allows that spectrum to be used lawfully, immediately and temporarily from an aerial platform. Establishing such arrangements in advance is therefore the most important spectrum access requirement for this use case.

8.3 Alignment with national strategies and policies

This use case sits at the intersection of spectrum policy and national resilience, and its alignment argument is correspondingly different: the requirement is not for spectrum to be found, but for access to be arranged in advance of the emergency that needs it.

The strongest precedent already exists within the programmes referred to in this report. Under the Shared Rural Network, Extended Area Service sites built by the Home Office for the Emergency Services Network were subsequently made available to mobile network operators, and deployment on those sites forms part of the obligations falling due in January 2027. Public-safety infrastructure has therefore already been shared with commercial networks under a pre-arranged framework at national scale. The arrangement required by this use case applies the same principle to spectrum rather than sites: a standing authorisation under which an accredited deployable-coverage capability may transmit, at temporary locations and at short notice, under the rights of the service it extends.

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Alignment with the wider policy landscape is straightforward. The Shared Rural Network's residual not-spots are, by construction, the terrain in which this capability is most valuable, and a deployable layer complements rather than competes with the fixed programme, converting the permanently uneconomic not-spot into an operational capability available when an incident demands it. The resilience of utility field operations during storm restoration connects directly to the availability requirements identified for the utility categories under Use Case 1, where communications must function precisely when public networks and grid supply are degraded. Ofcom's authorisation of satellite direct-to-device services from December 2025 also strengthens the backhaul and last-resort layers on which any deployable capability depends. The gap is procedural rather than technical: existing temporary and local licensing mechanisms were designed for planned events and extending them into a pre-registered emergency framework would require no new spectrum, only an arrangement designed for lawful, immediate and temporary use.

8.4 Social and economic impact

While this use case is not itself a source of new economic output, it provides a resilience layer that: (1) directly increases public safety, (2) protects value already at risk, and (3) extends the value of existing public safety expenditure. Its significance lies in minimising the risk of communications failure when such failure is both most likely and most consequential.

Avoided producer loss

The clearest producer-side saving arises from field engineering and storm restoration deployments. Extended power outages, for example, carry a defined and escalating compensation cost to network operators. Under Ofgem's current rules, customers are entitled to £85 compensation if power has been cut for 24 hours in severe weather, plus an extra £45 per 6 hours thereafter, up to a global cap of £2,165. Distribution network companies (DNOs) paid out £44million in total following Storm Arwen in 2021, when over 4,000 (many rural) customers were left without power for over a week[48]. Faster restoration, enabled by field engineers who can maintain full digital work-system connectivity, live sensor data, and remote technical support on site (rather than working blind in coverage gaps), directly reduces the duration of such outages. In turn, this limits compensation liability as well as the wider reputational and regulatory cost of prolonged restoration times.

Extending the value of public safety expenditure

Emergency services represent a very large item of public expenditures, spanning in the order of 300,000 frontline personnel and 45,000 vehicles. These rely on the Emergency Services Network for the bulk of their critical communications needs, but even the Extended Area Service sites will leave coverage gaps. A deployable aerial communications layer would enhance the effectiveness of the emergency services, especially in remote areas. As such, it would extend the value of the associated public safety investments at comparatively low marginal cost, by addressing exactly the residual not-spots that a fixed network cannot economically reach. In effect, drone-enabled network extensions would represent a small incremental spend that protects the value of a multi-billion-pound national programme.

Direct safety value

As outlined in section 8.1 above, mountain rescue is a paradigm case. In England and Wales, mountain rescue teams responded to 3,462 calls resulting in 2,775 deployments in 2023, with incident numbers rising 24% between 2019 and 2024[49]. These are precisely the terrain and weather conditions in which terrestrial and even portable ground equipment tend to struggle.

Faster location, coordination, and medical consultation during search-and-rescue operations, enabled by live mapping, shared location data, and remote medical support over a temporary aerial link, plausibly reduces both the incidence of fatality and the severity of injury outcomes

Where ESN coverage or capacity is exceeded, during a major incident, a natural disaster, or infrastructure damage from storms or wildfire, the cost of a communications failure is not measured in lost traffic but in delayed response and degraded incident command. In the most severe cases, this involves risk to life among both the public and responding personnel.

Drone-enabled temporary networks and coverage extension would address these issues directly.

48 Ofgem's six-month review into networks' response to Storm Arwen, June 2022.

49 Sources: Mountain Rescue 2024 Annual Report, and The Guardian, 'Social media and map apps blamed for record rise in mountain rescue callouts', 16 April 2025.

