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Rural Connected Communities

5G Test Bed & Trials Programme

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1. Executive Summary

1.1. Introduction

1.1.1. Major progress has been made with provision of fixed broadband communications to rural areas within the United Kingdom over the past three years. The situation with provision of mobile network services however has not been so impressive. Current UK Government policy is focussed largely on the Shared Rural Network (SRN), which aims to increase geographic coverage from at least one operator to 95% of the UK by the end of the programme in 2025. The project aims to provide coverage to an additional 280,000 premises[1] which are currently located within 'Not Spots'. Even if the SRN Project does deliver all of its targets, there will still be a substantial proportion (some 5+%) of the total UK landmass without any cellular mobile coverage from any Mobile Network Operator (MNO). These residual areas will not be commercially viable for MNOs to cover with conventional solutions; a more cost effective and downward scalable solution will be required to cover these sites

1.1.2. The purpose of the MONeH Project has been to assess whether a Multi Operator Neutral Host (MONeH) deployment can provide cost effective, rapidly deployable and feature rich service within a rural area with little mobile coverage.

1.1.3. The SRN deployments are focussed where UK MNOs admit to having no coverage. It has been demonstrated however that there are many areas where coverage is claimed, that have no workable service. The Chalke Valley in Wiltshire is an excellent example of one such location.[2]

1.1.4. Major barriers included gaining access to suitable spectrum, obtaining and engineering high capacity backhaul, obtaining full operator interconnect with other MNOs and sourcing suitable radio equipment with the required technical specifications within project timescales.

1.1.5. Currently (mid-2022) it is not possible to obtain native 5G (HTML2) interconnects with other MNOs, so all bilateral connections are achieved using 4G (Diameter) signalling. This also constrains operation to 5G Non-Stand Alone (NSA) architecture - where operation is controlled using 4G (Diameter) through an LTE Anchor Channel, with additional 5G New Radio (5G NR) channels being logically attached to the service using carrier aggregation.

1.1.6. The planned deployed radio architecture within the MONeH Project was a 4G Anchor Channel in Band 3 (1800 MHz FDD) with additional Carrier Aggregation (CA) channels in Band 38 (2600 TDD) and Band N77 (3.8-4.2 GHz TDD). However, difficulties associated with implementing carrier aggregation across two different radio platforms led this to be modified to two independent network segments, a 4G 5 MHz wide service in Band 3, utilising Nokia FlexiZone radios, offering wide area coverage for mobile users, and a 5G 20 MHz wide service in Band N77, offering Fixed Wireless Access to static users.

1.1.7. The project successfully demonstrated an inbound Local Roaming service for both UK and foreign users on multiple different networks. Inbound roamers are able to make and receive phone calls, send and receive SMS and access mobile data services on their own devices without any preparation or user interaction, in areas where there is no mobile service from their Home Network. The project are now well positioned to charge for services once agreements with MNOs are in place.

1.1.8. The project developed architecture and procedures for the deployment of small cell installations on privately owned buildings. Due to the small size, weight and power consumption of the small cells, they can be rapidly deployed without time consuming and costly planning approval from local authorities.

1.1.9. Small form factor radios are much better suited for deployment in sensitive rural areas, such as the Cranborne Chase Area of Natural Beauty, in which the Chalke Valley is located, as visual

[1] https://www.gov.uk/government/news/shared-rural-network

[2] Ofcom Mobile Coverage Checker, Bowerchalke Village Hall, https://checker.ofcom.org.uk/en-gb/mobile-coverage#pc=SP55BE&uprn=200001519932

impact is much smaller than conventional macrocell deployments from the large Mobile Network Operators.

1.1.10. Flexibility in coverage gives the ability to cover very precisely 'Not Spots' (areas with poor or no mobile coverage). The deep meandering Chalke Valley is a challenging area for conventional mobile network coverage, as most of the buildings are situated along the bottom of the valley. Much better coverage can be achieved with multiple small cells than with a small number of larger conventional masts.

1.1.11. The principal measure of cost of deployment of mobile infrastructure is expressed in terms of Cost per Unique Property (Cost/UPRN).

1.1.12. The cost of rolling out a 2Mbps mobile service with conventional macro architecture on both the DCMS sponsored Mobile Infrastructure Project (MIP) and the Scottish Government 4G Infill Project came in at around £5k per UPRN. The Shared Rural Network (SRN) will provide coverage at around £3.7k per UPRN (if it achieves all the planned coverage).

1.1.13. By contrast the MONeH Small Cell infrastructure deployed in the Chalke Valley achieved a cost of under £1k per UPRN.

1.1.14. There are different models for Neutral Host, for many of them it means one company installing separate radios for each of the operators, each using dedicated operator spectrum and each connecting to the individual operators' cores. All that is really neutral in this model is the installation. For the MONeH project we deployed a model where the entire network is neutral. One set of infrastructure, its own spectrum and one core all linked to the multiple operators. MONeH small cells provide a neutral Multi Operator Carrier Network (MOCN) solution in which a single radio access network is shared between all users. Significantly, this approach does not require any incremental investment of time or money from individual MNOs in order to function.

1.2. Busting Barriers

There still remain a number of significant barriers that require addressing in order to make the mass rollout of MONeH infrastructure practicable. These are:

1.2.1. Timely and Cost-Effective Access to Mobile Spectrum.

Whilst the MONeH Project was successful at obtaining Local Access and Shared Access licences for suitable primary mobile spectrum, the time and effort required to complete the processes was prohibitive. A much faster and economical method will be required to ensure that infrastructure and be deployed within budget and time constraints.

1.2.2. Implementation of Interconnects and Settlement with MNOs.

Engaging with UK MNOs in order to negotiate and agree mutually acceptable terms for interconnect and settlement is challenging. To be successful there must be sufficient revenue or resource returned to the MONeH operator(s) in order to ensure that rural deployments can self-support without additional Government funding.

1.2.3. Availability of Numbering Resources.

For a small MNO to offer a public service it is necessary to have Mobile Network Codes (MNCs) and Mobile Number Ranges (MSISDNs). Our experience with the project was that these assets were difficult and time consuming to acquire from Ofcom. In order to make public MONeH deployments feasible, numbering resources must be made available in a timely and cost-effective manner.

1.2.4. Grant Funding for Mobile Infrastructure.

Current BDUK Grant funding schemes only cover fixed broadband deployments. Whilst the MONeH project demonstrated that it is feasible to provide Fixed Wireless Access (FWA) services in both ‘Superfast’ (30 Mbps) and ‘Ultrafast’ (100 Mbps) categories, there is no equivalent grant category for ‘mobile’ service. We envisage this to take the same form as the SRN service definition, viz, a 2 Mbps service to a mobile device, both in-building and outdoor scenarios.

1.2.5. Availability of SIMs and Associated Management Infrastructure.

The specification and procurement of appropriately designed and configured SIMs which capable of working across multiple radio networks remains a major challenge for small network operators. Whilst it is possible to source SIMs for private network use, SIMs for public use require a considerably greater level of sophistication and associated network core elements.

1.2.6. Identification of Mobile Not Spots.

The current Ofcom Coverage mapping has been shown to be inaccurate, particularly in areas of low population density. To better build an precise model of where Not Spots are situated new and innovative means of surveying coverage and network performance are required.

1.2.7. Availability of Fibre for Backhaul

The processes for ISPs to deal with fibre providers, and in particular BT OpenReach, lead to delays which can make deployments uneconomic. OpenReach has a number of products each of which requires negotiation with a separate department. Costs and timescales are opaque with much of the UK only covered fibre on demand which has delivery times of between seven months and a year.

1.2.8. The Way Forward

The lessons learned and challenges encountered within the MONeH Project will be carried forward within the Telet-led Future Radio Access Network Competition (FRANC) ‘Best of British’ Consortium, with the intent of providing UK Government with a fully proven solution with which to plug the residual holes left within UK Mobile Coverage following the completion of the Shared Rural Network Project in 2025.

2. Introduction

2.1. Summary of MONeH RCC Project Objectives

The overarching objective of MONeH Rural Connected Communities (RCC) project within the 5G Testbeds & Trials Programme was to demonstrate the extent to which innovative use of 5G technology can provide rural mobile and fixed wireless connectivity in areas that currently have poor access. Specifically, the project set out to do this by deploying small cell infrastructure within rural scenarios. The aim of the project was to deliver a range of costed applications and services against which comparisons could be made with conventional mobile network architectures. Further, the project set out to illustrate how 5G network slicing allows new commercial models to be developed that show 5G rural deployment enables solutions that are commercially viable.

2.1.1. Deployment of 5G mobile connectivity within the Project area

The Project deployed a 5G core network and management infrastructure with supporting radio assets within two rural locations (Chalke Valley area and Thames Valley). By using small cells, mounted on local buildings with existing power and broadband backhaul, it was possible to dramatically reduce the time and cost of deployment whilst avoiding the need for planning permission or wayleaves. Operation of these radio cells on a neutral host basis, enabling shared access for both public and private applications, with a focus on network slicing, maximises the revenue and benefits derived. Provision of public services required the MONeH network to interconnect commercially with Mobile Network Operator-provided services, allowing local users to "roam" onto the project network. As the findings demonstrate, however, this requirement was not straightforward, even though Telet Research as a consortium partner is a GSMA operator member. Work continues to operate with MNOs via third party interconnect providers. The project employs state-of-the-art non-standalone 5G radio access network (RAN) and core network technologies, including Multi-access Edge Computing and wireless backhaul/meshing. Fibre backhaul is provided at 1Gbps to selected properties. It provides an alternative solution for small-scale rural deployment of 5G mobile services. In a number of scenarios it was possible to use a 5G service to provide high speed backhaul for a slower, but wider area coverage provided by 4G cells.

2.1.2. Spectrum acquisition to support deployment of the radio access network

The Project requirements necessitated the appropriate spectrum to be in place to support the network. Using the new Ofcom Local Access Licence, the Project obtained access to spectrum in the 1.8GHz (Band 3), 2.3GHz (Band 40) and 2.6GHz (Band 38) bands, whilst also utilising Shared Access spectrum (Band N77) to ensure optimum coverage.

2.1.3. Development and validation of new business models and technological approaches for network deployment in similar types of areas

The Project developed and tested different commercial models, including local community ownership (CIC), centralised (led by the consortium) and privately owned, e.g. Shaftesbury Estate. MONeH also explored different low-cost deployment solutions for 5G networks and generated a quantified assessment of multiple revenue streams and the different ownership models.

2.1.4. Development and assessment of agricultural monitoring use case

The project engaged with the local farming community and wider farming ecosystem to demonstrate how 5G implementation on an estate can provide not only a commercial model, but provide cost savings, time and economic and environmental benefits to the farms but the wider agricultural community.

2.2. Rural Not-Spots and MNO Coverage

2.2.1. The ambiguity in reporting on what constitutes mobile coverage by the MNOs and Ofcom in a geographical setting and thus what is deemed a not-spot is not reflective for members of the public armed only with an MNO SIM in a standard off-the-shelf mobile phone. The Chalke Valley in Wiltshire is case in point; there is a problem. One only needs to review the coverage maps on the operators' sites or Ofcom and these identify the Chalke Valley as having "good outdoor coverage". Operators' coverage maps are over egged at best. Practical coverage is considerably worse than they like to admit. At the end of the current round of Shared Rural Network (SRN) projects there will still be significant not-spots. A not-spot is defined as being unable to support 2Mbps data transfer consistently. However, when you try to make a call from your Android or Apple phone one realises the projected coverage MNOs state they cover, this just is not the case. If this is true of the Chalke Valley, then this is one location of many across the UK where MNO coverage reports do not accurately reflect utilisation of mobile coverage on the ground. Therefore, you have to question why the mobile network maps say they have great coverage and yet most people say they have problems.

2.2.2. When you ask mobile networks about coverage they give you a number, somewhere between 91% and 99% but are a little vague about what coverage actually means. EE will say that its standard 4G network covers 99% of the UK population. Three claims 91%, O2 says 99% over 3G and 4G with a caveat that it is a figure for outdoors whilst Vodafone says 97%. Ask residents how they view coverage, and the figures will be starkly different with residents saying their particular town or hamlet is somewhere between 9% and 1% with suspect service? An annual survey of National Farmers Union members reports that only 17% of members have ourdoor coverage across their whole farm and that 2022 figures were worse than 2021.

2.2.3. It is important to realise that the figures provided by MNOs are often given where there is a denser population and not in truly rural locations. You can cover just the 2,600 square miles inside the M25 and provide service to over 14m people, while the 30,000 square miles of Scotland is under 5.5m people. A thirtyfold difference. Therefore, MNOs will argue that their business models do not support areas of less dense users connecting to their masts and the ROI does not support the investment required to level up areas across the UK.

2.2.4. Recent research from Uswitch.com says that over a quarter of people (27 per cent) report having to move to another room because of poor mobile reception, one in seven (14 per cent) leave the house in a bid to get a better signal. A recent report by Which? Magazine shows that 18% of Three subscribers regularly experience problems.

2.2.5. Even in the places where there is a denser population, the coverage still does not hit better than a 90% figure. It is a long running problem, back in 2014 a survey by coverage experts Global Wireless Solutions found that one in three internet tasks failed on London commuter trains. These results were focussed on areas in highly populated areas where MNOs are claiming 99.99% coverage.

2.2.6. In rural areas such as the Chalke Valley the coverage situation is much worse; in many cases when you go onto an operator's website to check availability for a specific area it will claim "good outdoor coverage" and then as you drive down that road or walk across a field, mobile calls fail. The status-quo is not acceptable especially where Levelling-Up is an agenda item.

2.3. UK 5G Coverage – Non-Stand Alone (NSA) and Stand Alone (SA) – the issues

2.3.1. Different 5G Network Architectures

There are two different forms of 5G Networks currently deployed in the UK. These **are:**

2.3.1.1. 5G Non Stand Alone (5G NSA)

5G NSA is the cheapest and simplest form of 5G and is used by all of the UK MNOs in their current deployments. NSA utilises a 4G signalling 'Anchor Band' and associated core through which all services are accessed. The 4G service is then enhanced with the addition of one or more 5G waveforms in additional bands, which are logically combined with the 4G Anchor utilising Carrier Aggregation. The main advantage that this gives is much greater bandwidth/speed, although latency and range are not greatly enhanced.

The core signalling used within 5G NSA is the same as is used within 4G networks, viz, Diameter. Using Diameter and the existing 4G network core means that costs and deployment times are much reduced, but with the effect that only a limited subset of 5G functionality can be offered. However, for many use cases, where user requirements are not so demanding, a 5G NSA deployment is the most cost effective solution at present.

2.3.1.2. 5G Stand Alone (5G SA)

Most MNOs are currently experimenting with full 5G mobile network cores, which offer a much richer set of functionalities than the earlier 4G cores that are currently in service.

5G SA signalling (HTML2) provides support for a wide range of new capabilities, including support for independently configured and managed network slices, each of which can offer different Quality of Service, performance profiles and commercial models. This allows individual services to trade-off between bandwidth, range/power and latency.

2.3.2. Constraints Imposed by Current MNO Capabilities

At present, there are no inter-network roaming agreements to facilitate roaming between different MNO 5G SA networks. The existing 5G SA deployments are isolated single network configurations upon which only home network users can attach and gain service. The first 5G SA roaming pilots are scheduled to take place early next year (2023) with commercial 5G roaming services scheduled to start around 2025.

2.3.3. Billing and Charging Evolution (BCE)

One of the single largest missing components required to enable inter-network 5G SA roaming is the mechanism for financial settlement between operators. The GSM Association (GSMA) is leading the development of a procedure for carrying out these processes, under the title of Billing and Charging Evolution. Within BCE the old TAP-record based batch settlement system will be replaced by a near real-time charging system in which data sessions are charged depending on a number of different parameters, such as the Quality of Service (QoS) and network congestion.

2.3.4. 5G for Rural Deployments

With the current focus on large bandwidth 5G deployments (eMBB) within urban areas, it is not easy to identify where 5G capabilities can be best utilised within rural scenarios. Rural 5G will undoubtedly operate with much narrower waveforms than their urban equivalents, with 5 or 10 MHz channels offering much better coverage in areas where bandwidths are less important that maximising coverage. Whilst urban deployments are likely to be based on mid-band (2-6 GHz) and millimetric (6-60 GHz), rural deployments will require the better long range propagation characteristics of sub-2GHz bands.

2.3.5. Levelling Up with 5G

The importance of 5G and rural connectivity within the context of the current levelling up agenda is clear. Availability of effective and usable mobile communications is now seen as an essential service, on a par with supplies of electricity, gas and water. As was demonstrated very strongly within the Chalke Valley during the project; this is one of the main reasons that it is not possible to scale back the existing services provided by Ch4lke Mobile as the local population would resist most vigorously should any move be made to cease services.

Due to the difficulties involved in implementing bilateral settlement with UK MNOs, Ch4lke Mobile operates using a JOTS commercial model, viz, no revenue or direct benefit is passed to CH4LKE. Clearly this is commercially unsupportable in the medium term and further effort needs to be expended to establish forms of settlement that are sufficient to support ongoing operation. In the short term, Telet will continue to support the CH4LKE Network for use as a live testbed for SONIC and FRANC Projects.

Lack of mobile coverage has major effects on other UK Government programmes, in particular on the Emergency Services Network (ESN), which requires UK wide mobile network coverage before it can fully replace the existing outdated TETRA radio system. A multi-slice shared Multi Operator Neutral

Host solution could provide much of the missing coverage required to get ESN and other UK Government and Commercial applications launched.

3. MONeH RCC Project

3.1. Technology and Methodology

3.1.1. 5G Components

3.1.1.1. UEs/CPEs

Target User Equipment's (UEs) [phones] used within the project are standard off the shelf Android and Apple iOS devices as used by UK and other foreign MNOs

Customer Premise Equipment's (CPEs) used fall into two groups:

Indoor CPEs - with built in omnidirectional antennas.

Outdoor CPEs – with directional gain antennas.

3.1.1.2. Radio Cells (incl. Power supplies, antennas)

CableFree 'Emerald' in Band n41 (2600 TDD) and Band N77 (3.8 GHz).
Nokia FlexiZone eNodeB (4G) in Band 3 (1800 MHz FDD) and Band 38 (2600 MHz TDD).
CableFree 'Tribble' - a medium form factor gNodeB with three remote radio heads, operating in Bands 3, n41 and N77.
Local (Front End) Core

Locally deployed core, based upon Open 5GS, to offer local operation for private network applications and to act as concentrator for signalling passed to Central Core. Local cores are connected by VPN to Central Core.

3.1.1.3. Central (Back End) Core

Centralised core located in Telehouse North, based upon Polaris 5G Core with AuthC from Summa Networks and IMS from ngVoice. Provision of central authentication, profile management, accounting, and all interconnections to other public networks.

Interconnections with other networks implemented via dedicated point to point links and VPNs to other MNOs and roaming hubs (BICS and Commverse).

Settlement System - recording details of all traffic, classified by QCI.

SIM Management Platform - controlling configuration and deployment of SIMs (both in eUICC and eSIM versions) via Over the Air (OTA) system. [Not fully implemented].
OCS/BSS - For configuration and management of eNodeB/gNodeB platforms, plus deployed CPEs (using TR069 configuration).
Authentication (SIMs/Central Auth dB)

3.1.1.4. Backhaul / IP Networking Infrastructure (incl. routers)

Broadband Circuits. A variety of different forms of backhaul were trialled, including dedicated uncontended 1 Gbps fibre (for high capacity 5G operation), existing contended fibre circuits (Wessex Internet), domestic broadband, wireless mesh (between cells within local area) and bonded MNO wireless. In later stages 5G services were used to provide medium capacity backhaul for deployed 4G eNodeBs.

VPNs. Providing secure backhaul from deployed 'islands' of RAN. Configured using cost effective MikroTik routers at Front End Core which act as demarcation point for monitoring of transport links back to Central Core. A number of different VPN technologies were trialled, including standard IPSec , WIreguard and ZeroTier.

Configuration and Management. For configuration and management of deployed assets.

3.1.2. Small Cell MONeH

3.1.2.1. **Deployed** 'Islands' of RAN, sited on private buildings as close to locations where mobile services are required

3.1.2.2. Local Roaming services are offered to subscribers from any other MNOs in areas where access to their home network is not possible. This publicly accessible service requires no action on the part of the end user; their devices will automatically roam onto the local MONeH network without manual intervention. Voice, data and messaging services are offered for both inbound and outbound traffic at no additional cost beyond users existing subscription fees.

3.1.2.3. **Settlement**. There is a clear requirement for local MONeH networks to generate enough revenue and/or benefits to support running costs without requiring external subsidies from the Government. The proposed MONeH settlement scheme (not yet implemented with UK MNOs) is based upon exchange of traffic credits, where inbound roaming traffic by MNO users is netted against outbound roaming traffic from Telet users roaming onto MNO networks. There is provision for rebalancing adjustment payments to be made between parties where traffic imbalances occur; the pricing and threshold criteria for these payments is to be controlled by the UK MNOs.

3.1.3. Design Methodologies

In order to achieve the optimum balance between cost, functionality and ease of deployment the following strategies were utilised:

3.1.3.1. **Cost/Complexity Reduction.** At each stage in the design process, emphasis was placed on engineering out cost/time at every opportunity in order to reduce cost of deployment.

Shared RAN was used to support multiple application slices in order to maximise revenues and benefits.

3.1.3.2. **Optimised coverage templates** were achieved by deploying multiple small cells - in order to eliminate not spots (not accessible by single macro sites), with particular emphasis being placed on taking services to where users live and operate. This was found to offer better performance and coverage, particularly for in-building use.

3.1.3.3. **Reuse of shared spectrum** was used to achieve higher total throughput than conventional macro cell deployments by spatial reuse of spectrum.

3.1.3.4. **Use of existing power and backhaul** wherever possible lead to reduced costs and deployment times.

3.1.3.5. **Elimination of requirement for planning permission** by keeping form factor of externally mounted equipment below planning thresholds. The small cells used are treated in the same manner as domestic satellite TV antennas and as such no formal planning permission is required prior to deployment. This reduced cost and time required to deploy infrastructure. The reduced physical presence of system components was seen to be a great benefit for deployment within the AONB and on older listed buildings.

3.1.4. Differences between Fixed and Mobile Network Provision

3.1.4.1. Current BDUK Grant Funding has been focussed solely on provision of fixed broadband infrastructure. Whilst this has been extraordinarily successful at stimulating roll out of fibre services in rural areas, no such funding is currently available to support deployment of localised mobile RAN infrastructure.

3.1.4.2. **There** is a clear requirement for similar scheme aimed at stimulating the roll out of publicly accessible infrastructure for mobile users, such as Royal Mail, delivery, utilities, emergency services, public transport, and other commercial uses.

3.1.4.3. Typically a fixed communications service (such as fibre broadband) will supply service to solely one UPRN, whilst a mobile communications service is capable of providing an area service to multiple UPRNs and mobile users over a wide area.

3.1.5. Deployment Costs

3.1.5.1. Current Macro deployments (eg MIP and Scottish Govt 4G Infill Programme) cost circa £5k per UPRN (for 2Mbps 4G LTE service).

3.1.5.2. Shared Rural Network (SRN) will cost circa £3.7k per UPRN - if the project meets all of their deployment targets which many experts consider very unlikely, the programme has been running for 18 months at the time of writing and so far has only deployed in one total not-spot.

3.1.5.3. The MONeH Project has demonstrated small cell deployments that return sub-£1k per UPRN costs.

3.1.6. **Backhaul**

3.1.6.1. Deployment of MONeH infrastructure is constrained by availability of acceptable backhaul within the deployment areas.

3.1.7. **5G NSA vs 5G SA**

3.1.7.1. The project was unable to offer MONeH with 5G SA configuration as UK MNOs do not support 5G (HTML2) signalling and therefore was forced to use 4G (Diameter) interconnects

3.1.7.2. 5G NSA utilises a 4G (LTE) anchor channel, with additional Carrier Aggregation (CA) incorporating 5G NR waveforms to increase performance.

3.1.8. User Traffic Profiles

3.1.8.1. The MONeH Project has defined three user traffic profiles that coincide with existing SRN and BDUK Grant service definitions. These are 2 Mbps - Wide Area mobile profile, aimed at mobile endpoints with current UEs, **30 Mbps** - Super-Fast Fixed Wireless Access (FWA) and 100 Mbps - Ultra-Fast FWA.

3.2. MONeH RCC Use cases

3.2.1. Lower Cost Per Household

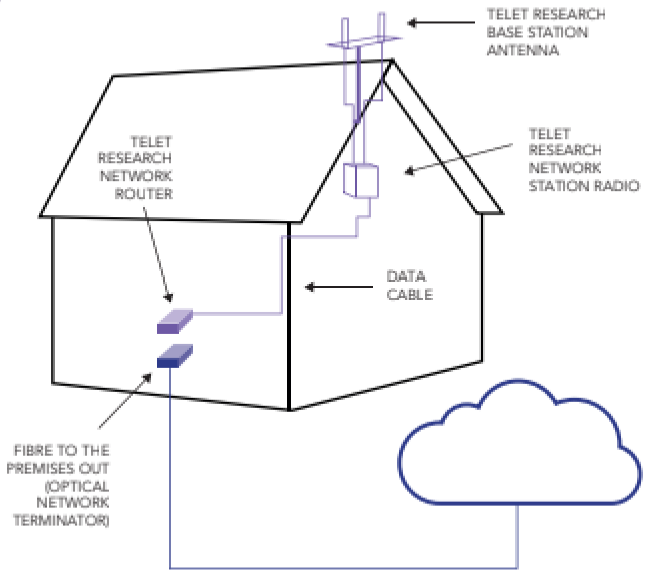
The Chalke Valley is one of the largest contiguous mobile phone blackspots in England. The combination of the deep sided chalk valley together with the protected status that comes with being an Area of Outstanding Natural Beauty (AONB) have made the area a particularly challenging one for MNOs to project workable service into. Residents and businesses have been frustrated for too long by mediocre quality phone reception and unacceptably slow internet speeds. The real impact of this has only been highlighted further by the recent COVID times to stay connected. Despite various initiatives by EE, O2, Three and Vodafone to provide coverage, there has been little improvement. Whilst the focus is on areas where MNOs can make significant revenue through phone attachments and areas of high phone usage, this has meant rural communities are being left behind at a time UK Government talks of levelling up.

MONeH RCC is utilising a community led approach where small radio cells mounted on domestic properties or businesses removes the need for eyesore towers within the Cranborne Chase Area of Outstanding Natural Beauty. By building a system with small components, each around the size of a couple of shoeboxes, attached to the roofs of buildings, Small Cell MONeH can provide faster connections at a lower cost than any of the major networks, without impacting the local area.

Together, MONeH RCC has:

- Vastly improved internet speeds and mobile reception, taking the area from the lowest 2% in the country to the highest 2%.
- Paved the way for a technological revolution for the Chalke Valley, bringing residents and businesses all the capabilities they need to stay connected.
- Enabled property owners to become integral to the structure of the MONeH RCC network.
- Preserved the unmatched beauty of the Chalke Valley. All of this connectivity is being provided without impacting on the beautiful surrounding environment with the construction of 30 m high masts on hilltops or digging up the arterial roads.

The design of the partnership is for the property owner there is no cost for the installation of the connection or the equipment, and no monthly charge for the 1Gbps internet connection, which would normally be c£900 p.a. In short, the property owner gets free fast fibre internet connectivity to use. In return, the property owner just needs to provide a suitable mounting site, typically a chimney or gable end, and access. The small radio cell needs to be kept powered up, the cost of doing this is estimated at c£50 p.a. MONeH RCC lays out the arrangement in a simple two-page agreement.



3.2.2. Fixed Wireless Access (FWA)

Whilst the concept of FWA is not new, current versions are based on 4G/LTE technology, it is spectrally inefficient, expensive to deploy, and is unable to provide the speeds needed to compete with wired broadband connections let alone fibre. The direction of travel of the market is for 5G FWA through beamforming and a high-frequency mmWave (millimetre wave) spectrum, to provide a competitive alternative to fixed-line DSL, Cable, and fibre. The intention being suburban and rural consumers can receive the bandwidth required to support high-definition streaming services and high-speed Internet access i.e., the provision of ultra-high-speed broadband to areas where the cost of laying fibre or maintaining fibre lines is prohibitively expensive.

The project brings improved speed and quality of service into a rural setting. The baseline is 2 Mbps with a latency of 40ms as delivered by copper connectivity in Broad Chalke. Ch4lke Mobile is delivering 5G FWA in excess of 35 Mbps with a latency of 20ms. The project will look at the commercial opportunities to ascertain a potential pricing model where current average cost per month of broadband services is £15pcm. This project will test the appetite to get a much-improved speed and to understand where the price point is and whether a £10pcm increase to £25pcm for faster speeds and lower latency is achievable.

Whilst 5G FWA speeds have reported 1,000Mbps, these have been undertaken in highly controlled environments with non-production equipment.

As part of the Broad Chalke deployment a 5G N77 CableFree gNodeB has been mounted to The Queen's Head pub. A 5G CPE, has been installed into the nearby Broad Chalke Community Hub and Shop with speeds and latency measured and monitored. The Hub has been chosen due to the dynamic nature of business and utilisation of connectivity needs to drive aspects of activity within the Hub. Secondly, the Hub sits within a Not-Spot area and is currently supplied with ADSL/Copper broadband with low levels of up and down links. The Community Hub contains the Village Shop and Post Office and therefore requires connectivity to manage the till as well as the PDQ machines as well as providing rich coverage to the community area which provides lunches, teas as well as a meeting place and facilitates remote working opportunities. The latest speedtest results at the Hub were 72Mbps download and 9Mbps upload.

3.2.3. Agricultural Monitoring and sampling

3.2.3.1. Use case 1 – Soil Sampling for better nutrient use efficiency

Current processes for testing soils to determine agricultural applications of fertilisers are currently slow and expensive. They require soil to be physically collected in the field, this is then bagged and sent to a laboratory for chemical analysis before the data that is needed to inform fertiliser applications is available.

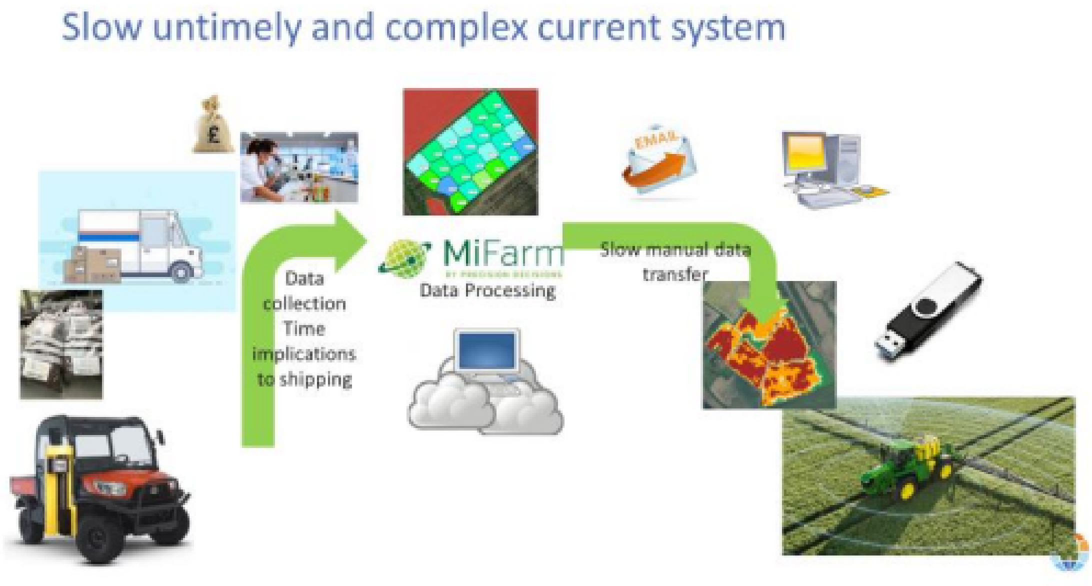
This data is emailed back before being processed into on-farm fertiliser application prescriptions that require manual transfer to vehicles via files or memory sticks. This process leads to delays in information gathering, uses expensive laboratory analysis to measure nutrients and is often complicated with technologies and lack of user skills preventing files reaching the tractor in time to allow timely applications. These combined factors often result in farmers being put off technology that is classed as too complex and costly and as a result best practice not being achieved.

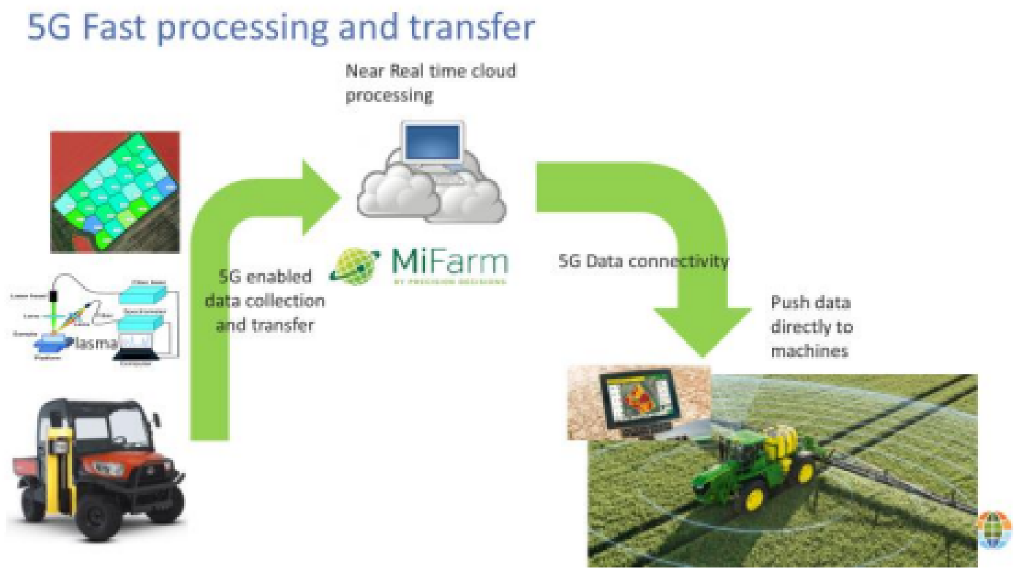
Latest state of-the-art technology for soil analysis for example the laser-induced breakdown spectroscopy as used on the MARS rover for chemical and rock analysis has been proven to be capable of being calibrated to measure soil nutrient content. This process is achieved by firing a laser at the soil to atomise and excite samples by creating a measurable micro plasma that is recorded in detail with a spectrometer. This works well in laboratory conditions, generating vast volumes of data that require processing to enable interpretation to soil nutrient content.

This concept has been proven to deliver real-time in-field analysis, but the progress has been limited as real-time access to databases and servers required to interpret these massive datasets in field are not currently available. The introduction of rural 5G offers a unique opportunity to highlight, develop and demonstrate this novel new process. 5G accessibility rurally to provide internet with capability to transfer data automatically to the servers to process the results offers the ability to transform the process and provide seamless data transfer removing complexities sighted as blockers by many farmers.

Furthermore, once the results are remotely processed, they can be sent back electronically to enabled equipment on the farm directly, removing the need for memory stick data transfer and manual computer data entry/manipulation some of which is also limited by low bandwidth and poor rural connectivity.

The availability of 5G connectivity rurally would therefore have the potential to transform agricultural production, by offering higher resolution soil analysis in more detail than has been achievable before to allow farmers to measure soils in extremely high resolution providing in depth insight on soil health and nutrition, while also providing ground-breaking benchmarking services to monitor soil carbon. This exciting use case can fulfil many roles, enhance farmers' sustainability credentials while reducing use of fertiliser and improving nutrient use efficacy so protecting the environment, water systems and farm profits. 5G connectivity could provide ultimate transformation of the services offered to agriculture and environmental management.





3.2.3.2. Use case 2 – Real-time crop sensing

The ability to analyse crops as they grow, offer farmers insight to fertiliser requirements during the growing season, which are particularly important to products such as nitrogen fertilisers. Nitrogen is an essential nutrient that plants require to increase yield and protein content which if mismanaged leads to reduced yield, lower quality grains and grass requiring additional inputs to be purchased further increasing livestock feeding costs or leading to crop losses.

Mismanaged applications of nitrogen which can be hard to judge by eye are also responsible for large proportions of nitrous oxide emissions contributing to climate change. Managing this nitrogen application is difficult particularly when farmers are using organic manures, as measuring the content of nutrient in these products is unpleasant, slow, and costly, and the ability to accurately calculate the availability of nutrient release is hard to determine.

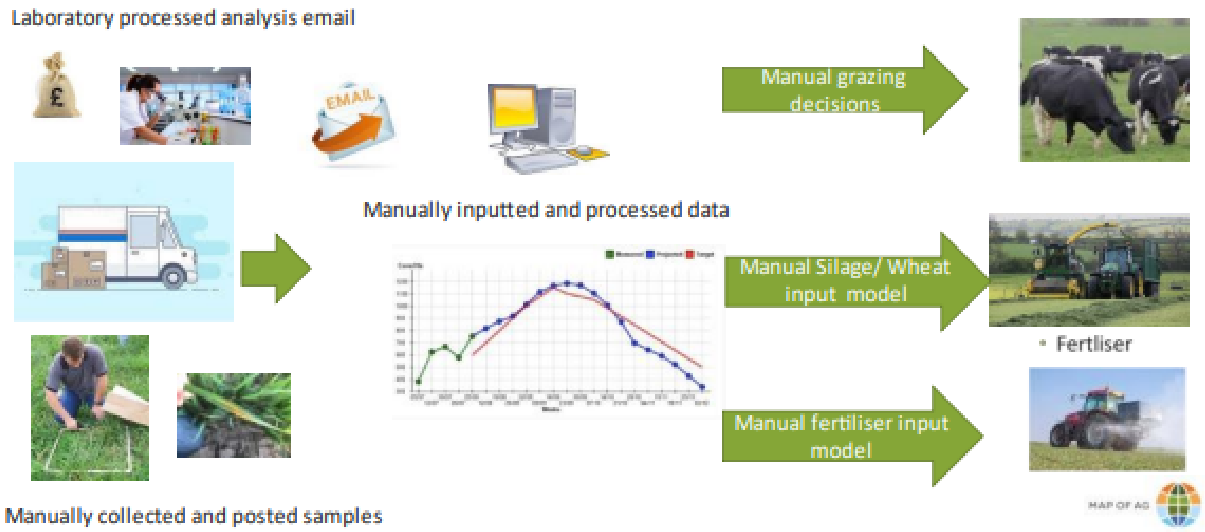
Technology does exist however in different forms to enable farmers to perform actions and measurements in isolation, but they still fall short of offering the ability to target measurements to deduce levels of variation or have the ability to measure wider ranges of crops, or manures.

Developments in multispectral handheld technology could deliver the support needed to farmers to provide both real-time insight into crop nutrient uptake, forage and grass quality, and manure nutrient values in near real time. The technology however has a large data requirement and requires the ability to measure and upload data in large volumes that are then processed by servers to feedback data directly to farmers to infer the crop or feed quality, or nutrient levels in manures.

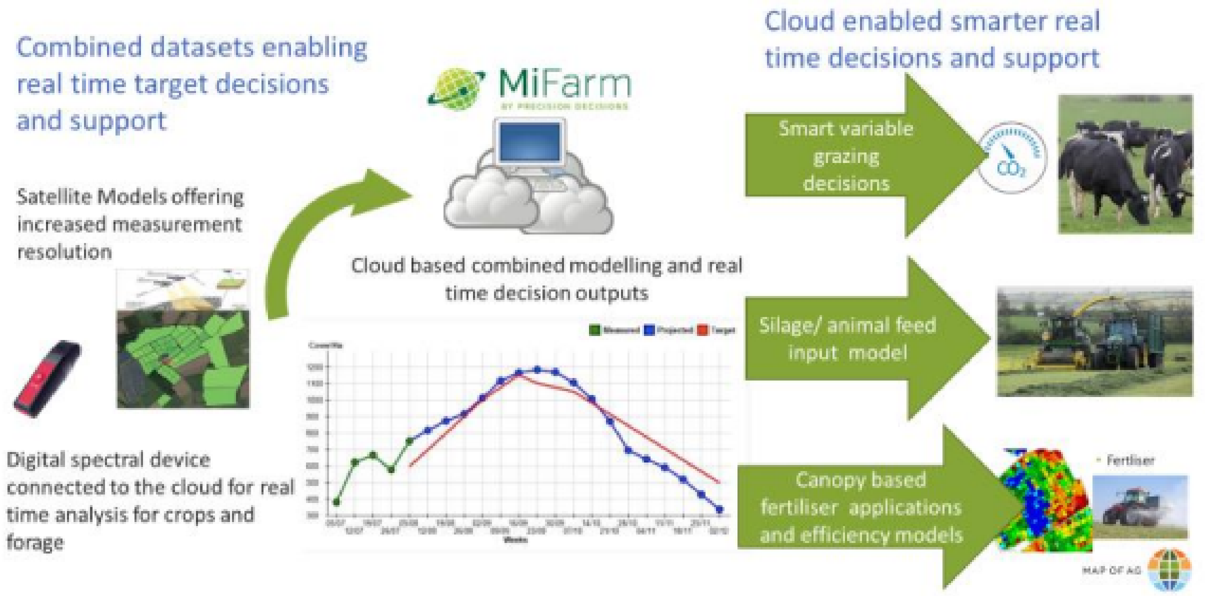
The opportunity of 5G provides farmers a communication infrastructure that would support the levels of data transfer to occur to allow large datasets to be interrogated and combined with existing remote-sensed images and technology to provide both informed decisions and application maps to allow farmers the ability to precisely meet crop nutrient requirements, to identify and overcome limitation in nutrition and to improve nutrient use efficiency.

This exciting opportunity not only supports the growing of crops to provide high quality nutritious animal feeds but also supports the measurement of feed stocks to ensure animals have a balanced diet, that if grown with higher quality offsets additional costs of imported proteins such as soya. The ability of such technology to also measure animal outputs allows farmers to precisely manage nutrient balances within agricultural systems: balancing fertiliser, manures, and animal nutrition in ways unachievable without the new spectral sensors that require the support of high bandwidth reliable data transfer. These progressions not only support more profitable farming, but also provide a baseline from which to catapult the industry towards Net Zero emissions and a significantly more sustainable future.

Current crop analysis and decision methods



5G Enabled technology models



3.3. The Approach to Security

Deployment of customer owned Radio Access Networks sharing a single backend core presents unique security challenges which need to be explored and understood. Throughout the entire design, development, and implementation we have encouraged and facilitated all members of the project to think about how security is impacted and the actions that need to be taken.

3.4. Methodology

The project has taken a secure-by-design approach throughout and a secure-by-default approach wherever possible; working in collaboration and with emerging technology and ideas, in order to deal with a set of potentially unique issues in a controlled manner.

The MONeH project has focussed on the following areas:

- Developing an ‘appropriate’ security governance framework that protects and secures both the customer owned Radio Access Network (RAN) and the operator owned central backend core.
- Understanding the requirements for working with different customer groups in a secure and controlled manner to run a stable, secure and resilient network.
- Working in conjunction with partners focusing on security and design but also prioritising security in relation to configuration, management and monitoring.
- Monitoring progress during the project to document best practice, results and lessons learnt

3.5. Security Domains within a MONeH Deployment

The MONeH project has been summed up as demonstrating “how small cell technology can be used to provide multiple user slices, serving different customer groups”. This short sentence can be broken down into four clear areas of technology, each managed as a separate security domain:

3.5.1. **Customer owned Radio Access Networks,** each with one or more radio cells together with a 'Front End Core', capable of operation as a standalone private network. Each of these individual Radio Access Networks is connected by VPN to:

3.5.2. **A Central Backend Core** (Telet owned and operated) - in which all of the centralised management components together with all of the interfaces to external public networks are located. This central core is connected to:

3.5.3. **International Signalling Hubs** - which facilitate Roaming of other MNO customers onto Telet networks and Telet users onto other MNO networks. These hubs are then connected to:

3.5.4. **Other Mobile Network Operators**, who authorise access for their users onto our networks and supply all required session configuration information

3.6. Security Policy and Components

We have derived a Security Strategy specifically for MONeH based upon the collated output from analysis of the following documents:

a. ISO 27001 / 27002
b. DCMS Draft Telecommunications Security Code of Practice
c. Electronic Communication Regulations (2022)
d. GSMA consolidated security requirements (FS.18 V8.1)
e. Joint Operators Technical Specification (JOTS) Neutral Host in Building (NHIB) operational processes
f. ENISA guidelines on security measures (4th edition)
g. Relevant Ofcom guidance, including General Conditions.

3.7. The Security Strategy and associated table containing security standards are below:

MONeH Project Security Standard Appraisal

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
A.5	**IS Policies**						
A.5.1	**Management direction for IS**						
Objective	**To provide management direction and support for IS in accordance with business requirements and relevant laws and regulations**						
A.5.1.1	Policies for information security	A set of policies for Information Security shall be defined, approved by management, published and communicated	Measures 5.09, 7.01, 7.02, 8.05, 8.06, 9.03, 12.01, 12.03, 12.04, 12.11, 12.12, 12.13, 12.15, 12.21, 12.33, 12.34, 12.35, 15.01, 17.06,	Regulation 10	Section 1.1.1	Req. 33	D1:SO1
A.5.1.2	Review of policies for information security	The IS Policies shall be reviewed at planned intervals.		Regulations 10 & 11	Section 1.2.1		D1:SO1
A.6	**Organisation of IS**						
A.6.1	**Internal organisation**						
Objective	**To establish a management framework to initiate and control the implementation and operation of IS with the organisation**						
A.6.1.1	IS Roles & Responsibilities	All responsibilities shall be defined and allocated.		Regulation 13	Section 2.2.2		D1:SO3

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
A.6.1.2	Segregation of duties	Conflict duties and areas of responsibility shall be segregated to reduce opportunities for unauthorised or unintentional modification or misuse of assets.			Section 10.2.1		D1:SO3
A.6.1.3	Contact with authorities	Appropriate contacts with relevant authorities shall be maintained					
A.6.1.4	Contact with special groups	Appropriate contacts with special interest groups / forums / professional associations shall be maintained					D8:SO28
A.6.1.5	Information security in project management	Information security shall be addressed in project management					
A6.2	**Mobile devices & teleworking**						
Objective	**To ensure the security of teleworking and use of mobile devices**						
A.6.2.1	Mobile device policy	A policy and reporting security measures shall be adopted to manage the risks introduced by mobile devices					
A.6.2.2	Teleworking	A policy and supporting security measures shall be implemented to protect information assessed, processed, or stored at teleworker sites.					
A.7	**Human resource security**						
A7.1	**Prior to employment**						
Objective	**To ensure that employees and contractors understand their responsibilities and are suitable for the roles for which they are considered**						

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
A.7.1.1	Screening	Background verification checks on all candidates for employment to be carried out.			Section 4.2.1		D1:SO3 D2:SO5
A.7.1.2	Terms & conditions of employment	The contractual agreements with employees and contractors shall state their and organisations responsibilities for IS			Section 4.1.1		D2:SO7 D2:SO8
A7.2	**During employment**						
Objective	**To ensure that employees and contractors are aware of and fulfil their information security responsibilities**						
A.7.2.1	Management responsibilities	Management shall require all employees and, where relevant, contractors shall receive appropriate awareness education and training and regular updates in policies and procedures, as relevant for their job function.			Section 4.3.3		D1:SO3 D2:SO6
A.7.2.3	Disciplinary process	There shall be a formal and communicated disciplinary process in place to take action against employees who have committed an information security breach.			Section 4.4.2		D1:SO3 D2:SO8
A.7.3	**Termination and change of employment**						
Objective	**To protect the organisation's interests as part of the process of changing or terminating employment**						
A7.3.1	Termination or change of employment responsibilities	IS responsibilities and duties that remain valid after termination or change of employment shall be defined, communicated to the employee or contractor and enforced.			Section 4.5.1		D1:SO3 D2:SO7 D2:SO8
A.8	**Asset management**						

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
A.8.1	**Responsibility for assets**						
Objective	**To identify organisational assets and define appropriate protection responsibilities**						
A.8.1.1	Inventory of assets	Information, other assets associated with information and information processing facilities shall be identified and an inventory of these assets shall be drawn up and maintained.	Measures 1.01, 18.04	Regulation 6	Section 10.6.1		D4:SO17
A.8.1.2	Ownership of assets	Assets maintained in the inventory shall be owned					D4:SO17
A.8.1.3	Acceptable use of assets	Rules for the acceptable use of assets associated with information and information processing shall be identified, documented and implemented.					
A.8.1.4	Return of assets	All employees and external party users shall return all of the organisational assets in their possession upon termination of their employment, contract or agreement.			Section 4.5.1		
A.8.2	**Information classification**						
Objective	**To ensure that the information receives an appropriate level of protection in accordance with its importance to the organisation**						
A.8.2.1	Classification of information	Information shall be classified in terms of legal requirements, value, criticality and sensitivity to unauthorised disclosure or modification			Section 3.1.1		D4:SO17
A.8.2.2	Labelling of information	An appropriate set of procedures for information labelling shall be developed and implemented in accordance with			Section 3.2.2		

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
		the information classification schemed adopted by the organisation.					
A.8.2.3	Handling of assets	Procedures for handling assets shall be developed and implemented in accordance with the information classification scheme adopted by the organisation.			Section 3.2.1	Req. 28 Req. 29	D4:SO17
A.8.3.1	Management of removal media	Procedures shall be implemented for the management of removable media in accordance with the classification scheme adopted by the organisation.			Section 3.2.2		
A.8.3.2	Disposal of media	Media shall be disposed of securely when no longer required, using formal procedures.			Section 3.2.2		
A.8.3.3	Physical media transfer	Media containing information shall be protected against unauthorised access, misuse or corruption during transportation.					
A.9	**Access control**						
A.9.1	**Business requirements for access control**						
Objective	**To limit access to information and information processing facilities**						
A.9.1.1	Access control policy	An access control policy shall be established, documented and reviewed based on business and IS requirements.	Measures 2.01, 2.02, 2.03, 12.25, 12.26, 12.27, 12.28, 12.29, 12.30, 12.31, 12.32, 12.36, 17.07, 17.08, 17.10,		Section 5.3	Req. 44 Req. 46	

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
A.9.1.2	Access to networks and network services	Users shall be provided with access to the network and network services that they have specifically authorised to use.	Measures 2.01, 2.02	Regulation 8	Section 10.3.2	Req. 45	
A.9.2	**User access management**						
Objective	**To ensure authorised user access to prevent unauthorised access to systems and services**						
A.9.2.1	User registration and de-registration.	A formal user access provisioning process shall be implemented to enable assignment of access rights			Section 10.3.2		
A.9.2.2	User access provisioning	A formal user access provisioning process shall be implemented to assign or revoke access rights for all user types to all systems and services			Section 10.3.2		
A.9.2.3	Management of privileged access rights	The allocation and use of privileged access rights shall be restricted and controlled.	Measures 2.02, 2.03, 2.04, 2.05, 12.05, 12.06, 12.07, 12.08, 12.09, 12.10, 12.17, 12.20, 14.20, 14.23, 14.24, 14.25, 14.26, 17.06, 19.01,	Regulation 8	Section 7.2.1		
A.9.2.4	Management of secret authentication for users	The allocation of secret authentication information shall be controlled through a formal management process.	Measures 2.07, 21.01,	Regulation 8	Section 10.3.3		
A.9.2.5	Review of user access rights	Asset owners shall review users' access rights at regular intervals	Measures 2.04,				

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
A.9.2.6	Removal or adjustment of access rights	The access rights of all employees and external party users to information and information processing facilities shall be removed upon termination of their employment, contract or agreement, or adjusted upon change.	Measures 2.01,		Section 4.5.1		
A.9.3	**User responsibilities**						
Objectives	**To make users accountable for safeguarding their authentication information**						
A.9.3.1	Use of secret authentication information	User shall be required to follow the organisation's practices in use of secret authentication information.		Regulation 8	Section 10.3.3		
A.9.4	**System and application access control**						
Objectives	**To prevent unauthorised access to systems and applications**						
A.9.4.1	Information access restriction	Access to information and applicable system functions shall be restricted in accordance with the control access policy.		Regulation 8	Section 10.3.1		D3:SO11
A.9.4.2	Secure log-on procedures	Where required by the access control policy, access to systems and applications shall be controlled by a secure log-on procedure.		Regulation 8	Section 10.3.2		D3:SO11
A.9.4.3	Password management system	Password management systems shall be interactive and shall ensure quality passwords		Regulation 8	Section 10.3.3		D3:S011
A.9.4.4	Use of privileged utility programs	The use of utility programs that might be capable of overriding system and application controls shall be restricted and tightly controlled.	Measures 12.16, 12.25, 12.26, 12.27, 12.28, 12.29,				D3:S011

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
			12.30, 12.31, 12.32, 14.21, 14.22,				
A.9.4.5	Access control to program source code	Access to program source code shall be restricted.					
A.10	**Cryptography**						
A.10.1	**Cryptography controls**						
Objectives	**To ensure proper and effective use of cryptography to protect the confidentiality, authenticity and / or integrity of information**						
A.10.1.1	Policy on the use of cryptographic controls	A policy on the use of cryptographic controls for protection of information shall be developed and implemented.			Section 6.4.1	Req. 56-62	D3:SO13
A.10.1.2	Key management	A policy on the use, protection and lifetime of cryptographic keys shall be developed and implemented through their whole lifecycle.			Section 6.4.2		D3:SO14
A.11	**Physical and environmental security**						
A.11.1	**Secure areas**						
Objective	**To prevent unauthorised physical access, damage and interference to the organisation's information and information processing facilities**						
A.11.1.1	Physical security perimeter	Security perimeters shall be defined and used to protect areas that contain either sensitive or critical information processing facilities.	Measures 1.04		Section 5.1.1		

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
A.11.1.2	Physical entry controls	Secure areas shall be protected by appropriate entry controls to ensure that only authorised personnel; are allowed access.			Section 5.2.1	Req. 25 Req. 27	D3:SO9
A.11.1.3	Secure offices, rooms and facilities	Physical security for offices, rooms and facilities shall be designed and applied.			Section 5.2.1		D3:SO9
A.11.1.4	Protecting against external and environmental threats.	Physical protection against natural disasters, malicious attack or accidents shall be designed and applied.			Section 5.2.1		D3:SO9
A.11.1.5	Working in secure areas	Procedures for working in secure areas shall be designed and applied.			Section 5.3.2		
A.11.1.6	Delivery and loading areas	Access points such as delivery and loading areas and other points where authorised persons could enter the premises shall be controlled and, if possible, isolated from information processing facilities to avoid unauthorised access.					
A.11.2	**Equipment**						
Objective	**To prevent loss, damage, theft or compromise of assets and interruption to the organisation's operations**						
A.11.2.1	Equipment siting and protection	Equipment shall be sited and protected to reduce the risks from environmental threats and hazards, and opportunities for unauthorised access. Protected from power failures and other disruptions caused by failures in supporting utilities.			Section 1.3.1		D3:SO10

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
A.11.2.2	Supporting utilities	Equipment shall be protected from power failures and other disruptions caused by failures in supporting utilities.			Section 1.3.1		D3:SO10
A.11.2.3	Cabling security	Power and communications cabling carrying data or supporting information services shall be protected from interception, interference or damage.			Section 1.3.1		D3:SO9
A.11.2.4	Equipment maintenance	Equipment shall be correctly maintained to ensure its continued availability and integrity.			Section 10.6.1		
A.11.2.5	Removal of assets	Equipment, information or software shall not be taken off-site without prior authorisation.					
A.11.2.6	Security of equipment and assets off premised	Security shall be applied to off-site assets taking into account the different tasks of working outside the organisation's premises.					
A.11.2.7	Secure disposal or re-use of equipment	All items of equipment containing storage media shall be verified to ensure that any sensitive data and licensed software has been removed or securely overwritten prior to disposal and re-use.			Section 3.2.2		
A.11.2.8	Unattended user equipment	Users shall ensure that unattended equipment has appropriate protection			Section 10.6.1		
A.11.2.9	Clear desk and clear screen policy	A clear desk policy for papers and removable storage media and clear screen policy for information processing facilities shall be adopted.			Section 3.2.2		
A.12	**Operations security**						