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9. Conclusions and potential areas for further research

This study has considered how spectrum demand in the United Kingdom may develop over the next 10 to 15 years, with particular emphasis on emerging uses whose requirements are not necessarily well represented in conventional forecasts. The analysis does not point to a simple shortage of spectrum that can be addressed through further allocations. Rather, it suggests a more complex challenge. Demand for wireless connectivity will continue to broaden across the economy while the spectrum that offers the most useful combination of coverage and capacity remains finite and already heavily used. Future spectrum policy will therefore need to focus increasingly on how spectrum is accessed, shared and used as well as on how much spectrum is available.

One of the clearest conclusions is that aggregate traffic is an increasingly incomplete measure of spectrum demand. Many of the emerging applications considered in this study generate relatively little data but nevertheless have demanding connectivity requirements. A rural sensor may transmit only a few bytes at a time. A drone command and control link may require little bandwidth. An emergency network extension may be used only occasionally. Yet failure to provide connectivity at the right place and time can have consequences that are disproportionate to the volume of traffic involved. Coverage, availability, latency, resilience, security, the number of simultaneous connections and the ability to obtain access when it is required can therefore be as important as bandwidth.

This has implications for how future demand is assessed. Traditional measures based on population coverage and aggregate data consumption need to be supplemented by measures that reflect geographical coverage, asset coverage, device density, peak concurrent use and the criticality of the service being supported. This is particularly important for rural infrastructure and aerial applications. The places where connectivity has the greatest value may be precisely those locations where commercial demand is normally weakest.

The study also reinforces the importance of spectrum below 10 GHz and particularly of lower frequencies for applications requiring wide area coverage. Rural monitoring, distributed energy resources and some aerial applications benefit strongly from frequencies below 1 GHz because of their propagation characteristics. However, these bands are already subject to competing demands. It is unlikely that all future requirements can be accommodated through further exclusive assignments. More intensive sharing will therefore become an increasingly important part of spectrum management.

This does not mean that all applications require the same form of sharing. The evidence points towards a spectrum access continuum. Routine monitoring and telemetry can often tolerate shared or licence exempt access. More critical control functions may require protected access. Public mobile networks will remain important where they provide the required coverage and service characteristics, while private networks, satellite services and local networks will have complementary roles. The challenge for policy is to provide access arrangements that allow these different models to work together without unnecessarily fragmenting spectrum into permanently dedicated blocks.

Use Case 1: Agritech, telemetry and distributed energy resource management

The rural portfolio illustrates the importance of looking beyond aggregate traffic. Demand from agriculture, environmental monitoring, utilities and distributed energy resources is likely to increase substantially but much of it will comprise very large numbers of devices carrying very small quantities of data. Coverage, connection density, affordability and reliability are therefore likely to matter more than aggregate capacity. There is also merit in considering these requirements collectively. Agriculture, energy, water, environmental monitoring and local government often require connectivity in the same sparsely populated areas and aggregating demand could improve the economics of rural infrastructure. The study recommends that:

- **A shared access product below 1 GHz should be developed.** The existing shared access framework should be extended to provide local licensed access to suitable spectrum below 1 GHz. The propagation characteristics of these frequencies make them particularly well suited to fixed rural monitoring and control applications. At present the lowest frequency available through the Shared Access framework is 1800 MHz, leaving a significant gap between the requirements identified in this study and the spectrum available for private and local networks.
- **The permitted transmit power in the lower licence exempt block below 1 GHz should be reviewed and consideration given to providing a network sub band.** The lower frequency block offers attractive propagation characteristics but operates under considerably tighter power restrictions than the upper block and does not provide an equivalent higher power provision for network equipment. With statutory monitoring requirements increasing across water quality, housing, flood management and energy, reviewing these arrangements could materially improve usable coverage without requiring additional spectrum to be released.
- **Future demand should be measured by device numbers and reporting frequency as well as data traffic.** Policy makers need a better picture of the number of connected devices, how frequently they communicate and the extent to which large numbers may communicate simultaneously. This should include private and licence exempt networks as

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well as connections carried by mobile operators. Without this information a substantial part of future machine connectivity demand will remain largely invisible in conventional traffic statistics.