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
A.12.1	**Operational procedures and responsibilities**						
Objectives	**To ensure correct and secure operations information processing facilities**						
A.12.1.1	Documented operating procedures	Operating procedures shall be documented and made available to all users who need them.		Regulation 10	Section 5.4.1	Req. 47-55 Req. 82-86	D4:SO15
A.12.1.2	Change management	Changes to the organisation, business processes, information processing facilities and systems that affect information security shall be controlled.	Measures 12.02, 18.05,	Regulation 8	Section 10.6.1	Req. 32 Req. 43 Req. 63-71	D4:SO16
A.12.1.3	Capacity management	The use of resources shall be monitored, tuned and projections made of future capacity requirements to ensure the required system performance.				Req. 34 Req. 35 Req. 37 Req. 90 Req. 91	
A.12.1.4	Separation of development, testing and operational environments	Development, testing, and operational environments shall be separated to reduce the risk of unauthorised access or changes to the operational environmental.	Measures 1.04	Regulation 3	Section 10.10		
A.12.2	**Protection from malware**						
Objectives	**To ensure that information and information processing facilities are protected against malware**						
A.12.2.1	Controls against malware	Detection, prevention and recovery controls to protect against malware shall be implemented, combined with appropriate user awareness.			Section 10.6.1		D3:SO12

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
A.12.3	**Backup**						
Objectives	**To protect against data loss**						
A.12.3.1	Information backup	Backup copies of information, software and system images shall be taken and tested regularly in accordance with the agreed backup policy.	Measures 7.03,		Section 10.6.2		D6:SO22
A.12.4	**Logging and monitoring**						
Objectives	**To record events and generate evidence**						
A.12.4.1	Event logging	Event logs recording user activities, exceptions, faults and IS events shall be produced, kept and regularly reviewed.	Measures 5.08, 9.16, 9.17, 9.18, 17.11, 17.12, 18.01, 18.02, 18.03, 18.04, 18.05, 18.06, 18.07, 18.09, 18.11, 18.13, 18.15, 18.16, 18.17, 18.18, 18.19, 18.20, 18.21, 18.22, 22.01,	Regulation 6	Section 10.7.1	Req. 74 Req. 78 Req. 80 Req. 81	D7:SO23
A.12.4.2	Protection of log information	Logging facilities and log information shall be protected against tampering and unauthorised access.	Measures 5.08, 18.08, 18.12,	Regulation 5			D7:SO23
A.12.4.3	Administrator and operator logs	System administrator and systems operator activities shall be logged and the logs protected and regularly reviewed.	Measures 2.06, 9.16, 18.14,	Regulation 5			

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
A.12.4.4	Clock synchronisation	The clocks of all relevant information processing systems within an organisation or security domain shall be synchronised to a single reference time source.	Measures 18.10,				
A.12.5	**Control of operational software**						
Objectives	**To ensure integrity of operational systems**						
A.12.5.1	Installation of software on operational systems	Procedures shall be implemented to control the installation of software on operational systems.					D3:SO12
A.12.6	**Technical vulnerability management**						
Objectives	**To prevent exploitation of technical vulnerabilities**						
A.12.6.1	Management of technical vulnerabilities	Information about technical vulnerabilities of information systems being used shall be obtained in a timely fashion, the organisation's exposure to such vulnerabilities evaluated and appropriate measures taken to address the associated risk.		Regulation 12	Section 10.5.4		D3:SO12 D8:SO28
A.12.6.2	Restriction on software installation	Rules governing the installation of software by users shall be established and implemented.					
A.12.7	**Information systems audit considerations**						
Objectives	**To minimise the impact of audit activities on operational systems**						
A.12.7.1	Information systems audit controls	Audit requirements and activities involving verification of operational systems shall be carefully planned and agreed to minimise disruptions to business processes.					D7:SO27

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
A.13	**Communication security**						
A.13.1	**Network security management**						
Objectives	**To ensure the protection of information in networks and its supporting information processing facilities**						
A.13.1.1	Network controls	Networks shall be managed and controlled to protect information in systems and applications.	Measures 10.16, 10.17, 10.18, 18.05,	Regulation 3	Section 10.5		D3:SO11 D3:SO12
A.13.1.2	Security of network services	Security mechanisms, service levels and management requirements of all network services shall be identified and included in network services agreements, whether these services are provided in-house or outsourced.	Measures 2.08, 2.09, 2.10, 10.13, 10.14, 10.15, 12.23, 14.01, 14.02, 14.03, 14.04, 14.05, 14.06, 14.07, 14.08, 14.09, 14.10, 14.11, 14.12, 14.18, 14.19, 17.01, 17.02, 17.04, 17.13, 18.06, 21.02, 21.03, 21.04, 21.05, 21.06, 21.07,		Section 10.5	Req. 72 Req. 73 Req. 75 Req. 76	D3:SO11 D3:SO12
A.13.1.3	Segregation of networks	Groups of information services, users and information systems shall be segregated on networks.	Measures 1.04, 1.05, 1.06, 8.07, 9.07, 9.09, 9.15, 12.17, 12.18, 12.19, 12.24, 14.13, 14.14, 14.15, 14.16, 14.17, 14.27, 14.28, 17.09, 21.03,		Section 10.11.2	Req. 40 Req. 41 Req. 42	

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
A.13.2	**Information transfer**						
Objectives	**To maintain the security of information transferred within an organisation and with any external entity**						
A.13.2.1	Information transfer policies and procedure	Formal transfer policies, procedures and controls shall be in place to protect the transfer of information through the use of all types of communication facilities.	Measures 8.08, 8.09	Regulation 4	Section 10.5.2		
A.13.2.2	Agreements on information transfer	Agreement shall address the security transfer of business information between the organisation and external parties.	Measures 8.09,		Section 10.5.2		D1:SO4
A.13.2.3	Electronic messaging	Information involved in electronic messaging shall be appropriately protected.	Measures 8.10,		Section 10.6		
A.13.2.4	Confidentiality or non-disclosure agreements	Requirements for confidentiality or non-disclosure agreements reflecting the organisation's needs for the protection of information shall be identified, regularly reviewed and documented.					D1:SO4
A.14	**System acquisition, development and maintenance**						
A.14.1	**Security requirements of information systems**						
Objectives	**To ensure that information security is an integral part of IS across the entire lifecycle. This also includes the requirements for IS which provide services over public networks**						
A.14.1.1	Information security requirements analysis and specification	The information security related requirements shall be included in the requirements for new information systems or enhancements to existing information systems.	Measures 1.03, 5.03, 5.04, 5.05, 5.07, 5.10, 5.11,				

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
A.14.1.2	Securing application services on public networks	Information involved in application services passing over public networks shall be protected from fraudulent activity, contract dispute and unauthorised disclosure and modification.	Measures 3.01-3.18 (Signalling) 6.01-6.11 (SIM Cards) 11.01-11.06 (CPE) 13.01-13.06 (Signalling) 16.01 (SIM Cards) 20.01-20.05 (Signalling)		Section 7.1		
A.14.1.3	Protecting application services transactions	Information involved in application services shall be protected to prevent incomplete transmission, misrouting, unauthorised message alteration, unauthorised disclosure, unauthorised message duplication or replay.	Measures 3.01-3.18 (Signalling) 6.01-6.11 (SIM Cards) 11.01-11.06 (CPE) 13.01-13.06 (Signalling) 16.01 (SIM Cards) 20.01-20.05 (Signalling)		Section 7.1		
A.14.2	**Security in development and support services**						
Objectives	**To ensure that information security is designed and implemented within the development lifecycle of the IS**						

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
A.14.2.1	Secure development policy	Rules for the development of software and systems shall be established and applied to developments within the organisation.			Section 10.10		D7:SO26
A.14.2.2	System change control procedures	Changes to systems with the development lifecycle shall be controlled by the use of formal change control procedures.			Section 10.6.1		D4:SO16
A.14.2.3	Technical review of applications after operating platform changes	When operating platforms are changed, business critical applications shall be reviewed and tested to ensure there is no adverse impact on organisational operations or security.					D4:SO16
A.14.2.4	Restrictions on changes to software	Modifications to software packages shall be discouraged, limited to necessary changes and all changes shall be strictly controlled.					D4:SO16
A.14.2.5	Secure system engineering principles	Principles for engineering secure systems shall be established, documented, maintained and applied to any information system implementation efforts.			Section 10.10.1		
A.14.2.6	Secure development environment	Organisations shall establish and appropriately protect secure development environments for system development and integration efforts that cover the entire system development lifecycle.					
A.14.2.7	Outsourced development	The organisation shall supervise and monitor the activity of outsourced system development.			Section 10.8.1		D1:SO4
A.14.2.8	System security testing	Testing of security functionality shall be carried out during development.	Measures 12.22,				D7:SO25

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
A.14.2.9	System acceptance testing	Acceptance testing programs and related criteria shall be established for new information systems, upgrades and new versions.					D4:SO16 D7:SO25
A.14.3.1	Protection of test data	Test data shall be selected carefully, protected and controlled.					D7:SO25
A.15	**Supplier relationships**						
A.15.1	**IS in supplier relationships**						
Objectives	**To ensure protection of the organisation's assets that is accessible by suppliers**						
A.15.1.1	Information security policy for supplier relationships	Information security requirements for mitigating the risks associated with supplier's access to the organisation's assets shall be agreed with the supplier and documented.	Measures 4.01, 5.01, 8.01, 8.02, 9.08, 9.09, 9.10, 9.11, 9.12, 9.13, 9.14, 9.16, 9.17, 9.18, 10.01, 10.10, 10.19,	Regulations 7 & 13			D1:SO4
A.15.1.2	Addressing security within supplier agreements	All relevant information security requirements shall be established and agreed with each supplier that may access, process, store, communicate, or provide IP infrastructure components for, the organisation's information.	Measures 5.01, 5.05, 8.01, 8.02, 9.08, 9.09, 9.10, 9.11, 9.12, 9.13, 9.14, 9.16, 9.17, 9.18, 10.07, 10.08, 10.09, 10.11, 10.12,	Regulation 7			D1:SO4
A.15.1.3	Information and communication technology supply chain	Agreements with suppliers shall include requirements to address the information security risks associated with	Measures 5.01, 8.03, 8.01, 8.02, 9.08, 9.09, 9.10, 9.11,	Regulation 7			D1:SO4

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
		information and communications technology services and product supply chain.	9.12, 9.13, 9.14, 9.19, 10.02, 10.03, 10.04, 10.05, 10.06,				
A.15.2	**Supplier service delivery management**						
Objectives	**To maintain an agreed level of information security and service delivery in line with supplier agreements.**						
A.15.2.1	Monitoring and review of supplier services	Organisations shall regularly monitor, review and audit supplier service delivery.	Measures 5.06, 9.03,	Regulation 7			D1:SO4
A.15.2.2	Managing changes to supplier services	Changes to the provision of services by suppliers, including maintaining and improving existing information security policies, procedures and controls, shall be managed, taking account of the criticality of business information, systems and processes involved and re-assessment of risks.	Measures 5.06, 9.03,	Regulation 7			D1:SO4
A.16	**IS incident management**						
A.16.1	**Management of information security incidents and improvements**						
Objectives	**To ensure a consistent and effective approach to the management of information security incidents, including communication on security events and weaknesses**						
A.16.1.1	Responsibilities and procedures	Management responsibilities and procedures shall be established to ensure a quick, effective and orderly response to information security incidents.	Measures 7.04, 8.04, 8.12,	Regulation 10	Section 2.3		D5:SO18 D5:SO20
A.16.1.2	Reporting information security events	Information security events shall be reported through appropriate management channels as quickly as possible.	Measures 7.04, 8.11,	Regulation 10	Section 2.3.1		D5:SO20

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
A.16.1.3	Reporting information security weaknesses	Employees and contractors using the organisation's information systems and services shall be required to note and report any weaknesses in systems or services.	Measures 7.04,		Section 2.3.1		
A.16.1.4	Assessment of and decision on information security events	Information security events shall be assessed and it shall be decided if they are to be classified as information security incidents.	Measures 7.04, 8.13,	Regulation 9	Section 2.3.1		D5:SO18
A.16.1.5	Response to information security incidents	Information security incidents shall be responded to in accordance with the documented procedures.	Measures 7.04, 8.14,	Regulation 10	Section 2.3.1		D5:SO20
A.16.1.6	Learning from information security incidents	Knowledge gained from analysing and resolving information security incidents shall be used to reduce the likelihood or impact of future incidents.	Measures 7.06, 7.07,	Regulation 10			D5:SO18 D5:SO19
A.16.1.7	Collection of evidence	The organisation shall define and apply procedures for the identification, collection, acquisition and preservation of information, which can serve as evidence.	Measures 7.05,				D5:SO19
A.17	**IS aspects of business continuity management**						
A.17.1	**IS continuity**						
Objectives	**IS continuity shall be embedded in the organisation's business continuity management systems**						
A.17.1.1	Planning information security continuity	The organisation shall determine its requirements for information security and the continuity of information security management in adverse situations, e.g., during a crisis or disaster.			Section 1.3		D7:SO24 D6:SO22 D6:SO21

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
A.17.1.2	Implementing information security continuity	The organisation shall establish, document, implement and maintain processes, procedures and controls to ensure the required level of continuity for information security during an adverse situation.			Section 1.3.1		D7:SO24 D6:SO22 D6:SO21
A.17.1.3	Verify, review and evaluate information security continuity	The organisation shall verify the established and implemented information security continuity controls at regular intervals in order to ensure that they are valid and effective during adverse situations.			Section 1.3.1		D7:SO24 D6:SO22 D6:SO21
A.17.2	**Redundancies**						
Objectives	**To ensure availability of information processing facilities**						
A.17.2.1	Availability of information processing facilities	Information processing facilities shall be implemented with redundancy sufficient to meet availability requirements.					
A.18	**Compliance with security policies and standards**						
A.18.1	**Compliance with legal and contractual requirements**						
Objectives	**To avoid breach of legal, statutory, regulatory or contractual obligations related to IS and any security requirements**						
A.18.1.1	Identification of applicable legislation and contractual requirements	All relevant legislative statutory, regulatory, contractual requirements and the organisation's approach to meet these requirements shall be explicitly identified, documented and kept up to date for each information system and the organisation.					D7:SO27

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
A.18.1.2	Intellectual property rights	Appropriate procedures shall be implemented to ensure compliance with legislative, regulatory and contractual requirements related to intellectual property rights and use of propriety software products.					
A.18.1.3	Protection of records	Records shall be protected from loss, destruction, falsification, unauthorised access and unauthorised release, in accordance with legislatory, regulatory, contractual and business requirements.					
A.18.1.4	Privacy and protection of personally identifiable information	Privacy and protection of personally identifiable information shall be ensured as required in relevant legislation and regulation where required.					
A.18.1.5	Regulation of cryptographic controls	Cryptographic controls shall be used in compliance with all relevant agreements, legislation and regulations.			Section 6	Req. 77	
A.18.2	**IS reviews**						
Objectives	**To ensure that information security is implemented and operated in accordance with the organisational policies and procedures**						
A.18.2.1	Independent review of information security	The organisation's approach to managing information security and its implementation (i.e., control objectives, controls, processes and procedures for IS) shall be reviewed independently at planned intervals or when significant changes occur.	Measures 1.02		Section 1.4.1		
A.18.2.2	Compliance with security policies and standards	Managers shall regularly review the compliance of information processing and procedures within their area of responsibility with the appropriate security policies, standards and any other security requirements.		Regulation 10	Section 1.2.1		D7:SO26

ISO 27001 Control	Item	Requirements	DCMS Code of Practice (Technical Measures)	Electronic Communications Regulations (2022)	GSMA Consolidated Security Requirements	JOTS NHIB Annexe 4	Enisa
A.18.2.3	Technical compliance review	Information system shall be regularly reviewed for compliance with the organisation's information security policies and standards.			Section 1.2.1		D7:SO26 D7:SO25

NOTES:

i. In conclusion, ISO 27001 is the most comprehensive framework and will be used as a baseline with the other industry specific standards brought in.
ii. For example, where there is a requirement in ISO 27001/27002 for monitoring and analysis, we will refer to the DCMS Telecommunications Security Code of Practice (in this example Regulation 6) for industry specific guidance which will be more detailed and relevant.
iii. We will also refer to ISO 22301:19 where direction for business continuity is needed.
iv. Some of the controls and measures in each standard overlap or are relevant to more than one area. In general, each control is only listed here once but may be used elsewhere.

Frank Manning
August 2022

4. MONeH RCC Project Results

4.1. Lower Cost per Household

UK Government policy is aimed at filling all mobile Not Spots to provide seamless mobile coverage to all properties within the United Kingdom. The current definition of required mobile coverage is a 2 Mbps 4G service[3]

4.1.1. **Mobile Infrastructure Project (MIP) & Scottish Government Rural 4G Infill Project (SGRIP)**

Both the DCMS sponsored Mobile Infrastructure Project [2016] and the Scottish Government 4G Infill Programme [2020] built out conventional macro site infrastructure upon which UK MNOs were encouraged to deploy their own RAN. The MIP delivered 97 mast sites at a cost of £35.81 million which delivered service to a total of 7200 Unique Properties (UPRNs); which results in a cost per UPRN of just under £5k.[4] As at September 2022, the Scottish Government 4G Mobile Infill Programme had deployed 36 live sites plus another 29 in build, at an average cost of £440k per site.[5] This results in a cost per UPRN of over £5k per UPRN.[6]

4.1.2. Shared Rural Network

The Shared Rural Network has a total budget of £1.023 billion and has declared that it will provide additional coverage to 280,000 premises by 2026; this equates to a cost per UPRN of around £3.6k. There is doubt that SRN will deliver service to all of their target population. The SRN is focussed solely on the areas in which the UK MNOs admit that they have no coverage; this does not include any of the Not Spots within areas where coverage has been claimed. This means the bulk of SRN deployments will occur in sparsely populated rural areas, not in urban not spots. Ofcom signed of the MNO Coverage Obligations in March 2018 against self-certified declarations confirming 90% land mass coverage from each of the UK MNOs. In March 2020 the SRN Agreement committed MNOs to provide an 88% land mass coverage[7], with an increase to 90% by 2026; this demonstrates that although obligations were signed of, targets were not met in 2018. There remain many documented accounts of mobile Not Spots within areas where coverage is claimed; for example, all four UK operators claim blanket coverage (99.99%) within the M25 boundary, yet numerous areas with poor or no coverage have been documented.

4.1.3. Building the Cost model

One of the main objectives of the MONeH Project was to demonstrate a costed model for deployment of small cell-based infrastructure within a rural environment, in order that a comparison can be made against the cost of rolling out conventional microcell network infrastructure (as used by MIP and SRN). This is not a simple task, there is a considerable mismatch between the service profiles provided by the existing mobile coverage projects and the MONeH project; MIP and SGRIP both only provide a basic 2 Mbps 4G service, whilst MONeH provides both 4G 2 Mbps and 30/100 Mbps 5G services. In order to compare

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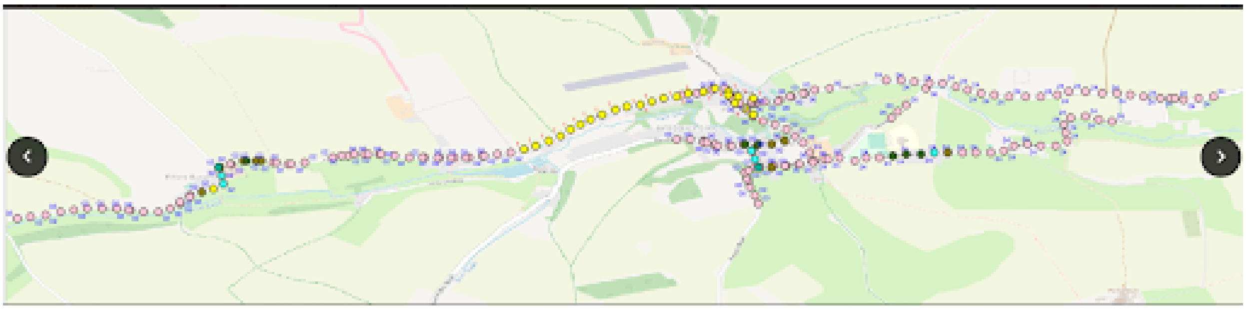
[3] **Ofcom – 2020 Coverage Obligations – Notice of compliance verification methodology**
[4] **DCMS – Mobile Infrastructure Project – Impact and Benefits Report – July 2017**
[5] **Scottish Government – 4G Mobile Infill Programme : Progress Update – September 2022**
[6] **DCMS – Shared Rural Network – Press Release – 9 March 2020**
[7] **Ofcom – Mobile Coverage Obligations – 27 Jul 2021**

services on a like-for-like basis we have only included the costs and coverage for the 4G overlay.

The methodology used to calculate cost per UPRN surveyed the coverage templates from each of the 4G cell sites deployed which was then used to generate listings of all UPRNs within each coverage template. The UPRNs covered are detailed in an Excel spreadsheet embedded here. This totals 899 UPRNs, broken down into 841 residential dwellings and 58 businesses. Detailed costs for each of the cell sites is included here – total costs of deployed 4G cells was **£729,234.29.** This results in a Cost per UPRN of **£811.16.** Spreadsheet with full breakdown is here.

Total coverage was validated with walk around surveys; a graphical representation of one of these surveys is shown below.



4.2. Fixed Wireless Access

The MONeH deployment provided 5G Fixed Wireless Access service profiles at 30 Mbps and 100 Mbps in addition to the 4G 2 Mbps mobile profile. These profiles were demonstrated using a selection of different internal and externally mounted Customer Premise Equipment (CPEs).

The 30 Mbps and 100 Mbps services correspond to the current BDUK service definitions[8] and as such qualify for grant funding in areas designated as without full fibre connectivity.

4.3. Agriculture Use case – Project Findings

The comprehensive Use Report and findings, '***Evaluation of the opportunity for 5G communications for real-time soil mapping – Chalke Valley 5G MONeH'***, is attached at Annex 1. This report (Annex 1) provides an in-depth statement of methodology and the findings of the Use case conducted at Shaftesbury Estate (St Giles Farm) on 21 February 22 – 25 Feb 22. Further, a synopsis of the findings has been included in the MONeH RCC 5G Testbeds and Trials Programme Benefits Realisation Record. A key real time demonstration of 5G NSA was achieved with the DCMS project team when they joined the MONeH RCC Project Board on Wed 23 February 22 and

[8] BDUK – UK Gigabit Programme Funding - Supplier Terms and Conditions – 23 April 2021 (Version 7.1)

through video link over 5G at St Giles Farm, Shaftesbury Estate, met the Map of AG (Precision Decision) team conducting the Use case on site. 4G was also demonstrated through utilisation of Telet SIM and again dialling into the same Project Board meeting.

4.3.1. Metrics and Analysis

As outlined in Section 3 of this report (above) the Agricultural Use case set out to achieve the following:

Soil Sampling

- Enabling soil sample equipment with 5G for data transfer
- Installing 5G on tractor and enable variable-rate applications
- Successful scanning of field and uploading scan data with 5G
- Successful identification of sample points and data transfer back to sampler
- Collection of soil spectra samples and upload data to cloud
- Interpretation of soil sample maps for recommendations
- Transferring variable-rate file to tractor
- Application of fertiliser

Crop Sensing

- Scanning of crop with spectral device
- Transfer of data to the cloud
- Transfer of recommendation to the tractor
- Application of fertiliser – this may not be appropriate in February and may need to be dummy-run

The report endeavoured to deliver on a number of metrics including:

- Improved accuracy for farmer
- Increased scale of sampling capability
- Speed (person-hours of delivering an end-to-end process)
- Savings in fertiliser use – in £s
- Savings in fertiliser use – product applied (weight)
- Greenhouse Gas Emissions

Current sampling practice involves collecting 16 sub-cores, which are amalgamated to form one sample. In this case (as described earlier due to the shallow soils) the core sample depth was restricted to 30cm, when in deeper soils two samples would be collected to depths of 0-30cm and 30-60cm. Nevertheless the 16 soil sub-cores were collected and merged into a single sample and analysed at the laboratory. The cost of this lab analysis for the conventional approach is £46.64 per sample taken, which is paid to the laboratory . When collecting 16 sub-cores per sample zone, this would represent 960 individual sample readings for every one which under current process is currently collected. In analytical terms, the cost at a laboratory for measuring each one of these would have been £46.64 therefore every sample point has an analytical value of £44,774. Therefore, looking at the cost versus value of the laser generation across this use case, this would represent a conventional cost of £1,865.60 versus value generated by the laser system of £1,790,976.00 a considerable difference.

The project sought to establish the time savings being undertaken due to the farm sitting within a 5G coverage umbrella where all analysis, sensing and data collection could be undertaken in real time and processed in the cloud and then sent back to the variable rate spreader for fertiliser application. The Precision Decision team identified that the standard practice would have taken them 510 person-hours or 21.5 working days but utilising the 5G network in place, this process was cut down to 28 person-hours or 1.25 working days. The team believe that due to the R&D nature of their own software and the manual intervention required, this time could have been further reduced.

The Map of Ag (Precision Decision) team found the following examples from within a much wider process as time saving benefits due to the utilisation of a 5G network:

- **Sample point generation and upload**: Normally a manual job and rarely done together, the sample points were defined, job generated and ready to be uploaded in 12 mins compared to at least half a day's work under normal practices.
- **Soil Sampling** – Under the current conventional system, all uploading is done at the end of the day/week when the operator returns to their hotel or office with Wi-Fi. Uploading

The laser approach offers the ability to collect much more data. At Shaftesbury Estate, the laser was set to measure the soil at a rapid rate and spectral data was collected with the associated depth of the soil's position in the soil profile. In analysing this spectral data with the depth data, one laser reading (full nutrient spectral measurement) was collected at approximately every 5mm depth change. Had the team collected each one of these depth zones for analysis, they would have collected the equivalent of 60 samples for each soil core collected. Given the team typically would take 18 mins and the bagging and sampling exercise in the Use case would need nearly 5 hours. Utilising the 5G network, the system was continually uploading to the cloud and therefore to make comparable times in upload speeds was not achievable. As the Use case team stated, 'this was one of the first times that sampling, and scanning were completed in such quick succession without further manual processing in the support office'.

- **Analysis of soil samples** – the current process of 'bagging samples' and sending to lab analysis was conducted as part of the Use case. This process commenced with soil samples being shipped on 24 February 22 with results returned on 14 Mar 22. Using the 5G network and cloud analysis, this process commenced at 1820hrs 22 February 22 with results returned 18:35 23 February 22.

Time becomes an important factor when farmers are looking to buy fertiliser at the lowest cost. Whilst the situation in Ukraine is extreme, it demonstrates to serve the volatility in the market and the knock-on effect. The Use case found that taking nitrogen as an example, the impact of Russia's invasion of Ukraine over the period caused the following:

- AHDB (benchmark) market price for 1tonne 34.5% ammonium nitrate was £649
- 9 March 22 prices were being quoted as £850-£1,000 per tonne

Thus, a price increase of £351/t occurred in three weeks. It may be an extreme, but it was the reality. This would have had an impact of over £9k per 26t lorry load of fertiliser for the delay. While nitrogen volatility has been the worst, it has also occurred with phosphate and potassium fertilisers too and highlights the importance of timely data and recommendations. It is important to note here that the LIBS (Laser Induced Breakdown Spectroscopy) system with 5G can both revolutionise the sampling process and also deliver much more value to the farmer with the information collected and new perspectives and accuracy delivered about a soil's nutritional status. A final consideration for the implementation of 5G in any sampling system is that timely data transfer could also improve efficiencies in conventional circumstances and in this instance even without the impressive transformation of LIBS sampling, 5G shaved two days off processing and data upload delays that would have otherwise occurred as a result of not having this communication channel – a 10% improvement in conventional sampling.

4.3.2. Financial, economic and environmental impact

The last evaluations the use case conducted are for the financial, economic, and environmental impact of applying a variable-rate approach to fertiliser applications based on the canopy spectral sensing imagery and on the LIBS soil analysis, with the enabling of 5G for file transfer to the tractor.

Shaftesbury Estate currently uses digestate and sewage cake at different points in the cropping rotation. This supplies cheaper sources of crop nutrients and applies valuable organic matter to the soil. The main Use case report undertook calculations at 'farm level' and scaled with secondary modelling analysis to extrapolate these values to a UK perspective to see the potential the services could provide to the UK industry. It is important to note that this is based on the variability on this farm which may not be wholly representative at a UK scale.

Current farm practice would apply the following kg/ha of plant nutrient to the crops:

	Winter Barley	Milling Wheat	Feed Wheat	Winter Oilseed Rape
Nitrogen	124	300	265	180
Potassium	45	100	110	56

Two variable-rate approaches were tested by the 5G system. Firstly, LIBS soil analysis to calculate the amount of potassium fertiliser based on fertiliser recommendations from the industry standard RB209 guide to maintain soil indices. Utilising this approach, a farmer will apply more than the crop requires to soils with deficient nutrients to build levels and less than crop requirement to soils with an excess to mine the oversupply. The team calculated fertiliser application rates based on this approach across the farm with the yield and soil requirement for all the fields that were tested for potassium. Secondly, for nitrogen they used handheld 5G spectrometry to measure crop uptake and have recommended nitrogen application rates based on the crop demand from measured nitrogen levels within the plant. The table below shows the recommendations as the variable rates.

	Winter Barley	Milling Wheat	Feed Wheat	Winter Oilseed Rape
Nitrogen	120	280	220	148

Potassium	41	44	44	44

From these recommendations, a benefits calculation to the farmer can be undertaken for the investment in the technology and approach of variable rate applications. For nitrogen, the use of the technology would cost £2/ha per annum a total of £1,178 if used across all 589 Ha. It is estimated that the market price for the LIBS analysis would be £55/ha, but the results would be valid for a four-year period. Therefore, the annual investment to the business for the analysis would be £8,098.75 The total investment annually that the farm would need to make for both approaches would be £9,276.75.

The team further calculated the value to the St Giles Farm on Shaftesbury Estate of this more accurate approach from the LIBS and spectral analysis across the crops on the farm and across the UK, based on UK cropping area.

	Winter Barley	**Milling Wheat**	**Feed Wheat**	**Winter Oilseed Rape**	**Total Area**
Farmed Area/Ha	85	102	235	167	589
UK Total Ha	502,809	364,915	1,210,511	339,798	2,418,033

When calculating the difference in farm practice to variable-rate practice, you can calculate the total changes in fertiliser rate between variable and farm standard. Once we know the amount of change, you can then calculate the value and if it is profitable or not to adopt this approach.

This analysis undertaken was done on a cost of input basis only and ignores any potential yield enhancement from the correction of nutrient restrictions (which was not measured in this project). The table below shows the amounts for fertiliser that the current farm practice applies less the recommendation from the variable applications. If the values are positive (which in this case they are), then the farm is applying more than the crop requires and if they are negative, then the crop needs more than the farm currently supplies.

Nutrient	**Plant Nutrient kg**	**Fertiliser Weight Kg**	**February 22 Price**	**Fertiliser Value**
Potassium	23,566	39,277	£543	£21,327.23
Nitrogen	18,299	53,041	£649	£34,423.34
Total	**41,865**	**92,317**		**£55,750.57**

The table above suggests that an excess of 41,865kg of plant nutrient is being applied unnecessarily, which equates into product weight of 92 tonnes which could be saved across the farm.

Using February 22 nutrient prices (as they were at time of sampling) then if the fertiliser had been purchased under the variable-rate recommendation approach this would have saved the farm

£55,750.57. If we subtract the annual costs of the service, then this would provide the farm an additional £46,473.82 which is a significant improvement in margins representing a saving of £78.90 per ha across the farm. If we assume this is the same across the whole of the UK, then the following impact can be had for the industry benefit:

Nutrient	Plant Nutrient kg	Fertiliser Weight Kg	February 22 Price	Fertiliser Value
Potassium	106,417,778	177,362,963	£543	£96,308,089.09
Nitrogen	74,656,067	216,394,397	£649	£140,439,963.72
Total	**181,073,845**	**393,757,360**		**£236,748,052.81**

This shows that over 393,757,360kg of fertiliser product would potentially be applied unnecessarily and with current fertiliser prices (as of Feb 22) this would represent a saving to the agricultural sector of £237m.

The avoidance in excess of fertiliser being applied would have a positive environmental impact due to loss of ammonia, nitrous oxides and potassium into the environment, improving air and water quality in the process. Further benefits can be calculated for the impact this excess would have in terms of GHG (Greenhouse Gas) production and release of CO2 equivalents (CO2e) into the atmosphere.

Using the Fertilizers Europe's Carbon Footprint Reference Values, the following emissions are associated from the production of and application of potassium and nitrogen:

- Potassium – 0.43 CO2e/kg nutrient
- Nitrogen – 9.14 Co2e /kg nutrient

Using these values, it was possible to calculate the impact of both the application and production environmental costs across the farm and if scaled up, across the UK:

Nutrient	Plant Nutrient kg (Farm)	CO2e	CO2e Total (Farm)	Plat Nutrient kg (UK)	CO2e Total (UK)
Potassium	23,566	0.43	10,133	106,417,778	45,759,645
Nitrogen	18,299	9.14	167,253	74,656,067	682,356,452
Total	**41,865**		**177,386**	**181,073,845**	**728,116,097**

What this shows is the clear impact in reducing UK agricultural carbon emission on winter combinable crops of 728,116t per annum.

What the Use case has shown, from the evidence that enabling rural 5G communications could have a significant positive impact to the levels of accuracy achievable by the development of new sampling and testing strategies. The speed of delivery and information capture and supply has been shown to be improved by 20 days, and the information collected, and scale could be increased by over 700% which, while this has not been qualified in these use cases, could significantly impact further the accuracy of the services provided. It is also clearly shown that benefits of over £78.90/ha can be delivered on farm, that communications can de-risk and improve the workflow by wireless data transmission, and that there could be a UK-wide impact of over £236,748,052 a year while at the same time reducing agricultural carbon emissions by over 728,116 tons of CO2e.

4.4. Chalke Valley History Festival

The Daily Mail Chalke Valley History Festival (CVHF) is "the largest festival entirely devoted to history in the world and takes place annually"[9] and attracts c44,000 visitors. The festival takes place in Broad Chalke, Salisbury, Wiltshire and is spread over 60 acres in the heart of the beautiful Chalke Valley Countryside. The festival took place Monday 20 June 22 - Sun 26 June 22 and consisted of:

- 400+ talks and events
- 60 acres of interactive and living history and experiences
- Children's events
- Air Displays
- Workshops
- Archaeology Walks
- Vintage vehicles
- Book store
- Shopping Emporium
- Live Music
- Bar
- Cafes
- Fine Dining
- Street Food
- Camping and Glamping

Whilst a hugely successful festival the provision of mobile connectivity and Wi-Fi has always been a huge problem for the event organisers. The festival in 2019 and 2021 (note no festival in 2020 due to COVID) both had recurring issues where stall holders, cafes and the bar, including the box office, resorted to a cash only basis due to lack of Wi-Fi and mobile connectivity. In 2021, a COVID restricted event meant the handling of cash was more problematic than before due to COVID concerns. Further, the Box Office in the run up to the 2022 Festival was operating on a paperless ticketing system utilising QR codes and scanners to admit Festival goers; this dependent on Wi-Fi connectivity. Those arriving on site required Wi-Fi to log onto their emails and also for the box office to distribute, check and sell tickets 'on the door'.

[9] **Open Air - The Outdoor Hospitality Magazine**

The Festival in 2022 secured the services of BytesDigital to provide the communication infrastructure and it was agreed that MONeH RCC would provide a secondary support to them through the provision of 5G.

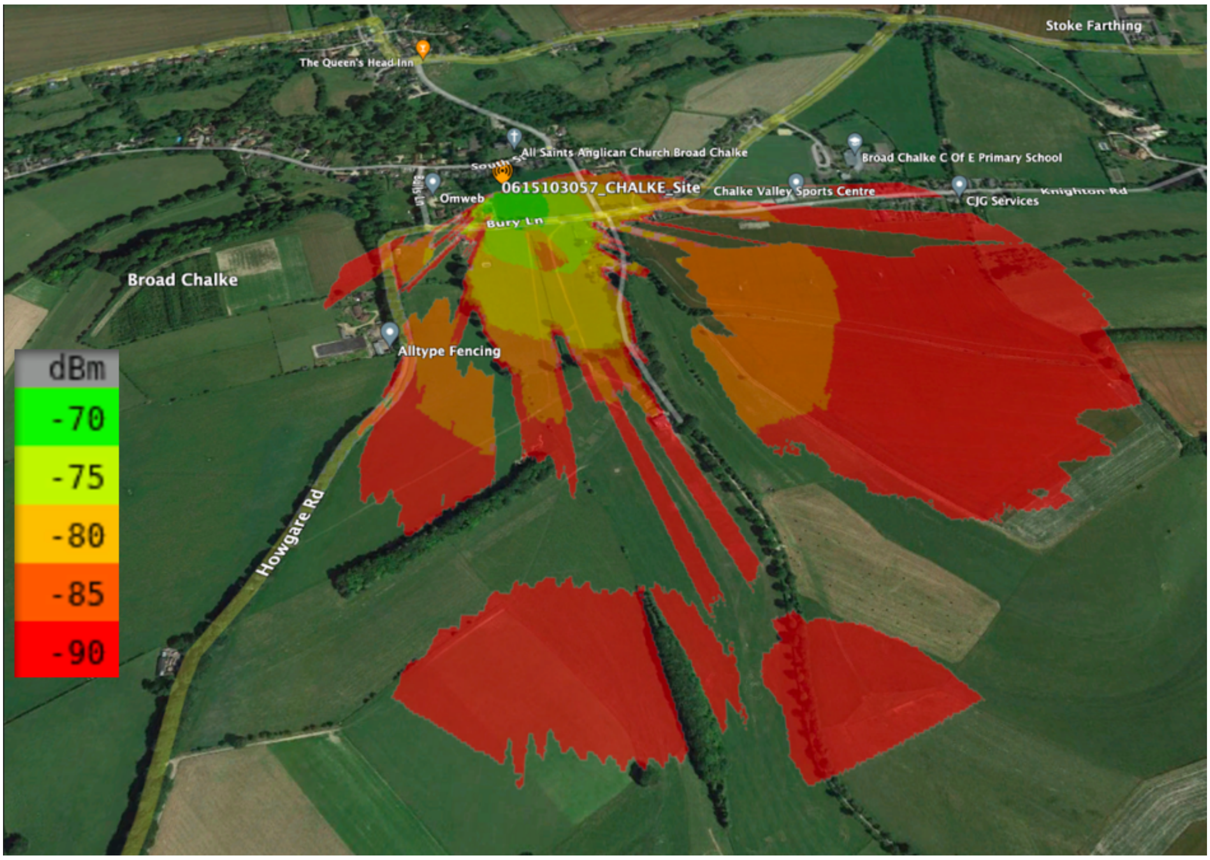
4.4.1. MONeH RCC deployment of 5G

MONeH RCC deployed the Trailer and Mast on 14 June 22, as shown below, utilising the Cablefree 5G B38 (n41) radiohead and deployed in a field behind the CVHF location. Backhaul and power was provided by one of the houses within the MONeH project utilising their 1Gbps fibre connection. The Cablefree Base Band Unit was installed within the garden shed with ancillary power and connectivity brought across scrub land to the trailer and mast. A Kathrein Directional antenna was installed to provide the greatest coverage to the festival. Within the festival 60 acre site is an agricultural barn which was used by Bytes Digital to run three ADSL lines into (FTTP not available to them) and to house their equipment. Further, they mounted on the side of the barn a Starlink system. The MONeH project sited on the pole, below the Starlink, a 5G receiving CPE and connected it to a cellXica M3Q radio cell to provide the MONeH coverage. The spare backhaul/download of approximately 90Mbps could then be used by BytesDigital to plug into their switch from which they could run their network as spare capacity.

5G Trailer and Mast with 5G b38 radio and directional antenna configuration

4.4.2. Propagation Map of 5G B38 radio

In order to better understand the capability and radio signal, MONeH RCC worked with Cloud-RF, specialists in radio planning, to record the propagation of the 5G CableFree B38 radio once deployed at the festival site. The receiving CPE was a Unicom VN007. The findings are below:



In order to put this propagation map into context of the CVHF site, this is better shown in the picture below.

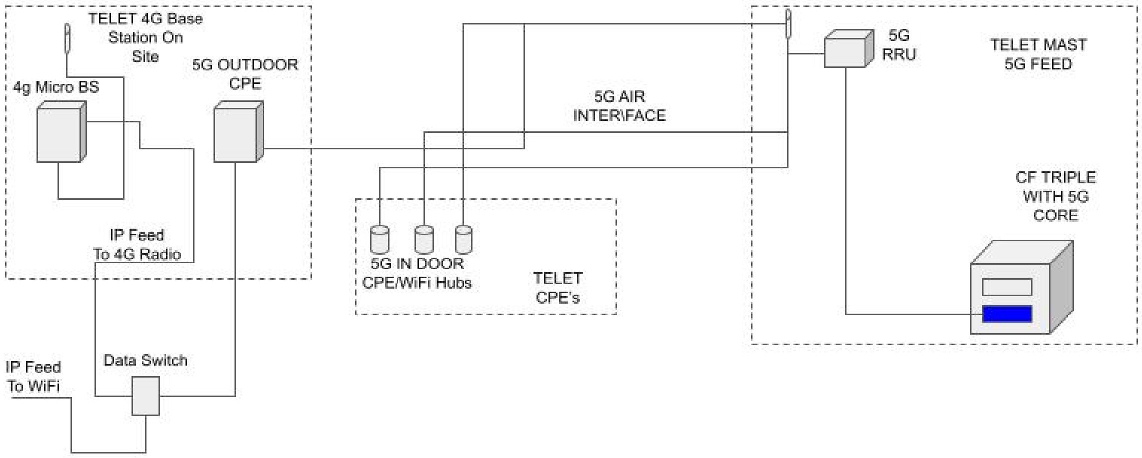
4.4.3. MONeH 5G in practice

The festival area and provision of 5G radio (mast and trailer) is illustrated from the following picture taken:

The initial Festival deployment by BytesDigital did not require Telet's indoor CPEs (fitted with Telet 5G Sims). BytesDigital setup 4 different networks to operate throughout the 60 acre site:

- Yellow Network
- Green Network
- Red Network
- Public Network

During BytesDigital set up of Fri 17 June 22 - Sun 19 June 22 it became evident that the differing networks were struggling to meet the needs of the organisers and at times there was no Wi-Fi connectivity at all. By Monday 20 June all four networks were up but by lunchtime of 20th, the public network had been taken offline due to 'noise on one of the ADSL lines' and was never reinstated for the remainder of the festival. Some stall holders were soon complaining that the Wi-Fi signal was intermittent and was causing problems. At this stage, BytesDigital called upon MONeH RCC to deploy their internal CPEs around the site which linked directly to the 5G b38 Trailer and Mast. The MONeH solution was used to connect three 5G routers to various areas of the site where pockets of Wi-Fi dead spots were found. Secondly, BytesDigital brought in a switch to plug into the CPE to utilise the spare 90 Mbps downlink capacity the 5G radio was providing. The link from the outdoor CPE was broken and a layer 2 Switch inserted - to feed the cellXica M3Q BS (Base station) and also to feed the Bytes Digital Wi-Fi sector equipment - this is shown below.

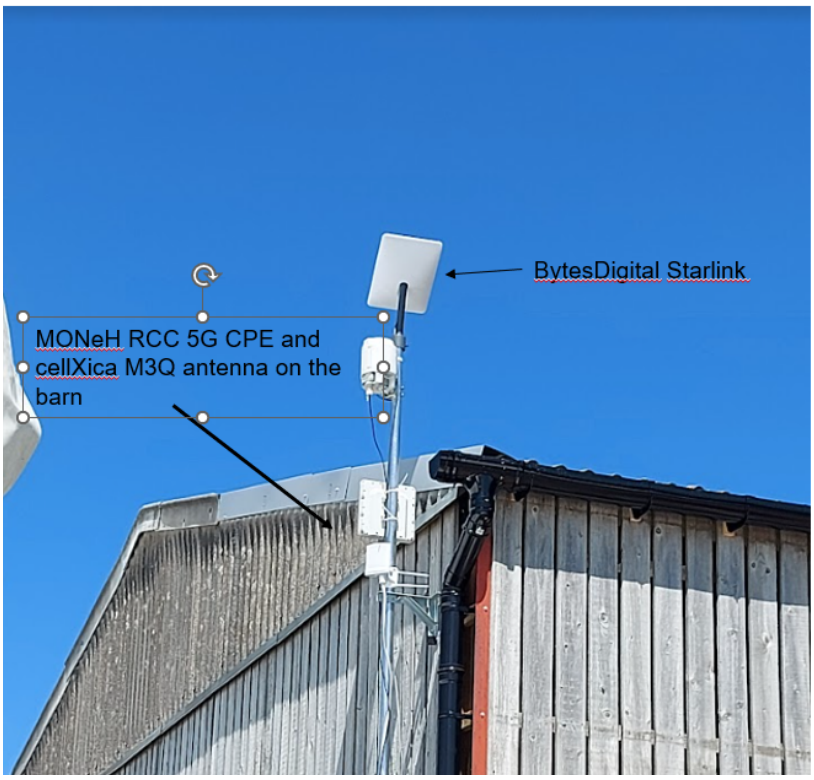


The three indoor CPEs were deployed around the 65 Acre site to give coverage in key areas:

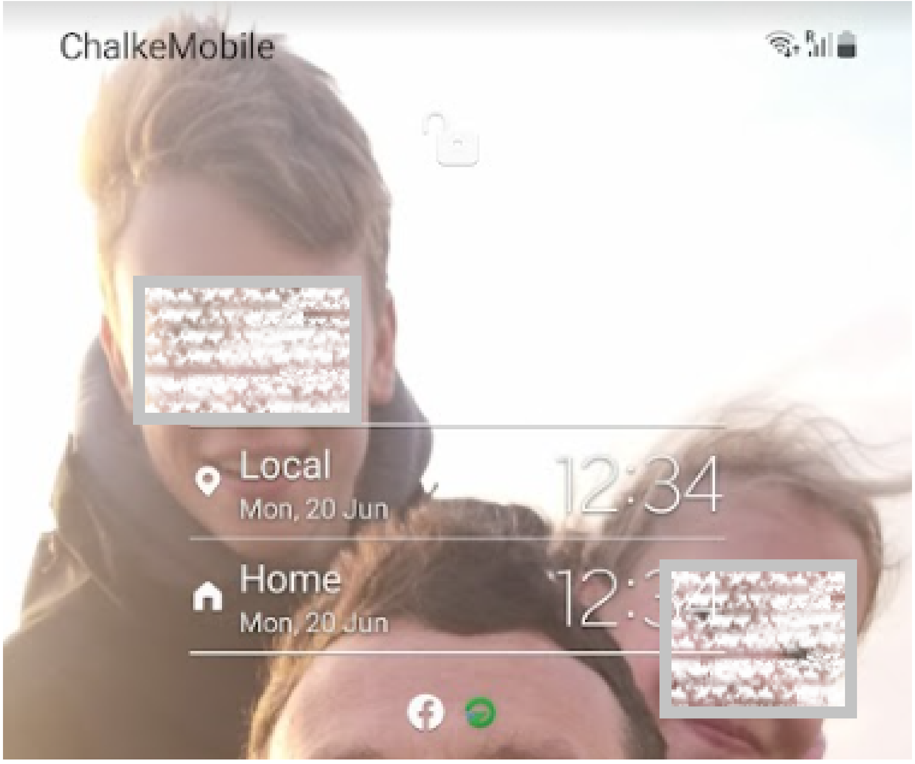
- Purbeck Ice Cream Stall - this provided coverage to all Street Food vendors.
- Big Top Bar – the main drinks provider at the festival running up to 6 PDQ machines and tills and in a central location within the festival site.
- The Copper Pot - a Historic Lives area of the site at the far end of the festival ground.

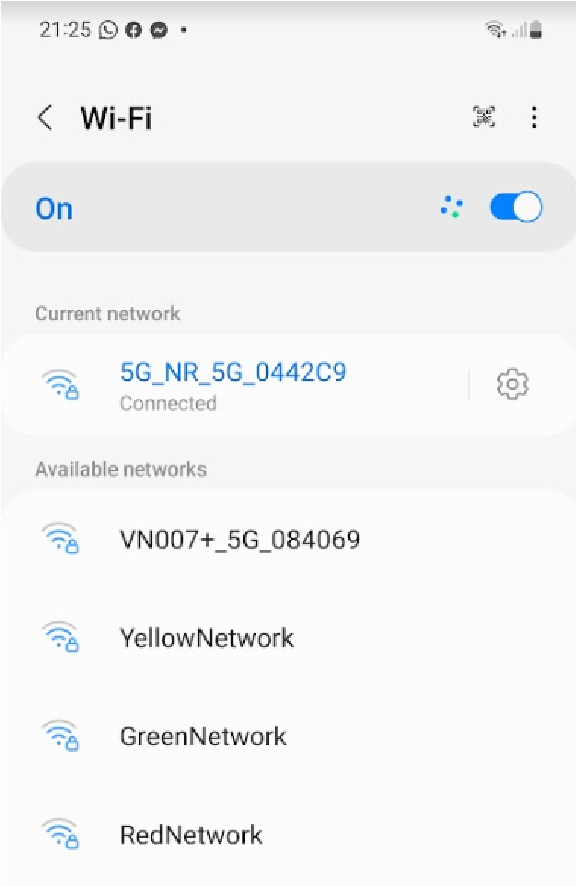
The Indoor CPEs used by MONeH RCC were three Unicom VN007 devices.

The externally mounted CPE was connected to the cellXica M3Q to provide MONeH voice comms under the Ch4lke Mobile banner:



Coverage provided by the MONeH cellXica M3Q





The resulting impact was the ability for the festival site to have continuous Wi-Fi signal across the site made up of a mix of ADSL backhaul and 5G backhaul from the MONeH RCC mast and trailer. This facilitated a seamless use of PDQ for stall-holders and the ability for the box office and entrance to operate a paperless ticketing system based on QR codes. Of interest, was that MONeH RCC switched off the 5G cell at 0915hrs on Monday 27 June 22 to take down and take away the mast and CPEs. When we went on site to remove the outdoor CPE and M3Q we were asked by the onsite engineers as to why we had taken down the entire network. Their perception was MONeH were BytesDigital and that BytesDigital were contracted to keep the network operational until Thursday 30 June 22 for the entire site 'teardown'.

5. Impacts and Benefits of MONeH RCC

5.1. Key Impacts

- *The MONeH Project has demonstrated that it is possible to deploy small cell based Private RAN that can offer public service concurrently alongside private applications.*
- *This solution is a particularly flexible and cost-effective solution for Rural Not Spots.*
- *Multi use RAN allows maximum benefit/revenues to be gained from deployed infrastructure.*
- *MONeH can offer local roaming services to all customers of Public MNOs and MVNOs in scenarios where Home Network coverage is not available.*
- *No customer interaction is required to make use of the MONeH – it just works!*
- *The solution delivers minimal effect on local environment; as such it is well suited for deployment in sensitive areas such as AONB, National Trust, Listed buildings etc*
- *Service coverage templates and service profiles can be easily customised to cover a wide range of terrain types areas and operational requirements.*
- *MONeH is capable of meeting the communications requirements of both MOBILE USERS and FIXED WIRELESS ACCESS subscribers.*
- *The proposed commercial settlement scheme is low cost and is intended to be as MNO-friendly as possible; the aim is to reduce the financial exposure for MNOs to a level that they will not vigorously oppose rural MONeH deployments.*
- *Traffic trading effectively swaps inbound roaming traffic on MONeH RAN into roaming traffic on MNO networks in areas where MNO have plenty of spare capacity.*
- *MONeH will help MNOs to meet their mandated coverage obligations.*
- *Local Access Licences deliver efficient use of primary mobile spectrum that would otherwise be unused*
- *The total aggregate bandwidth of multiple small cells within a rural area will normally exceed the total capacity offered by a single macrocell and will deliver much better coverage.*

6. Key Learnings

6.1. Private and Public 5G Networks – impact on UK Coverage

6.1.1. Private vs Public Deployments

It is still comparatively early in the evolution of public 5G deployments by MNOs and private/closed networks by other entities. Private deployments are considerably simpler to roll out as the core signalling requirements are far less complex. The UK Government is particularly focussed on deployment of public infrastructure, however, very few projects managed to demonstrate practical use cases where external users were able to attach and receive service.

The MONeH Project demonstrated full Local Roaming, where devices equipped with SIMs from other MNOs were able to attach to the CH4LKE Mobile Network and gain access to both inbound and outbound voice, data and messaging services - without any user intervention.

6.1.2. 5G Roaming in UK

At present there is no native 5G roaming operational within the UK. Current 5G NSA infrastructure deployed by UK MNO still uses Diameter signalling for mainstream services as an extension of 4G roaming. Only narrowband IoT 5G devices are currently capable of roaming between different networks; this uses a completely different infrastructure to wideband 5G.

6.2. Mapping Mobile Network Coverage

Collaboration and consistency

In the Chalke Valley there is a problem with mobile coverage yet looking at the coverage maps on the operators' sites or Ofcom it says there is "good outdoor coverage". However, to live and work there the local resident will dispute these findings. So why is there such a disparity between MNO and Ofcom claims and local resident experience of reality?

When MNOs are asked about coverage they give you a number, somewhere between 90% and 99% but are a little vague about what coverage means. EE will say that its standard 4G network covers 99% of the UK population. Three claims 91%, O2 says 99% over 3G and 4G with a caveat that it is a figure for outdoors and Vodafone says 97%.

So why does everyone think that their particular town or hamlet is in the 'somewhere between' 9% and 1% with suspect service?

It is important to realise that the figures are given for where people live. You can cover just the 2,600 square miles inside the M25 and provide service to over 14m people, while the 30,000 square miles of Scotland is under 5.5m people. A thirtyfold difference.

Recent research from Uswitch.com says that over a quarter of people (27 per cent) report having to move to another room because of poor mobile reception, one in seven (14 per cent) leave the house in a bid to get a better signal. A recent report by Which? Magazine shows that 18% of Three subscribers regularly experience problems.

So even in the places where people live the coverage is not hitting the better than 90% figure. It is a long running problem, back in 2014 a survey by coverage experts Global Wireless Solutions found that one in three internet tasks failed on London commuter trains. And again this is in highly populated areas.

Coverage and service levels are much worse in rural areas such as the Chalke Valley where inspection of operator coverage maps will show "good outdoor coverage", yet as you drive down that road or walk across a field calls fail and data speeds are non-existent.

How do the mobile networks claim that they have coverage when experience shows that they do not? It is all to do with what constitutes a signal. Radio power is measured in decibels but because that is a scale which is difficult to understand we need to also use picowatts. This still gives numbers which do not have loads of zeros after the decimal point and what we are really interested in is the relative powers not the actual measure. Therefore, the sector needs to talk about thousands and thousandths of picowatts rather than nano and femto as using the same scale for everything gives a sense of proportion. A more precise method would be volts per square metre, as that excludes the antenna factor, but that information is not available.

6.2.1. What constitutes a good signal?

A large mobile phone base station does not have the strongest signal right below it. The antennas are arranged so that there is a donut shaped area of strength around the base station, with a ring of very strong signal. In an ideal environment, such as a city, the rings overlap so your phone can hop from strongest signal to strongest signal. For our sources we are using https://wiki.teltonika-networks.com/view/Mobile_Signal_Strength_Recommendations and work done by James Body from Telet Research with Network Signal Guru.

Although there is no standard among the phone manufacturers as to how much power corresponds to how many bars on the screen, anything better than -70 dBm (100 picowatts) is a good signal. In research performed by Telet Research and Telco Electronics we have seen signals over -59 dBm (1200 picowatts). When a mobile phone displays a good solid five bars, it can probably see the antenna. The point at which a phone gives up, and drops the signal is around -93 dBm (0.5 picowatts).

But the standard Ofcom gives out, in its coverage obligation, goes all the way down to -105 dBm (0.032picowatts). The limit is dependent on frequency but that is for an 800 MHz 4G signal and is the bottom limit. The new Shared Rural Network (SRN), which aims to solve the UK's rural connectivity problems is basing acceptability as -105 dBm (0.032) picowatts which is ridiculously low at a time Government talks about Levelling-Up across the UK. SRN is about enhancing the UK coverage but if the reflective measurements of acceptability are not stipulated at 2.5 picowatts as a minimum then communities will be left behind at a time there is a population shift from cities to rural locations. The operators insist that -105dBm is an accurate reflection of what handsets are capable of. But real life does not bear this out. While proponents of 5G will talk about five nines reliability day to day experience of regular dropped calls shows that this is not the case.

A phone will show that you are within coverage if it can hear a base-station and can at least occasionally get a message back to the base-station to confirm that it is still listening. Networks are engineered, sensibly, so that service is only limited in one direction, the return link or 'uplink' from the phone to the base-station which carries less traffic. At the edge then, the real limit only becomes apparent when you take hold of your phone (in a hand that absorbs radio waves) and actually try to use it.