Use Case 2: Aerial platform communications

Aerial platform communications present a different challenge. Demand is expected to grow as beyond visual line of sight operations, infrastructure inspection, logistics, environmental monitoring and public safety applications become more common. The important issue is not simply the total number of drones but how many are operating simultaneously within a given area and the communications links each requires. Command and control traffic is modest but requires very high availability while payload traffic can create substantial uplink demand. Existing mobile networks may support much of this activity but terrestrial coverage cannot be assumed to translate into reliable coverage at altitude. The study recommends that:

- **The definition and measurement of mobile coverage should be broadened to include aerial assets.** Mobile networks are primarily engineered to serve users at or close to ground level, with antenna systems generally directing signals downwards. Coverage above rooftops can therefore be materially different from the coverage experienced on the ground. As beyond visual line of sight operations increasingly depend on mobile networks for command and control, there is a case for aerial coverage to become an explicit part of the way network availability and performance are assessed.
- **The direction established by Ofcom's current drone spectrum consultation should be supported but longer term provision will ultimately be required.** The proposed access at 453 to 462.5 MHz and 5040 to 5060 MHz addresses an important gap identified by this study. The lower frequency provision is particularly relevant to operations in remote and rural areas. However, the proposed arrangements are time limited. As the drone sector develops, consideration should therefore be given to how suitable provision can be placed on a more permanent footing and, where possible, aligned with international arrangements.
- **The continued suitability of airborne use within the low band licence exempt provisions should be reviewed.** An elevated transmitter has a very different interference footprint from an equivalent device operating at ground level and may be visible over a much greater area. Existing power limits and access conditions have largely been developed around terrestrial propagation. As the number of airborne devices increases, the assumptions underpinning these provisions should be reassessed to ensure that they remain appropriate for aerial operation.

Use Case 3: Temporary drone enabled network extensions

Temporary drone enabled network extensions provide perhaps the clearest example of why spectrum access arrangements can matter more than spectrum availability. The technologies and spectrum required largely exist already. The gap is the ability to use them lawfully and immediately from an aerial platform at an unplanned location. An authorisation process taking days or weeks is of little use during a major incident, network failure or search and rescue operation. The study recommends that:

- **A standing authorisation should be developed to permit aerial transmission using an existing licensee's spectrum at short notice.** Accredited operators with approved deployable capability should be able to activate aerial coverage at an unplanned location under defined circumstances using the spectrum rights of the service being extended. The arrangements could be agreed in advance at programme level and activated when an incident is declared. This would avoid the need to seek individual regulatory approval during an emergency when communications may be required within minutes.
- **Existing precedents for sharing national communications infrastructure should be applied to temporary aerial network extension.** The arrangements through which Emergency Services Network infrastructure has been made available to mobile operators under the Shared Rural Network demonstrate that public safety assets can be shared with commercial networks through an agreed national framework. A similar principle could be applied to spectrum access for temporary aerial coverage, with the necessary technical, operational and regulatory safeguards agreed before an incident occurs.

More broadly, the three use cases demonstrate that the value of spectrum cannot always be inferred from commercial willingness to pay. Some of the most important benefits arise through avoided losses, public safety, resilience, environmental protection and the more effective use of existing public infrastructure. Rural monitoring can support statutory environmental and housing obligations. Distributed energy resource management can improve the efficiency and resilience of the electricity system. Aerial platforms can reduce the cost and risk of infrastructure inspection. Temporary network extensions can improve emergency response in locations where permanent coverage cannot economically be provided. Spectrum policy should therefore continue to consider wider social and economic value alongside direct commercial value.

Areas for further research

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Given the uncertainty associated with a 10 to 15 year horizon, the findings should not be regarded as a fixed forecast. The recommendations above identify actions which merit consideration now but there remain important areas where the evidence base needs to be strengthened. A programme of targeted research, practical trials and continuing monitoring would allow policy to respond as technologies develop and demand becomes clearer. Priority areas include:

- **Quantifying machine connectivity demand.** Further work is needed to understand the likely number, geographical distribution and characteristics of rural sensors, utility assets, agricultural devices and distributed energy resources. This should include reporting frequency, criticality, expected growth and the extent to which demand coincides during storms, floods and other events when communications infrastructure may itself be under stress.
- **Developing better measures of coverage.** Population coverage alone is a poor measure of the ability of networks to serve many of the use cases examined in this study. Further analysis should consider geographical coverage, asset coverage, coverage at altitude and coverage in difficult environments including valleys, woodland, basements and below ground infrastructure.
- **Examining shared access below 1 GHz.** More detailed work is required to identify which bands could realistically support shared rural connectivity, the requirements of incumbent users and the technical and geographical conditions under which sharing could be introduced.
- **Reviewing licence exempt provision below 1 GHz.** Further work should examine whether current licence exempt arrangements remain suitable for the expected growth of wide area monitoring networks and whether higher power network capability could be provided in appropriate parts of the low frequency range without creating unacceptable interference.
- **Assessing commercial models for mass telemetry.** The capacity required by individual devices is small but conventional mobile subscription models can become uneconomic when millions of low value connections are involved. Research should consider wholesale, aggregated and shared infrastructure models capable of serving agriculture, utilities, local government and environmental monitoring at sustainable cost.
- **Monitoring aerial mobile coverage and interference.** As beyond visual line of sight operations expand, actual mobile coverage and interference at different altitudes should be measured rather than inferred from ground based coverage. This work should consider flight corridors, areas of concentrated drone activity and the effect of large numbers of simultaneous aerial users.
- **Assessing future aerial spectrum requirements.** Further research should examine the appropriate balance between public mobile networks, satellite services, dedicated aviation spectrum and local or dynamically coordinated access as aerial operations grow. Particular attention should be given to safety critical command and control, uplink capacity and the communications requirements of unmanned traffic management.
- **Trialling temporary drone enabled network extension.** Practical trials involving Ofcom, the Civil Aviation Authority, emergency services, the Emergency Services Network, mobile operators and infrastructure operators would help establish the viability of deployable aerial networks. These should test deployment times, interference management, satellite backhaul, integration with standard user devices and operation during the loss or congestion of terrestrial infrastructure.
- **Developing arrangements for immediate temporary access.** Further work should consider how spectrum authorisation can be arranged in advance for emergency and resilience applications. This should examine standing permissions for accredited operators, arrangements operating under the rights of existing licensees and automated systems that allow spectrum to be activated according to location, altitude, duration and operational need.
- **Evaluating dynamic spectrum access.** Geolocation databases, automated coordination, improved sensing, smart antennas and artificial intelligence could enable more intensive spectrum sharing. Further study should focus on where these approaches can operate reliably and securely in practice and whether the benefits justify the additional complexity and cost.
- **Improving the assessment of social and economic value.** Further work should develop ways of capturing benefits that are not reflected adequately in traffic volumes or commercial willingness to pay. These include resilience, avoided economic losses, public safety, environmental protection and the value created by making better use of existing public and private infrastructure.

The overall conclusion is therefore not that every emerging use will require additional spectrum. In many cases the frequencies, technologies and networks needed already exist. The more important question is whether users can obtain suitable access where and when it is needed, with the appropriate level of protection and at a cost that reflects the value of the application. The priority over the next 10 to 15 years should be to improve the evidence base, develop more flexible

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access arrangements and test new approaches before demand reaches a scale at which spectrum access becomes a constraint.

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Annex 1: Stakeholder interview list

In the preparation of this report, we have conducted a wide range of interviews with many of the key the stakeholders who with an interest in future spectrum usage and all interviews were conducted under Chatham House rules. In addition, we interviewed a panel of experts from Coleago with knowledge of the topic.

In total 9 external stakeholder organisations were interviewed including:

- ESN/Home Office
- JRC
- Nokia
- Ofcom
- Spirit Public Sector Ltd.
- Telint Ltd.
- University of Strathclyde
- Vodafone
- Wave Mobile Ltd.

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Annex 2: Glossary

3GPP	Third Generation Partnership Project, the standards partnership responsible for mobile communications specifications including LTE and 5G.
4G	Fourth generation mobile communications technology, commonly based on LTE.
5G	Fifth generation mobile communications technology.
5G Advanced	The continuing evolution of 5G standards, adding further capability before the introduction of 6G.
6G	Sixth generation mobile communications technology, expected to emerge during the period considered by this report.
AI	Artificial intelligence.
BEIRG	British Entertainment Industry Radio Group.
BVLOS	Beyond visual line of sight, referring to unmanned aircraft operations where the remote pilot cannot maintain direct visual contact with the aircraft.
CAA	Civil Aviation Authority.
CAGR	Compound annual growth rate.
CBRS	Citizens Broadband Radio Service, the United States framework for automated tiered spectrum sharing in the 3550 to 3700 MHz band.
CNI	Critical national infrastructure.
D2D	Direct to Device or device to device communications, depending on context. In this report it includes direct satellite connectivity to end user devices and direct communications between nearby devices.
DCIA	Digital Connectivity Infrastructure Accelerator.
DCMS	Department for Digital, Culture, Media and Sport, the UK Government department associated with the DCIA programme at its launch.
DEFRA	Department for Environment, Food and Rural Affairs.
DER	Distributed Energy Resource, such as distributed generation, battery storage, electric vehicles and flexible demand connected to the electricity system.
DNO	Distribution Network Operator.
DTT	Digital terrestrial television.
EB	Exabyte, equal to one billion gigabytes.
ESN	Emergency Services Network.
EV	Electric vehicle.
FSS	Fixed Satellite Service.
GDP	Gross domestic product.
GEO	Geostationary Earth orbit.
GHz	Gigahertz, equal to one billion hertz.
GNSS	Global Navigation Satellite System, the generic term for satellite based positioning and navigation systems.
GPS	Global Positioning System.
GW	Gigawatt, a unit of power equal to one billion watts.