This is the very crux of the problem as to why phones drop their signal in areas where the network claims to have good coverage. When the network measures the signal it is well within the stipulated limits, when a phone tries to use that signal it cannot maintain a connection. And it stems from regulation failing to keep up with the phone market.

6.2.2. Why phones do not perform

Phones have always been a fashion item. All the way back to the 1980s big hair and shoulder pads era having a mobile phone has been a statement of self. But the real inflection point came in 2007 with the iPhone, it is when marketing overtook engineering in the decision as to which phones a network would sell to its customers.

Before the iPhone the engineering tests were crucial. How quickly a phone logged onto a network when you switched it on. How quickly it connected when you pressed the green button and crucially how good a phone was at holding onto a signal.

The iPhone broke the rules. Indeed, it was so greedy with signalling it broke some networks and there were panic talks between the mobile network operators and the infrastructure manufacturers to re-engineer the networks to cope.

Selling iPhones however caused consumers to jump from one network to another. No matter that O2, which had planned to go from 2G to 3G suddenly had to introduce 2.5G (Edge) across the whole network, going out to every single base station to upgrade it. The cost was worth it for the customer acquisition.

And that changed the rules. No longer were phones engineered to provide the best possible connection, they were engineered to sell. We had seen a hint of that before when the hair-tangling retractable antenna was removed but this was on a whole new scale.

Have you ever wondered why the battery is glued into a phone, and wished it were not so that you could carry a spare? It is because without connectors and a hatch you can make the phone slimmer and stiffer. The battery becomes a structural part.

Making phones as sexy as possible for the 90 seconds you handle it has become significantly more important than how well it will work over the next two years of the individual contract.

So, phones use nice materials, they have astonishing screens and are thin as they can be without breaking in jeans pockets or having less than a day battery life. Giving the phone store appeal means that other things fall by the wayside, anything which needs space in the phone suffers. Earpieces do not have decent echo chambers, expensive radio components like power amplifiers are downgraded and antenna design compromised. This is exactly the situation which led to the "*you are holding it wrong*" Apple scandal.

That is not to say phones have not moved on. They have, in general we are talking about receive sensitivity here – what the phone can hear and how well it can be heard, but to give a sense of scale, an original 2G phone on Orange or One2One transmitted at 2 Watts, that is two trillion picowatts. Modern phones have to squeeze in many antennas to cope with the many different frequencies that have been allocated to mobile services, to combine signals for faster data, and also to try to work around the different ways we hold and carry our devices.

6.2.3. The Regulation Gap

Testing and regulation has failed to keep up with this and engineering has become subservient to marketing. While regulators assume that a phone will work at 0.032 picowatts a much more sensible limit would be 2.5 picowatts alongside a corresponding requirement that the base-station has good enough antennas to hear the uplink from a hand-held phone reliably at the same range.

If the maps were drawn to match what a hand-held, battery powered phone can do they would be very different. But then perhaps we would be less likely to buy a new phone.

There is a big problem with accurately reflecting how complete coverage is, particularly for O2. Its spectrum came with a coverage obligation. At -105 dBm (0.032 picowatts) it did it and met its obligations. At -93 dBm (0.5 picowatts) it would require a significant investment in infrastructure, particularly in areas where there is very little return. O2 would argue, rightly, that to make that change is moving the goalposts. The problem however is that we currently have a standoff where we cannot admit that the limits are not fit for purpose.

6.2.4. Levelling up

Clearly rural coverage is a problem. Some MPs have it as part of their policies (https://www.alistaircarmichael.co.uk/mobilephones). In many of the rural areas it is a significant issue and if those areas are told that they have coverage, when they do not – which is the case - it sows disillusionment. Under project Gigabit the promise of, what was initially fibre to every home and has been commuted to 85% of the UK getting a "gigabit like experience" the provision of high-speed mobile connectivity is an excellent last mile method of delivery. At current levels of signal strength this is not possible.

The MONeH recommendation is that there is a comprehensive analysis of real-world ability of handsets to hold onto a signal. This should be attached to a phone like eco ratings with electrical goods. This is complicated by the way handsets interact with networks. The same device will perform differently on different infrastructure and allowance will need to be made for this. Ironically what we need to see is akin to a return to what we had in analogue cellular days where coverage maps reflected the device, be it a handheld, transportable or car phone.

Operators' maps will then need to be re-drawn up based on real world testing. Not only is the -105dBm (0.032 picowatts) limit unreasonable, but much of the published information is also based on extrapolation from models which is not accurate enough. MNOs will never provide the requisite coverage based alone from the large mobile base stations and therefore must have a small cell component to intersperse with these large base stations to affect improved coverage. This can only be forced upon them if the minimum standard imposed is to provide a dBm, far greater than -105 dBm (0.032 picowatts) where current mobile handsets can maintain calls and meet the general public's expectation of continuous mobile call coverage. By doing nothing and accepting the MNO argument that -105 dBm is sufficient and too expensive to change means rural communities and other areas where there is currently poor coverage, as defined by the ability to make a call, will continue to be left behind at a time when Levelling-Up is a key agenda item and the investment to support it is there. Action needs to be taken now.

6.3. Spectrum – complexity and availability of securing

The Telet Team have invested inordinately substantial amounts of time into the current Ofcom systems for securing both Shared Access and Local Access licences for mobile spectrum. As a result, Telet now hold more Local Access licences than the rest of the UK user base summed together.

6.4. Local Access Licences

6.4.1. Overview

MONeH has strong views on the reform of spectrum, licences, applications and processes. The project has worked with all four operators, Ofcom, DCMS, the Spectrum Policy Forum and 5G New Thinking on improving the process for obtaining Local and Shared Access Licences.

From a workshop run by MONeH with all these organisations we derived four key learnings:

- The operators are not set-up to administer the process; each one is handled as an unfamiliar request.
- Each of the operators handles the requests differently.
- The operators want Ofcom to shield them from dealing with applicants.
- Ofcom wants applicants to work with the operators before applying.

Local Access Licence is a new process and so it would be surprising if there were not some problems to iron out, however the tiny number of Local Access Licences granted in comparison with the similarly new Shared Access Licences shows that there is more to do with Local Access to simplify the process. The disparity is made more alarming by the extreme shortage of equipment to support Shared Access Licence spectrum and plentiful availability of that which can use Local Access Licence Spectrum. Applicants are going for Shared Access because getting Local Access Licences is a much more complex process with a lot more parties involved, and a much greater degree of checking required.

MONeH RCC is the only organisation to have obtained Local Access Licence spectrum on those bands where the principal licence holder is EE, and the only one to have spectrum from Vodafone and O2. Of the 18 licence applications granted, MONeH has been instrumental in 15.

The first issue encountered by MONeH RCC is that the current application form (OfW 588) is designed to grant access on a cell-by-cell basis. This is impractical for a small cell deployment within rural areas where the precise final location of the cells is not known and is likely to be adjusted to achieve optimum coverage within the local area. This also means one application stalled or refused looks like very many more.

James Body (CEO of Telet Research) negotiated an agreement with Cliff Mason (Manager Mobile & Wireless Broadband Policy, Ofcom) that MONeH RCC can submit Local Access applications using a procedure similar to that currently used with Test and Development (T&D) applications. This involves the definition of an operational deployment area defined by a fixed point combined with a radius of operation; this procedure is known within Ofcom spectrum licencing parlance as point and radius. Telet is proud of having pioneered this approach, and now possesses a number of granted licences in different bands and a number of additional ones in progress. For small cell deployment, this point and radius licence becomes a 'must have' which offers the MONeH operator the level of flexibility required in siting of cells for optimum performance.

Ofcom often has problems getting operators to be cooperative and this is something the MONeH team has witnessed since the days of Don Cruickshank when Director General of the telecoms regulator, Oftel. For the Local Access Licence there are many more problems. It is the private networks which are engaging with the operators and there are no ground rules for the discussion. This makes the process even slower. To be successful commercially, the Local Access Licencing procedure must be both predictable and repeatable.

There is also no incentive for the operators to be co-operative. And every incentive for them to turn down applications, so the departments responsible are under-resourced with the operators claiming that those responsible for the work do it as an adjunct to "more important" network planning.

In the main, the operators fail to accept that they do not own spectrum, only a licence to use it. Ofcom works on the basis that operators have bought the right to use the spectrum they bought at auction and that if they do not use it Ofcom can give it to someone who will; this is not the view held by the operators. They believe that having invested many billions of pounds on licences, they should have exclusive ownership. And you can see why they might think that.

Asking an MNO to share something it has spent a vast amount upon, for free, and to do all the analysis on propagation and interference is particularly unattractive to them. It also has no way of covering the cost of doing this. While the licence fee covers Ofcom's admin it does not cover the admin for the operators.

The result of this is overworked departments with no incentive to complete the task. With one operator we applied for spectrum we knew that they would not want to use and were rejected on the basis that they had plans to use it. We have since gone back (with the help of the press office who have instructed them to be co-operative) and been told that on second thoughts, and in the light of SRN perhaps they will reconsider but are maxed out over Covid-19 and we are at the back of the queue again. It feels a lot like they have spotted some new long grass to kick the ball into. The MNO Three, claims that it will be using all of its spectrum at all of its sites – which is clearly untrue, while Vodafone charges an admin fee of £10,000 per site for a three-year licence. This feels a lot like a number plucked out of the air to make the process uneconomic and unattractive for operators to approach Vodafone for Local Access. Vodafone claims that it will waive the fee where the build complements its infrastructure. This is a reference to MONeH, where the reality is that Vodafone was caught on the hop with the application. Repeated requests for a licence, with a waived fee, for Telet Research's Llanthony project (a commercial venture for Telet based on the MONeH RCC project) have been ignored.

This may well be tied up with the way the network accounts for the asset value of the spectrum and the effect that has on the value of their businesses. The most aggressive in this respect is Three, which ironically is the network that has the most to gain from the MONeH approach. Stephen Lerner from Three has publicly stated that it will not release any spectrum for Local Access Licences. Applications have been met with delays, obfuscation, and a perception of deceit.

The official approach is to do a radio survey, determine which frequencies are not being used and then apply to Ofcom for a licence. This does not work. Ofcom will pass the request onto the operator who will refuse.

The approach which can be made to work is to identify your area, approach the right person at the operator and then ask what frequencies they may be willing to let you have. However, this is on a case by case and not scalable.

Officially Ofcom is neutral about which approach should be taken but privately concedes that the approach operator first route is more likely to succeed. It points out that the operators prefer organisations to go to Ofcom first as that weeds out the no-hope applications.

For the MONeH applications we used GWS and Real Wireless to do our surveys and did our own using Network Signal Guru for which Telet Research has produced a tutorial as part of further collaboration activity. An abridged version of the tutorial was published in UK5G Innovation Briefing.

The Contacts for applications are:

Ofcom	Paul Chapman	Paul.Chapman@Ofcom.org.uk
EE	Chris Cheeseman	chris.cheeseman@bt.com
VMO2	Julia Lee	julia.lee@virginmediao2.co.uk
Three	Anil Darji	Anil.Darji@three.co.uk
Vodafone	Paul Rosbotham	paul.rosbotham@vodafone.com

It is worth looking at planning permission to try and understand what the networks have in mind. Vodafone says it takes them 18 months from scouting out a site to getting anything built. It is also important not to just fill in the form and discuss it with the operators but to engage Cliff Mason and Paul Chapman at Ofcom ahead of filing the OfW 588 form.

Although the form is designed for small areas, centred on a postcode, Ofcom has said that it will look at large area applications based on a point and radius, much like the Test and Development application process. This allows Telet Research, which is putting small cells on residents' homes, flexibility as to which homes it uses. Often driven by backhaul availability. It is also cheaper. Each application costs £950 so having one licence for a large area is much more economical than multiple licences. We hold licences for spectrum covering an area akin to that of Luxembourg.

The approach from Ofcom is part of a general willingness to cooperate. Telet Research on behalf of MONeH RCC has been told that if there is anything which the form cannot handle, we should include a note with the application. One example of this is to ask Ofcom not to anonymise the application. When the form was designed, it was envisaged that there might be some military applicants who would not want the incumbent to know who was doing the licensing. So as standard the form is anonymised. Telet strongly recommends asking Ofcom not to anonymise the form in your application, because everyone talking to everyone else is really what makes this work.

Applications are made to the spectrum licensing email address, and while it is prudent to copy applications to Cliff Mason the application acknowledgment is produced, with its reference number, automatically. This means that if you submit multiple applications within a short period of time, correlating which application produced which reference number can be uncertain. It is better to apply, and then wait for the response before submitting a subsequent application.

The first sign of success is when you get an invoice. Ofcom has been quite badly hit by COVID and everyone working from home, and the time between everyone agreeing that you can have a licence, and it coming through is really quite long. But Ofcom can give you a nod that you are going to get the licence, and you can start work.

The existence of Local Access Licences is potentially fabulously valuable to solving the issues of rural coverage. The bare bones of a system exists but it needs significant refinement to realise its promise and ability to be automated and scalable rather than depending on who you know.

6.4.2. Local Access Spectrum - Recommendations

MONeH RCC would suggest the process should be aimed at putting more onus on both the applicant and the operator. This should streamline the process for the operator and compel them to act.

Specifically, it is recommended that the applicant is required to provide detailed coverage maps of the proposed area, as We have all been to places where the operator maps say, "good indoor coverage" and yet you cannot make or hold a call. In the Chalke Valley where we are building MONeH we know exactly where along each road calls will drop. It is suggested the applicant is required to submit details of the closest places they know of which use the spectrum they plan to licence, and further to radio plan what they intend to put in.

It is necessary to look beyond the spectrum and ask for details of interconnect and hand-off. This might be outside Ofcom's remit but is valuable for the operator.

With these new requirements on the applicants, it should provide for a very much quicker turn-around from the operator.

There needs to be a time limit on how long the MNO has to process each request. MONeH RCC suggests a month. If the operator has solid plans to use a block of spectrum, it needs to clearly explain and articulate what those plans are and the timescale to Ofcom but not the applicant.

Operators should be paid for processing the application at a similar level to that Ofcom receives for their administration. While this doubles the cost of the application process, it does not do so for any on-going fees. The amount of work necessary for the applicant far outweighs the few hundred pounds licences may cost.

This shifts the use of spectrum from "We might want to use that sometime in the next three years", to details of a solid 'plan to use it and when'. Refusal should be a formal process with a suggestion as to what alternative spectrum might be deployed. Ofcom being the ultimate arbitrator where there remains disagreement.

If the time period is exceeded the operator can apply for an extension of a further month. Ofcom will decide if this is warranted. After two extensions, or if an extension is not warranted, it will be considered that the application is granted.

Granting of the spectrum should automatically kick off the PLMN process.

Whilst Telet's suggestions do add quite a bit of cost and complexity to something which was conceived as being quick, simple and cheap we need to find a mechanism by which applications do not stack up at the operators with little hope of an outcome.

Ofcom and the operators have different views on the best form of initial contact. Ofcom claims that applicants can either apply through Ofcom or speak to the operators first, with a preference for applications through Ofcom. It argues that this allows Ofcom to screen out "no-hope" applications. The Operators say applications should be through Ofcom. This makes it easier for them to refuse. Telet has found that the only way to make Local Access Licence applications work is to horse-trade with the operators first.

We need to look at reform in two timescales. What can be done to improve the process to reduce the effort by all participants and make it repeatable, and what should replace the process to make the best use of spectrum.

It is recommended that we morph the complete process into a semi-automated dynamic spectrum access scheme, changing from a licence for a specific frequency to becoming licensed to operate dynamic spectrum access anywhere within a specific band. The radio would then choose the optimum spectrum to use based upon what is being used. This puts the onus of interference on the new entrants. While the incumbent operators are free to use high power macro cells, the new entrants have limited power and will always be the ones affected by interference. The small cell will always choose the optimum spectrum to use, the one where there is no other activity. The reason for this is because it is an extremely low powered cell. It does not want to compete with a much bigger, more powerful cell. If there is something local using that spectrum, it is just going to be avoided. The end result is you get much better use of your valuable spectrum, the system will automatically use the gaps. The other really good thing that Ofcom gets out of it is they get visibility from each deployed radio cell on what spectrum is being used.

Telet will look at building an intelligent cell with dynamic spectrum access, as part of its Best of British programme for FRANC. This is fundamental to a move to a model where, as with the more successful Shared Access Licence there is no operator involvement.

In the meantime, Ofcom needs to be more aggressive in dealing with the operators. It needs a default position that the application will be granted, strict limits on the time operators have to respond and crucially, over-rule an operator's refusal to grant a Local Access Licence.

6.5. Shared Access Licences and Understanding Band N77

Ofcom licences three bands, as Shared Access: bands 3, 77 and 258. While this is hailed as revolutionary it has its roots in the guard band licences. When 1800MHz, Band 3, was originally licenced to Mercury One2One and Hutchison Microtel for Orange it was considered that there was a risk of interference with the cordless phones DECT frequencies at 1900MHz so a fallow guard band was set aside. In practice digital electronics proved to be better than anticipated so two channels of 3.3Mhz were licenced to 10 companies on a Dutch auction. There were no rules about where it was to be used; the operators just had to play nice. It was not successful. None of the companies did very much, Mapesbury Communications, trading as 01 built a small network in East London, Coffee Telecom was bought by Talk Talk, and had plans for a national network but ended up cancelling them having bought many thousands of cells which then had to be disposed of. FMS did "security stuff", but at the end of the ten year licences there was not much to show for the attempt.

Band 3 was rolled into the Shared Access Licence regime. This however has the problem that 3.3Mhz is a custom bandwidth. Cells typically run at 5MHz or 10MHz channels, so the hardware to support it is expensive. A 5Mhz Nokia cell can be picked up second-hand for a few hundred pounds. A variant that supports 3.3Mhz is thousands. In some countries, notably The Netherlands the guard band was set to 5MHz wide, and appeals have been made to Ofcom to follow this, but the spectrum EE has is too close to the top of the band.

6.5.1. Device manufacturers and Band N77

By far the most interesting was Band N77, which runs from 3.8 to 4.2 GHz. Initially there was disappointment with these frequencies due to the lack of device support. That will come right over time, but a more nuanced issue is infrastructure availability. The initial enthusiasm for a band that was 400MHz wide, and the promise of exceptionally fast fixed-mobile access, have been moderated by Ofcom's restricted allowance of only 100MHz per applicant, although in the real world many cells do not support more than 50 MHz or 80 MHz wide channels.

As more and bigger markets supported Band N77, there was an incentive for device manufacturers to supply relevant kit, but it is important to understand why many handsets may say Band N77 on the spec sheet but in many cases do not currently enable operation in that band.

Band N77 is a non-operator spectrum. Operators buy the vast majority of mobile handsets. Most people get a new phone free or discounted when they sign a contract. The major handset manufacturers have three top priorities when they consider which features to include:

- **Operators Specifications** - Overwhelmingly the most important of these is what the operators have specified. Meeting the requirements of customers with very exacting specifications is tough, and often leads to internal battles between salespeople, who are responsible for different operators, to get their work done first. As Band N77 spectrum is not on any of the operators' lists, it will not be in the prominent requirements by the manufacturers.

- **Matching rivals' specifications** - As shipping deadlines are very tight, manufacturers may never get to the second priority, which is the addition of features that rival phones have but that the supplying manufacturer does not. This consideration is also with an eye to the operator buyers. It will include features such as a camera with a smile sensor, an under-glass fingerprint reader, or a better camera. It is usually something that helps the sales process, such as radio performance and battery life rather than support for un-regarded radio bands.

- **Getting ahead of rivals** - The third priority is the addition of features that will make the phone stand out against rivals. It is only in this phase that Band N77 gets a bit of a look-in because enterprise customers are increasingly important and are pushing the demand for private 5G networks. In recent years, all manufacturers have been dreadful at finding innovative new features for phones. They have played with reducing the bezel, improving the camera, or having a notch or a punch hole. The Motorola Razr and Samsung Flip apart, there has been precious little experimentation with form factor, so instead it is a race to the bottom on price. That means there is no desire to introduce new spectrum bands with the associated radio testing. So, while MediaTek and Qualcomm might have Band N77 available on the chipset, this is unreliable information when trying to determine if the phone will actually work in Band N77, as it is often not enabled in the operating system.

MONeH RCC has worked with others to get custom firmware loads which support Band N77 Standalone. For some applications this is an excellent remedy, but for the residents of the Chalke Valley who have an iPhone or Samsung this means no connectivity.

Few phones support Band N77, but the most mainstream of all, the iPhone 12, does. Sort of. Whether an iPhone will work in the Band N77 depends on who, as a member of the public, is owning and managing the phone. The iPhone has operator profiles. This determines which features in the phone are switched on or off. To ensure an iPhone has support for the Band N77, members of the public need to buy it from an operator that has specified it. Therefore, there are inherent problems with this methodology and user know-how.

There are some further issues: you do not have to be an operator to get an iPhone profile, just a customer important enough to Apple for the company to get one written. This typically means you must buy several million dollars' worth of handsets. But US operators such as Verizon are pushing the door for private 5G and eSIM, which is encouraging Apple and others to develop support.

For the majority of Android handsets, the waters are similarly muddy. Support for Band N77 depends on two things: what you mean by Band N77, and what software is in the phone. To deal with the second one first, the software loaded onto a phone varies by region and by the local customers. Some parameters can be enabled by re-flashing the phone with the right release of the firmware. This is often available through a bit of web searching, but you people need to know what they are doing. It is easy to “brick”, or kill, the phone. Understanding what you mean by Band N77 is down to standalone or non-standalone. In brief, NSA, or non-standalone, means a version of 5G that uses a 4G network other than in the radio stage. SA, or standalone, is a buzz-word bingo of containerisation, http2 and use of commercial-off-the-shelf products and promises a step change in the way networks are built and delivered. The holy grail is a device that supports B77 SA, but for now you will probably have to speak to the handset manufacturer to get the software for that and then re-flash the phone. Still, 5G is not just about handsets; there are many use cases with connected devices that do not need mainstream phones.

You would have thought that lack of operator interest in Band N77 would have been reflected in radio hardware. While operators buy most of the handsets in the world, they buy all of the network infrastructure. After all, that’s the definition of an operator. Ofcom’s vision that Japan would unlock devices for Band N77 might not yet be realised, but there has been a significant benefit in infrastructure. Network infrastructure vendors have been making apparatus for that market for a while. There is a shortage of available 5G radio equipment, but the need to support Japan means that there is some mainstream equipment – or almost.

Japan does not use the whole of the 3.8 to 4.2GHz band; it uses 3.85 to 4.1GHz, so much of the existing equipment does not cover the whole band. Some other manufacturers make equipment that runs from 400MHz to 4GHz, so again the top 200MHz is not catered for. As a side project to MONeH RCC, Telet Research is looking at a Band N77 for Westminster. The only spectrum Ofcom could let us have was 4.1 to 4.2 because of a nearby Permanent Earth Station. Finding equipment for this is proving exceedingly difficult. Neither Nokia nor Ericsson currently have anything suitable.

6.5.2. Seeking appropriate spectrum

Understanding spectrum requirements and available hardware needs to be borne in mind when applicants seek spectrum. The pricing is simple; it is £80 per 10MHz per year. There is no cost difference between the rural, medium-power licence of 42dBm and the urban, low-power licence of 24dBm. Ofcom reasons that shared-access spectrum is for sharing, and therefore, by capping to 100 MHz the amount that any applicant can have, it is possible for up to four organisations to licence in the same place. In reality this is not much of a limitation, as the radio heads are limited to 80MHz or 100MHz. At £800 a year to provide the kind of levelling up broadband the nation is looking for, 42dBm is far from economical in sparsely populated regions. An island like Eday in Orkney which has a population of 100 would need half a dozen cells to provide the requisite coverage. This would equate to c£50 per year per man, woman and child on the island, in an environment where maintenance and backhaul are expensive which nixes the idea that the licences were created for. We need to see point and radius versions of the licence to keep the costs down.

As an aside on the £80 per 10 MHz, the entry cost is not £80 but £160. Qualcomm chipsets can only go down as far as 20 MHz so that is the smallest licence that should sensibly be applied for.

Avoidance of interference between radio users is fundamental to the existence of Ofcom. It is a credo that predates Ofcom, its ancestor Oftel and the Home Office before that.

It goes all the way back to the Wireless Telegraphy Acts of 1904 and 1949. So, it seems sensible that when organisations apply for Band N77 spectrum, Ofcom chooses to allocate the higher parts of the frequency band. This keeps the entrant away from the licensed spectrum that is used by operators at just below 3.8GHz.

For an applicant, however, there may be other considerations. If applying for multiple, overlapping licences, it may be sensible to have different parts of the spectrum for re-use. This is not the only option. It is quite possible to have multiple sites on the same spectrum but split on the time domain.

An aligned concern is that it is better to have the lower frequencies because the propagation is better. Whatever the driving reason, it is important not to apply just for Band N77, but for operators to specify where within the band they would like their allocation. Bear in mind that space has to be left for other users to cohabit, so odd, small chunks in the middle are a bit anti-social.

One notable example of Ofcom's flexibility is that it is open to organisations making multiple applications on a single spreadsheet. It is preferred that you fill out one OfW589 form to accompany the spreadsheet, which gives details of all the equipment used.

A second form that can be asked for is an exception form, which enables an operator to state a case for using the spectrum in a way that is not covered by the general rules – for example, to use medium power in an urban environment. Ofcom is always willing to listen.

When seeking appropriate spectrum, you need someone to fundamentally understand and piece together the spectrum application, availability and actual usability as this process is not well signposted or understood. Ofcom need to look at how spectrum is applied for and allocated and its usefulness as potentially N77 and Shared Access Spectrum becomes more mainstream with potentially more players in the market.

6.6. Interconnecting networks with MNOs

In the UK, there are two possible modes of interconnection with UK Mobile Networks. Firstly, it is possible to provide a "radio network extension" using an approved specification such as the "Joint Operator Technical Specification". Secondly, it is possible to roam subscribers between the networks using GSMA standard roaming, which is the MONeH preferred option, as discussed.

In the international market, inbound roaming is seen as an important revenue source, e.g. SFR in France will have many customers who want to visit Italy, to Telecom Italia will wish to charge for this (NB within Europe, the rates for roaming are of course regulated) and therefore they will negotiate (a) a fair bilateral price for Italians in France and (b) seek to maximise their revenue stream.

Applying these commercial principles to the relationship in the MONeH case, we can see that it is no longer balanced. Telet is a small operator with a minimal footprint, whilst BT/3/Vodafone and O2 provide almost national population coverage.

Therefore, these operators objection to roaming with Telet is threefold:

- Firstly, they do not agree that they have a coverage problem (as in Ofcom has signed off their mandatory coverage obligations as being met) and they believe that their current initiatives and roll out plans, both internally and via Shared Rural Network, will complete any remaining gaps.

- Secondly, if they felt that there was a coverage problem Telet does not, presently, offer significantly improved coverage to make a meaningful difference and they would prefer a JOTS solution rather than a local roaming based one, as it would allow them to control the quality of experience more easily.
- Thirdly, they therefore see that giving access for Telet to connect to their network is significantly more valuable and therefore, they wish to seek an elevated level of financial commitment, in line with their typical MVNO agreements.

Telet has engaged with all UK operators via roaming teams, network teams and using executive level contacts, but it has thus far not been possible to make a commercial agreement for bi-lateral roaming.

6.7. Mobile Network Codes (MNC) – a level playing field?

In order for MONeH RCC to demonstrate the commercial viability and its provision as a network provider, it needs to adhere to the global standards of how a GSM operates. Every operator is uniquely identified by a combination of Mobile Country Code (MCC) and Mobile Network Code (MNC). This combination is used by all mobile operators which operate using GSM, WCDMA, LTE, iDEN public land mobile networks as well as some CDMA, TETRA, and satellite mobile networks. This combination of MCC and MNC is also uniquely identifies Public Lang Mobile Network (PLMN). Each operator providing mobile service should have their own PLMN identity. With the International Telecom Union (ITU) delegating authority to each local country, Ofcom handles all MNC requests for the UK. Since the inception of MONeH RCC as part of the 5G Test Bed and Trials Programme, Telet Research, as the Consortium Lead and operating member of the GSMA, has been actively applying for an MNC in order to meet the requisite obligations. The experiences of MONeH RCC have been complex and problematic and will be experienced by any new network operator outside of the main MNOs should there be no change from Ofcom. Therefore, the below serves as an explanation of how Telet undertook the application, its experience, and learnings. With the code not being forthcoming, this provides evidence for the requirement for Ofcom to re-evaluate MNC provision and the role of DCMS to review and direct policy change.

6.7.1. Telet Mobile Network Code Application

Telet has engaged with Ofcom since the beginning of the project, and in written correspondence since November 2020, with a view to securing a Mobile Network Code (MNC).

Initially, Telet looked to reinstate/continue the 23588 MNC which was allocated to Telet as part of a test spectrum licence, but then we have rapidly followed up the discussion with a view to securing a permanent MNC for our commercial endeavours.

In the correspondence with Ofcom, we believe that we have continued to demonstrate that Telet is building a well-funded, public mobile network as the UK's 5th Mobile Operator, which will have both its own subscriber base and permit inbound roaming for all mobile operators, with the intention of improving mobile coverage for all, particularly those located in "mobile not spots".

In building this business, Telet has achieved a number of significant milestones

- Telet was formed in 2016 and began trialling its technology approach, funded by a group of entrepreneurs & investors in the communications industry.
- Telet was granted the 23588 MNC under a test & development licence in 2018 and issued SIM cards to subscribers using that MNC.
- Telet received a £2.3M grant from DMCS under their Rural Connected Communities programme & secured additional investor support to roll out of the service in Chalke Valley in January 2020.
- Telet was granted use of Spectrum by Ofcom under the local access licence regime in July 2020. Telet has a number of other spectrum licence applications pending Ofcom's response.
- Telet has interconnected with other mobile networks, principally the BICS roaming hub.
- Telet applied for reinstatement of the 23588 MNC in November 2020, along with an additional code 23488.
- Telet signed its first GSMA standard international roaming agreement with Hutchinson Lanka in January 2021.
- Telet is now actively deploying its network across 5 geographical regions in the UK and is in active discussion with partners and customers about additional locations. The Telet launch footprint will be at least as large as other initial operator launches, e.g. the one2one launch footprint.

The requirements for a mobile network code, per ***ITU-E.212, Annex B*** are given below and how Telet has demonstrated to Ofcom in how it meets the requirements:

ITU-E.212, Annex B

1) MNCs under geographic MCCs are administered by the respective national numbering plan administrator who has responsibility for specifying criteria for assignment, conditions of use and procedures for reclamation at the national level in accordance with this Recommendation.

2) The applicant must demonstrate a need for the resource and must further demonstrate that other reasonable technical and operational alternatives (e.g., use of already assigned MNCs, use of national allocated or assigned shared MNCs, use of embedded SIM) are not appropriate. The applicant must attach substantiating documentation justifying this fact.

- Telet is deploying as a full UK Mobile Network Operator in multiple locations across the UK, with full international roaming capability. Telet has previously shared its full Operator Membership of the GSMA with Ofcom.
- Telet is issuing its own SIM cards with its own IMSIs and requires continuation of the 23588 MNC which was previously issued under a test and trial licence.
- Telet's network exists as a standalone network, which is interconnected with others. Telet has shared a GSMA standard international roaming agreement with Hutchinson Sri Lanka, Orange Romania, Orange Luxembourg, and others which permits customers with Telet IMSIs to roam in multiple territories.

- Telet has previously shared the network core plans, initially deployed geographies, and spectrum applications (in process and granted by Ofcom).
- Telet cannot use another network's mobile network code because it is providing roaming to all global operators, including the other 4 UK operators, and those operators do not wish to permit Telet to use their networks to support national roaming of other operators' traffic onto theirs.
- Telet will not be able to operate its business without a mobile network code.

ITU-E.212, Annex B

3) As required, applicants for MNCs must comply with applicable standards and national regulations relative to the provisioning of public telecommunication services. The applicant will affirm that it complies with interworking requirements among public networks.

- Telet is compliant with the Ofcom General Conditions.

ITU-E.212, Annex B

4) MNCs are to be assigned to permit the most effective and efficient use of a finite resource in order to defer, as long as practical, the need to request additional MCC resources. For networks and services to be provided in more than one country, excluding mobile roaming services, an applicant for an MNC under a geographic MCC should be encouraged to apply to the ITU for the assignment of an MNC under a shared MCC (Annex A) to avoid the need for multiple assignments of MNCs under different geographic MCCs.

- Telet does not require a shared MNC across multiple countries. Our network is a UK network.

ITU-E.212, Annex B

5) A country's national numbering plan administrator may assign one MNC within an MCC assigned to that country by the Director of TSB to the applicant if the applicant demonstrates compliance with the criteria established by the administrator including the respective right to apply for an MNC. The administrator may assign additional MNCs if the applicant meets the criteria for additional assignments established by the national numbering plan administrator, e.g., testing, national roaming, another mobile system.

- Telet has now been issued with **two** UK MNCs, 235-88 and 234-88.

ITU-E.212, Annex B

6) MNCs are to be assigned to applicants and used by assignees for public networks offering public telecommunication services. In addition MNCs may be assigned to other applicants (e.g. for GSM-R networks) and these assignments are to be made according to procedure and criteria established by the national numbering plan administrator.

- Telet is operating a public telecommunication service.

ITU-E.212, Annex B

7) The assignment of MNCs to small geographic areas within a country is not recommended because it is not an efficient or effective use of the MNC resource.

- Telet appreciates that this is a key point for Ofcom, given the scarcity of resources. However, Telet would note that:
- Telet cannot use the 999 MNC because it does not signify a globally unique mobile network and cannot be used for roaming.
- Telet's initial network deployment footprint is already larger than some of the early UK mobile network launch deployments, for example One2One was deployed only in the London region. We are targeting 5 UK regions and have aggressive expansion plans - for example there are 1.7m homes in the UK within a not spot (per Ofcom 2020 Communications Market Review). We do not concur that our network will cover a small or isolated geographic area.

ITU-E.212, Annex B

8) MSINs are to be assigned by the MNC assignee to their subscribed users. A user may have multiple IMSIs.

- Telet plans to issue SIMs with Telet IMSIs to its customers.

ITU-E.212, Annex B

9) IMSIs are a public resource. The assignment of any portion of an IMSI (i.e., MNC, MSIN) does not imply ownership of the resource by either the entity to which it is assigned or by the national numbering plan administrator.

- Telet noted this position

ITU-E.212, Annex B

10) Should an assignee transfer control of all or a portion of its business using its assigned MNC under an existing arrangement, then the use of the assigned MNC may be transferable by the national numbering plan administrator.

- Telet noted this position

6.7.2. Ofcom's reticence to allocate an MNC

Ofcom has consistently declined to allocate an MNC to Telet on a permanent basis. Ofcom's current view is that the definition of coverage for the relevant area can only be achieved by a new market entrant purchasing a national roaming agreement directly from an incumbent UK operator. Their concern appears to be that they have no good mechanism for determining which applicants have meaningful network deployment plans, vs those who are simply looking for an MNC for a small-scale trial.

However, as above, Telet believes that this is the wrong test. The challenge with this means that new entrants are required to make an expensive contractual arrangement (usually multiple £ million) where there is no regulated reference offer, and that agreement must be struck with an organisation that is commercially incentivized to block new market entrants.

Finally, Ofcom does not appear to permit new entrants to purchase UK roaming services from international providers, which is a much more competitive market. However, Telet does not believe that it is required to have an agreement with a primary UK operator and has provided a letter of support from its main interconnect partner "Sure" to confirm that an MNC is required for Telet's contract with them.

Too often Ofcom has requested further information to be received within 7 days of receipt of their email e.g. opportunistically over the Christmas break where failure to respond within 7 days would result in MONeH RCC having to resubmit their application, yet for Ofcom their response period was often over 30 days to acknowledge an email from Telet.

6.7.3. Log of interaction with Ofcom for MNC applications

Date	Nature of Communication
16 Nov 2020	Initial Application & Rejection of our Application. Told to come back when we had an MVNO / National Roaming Agreement.
8 December 2020	Telet Supplied IPX Agreements and details of network deployments.
18 December 2020	Ofcom confirmed they could not resolve until the new year.
26 Jan 2021	Telet supplied Signed Roaming Agreement with Hutchinson.
3 Feb 2021	Ofcom confirmed still insufficient grounds to allocate MNC.
5 Feb 2021	Written Correspondence from Telet to set out the case for an MNC.
24 Feb 2021	Conference Call with Ofcom
17 March 2021	Telet chased Ofcom for conclusion
7 October 2021	Ofcom rejection of latest application.
29 October 2021	Telet chased Ofcom for detailed discussion. Submitted new application.
24 November 2021	Telet provided a letter of support from Sure to confirm its necessity.
10 January 2022	Telet confirmed to Ofcom the DCMS FRANC announcement to demonstrate necessity.
9 February 2022	Conference Call with Ofcom.
21 February 2022	Telet supplied additional information about projected coverage plans.

2 March 2022	Additional request from Ofcom on Telet coverage plans.
13 March 2022 and 31st March 2022	Telet provided supplementary information and then chased for acknowledgement of response.
1st April 2022	Telet confirmed signed FRANC Grant Funding Agreement and plans for launching commercial services.
6th April 2022	Ofcom Granted 23488 Mobile Network Code.

6.7.4. Realigning the application and allocation of MNCs

The current process and stance on the allocation of MNCs to new operators needs to undergo an urgent review. By virtue of the current approach by Ofcom into their allocation of MNCs, the playing field is not level, and the impact will have far reaching consequences not just for new entrants but the wider general public. New market operators ensure there is a fair and just 'market' in the UK and secondly to work with SRN in the provision of mobile coverage in areas such as rural not-spots where the current business models of MNOs does not reflect the need to ensure the UK has genuine 4G & 5G coverage. This will make levelling-up across the UK for the provision of improved mobile connectivity ridiculously hard to achieve as new entrants to the market cannot get a foothold, due to the bureaucratic and closed shop approach currently being undertaken. Whilst this report is not advocating that there should be no acceptance criteria or due diligence undertaken by Ofcom, what has been demonstrated to date is an intransigent approach to how MNCs can be applied for and allocated based on legacy criteria in what was a 'closed' market. With the advent of DCMS funding initiatives to ensure greater coverage of 4G & 5G across the UK, then this will naturally attract new operators. Therefore, Ofcom need to review their own processes and requirements in how MNC are applied for and allocated otherwise the intended change required by the Government will not play out.

6.8. SIM Cards

SIMs are a 'key' component in any mobile network. Without correctly configured SIMs it is not possible for the mobile network to function. As mobile network technologies have evolved, the complexity of the SIM and the amount of information that they carry has increased with each generation of mobile network standard.

A modern 5G SIM card (UICC or eSIM) contains multiple SIMs, including 2G SIM, USIM (3G/4G), IMS Profile (for VoLTE/VoNR), 5G SIM and operator/carrier profile. Developing the operating system and profile therefore requires specialist knowledge and a process of 3-6 months.

Commercial Viability of SIMs for Small Networks

Normally, a minimum order for SIM cards will be for a quantity of 5,000 units, with most manufacturers expecting run rates of 10,000-50,000 a year. This presents a problem for many small and private networks which typically want tens of SIM cards and at most want a few hundred. A SIM order also requires the completion of a bespoke software profile, costing upwards of £15,000 (e.g. from G+D). Therefore, even at order volumes of 5,000, a typical unit price of around £3-5 is normal, so a £20,000 bill for a project which needs even 300 is significant. There is an additional overhead beyond this of developing and testing the cards to meet the requirements of the individual networks.

We have identified a requirement to develop suitably configured SIMs (both in UICC and eSIM formats) that will meet the growing demand from the UK private network sector.

This will allow projects which cannot justify the expense of ordering thousands of SIM cards that they are not going to use to buy in sensible quantities from Telet. This action works well for Telet, allowing it to bear the cost of developing and buying the SIM cards. The company has several experts on development and procurement of SIM cards, and to amortise the cost by selling excess quantities to the other 5GTT and FRANC projects.

Mobile Network Codes/IMSI Ranges

Each SIM card (or eSIM) contains IMSIs which are derived from Mobile Network Codes. For test or private networks it is widespread practice to use test codes, typically in the 001-01 MNC range, or private network codes in the 999-xx range. To be able to interoperate with other **public** networks, the SIM card must have a MNC issued by the national telecoms regulator (in the UK this is Ofcom). All Mobile Network Codes consist of a three-digit country code and a two or three digit identifying code. For example, in the UK, Ofcom holds two country codes, 234 and 235, issued by the ITU. Both 234 and 235 currently are used with two digit network codes, limiting the total number of unique MNCs available for issue to public mobile networks to 200. Around a third of the 200 UK MNCs have been issued to date. Ofcom informally classes 235 MNCs as being for experimental use. Ofcom has concerns about the risk of running out of Mobile Network Codes, possibly driven by analysts reports that deployed few mobile networks in the UK to thousands. With only 200 available it is guarding them closely and as a result Ofcom has brought in exceptionally onerous conditions for allocating a Mobile Network Code. A good stop gap solution would be for Ofcom to go to three-digit network codes. In the meantime many projects will struggle to obtain Mobile Network Codes and so be unable to order SIM cards.

Through the MONeH RCC project and necessity to obtain SIMs, Telet has over a period of two years negotiated a temporary mobile network code of 235-88 and then, following an arduous 12 month negotiation with Ofcom, a permanent code of 234-88. This allows the company to introduce the revolutionary model of SIMs as a Service. These are multi IMSI, multi crypto sims. Each identity will support a different Mobile Network Code. Telet through collaborating with other Testbed & Trials projects has envisaged a scenario where a factory in Doncaster and the University of Exeter, could operate using the same MNC. They would be set up with a generic configuration, which can then be configured using Over The Air for the specific use case.

Multi IMSI Capability

Telet SIMs will come as standard with a 001-01 test range, with a 999-88 private range. A network which is going to be private-private, should always use a private 999 MNC/IMSI range. This can be likened to the use of a 192.168 IP address within private IP networks. But anything which requires interaction with other networks will want 234-88. To support this the Telet SIMs are Multi-IMSI.

Multi Crypto Capability

Normally a SIM will only be required to authenticate with a single mobile network. However, in scenarios where a hybrid configuration which uses both Private and Public mobile networks, the SIM is likely to need more than a single set of cryptographic key variables in order to facilitate authentication with multiple mobile networks.

Consequently, our planned SIM development will include multiple sets of cryptographic key variables (and possibly different cryptographic algorithms) such that a single SIM can operate seamlessly across multiple different networks.

Carrier Profiles

Smartphones and other mobile devices sold by Apple, Samsung and other major manufacturers have their settings controlled by a manufacturer provided **"Carrier Profile"** which is built in conjunction with the mobile network operator. For example, Apple only enables 5G service once it has completed integration testing with an MNO who has rolled out 5G to Apple's specification. This carrier profile will control settings such as VoLTE/VoNR, for voice, but also which spectrum bands the phone should search on. For example, a Vodafone UK operator profile will be set only to search on the bands they utilise, and will therefore exclude N77 (and effectively turn it off), the shared access band used by most UK private 5g networks. This makes the phone more efficient and saves the effort of scanning bands that the operator thinks it will never connect to..

Additionally, once a phone has configured itself to a specific profile, e.g. by inserting a Vodafone UK SIM, it will then remain in that state until a different SIM updates the settings with a different Carrier Profile.

It is not possible for small operators, or private network operators, with small order volumes, to engage with vendors such as Apple or Samsung to have their own carrier profiles developed, which has so far excluded these vendors from working in the Private 5G network market.

Telet has engaged with Apple on this topic and Apple have feedback that they do not have (and do not intend to have) a mechanism for Operators which are not primary retailers of their devices to be enabled on them - as it was put to us *"we sell phones, not carrier profiles"* and in the context of a niche B2B marketplace, Telet is never likely to bring a mass-market consumer device to market, as it wants to sell network services, not mobile devices.

5G SIM Functionality

Telet identified that if a 5G Standalone network user deploys a SIM with a 4G profile, it is possible to use that SIM to authenticate, but it does not then enable all of the new 5G Standalone functionality, particularly security focused functionality such as:

- Use of different encryption methods (limited to a single encryption technology, and in many security focused private networks it would be sensible to deploy a more-secure and non-standard encryption technique).
- Does Not support hiding of SUCI (IMSI).

IMS / Voice over New Radio Profiles

In order to make Voice Calling and SMS function reliably on a 4G / 5G mobile network, it is necessary to have an IMS profile on the SIM. This defines the server, numbering and codec settings which the phone should use for messaging.

As with the carrier profile, discussed above, it is not simple to define an IMS profile and again the methodology is designed to support a large mobile network where there is a single IMS core, not a large number of private networks, where each would have their own settings.

6.9. Fibre availability – Rigour of ISP reporting

The early concept of the project was to deploy a 4G network with 5G in NSA utilising a multi-vendor radio cell approach within the Chalke Valley in Wiltshire widely recognised as one of the worst not-spot areas within England. The intention was to cover a geographical area from Salisbury Hospital to the West of Salisbury through to Shaftesbury effectively using the A354 as a southern boundary and the A30 as a northern boundary with the area's western extremity being Shaftesbury. Further, an additional area around Stourhead National Trust property within the Stourton/Gasper area was included due to the complete not-spot but high density of visitors. The initial intention had been to deploy a large quantity of both 4G and 5G radios to saturate the area and provide continuous coverage, however this required an elevated level of fibre connectivity within the Chalke Valley from which to deploy the proposition to property owners

6.9.1. Working with Openreach

The Ofcom Connected Nations report poses the question "***Why, when there is gigabit fibre available to 8 million homes, is take up so poor?***" The reason is that word "**Available**". The BT Openreach definition of Available is that fibre is rolled out to the location. It says that it is then the responsibility of local ISPs to deliver it to consumers and if they do not want to do that then it is the fault of the consumer or the ISP. BT has done its bit.

This is being cautious with the truth. What is missing is that the ISPs and consumers do want the service, it is just that Openreach is so difficult to work with that they give up. The model for Openreach is as a wholesale supplier. It provides fibre to an area and then a retail ISP sells it on to consumers. This is not a level playing field; the small retailers are competing against BT Retail which whatever BT Openreach says about Chinese walls and treating BT Retail equally seems to get preferential treatment in terms of duct and cabinet space.

Openreach only rolls out fibre to its agenda, which may or may not match that of BT Retail. It is fantastically secretive about where it has fibre. In part because it does not know and in part because for some reason it appears it likes to hide behind the 'greyness' of this subject.

Ask BT Retail where it has rolled out fast services and no-one will tell you. All questions were answered with "Type in your postcode and it will tell you if you can get it". In reality, what is going on here is that BT announces it has a product and does not make it available. Call Gigaclear and the person who answers the phone will email a map. BT – both Retail and Openreach has a long track record of claiming things are available and then not selling them. Using BT Broadband Availability Checker requires you to know every postcode in the area you want to search. Each postcode then displays a lengthy list of properties and each property shown needs a 'double-click' to ascertain fibre availability, which in many cases is not available. A thankless task made even harder when a significant update is required to stop the platform from freezing (to then reload on a browser) which Openreach freely admits is a problem. This methodology of identifying properties where FTTP is available is not only not user friendly but is not scalable when looking to deploy small radio cells to improve mobile comms where fibre is a prerequisite into many rural areas.

One of the reasons that Openreach is secretive is fear of regulation. To get details of fibre availability you have to sign a heavy-duty NDA. The data has been leaked to Think Broadband and parts of Openreach are quite pleased about this. It means the data is out there without having to go through BT legal.

Another reason is potentially incompetence. The internal mapping tool does not show what is in a duct, only that a duct exists. It may contain fibre, copper, both or nothing. You can infer what might be there by inspecting nodes and seeing what is available but often the information is incorrect.

These two factors combine to make the tool next to useless, the map only shows one postcode at a time you cannot say "***what is the nearest connection point to a given location***", you have to try all the likely candidates and then infer. This is apparently to hide the monopoly advantage of BT. Unfortunately, postcodes vary hugely in size, so for some rural areas you cannot see the whole postcode on the map. So, for some of the places which most need it there is no way of knowing if you can or cannot get fibre.

6.9.2. Fibre to the Premises on Demand (FTTPoD)

Even if you can get fibre, Openreach makes it a nightmare to process. Each stage seems to come to the organisation as though they had never done it before. If there is any reason for a delay –experience suggests this is a manufactured reason – all other steps in the process stop. No-one you can talk to as an ISP knows what the situation is on the ground. That is the job of the Patch Lead, but when we asked to speak to the Patch Lead for a Chalke Valley deployment, we were told that to do so would be "illegal". Because of a personal relationship between Simon Rockman in the MONeH RCC team and Openreach chairperson Mike McTighe, MONeH had been promised executive oversight in the deployment of Fibre on Demand to three sites. Each proved problematic. The fastest deployment took seven months, the slowest ten and a half.

The longest deployment was into Bowerchalke, Wiltshire, and FTTPoD was ordered in March '21. It took until September 21 for Openreach to determine that it would need duct clearing and the road shutting for trees to be trimmed. In October Openreach approached the council for permission to close the road and supplied paperwork that was both inadequate and contradictory and needed resubmitting. In the meantime, it was established that the duct was clear, and the trees did not need trimming. The people running the process clearly do not talk to those on the ground. We had the experience of the property owner in question talking to the Openreach engineer installing the fibre onto a telegraph pole opposite his house (November 21) only for the claim of fibre now across the road being refuted by Openreach. They had their processes and methodology of working and therefore they claimed there was no way fibre was less than 15m from the property as ducts and trees still remained a problem. So, the wait went on. The last mile install was completed on 31 December 21 after massive amounts of lobbying and protesting. If MONeH RCC did not have the connections and knowledge of how fibre is installed, it would have been at least 12 months+ from order to install.

In theory the village of Bowerchalke has Openreach availability. In practice even if you know the Chairman of Openreach and are a well-connected journalist you still cannot get fibre. Normal people have no hope. In the end going back to the executive support led to the support line we would have been given exclusive access to, hanging up on us, and threats that our ISP would be cut off from being an Openreach reseller if we did not back off.

As FTTPoD was identified from the outset of the project as a key component part of securing fibre in rural locations due to the lack of infrastructure in place the lag time of c7 months made further rollouts not a viable option as site surveys, installer surveys need to be conducted prior to fibre procurement and installation. There is no point installing fibre if the property cannot have a radio cell mounted to it. MONeH RCC was able to secure meetings with Openreach due only to the personal relationship with the Openreach Chairman who ensured a meeting was held between MONeH and Openreach. Meetings with Bertrand Mazieres (Commercial Director) and Andrew Snellgrove (Head of FTTP Product Management) highlighted the issue that FTTPoD is not a priority for them and that the roll-out of FTTP was more the focus. What was discovered was that the Chalke Valley is not even on the Openreach radar for FTTP. The standard line as to why FTTPoD is not seen as a key product was that few people buy it. Whilst this may be in part true, the real reason no one orders it is because it is impossible to get installed within a meaningful timeframe and is incredibly expensive. BT quotes an install time of seven months and then fails to hit even that. The reason no-one buys it is because BT does not want to sell it.

Once Openreach did deliver FTTPoD to Bowerchalke and parts of Broad Chalke, the opportunity to ensure other residents could capitalise and benefit was not taken. Bowerchalke had no FTTP, only FTTC. One house in the village now has fibre installed. With the work undertaken in 10.5 months to get fibre to a single domestic property, it must be questioned the reasoning and methodology of Openreach not to ensure the entire village (379 people) has access – is not this part of Levelling-Up? Yet, when you undertake the laborious process of using BT Broadband Availability Checker by postcode, FTTP remains unavailable.

And it is not just in Rural Wiltshire. Simon Rockman met someone (who wishes to remain anonymous) from Southwark Council charged with putting in fibre broadband, she said she refuses to deal with Openreach and will only work with alt nets such as Hyperoptic and CityFibre because dealing with Openreach is too difficult, time-consuming and delays of installation too large. This is the "Fibre on Demand" product. This ONLY exists to bump up the "availability" figure.

From the other side – suppliers to Openreach rather than customers find dealing with Openreach just as bad. One supplier Simon Rockman visited said "Simon, do you want to buy a Cherry Picker". The supplier had won an Openreach contract to install fibre and bought a load of equipment. When it came to do the work, the overhead of dealing with Openreach was so great he walked away from the deal and sold the equipment at a loss.

6.9.3. Who owns the fibre area?

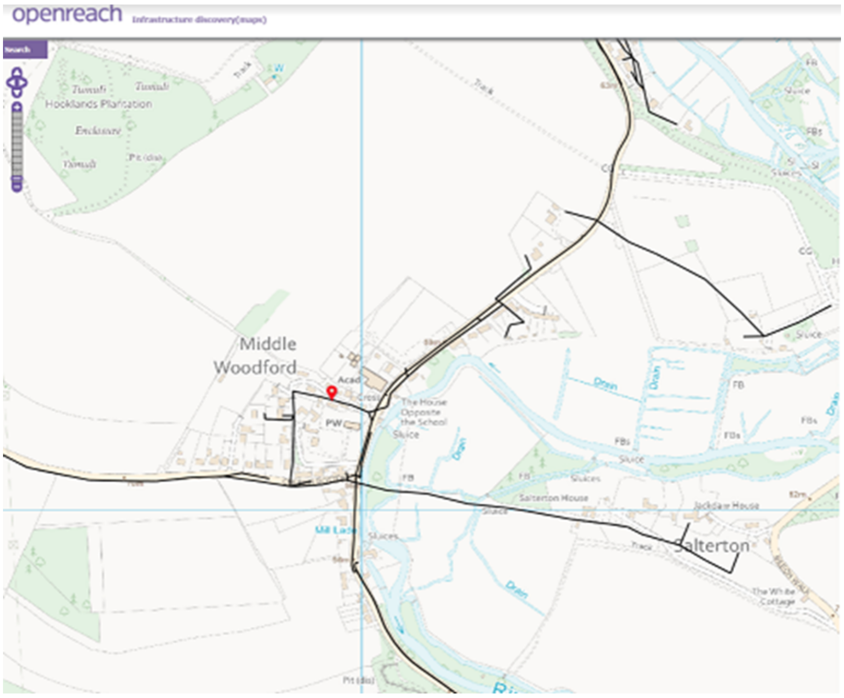
The insidious effect of Openreach saying an area is connected and then failing to enable the last mile is that no other operators will touch that location. The alt nets can only raise finance to cover areas which are not already connected. This means those places where Openreach does not claim to have rolled out fibre are very often better served than those where Openreach has done. How defining an area 'is connected' needs considerable review. As the government looks to Level-Up the roll out of FTTP will continually lag behind urban areas if organisations such as Openreach can 'claim' connectivity. Bowerchalke is a case in point. One house has FTTP, yet the village is organising a collaborative movement to seek to get fibre into the entire village, yet they are struggling as Alt Nets view Bowerchalke as 'claimed' by Openreach. Other examples are Ebbesbourne Wake, Wiltshire, where a single domestic property has FTTP, but they sit on the outside of the village. The centre of the village has FTTC, but no other property has FTTP. This single dwelling has fibre due to Openreach contacting the property owner asking to install a telegraph pole onto their land and in return would provide FTTP availability. When the alt nets look at the provision of fibre into the central part of the village this is seen as 'Openreach land'.

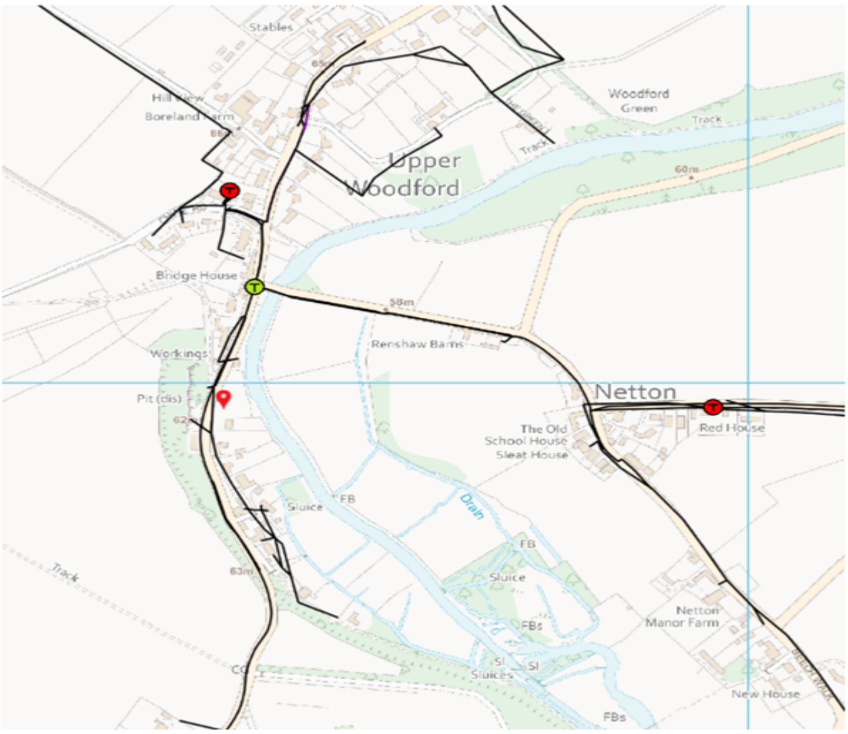
Looking at the methodology for the Ofcom Report, Ofcom works extremely hard to match the GIS data, but does not knock on doors to verify that what all the service providers tell it, is true. That would yield the answer to the question posed by the report.