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GVA	Gross value added.
HAPS	High altitude platform systems or stations, using aircraft, balloons or similar platforms operating at high altitude to provide communications or other services.
IMT	International Mobile Telecommunications, the ITU framework covering successive generations of public mobile technology.
IMT 600	Potential use of spectrum in the 600 MHz range for International Mobile Telecommunications.
IoT	Internet of Things, covering connected devices and machine type communications over fixed or wireless networks.
LAL	Local Access Licence.
LEO	Low Earth orbit.
LPWA	Low power wide area technology, designed to support large numbers of low power devices over wide areas.
LTE	Long Term Evolution, the principal radio technology associated with 4G mobile networks.
Mbit/s	Megabits per second, a measure of data throughput.
MHz	Megahertz, equal to one million hertz.
MIMO	Multiple Input Multiple Output, an antenna technique using multiple transmit and receive paths to increase capacity and improve radio performance.
MNO	Mobile Network Operator.
MOD	Ministry of Defence.
MSS	Mobile Satellite Service.
MWh	Megawatt hour, a unit of energy.
NFC	Near Field Communication.
NFU	National Farmers Union.
NGSO	Non geostationary satellite orbit.
NTN	Non terrestrial network, providing connectivity from platforms in space or the stratosphere rather than solely from terrestrial infrastructure.
OPEX	Operating expenditure.
PAN	Personal Area Network, connecting devices over a short range around an individual or local workspace.
PB	Petabyte, equal to one million gigabytes.
PCL	Passive Coherent Location, a passive radar technique that uses transmissions from third party sources rather than a dedicated radar transmitter.
PMR	Private or professional mobile radio, typically used for operational communications by businesses, utilities and public services.
PMSE	Programme Making and Special Events, including wireless microphones, in ear monitors and related production equipment.
PNT	Positioning, navigation and timing.
PSTN	Public Switched Telephone Network.
RF	Radio frequency.
SAL	Shared Access Licence.

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SAS	Spectrum Access System, the automated coordination system used in the United States CBRS framework.
SBSP	Space based solar power.
SCADA	Supervisory Control and Data Acquisition, systems used to monitor and control industrial and infrastructure assets.
SD WAN	Software defined wide area networking.
SIM	Subscriber Identity Module.
SME	Small and medium sized enterprise.
SPF	Spectrum Policy Forum.
SRN	Shared Rural Network.
TETRA	Terrestrial Trunked Radio, a digital radio standard used for professional and public safety communications.
TT&C	Telemetry, tracking and command, used for monitoring and controlling satellites and other space systems.
TVWS	Television White Space, locally unused frequencies within spectrum allocated to television broadcasting that can be made available for other uses under controlled conditions.
U6	Upper 6 GHz band.
UAS	Unmanned Aircraft System, comprising the aircraft and the associated control, communications and operational systems.
UAV	Unmanned Aerial Vehicle.
UHF	Ultra High Frequency, covering 300 MHz to 3 GHz.
USB	Universal Serial Bus.
V2X	Vehicle to Everything communications, covering communications between vehicles and other vehicles, infrastructure, networks or road users.
VHF	Very High Frequency, covering 30 MHz to 300 MHz.
VLOS	Visual line of sight, referring to unmanned aircraft operations in which the remote pilot maintains direct visual contact with the aircraft.
VoLL	Value of Lost Load, an economic measure of the cost to consumers of electricity supply interruption.
vRAN	Virtualised Radio Access Network.
Wi Fi	Wireless local area networking technology based on the IEEE 802.11 family of standards.
WRC	World Radiocommunication Conference, the ITU conference that reviews and revises the international Radio Regulations.

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