6.9.4. Ethernet Access Direct

Having been informed by Openreach the lack of take up of FTTPoD and that Chalke Valley was not yet on their radar for FTTP, we were advised to look at Ethernet Access Direct (EAD) which provides a point-to-point data connection between sites. However, this is aimed at businesses and therefore prices reflect. However, it still uses the Openreach duct network and even if affordable for the MONeH RCC requirements it still leaves the property owner operating on business T&Cs and not domestic. Further, once removed i.e. out of contract, the property is no closer to having FTTP than before, back to copper! Establishing where the EAD availability was, was again a closed shop unless an Openreach reseller. Even then when having a demo with Openreach, they freely admitted the software tool was cumbersome and difficult to use and a laborious and painstaking process to ascertain availability.

What the MONeH project did learn was the frustrations of seeing EAD fibre availability (in areas of single digit businesses just residential properties) in areas where there is no FTTP availability. A good example is the Woodford Valley (north of Salisbury). The valley is split into 3 key villages: Lower Woodford, Middle Woodford, and Upper Woodford. Lower Woodford has very few FTTP locations with Middle and Upper Woodford having none. When looking at the possibility of using EAD, the following two maps were provided showing the Openreach duct and T-nodes (availability) within Upper Woodford.





The green T-node on further investigation showed that 30+ fibres were available to be used however this was cost prohibitive and T&Cs prohibitive for the MONeH RCC project. However, the Green T-Node was next to the Bridge Inn who had expressed interest in hosting a radio cell for the project. Similarly, we had properties in Middle Woodford keen to be part of the project but backhaul availability was the issue. When asked as to why FTTP fibre could not be linked through the duct and connected at the Green T-node or why duct for Openreach ran comprehensively through the Woodford Valley could not be used, there was no forthcoming answer less EAD and FTTP are two hugely different departments who do not talk to one another.

Asking Openreach EAD to search on other villages in Chalke Valley where there was no FTTP available showed plenty of Green T-Nodes with plenty of spare fibres (not ethernet) available. However, this was EAD and not FTTP and never the twain shall meet. Whilst Openreach will undoubtedly argue a more complex and comprehensive argument, the reality is there is fibre available and is not being used and highly unlikely to be used in a business EAD context. Whilst the terminations etc are different and two different systems, if there truly is a need to speed up role out and bring rural communities into the 21st century then Openreach need to be made to look at their provision of FTTP v FTTPoD and EAD. For residents knowing there is connectivity available but unable to procure for domestic purposes is incomprehensible.

6.9.5. Can we live with the status-quo?

If the MONeH RCC project has shown one thing, it is that the provision of fibre needs to change. The dominance of Openreach and their relationship with BT Retail and Alt Nets needs to be scrutinised. Availability of fibre and how it is reported must be questioned. Like how MNOs claim full coverage, so must true availability of fibre be measured. Huge sums of money are about to be invested into Levelling-Up whether that is the North of England with the South or areas within the devolved governments but Levelling-Up is also bringing opportunities to rural communities who have been left behind as cost of rolling out does not appeal to the ROI. However, a more pragmatic approach to reporting and identifying available fibre is key. It is suggested that:

- Look for a breakdown between the backbone Fibre Providers such as Aql, Openreach, Vodafone and Virgin Media to ask what the connection rate is for houses passed. This is not about last mile providers, it is about the relationship between the last mile and the backbone.
- Do not ask Openreach what it is doing to roll out Broadband. Speak to its customers and suppliers about dealing with Openreach. You would have constant tales of "but I can see the cabinet or pole from my house, and I can't get connected".
- Review how fibre grants are distributed and what constitutes a connection within an area. An area is covered when all domestic properties have access to FTTP and not a few. There needs to be a market for the provision of fibre in an area and not a 'flag' waving exercise once a sole property is connected.
- Openreach must be more transparent with their 'fibre runs' and ability to source whether domestic properties have fibre connections or are eligible for FTTP. The circuitous route using old BT Broadband Checker is a poor substitute and not an effective tool for alt nets nor other businesses where understanding availability is core to their requirements. Even as an Openreach supplier, the options available for identification purposes are sub-standard.
- EAD v FTTP v FTTPoD. Understanding how spare fibres can be better utilised. Do not put FTTPoD into a unique location, instead saturate properly to ensure all domestic properties in an area can benefit. EAD and FTTP. Whilst undoubtedly not

simple, has it been looked at. Are the barriers so cumbersome that utilisation of the many spare fibres sitting in a village (very few business connection opportunities!) this cannot be reviewed? Openreach needs to be part of Levelling-Up and therefore more BlueSky thinking is required of what could be achieved.

6.9.6. Utilising FTTP already installed

Once having identified whether there is fibre available in a rural setting what became evident was when there is fibre, it has already been installed by residents due to the significant improvements of connectivity it affords. This then gave rise to the difficulty of utilising already installed fibre due to the stipulations within the domestic Terms & Conditions which preclude any 3rd party utilisation and non-domestic use. Most connections already installed within the Chalke Valley were with BT Retail and the BT T&Cs state:

Clause 6. How you can use the service

> *a. Each **service** is just for you and your household for personal use (meaning that it should not be used for any trade, business, or profession). You are responsible for how each **service** and the **loaned equipment** are used.*

Asking a property owner to host a radio cell which requires fibre would put the owner in breach of their existing fibre terms. Conversations with BT Retail required changes through their legal department which due to this being a Testbed & Trials Project was not reason enough for them to explore further.

Working with Giganet and Wessex Internet meant any new connections could have similar clauses removed.

Therefore, a programme of connectivity using small cells in a rural setting where fibre is a key requirement, will require that allow domestic contracts with ISP providers to be migrated to business accounts in order that small cells can be used within a domestic contract. This will likely be met with resistance and significant cost which will hinder advancement of small cell technology as a means of ensuring true total coverage across the UK.

6.10. Fixed Wireless Access – incentivising as part of fibre roll out

The MONeH project has declared an aim of demonstrating that the SRN target of 2Mbps and be achieved at a cost of under £1,000 per Unique Property Reference Number (UPRN). The installation at The Queens Head in Broad Chalke was cited by the Sunday Times when it declared that the Chalke Valley is the best place to live in the South West of England. In a population of over 5.5 million, the 1,000 or so people lucky enough to live in Broad Chalke not only live in the place, but also enjoy excellent communications. The presence of a 5G service in such an idyllic rural location clearly had some impact in the decision to select the Chalke Valley as. The winning location – and has increased the already high valuations of properties on the local market.

The River Ebble; Kate Woolven, assistant manager of Chalke Valley Stores with volunteer Ron Ibes; the Queen's Head pub in Broad Chalke

The economic benefit goes beyond the ability of residents to work from home and not have to suffer the equally notorious A303 or South Western Trains. The cell on The Queens Head also covers the neighbouring Broad Chalke Hub which is part community centre, part village shop and part church for the residents who want to work, rest and pray. The MONeH project has supplied The Hub with a 5G CPE to provide visitors with high speed broadband.

The Queens Head is realisation of the project strategy of the Telet strategy of fixing not-spots and an illustration of the need to extend the hugely successful BDUK scheme to be extended to mobile coverage from the new breed of mobile phone networks. Just as the growth of B4RN, Gigaclear, G. Network and others has provided an incentive for Virgin Media and BT Openreach to up their game, there is a similar need in mobile to shake EE, Three, Vodafone and VMO2 out of their complacency. Those networks cite coverage of between 91% (Three) and 99% (Vodafone) and yet in a 2022 survey of National Farmers Union members only 17% said that they had coverage in all outdoor areas of their farm. The survey reported that 56% of farmers felt that poor connectivity was causing serious harm to their business, and perhaps worst of all the 2022 figures gave lower levels of coverage than the 2021 survey. The rural problem is severe and not getting any better

Understanding the gap between the operator's claims and rural residents' experience is the first of three steps taken in the Telet strategy: that of identifying not-spots. While apps like OpenSignal identify where there **is** a signal and how fast the data transfer is, the Telet approach is to identify where there is **no signal**. As a SIM-based application this will be much simpler to deploy than a solution which requires a smartphone. The application can also be distributed in an eSIM format, thereby offering an extremely rapid and low cost means of collecting Not Spot data.

Step two is then planning the deployment of mobile infrastructure specifically designed to cover the identified notspots. Telet has already designed a planning tool to carry out this role and will further develop it as part of its FRANC Project work. This takes a need identified in Testbeds and Trials and rolls it into a solution developed for the Future Networks Programmes.

The current SRN baseline of 2Mbps service may not meet the demands of today's users of smart devices. Indeed, an urgent iPhone update would take four hours to download if each user had the full 2Mbps and there were no errors. Rural mobile coverage needs to be both more complete and faster.

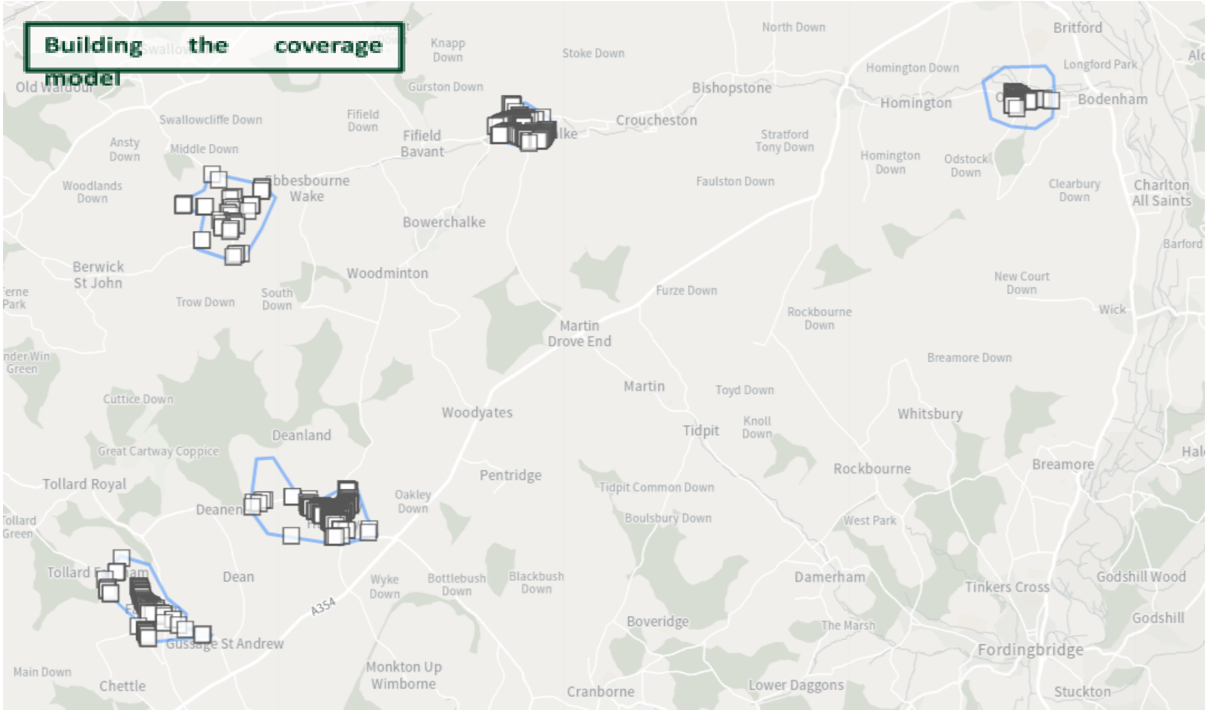
While the government was elected on a pledge of 1 Gbps to every home by 2025, which was then modified to 1 Gbps to 85% of homes by 2025 and the rest by 2030, we have the reality that the Shared Rural Network which formally started on 9 March 2020 after years of planning has so far only installed infrastructure at one total not spot. The project is so far behind schedule that equipment bought for it is sitting in warehouses and will see its warranty expire before installation. The previous **Mobile Infrastructure Project**, which started with similar aims only ever achieved a fraction of its intended coverage; the Chalke Valley was scheduled to receive a total of FIVE MIP macro sites, none of which materialised by the end of the project.

Even if it were running to plan the metrics for coverage are the same as the operators use when they claim coverage in areas where there is none. For a major £1bn project the aspirations of the SRN Programme are still low by 2022 standards, yet it is unlikely that all the planned coverage targets will be met. The programme architecture is based solely on 4G solutions.

It is unlikely that a top-down traditional approach like SRN will ever provide the levels of coverage and capacity rural Britain needs. It does not even attempt to deliver Gigabit Britain.

6.10.1. Demonstration of Cost per UPRN

The methodology for calculating cost per UPRN consists of the following stages:


Building the coverage model
Britford
Longford Park
Bodenham
Homington
Homington Down
North Down
Stoke Down
Knapp Down
Gurston Down
Bishopstone
Croucheston
Stratford Tony Down
Fifield Down
Fifield Bavant
Swallowcliffe Down
Middle Down
Ansty Down
Woodlands Down
Ebbesbourne Wake
Bowerchalke
Faulston Down
Odstock Down
Clearbury Down
Charlton All Saints
Barford
Berwick St John
Woodminton
Trow Down
South Down
Furze Down
Rockbourne Down
New Court Down
Wick
Martin Drove End
Breamore Down
Cuttice Down
Martin
Toyd Down
Whitsbury
Woodyates
Tidpit
Knoll Down
Deanland
Great Cartway Coppice
Tollard Royal
Pentridge
Rockbourne
Breamore
Oakley Down
Tidpit Common Down
Boulsbury Down
West Park
Dean
Wyke Down
Bottlebush Down
Blackbush Down
Damerham
Tinkers Cross
Godshill Wood
Godshill
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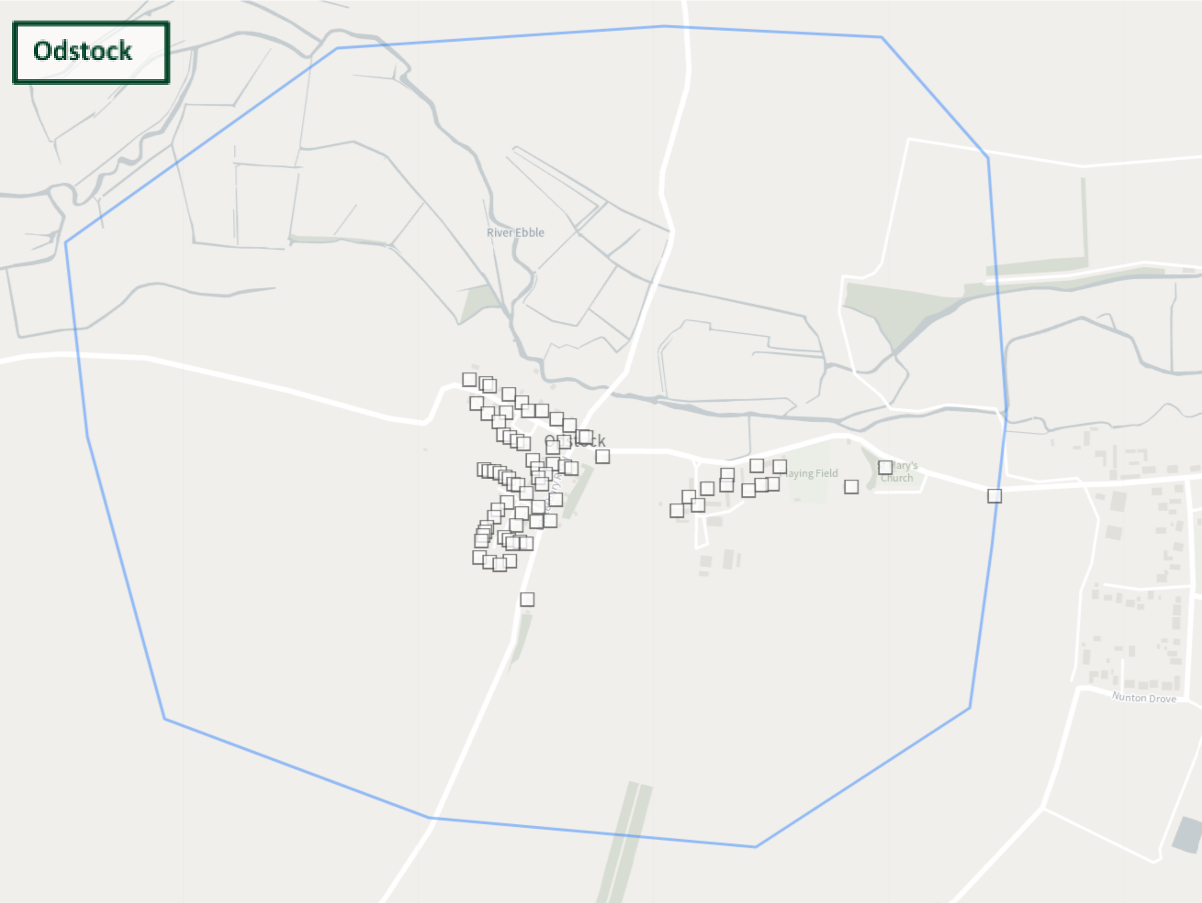
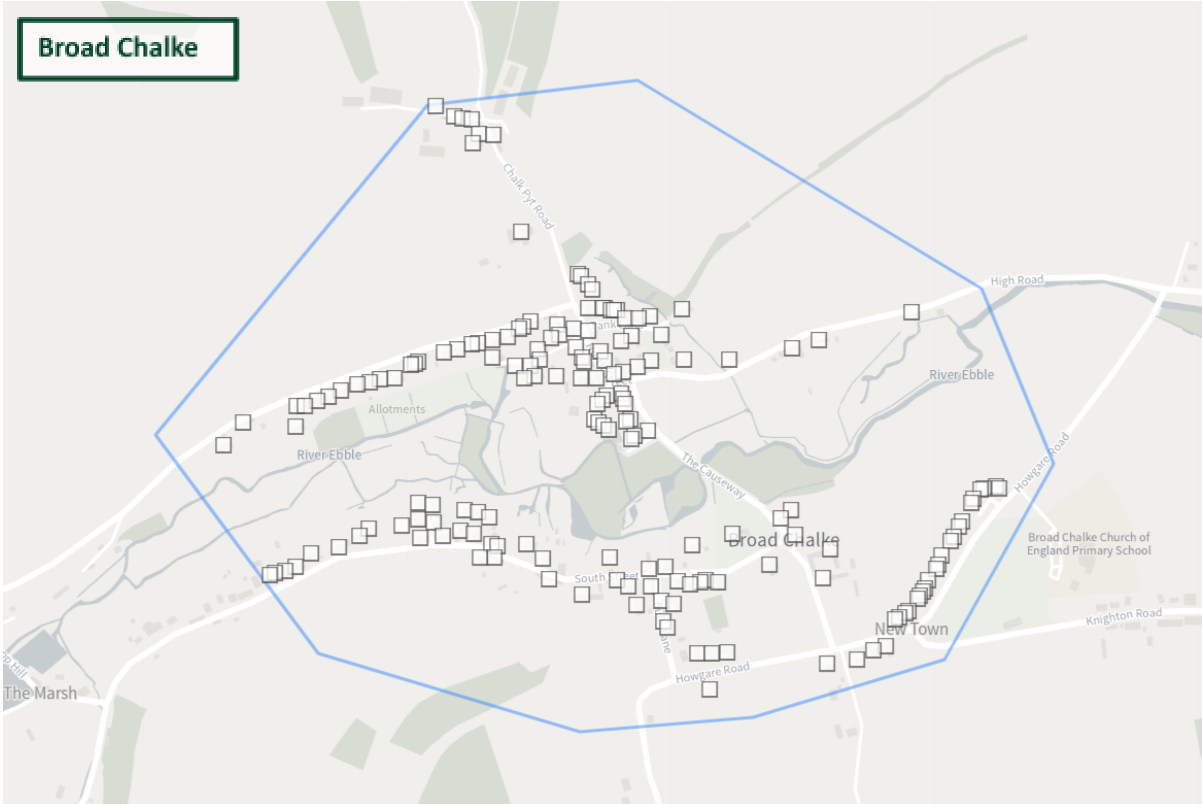
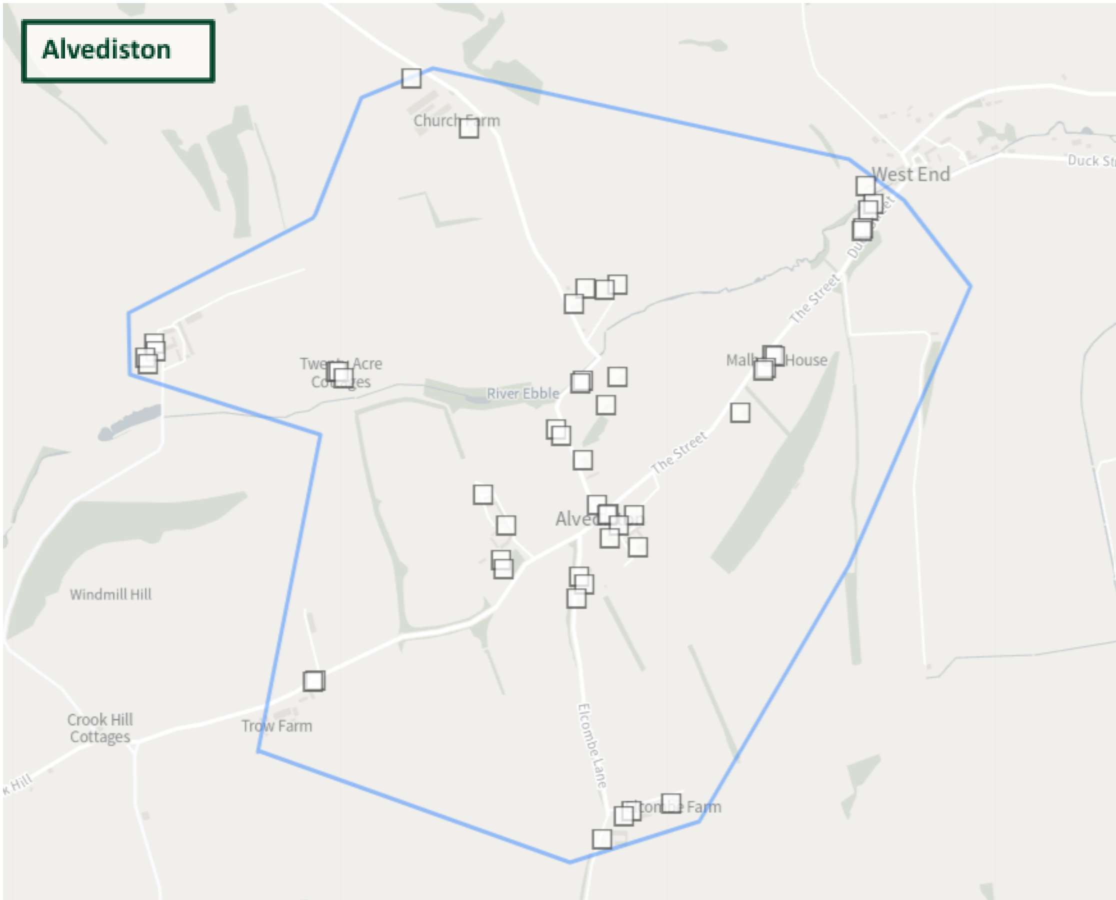
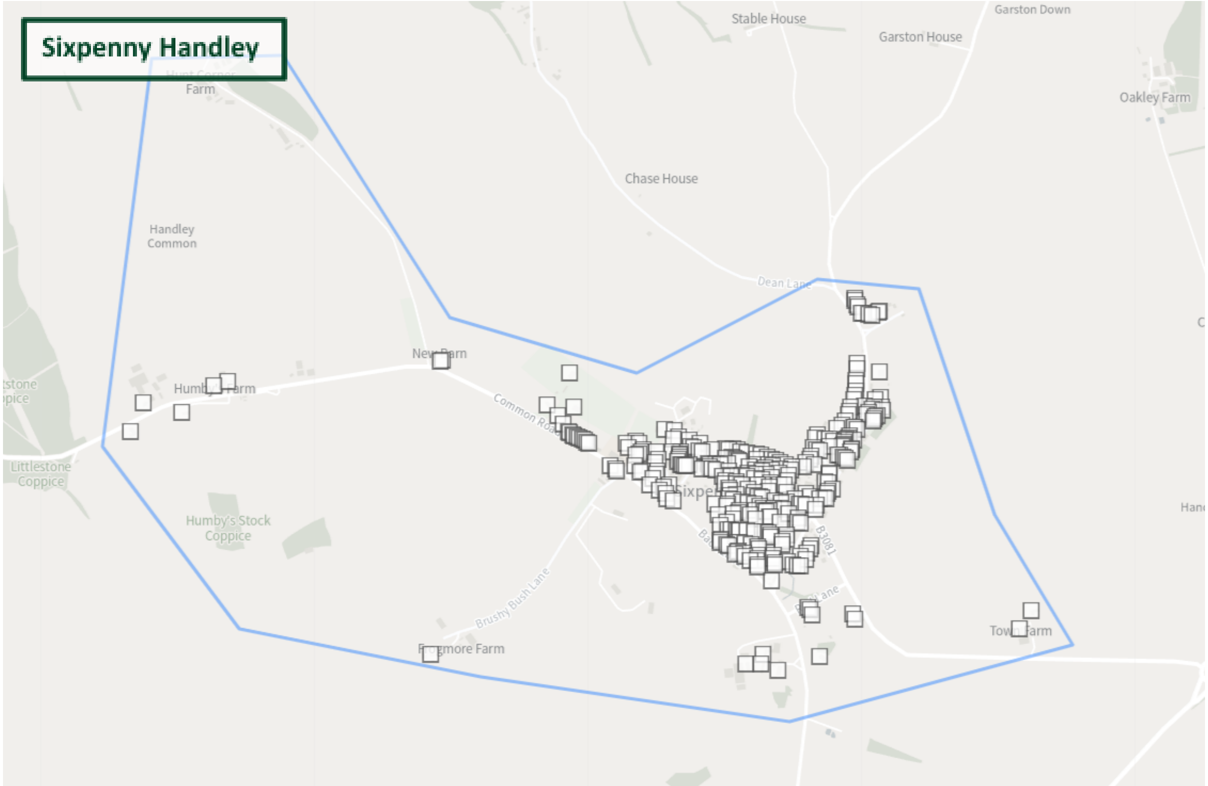
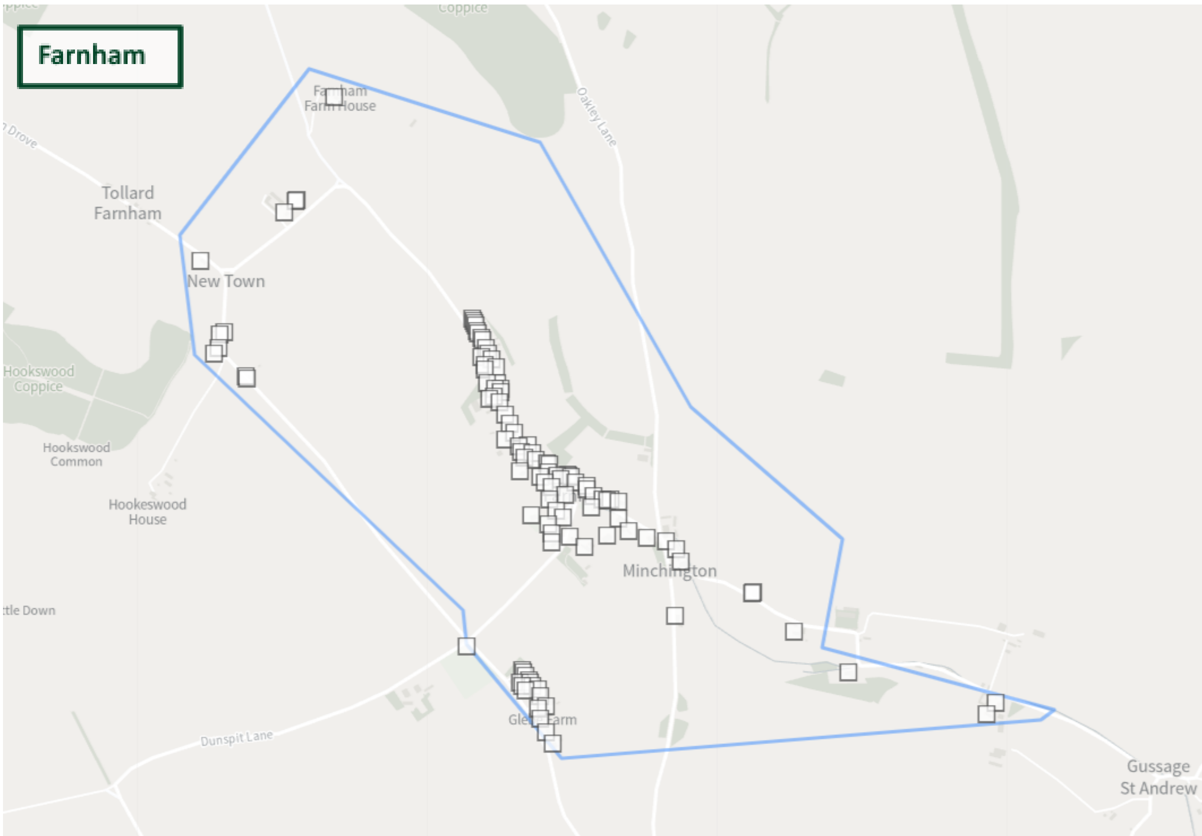
Gussage St Andrew
Fordingbridge
Main Down
Chettle
Monkton Up Wimborne
Cranborne
Lower Daggons
Stuckton


Odstock
River Ebble
Nunton Drove


Broad Chalke
Chalk Pyt Road
High Road
River Ebble
Allotments
River Ebble
The Causeway
Broad Chalke
Broad Chalke Church of
England Primary School
New Town
Knighton Road
Howgare Road
Howgare Road
The Marsh


Alvediston
Church Farm
West End
Duck St
The Street
River Ebble
The Street
Windmill Hill
Crook Hill
Cottages
Trow Farm
Elcombe Lane





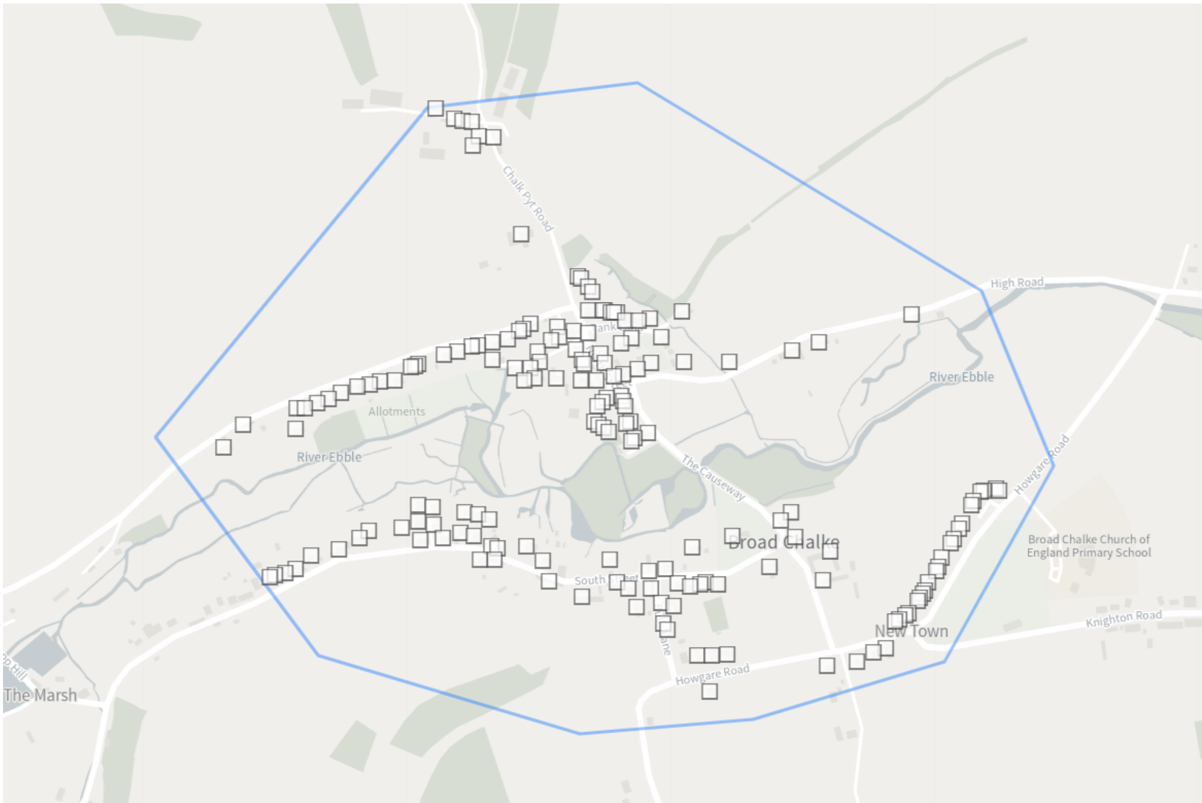
6.10.2. Collecting UPRN data within coverage area.

A listing of all the UPRNs situated within the areas covered by the CH4LKE eNodeB RAN can be found **here** (in Google Sheets). This totals 903 unique UPRNs, broken down into the following:

- Residential – 842
- Commercial - 57
- Places of Worship - 4

6.10.3. Derive Cost per UPRN from data.

The third step in the Telet strategy developed out of the MONeH experiences to be able to use accurate coverage prediction to be able to calculate the total number of UPRNs that can be covered by different service profiles in order to calculate the size of grant a Grant Funding award. This will require an understanding of the radio coverage of a small cell or a cluster of small cells. The radio planning can then be adjusted to give the optimal coverage of UPRNs for the lowest cost. Getting a single 1Gbps fibre into the Queens Head took seven months of detailed negotiation with OpenReach; this was with significant senior management leverage as one of our team knows the chairperson. A second installation a short walk away was treated as a separate operation. Even when both sites had the fibre installed the commissioning took place weeks apart. There is no way the entire village could be connected in anything like a timely manner. The Testbeds and Trials cell has given much of the village connectivity from a single installation. It has also driven commerce to the pub, which is one of the few places in the village that offers unrestricted access to broadband service. It is also possible to now use point-of-sale terminals in the gardens; a use case that was simply not possible before the deployment of MONeH 5G cells.



The graphic above demonstrates the coverage area served by the 5G cell located on the Queen's Head pub in Broad Chalke. Each small square on the map represents a single UPRN that lies within the coverage area. The MONeH project also implemented similar deployments at Odstock, Alvediston, Sixpenny Handley, Farnham and Preston Bisset in Buckinghamshire.

The residents of these areas are not able to access gigabit speeds on the 5G network, but both 30 and 100 Mbps profiles **are** available. Whilst today's deployed solutions in the Chalke Valley offer speeds in excess of 100Mbps, the technology already exists to push bandwidth delivery up to over a gigabit per second. To achieve this level of service further funding will be required. We have demonstrated that a rural mobile 5G deployment can deliver a cost effective and rapidly deployable broadband solution, which could easily qualify for BDUK grant funding.

While BDUK Grant Funded fixed fibre schemes may offer high speed data to a specific location, a mobile solution can deliver service to an area in a form that can be shared by a community and visitors. We have identified multiple areas such as Staffordshire and Shropshire where no ISP wants to bid for a large, county wide deployment for whom a Grant funded MONeH solution could be a particularly attractive solution.

The experience that we have gained with the deployments listed above and some additional 2G/4G installations including Bowerchalke Village Hall, National Trust Stourhead and the Chalke Valley History Festival have seen enormous numbers of inbound roamers, including a large number of overseas visitors, attach to the MONeH Network and receive service. Perhaps for the most beautiful village in the most beautiful part of the Southwest this is not such a surprise, especially when The Queens Head serves 5G.

6.11. 5G Devices – is there appropriate transparency?

The situation with 5G user equipment (UEs) and Customer Premises Equipment (CPEs) is more complicated than is immediately apparent at first inspection and is not transparent due to the substantial number of different variants being produced by multiple manufacturers and a lack of published information.

One particular area of complexity that the Project encountered was that presented by Multi-band Carrier Aggregation. This is used to bond together multiple radio channels into a single logical data service; in our intended model this was to use a Band 3 4G anchor channel (offering wide area coverage) with a 5G NR channel, aimed at providing much higher transmission speeds particularly for Fixed Wireless Access applications.

5G devices used within the project fall into distinct categories, these are:

- **5G User Equipment (UEs)** – either in the form of phones or portable MiFi devices, which are typically carried by individual users. These typically have low gain (omnidirectional) antenna characteristics and are used both inside and outside of buildings, usually with modest data throughputs. These devices are normally powered by battery.

- **5G Customer Premise Equipment (CPEs)** - these typically remain in a fixed location to provide data connectivity for a specific location. These can be separated into two distinct classes:
    - **Indoor CPEs** – usually powered by a mains power supply and mounted within a building in a position where a workable signal can be accessed. These are best suited for deployment in areas where there is good radio coverage from a local cell. They typically have some directional antenna gain and provide a slightly better service than portable UEs.
    - **Outdoor CPEs -** these are deployed in locations situated too far from the cell for an indoor CPE to be used and are mounted on the outside of the building. These usually have relatively high antenna gain (in the region of 10-14 dBi) and so can operate within areas of lower signal strength. They are more expensive than indoor units and usually will involve a professional installer to deploy.

Calculating what the coverage of the system is and this is dependent on the equipment in use.

Configuration and management of deployed 5G RAN is considerably more complex than originally envisaged.

For large scale deployments, management of spectrum in both frequency and time domains is required, together with high quality timing and synchronisation.

Operating range will be dependent on the equipment in use at both ends

The performance of devices, particularly UEs, is governed by the operator profile that the device is working with, therefore, to be able to have full functionality, it is a requirement to be able to change the operator profile. These Operator Profiles are normally managed through the operator SIM that is inserted into the device. This is difficult for anyone who is NOT a fully featured MNO to do. Telet intends to provide a solution based on multi-IMSI/multi-crypto SIMs which incorporate a carrier profile, which will unlock full functionality of all user devices and equipment.

6.12. 5G Hardware availability

Despite manufacturers' claims, the majority of 5G RAN components that are suitable for use with UK shared access spectrum (Band N77) are still at TRL 6 (Prototype System Verified) and not at TRL 8 (System Complete and Qualified). The impact of the differing levels of technology readiness means that you cannot buy technology straight off the shelf.

Currently UK MNOs are incapable of providing bilateral roaming interfaces with a native 5G interconnect as standards, particularly the 5G settlement mechanism, the GSMA defined **Billing Charging Evolution (BCE**) is still to be fully defined. The impact of this is that the only way that we can CURRENTLY offer a multi-operator neutral host is service is by deploying a 5G NSA architecture, which utilises 4G (DIAMETER) signalling.

6.12.1. Securing appropriate spectrum for rural 5G deployments

Whilst the main UK Shared Access 5G band N77 (3.8 - 4.2 GHz) is well suited for deployment in urban and suburban environments, the less dense population and greater area to be covered demands spectrum lower down within the frequency range, preferably sub-2 GHz bands. There is usually an opportunity to utilise some of the primary mobile spectrum which is licenced to UK MNOs through the Ofcom Local Access Licence scheme.

We have identified Band 3 (1800 MHz FDD) as being particularly for this suitable for such rural use cases; all four of the UK MNOs have licenced segments of this band, so the likelihood of ALL FOUR deciding to deploy assets that utilise this band at the same time is tiny.

When considering which spectrum to utilise first, MNOs will normally make use of their lower frequency spectrum in the 700, 800 and 900 MHz bands in preference to Band 3 as they offer better propagation in rural areas. Also, Band 3 is particularly well supported by about all the current devices that are currently commercially available.

As rural areas do tend to fall into the category of partial or full 'Not-Spots', there will always be some B3 spectrum that can be accessed through the **Ofcom Local Access Licence** scheme.

6.12.2. Supply Chain Issues

There is a global chip shortage has had a major impact on development, availability and cost of 5G RAN components

The N77 band is still not a widely supported band, therefore, it was necessary to produce our own custom antennas (both omni directional and sector).

There is little in the way of domestically produced equipment on the market, with the majority being manufactured from either or Asian or Scandinavian companies. Products from Asian manufacturers tend to be much more commercially attractive as they are cheaper and offer more technical flexibility. However, some of the largest of them fall into the 'high risk' vendor category, which makes them unsuitable for UK deployment scenarios. The Scandinavian products are generally much more expensive, particularly their support costs.

The majority of the mobile infrastructure manufacturing industry capability is focused on the large MNOs, however, there is evidence that the market focus is shifting with more attention given to private network deployments. We have identified a particularly attractive market segment which covers the intersection between private networks and public networks; within this sector it is possible to deploy a private network which utilises part of its capability for public use. One of the key commercial drivers for native 5G is the ability to run multiple network application slices, each one of which delivers a revenue stream and/or benefit.

6.13. Commercial Viability to run a rural network

6.13.1. Services of General Interest (SGI) and Services of General Economic Interest (SGEI)

Telecommunications is classed as a **Service of General Interest** (**SGI**). These are basic services which are essential to the majority of the general public; as such, the state has an obligation to ensure public standards. Examples can be things like water, or rubbish collection, or policing and security. There is a subclass of SGI defined as **Services of General Economic Interest** (**SGEI**). SGEIs are services the state wants to provide for the general public which are <u>not adequately supplied by market forces alone</u>. The difference between SGIs and SGEIs is that the latter are services which <u>need to be provided</u>, even where the market is not sufficiently profitable for the supply of such services. Examples of this are electricity in rural areas, gas supplies, or telecoms in rural areas. That is where the state comes in, and subsidises the installation of the infrastructure, because it is deemed to be an **SGI**; something you cannot live without. Broadband, or phone service, or electricity supply are **SGEI**s.

The electricity supply did not become an **SGI** until the early 1930s. In a period of about two to three years, the national grid was rolled out over the entire UK. The standard model for supplying an **SGEI** is to make it the responsibility of a big commercial company and in telecoms the obvious candidate is BT, which is given a coverage obligation and a universal service obligation. The supplying companies then push back in terms of the level of the obligation and push for increased subsidies. This often does not result in the best solution for the company, government, or consumers, because the supplying company just is not geared up to provide what is ultimately a specialist service. This is where the user initiated MONeH model comes into its own, the Telet solution is substantially less expensive than any other equivalent, faster to implement and provides support for all the networks. Iin essence, the MONeH solution ticks all the boxes.

Big operators want to put up 30 metre masts in the middle of an area of outstanding natural beauty, which leads to considerable resistance from residents. The problem with conventional deployments is that it is not possible to put a big mast in the middle of a village, so they end up being pushed out somewhere in the hinterland. The end result of that is, it simply does not cover the ground. Some villages are funny shapes, and many are long and thin, based on a single high road. This does not lend itself to a single mast, particularly if the village is in the bottom of a valley because there are always going to be shadows.

Relying upon a one-size-fits all approach to SGEI is not in the best interest of the Nation. We have seen with community broadband – projects like B4RN – that putting the power, and the subsidies, in the hands of those that want the service is an effective solution. The MONeH consortium is looking to do something like support community-led initiatives that will address the needs of SGEI but without the overheads.

6.13.2. Incentivising mobile networks - voucher scheme

What Telet is proposing because of learnings from MONeH is a need to incentivise operators via a grant funding scheme for deployment of mobile infrastructure or mobile services in Not Spots. Policy needs to follow the government's levelling up agenda which includes rural not-spots. We would look at the services being categorised under the definitions which are already defined under the universal service obligation of 2Mbps, 30Mbps and 100Mbps services. They are significant because each one of those three corresponds to an existing, clearly defined service. The 2Mbps figure is derived from the minimum requirement for the Shared Rural Network. 30Mbps is the definition for super-fast and 100 is the ultrafast.

Note that these all fall far short of the numbers given by Project Gigabit, but we cannot get into a situation where if we cannot have a gigabit, we cannot have anything. It is possible to deliver 1Gbps over wireless but the Ofcom licences for this at £80 per 10MHz make it crushingly expensive. You would need a £800 a year licence for only a few houses.

The challenge for mobile is that with an existing grant scheme, it is remarkably simple to give a tick in the box because you have a fibre that goes to one place and delivers a clearly definable service. Whereas with mobile, you have a cell which then provides multiple services, at various levels to separate places. And that is difficult to prove. One of the key components has got to be a validated prediction model, which demonstrates how valuable this is to a community. The MONeH project has taken the stance of measuring the number of Unique Property Reference Number, or UPRN sites that are covered by a single or multiple radio cells. UPRN was created by the Ordnance Survey, and it consists of numbers, up to 12 digits in length, where Local Governments, in the UK, have allocated a unique number for each land or property. Measuring by UPRN coverage, gives the fixed coverage benefit of the service, although of course does not show the additional benefit for people transiting through an area. In the MONeH project We have already seen the local bus using our cells to update arrival times.

While an extension to BDUK to cover mobile would not give the gigabit headline speeds, it would provide a significantly greater level of community benefit than fibre to just one location. As with BDUK the grant could be either an individual or a community collecting vouchers. We envisage such a process being an extension of the existing system and the existing ISP and Wireless ISPs would gather the grants and then pass the mobile element on to the community mobile supplier.

6.13.3. A proposed roaming settlement - traffic exchange mechanism

The most revolutionary proposal from MONeH RCC is a new model for roaming settlement. This builds on work done between operators in the US and the mechanism Three has used for its ***Roam At Home*** Service. To date we have not been successful at getting this in place in the form of a commercial agreement with other UK Operators, so we have proceeded with the implementation of an interim solution, based upon ***Hosted Inbound Roaming*** with another MNO, who already have conventional inbound roam agreements in place with each of the UK MNOs. This has the advantage of working immediately, but results in the UK MNOs paying a higher tariff for inbound roaming traffic than they would under the traffic exchange scheme. Our strategy is to proceed with the interim solution until we reach the point where inbound roamers complain about the cost of inbound roaming traffic on the Telet Network, at which point, we then offer to replace the sponsored roaming solution with our preferred traffic exchange scheme. As of the end of the project, despite our best efforts, we are unable to charge users or existing MNOs. Work on resolving this is continual and ongoing.

There is a large structure, run by the GSMA, which looks after roaming, the organisation even has a daily set of exchange rates. They use TAP records and TADIG codes to record how much and who to bill for transactions. And they are unwieldy for the small generation of small operators, yet it is crucially important. If the network is truly private, or only used for Fixed Wireless Access there is no need to roam, but in the scenario where a SIM spends part of its time on the privately owned network but part of it on public networks there is a need to share the costs.

A university is a good example. It might have a campus with several non-contiguous sites, even international sites. Some with low traffic may not have the coverage the university wants but there is no incentive for the major networks to fill in the not-spots or partial not spots. The solution is for the university to install its own network. Students and staff using SIM cards issued by the university get priority coverage with full access to the university systems and servers. Visitors, using SIM cards from another mobile network operator may roam onto the university network. They still get the coverage that would not have been there without the network, but they do not have the same access to the university systems.

This example of which there are many where the private and public networks meet, then facilitates the traffic exchange scheme. So what MONeH RCC findings is proposing as the medium to long term solution is not full GSMA settlement, but a traffic exchange key.

The traditional way to do this is to measure all the traffic used by a visitor and then bill the host network for every kilobyte, message, and minute that customer has used daily. While this is highly automated it means a huge amount of reconciliation for what is rapidly becoming a low margin business. While the big operators can gear up to do this it is not economic for small networks run by campuses, companies, and communities.

The solution that MONeH RCC is proposing is that instead of a transaction-by-transaction model with payments in both directions the currency used is mobile traffic. When a Vodafone customer roams onto Telet's MONeH network, Telet earns credit for spending on the Vodafone network. For every Kilobyte a Vodafone consumes on MONeH, a Telet customer can use a kilobyte on Vodafone. If there is an imbalance there needs to be a mechanism for recentring. This takes the form of a single payment when the threshold is reached. The MNO gets to define the threshold level and the cost per Kilobyte. This works for both parties because Telet controls the steering of its SIMs when they are roamed out, so it can make the most efficient use of data which is "in stock" and if an operator prices minutes too high or too low it ends up self-regulating.

The system should be attractive to the MNOs as in the main they will not be paying money to an organisation which they consider is a rival. Because the traffic is going to ebb and flow. So over time, it will correct itself anyway. And it is a case of working out how much financial exposure you want to have. But again, the whole point of doing it the way that MONeH RCC is proposing is that it is the MNOs that choose how much the recentring payment is; anything that involves them paying money is unattractive. The Telet seesaw system is designed to be cost neutral, all you are doing is moving traffic from one place to another.

So, in theory, what is being recommended is a scheme whereby a service provider such as Telet/MONeH provide coverage in these difficult-to-cover expensive areas, and the settlement exchanges that traffic for traffic that is deposited in an MNOs existing coverage area, where they do genuinely have effective and usable coverage.

Telet has been actively involved with the Liverpool 5G projects, where you have the Liverpool health and social services people doing the bulk of their stuff on the Liverpool 5G network. But every now and then, they manage to manoeuvre themselves into a Liverpool 5G not spot, in which case they then drop onto a public service. In this scenario, Telet has a model of selling the whole service to Liverpool City Council for an entire network, but SIMs can work both on the private network and on the public network.

The result is the operators will set a fair price because if they set it is too high, Telet will then force the traffic in one direction. If they set it too low, Telet will force it in the other direction. If the price is fair, then traffic flows between networks will be balanced. The feedback loops built into the mechanism effectively self-regulate the price.

6.13.4. Can a rural network be run as a Community Interest Company?

Introduced in 2005 in the UK, a community interest company (CIC) is a type of company designed for social enterprises that want to use their profits and assets for the public good. As a business, a CIC reinvests its surpluses to achieve its social objectives, rather than being driven by the goal of maximising profit for its shareholders or owners. It is possible for a community interest company to make a profit or have surplus, whereas a charity is considered as 'not-for-profit'. It is expected that a CIC reinvests its surpluses to achieve more of their social objectives, but they can also pay a proportion of their profit out to owners or investors in the form of dividends.

At the outset of the MONeH RCC programme the intention was for Ch4lke Mobile, set up as a Community Interest Company (CIC) to take over from Telet Research a fully functioning network where the CIC would be community owned, led and run operating as a Not-for-Profit to serve the local community. With the Ch4lke Mobile network filling the not-spots within the Chalke Valley the intention was for residents to be able to roam onto and off the network when their parent MNO signal was stronger. Due to the complications with direct interconnect with the MNOs and being unable to validate the credit transfer mechanism, the CIC was then looking to be able to provide a service as a paid for Sim to Network and ability to deliver Fixed Wireless Access.

A key aim, from the outset, was to set up a CIC model that could be repeated many times for rural local communities to run their own network, as a not-for-profit, in areas where the MNOs have neglected or provide limited connectivity which is 'useful'.

CIC SIMs to Network

Telet Research are still able to commercialise the establishment of a MONeH network - though it requires MNO interconnect to provide a true MONeH solution – through what has been demonstrated to date which is the ability for a network such as Ch4lke Mobile to have its own Sims to sell to residents who fall within that network. MONeH RCC project has provided research into 5G sims, 4G sims and eSIMs and compatibility with the major handsets. The opportunity to sell localised network Sims i.e. Ch4lke Mobile sims by a CIC is potentially there. The concept being that an individual has their handset with its parent MNO sim but can then have a Ch4lke Sim inserted as well. Whilst residents continually bemoan the poor communications provided by MNOs the concept of, at additional cost, a second Sim is an interesting proposition. However, residents believe that MNOs should be providing this service and strongly believe that MNOs should be collaborating with ventures such as MONeH RCC/Ch4lke Mobile in providing that connectivity. They currently perceive themselves as disadvantaged with regards to communications due to where they live but to have to pay additionally to a 3rd party i.e. CIC, to provide the comms they believe MNOs should be providing is a differing matter. The concept of smaller MNOs such as Telet Research providing a network where you can roam onto and off your parent MNO where billing is undertaken 'behind the scenes' and settled as is currently the way without additional costs is widely applauded and deemed a sensible solution. In this way, the signal being provided by Telet Research via a CIC such as Ch4lke Mobile or even Telet themselves but to be used as a 'filler' for MNOs but at no extra cost to the user is fully supported. Further, providers such as Telet Research could look to have their signal called 'Vodafone' or 'O2' depending on who the parent MNO operator is. As MONeH Research has demonstrated the provision of a network for less than £1k per UPRN is something the main MNOs should consider working alongside as part of SRN and their wider commitment to the provision of connectivity into not-spots. MNOs need to leave their competitive egos behind and look at viable solutions as to how mobile not-spots can be achieved without blighting countryside with huge masts which often do not cover UPRNs in the valley bottoms.

Whilst the provision of selling Sims is something a CIC could do as a concept, the provision of support and Insurance precludes this from being a viable solution as discussed below.

Fixed Wireless Access

Another option that was potentially identified as a means for a CIC to generate income, as a not-for-profit, is to sell Fixed Wireless Access as a service. MONeH RCC has shown that FTTP is a reality a long time in the making and unlikely to happen anytime soon. Therefore with the ability to utilise 5G radios and CPEs, download speeds of 100mbps are sufficient to run within a household and feasible income generating methodology when operating alongside a network provider such as Telet Research. FWA in rural locations would be a workable solution but is dependent on the ability to have some FTTP to locations from which the 5G radio cell can be mounted. Strategically placed, this could provide an 'umbrella' of connectivity from which UPRNs falling within can access download speeds of up to 100Mbps.

However, to commercialise an offering for a CIC to sell requires 24/7 support, or at least business day support, SLAs with customers and network providers and insurance. This is where the CIC becomes a less attractive proposition for the delivery of services and is discussed below.

Insurance

Due to the nature of a CIC and how they are currently utilised within the community means the exposure to liability is relatively low. Community led shops or pubs have clear property insurance requirements but their liability on the nature of service they provide is straightforward and uncomplicated to insure. The issue with the provision of a mobile network is the liability on the business and directors becomes ever more significant due to the dependency of a network whether mobile connectivity or internet provision through FWA. When insurance was sought for Ch4lke Mobile, originally, via brokers specialising in the Charity Sector as well as private sector, the complexity became evident and that the appropriate levels of insurance required could not be sought without it becoming ridiculously expensive. The governance structures of a CIC differ to a LLP or limited company and the obligations of Directors differ. Therefore, Directors of a CIC would be placed at unnecessary risk due to the nature of liability a CIC would face as a network service provider over a CIC which runs a local village shop. In order to run the mobile network, as a minimum the entity would require Professional Indemnity of at least £1m plus also Public & Products Liability of at least £5m. Insurance is not yet equipped to provide such Insurance to a CIC. Risk is deemed too high. Directors of CICs typically are not remunerated and often operate on a voluntary basis therefore the provision of a working network and associated liability becomes one step removed and unattractive to maintain directorship. Users of a network will not accept lower quality of service because they are dealing with a CIC even if they have a vested interest. A working service, with support etc is an expected minimum. Therefore if they face a situation where the network has let them down they will not hesitate to look for compensation if the CIC is indeed liable.

With Insurance brokers not used to insuring CIC managing complex services and therefore specific sector insurance required over and above the standard property, contents and employer this makes the ability for the CIC to undertake a network to manage, run and service clients almost impossible to take forward.

Maintaining a network and Customer Support

Due to the nature of services required to provide a mobile network, provider of SIMs or FWA will be required to provide a comprehensive support mechanism. This would involve a ticketing system to coordinate, log and ensure all enquiries are answered by 1st line and 2nd line technical support staff. As a minimum, these services would need to be staffed during business hours but as an ideal 24/7. It would be unrealistic to expect anything less than a sophisticated support mechanism when providing key services to a paying consumer base, whether individuals or local businesses. When dealing with the latter, it is likely they will require a comprehensive Service Level Agreement which not only guarantees uptime of service but fixed time to repair with service credits where the provider fails to meet these agreements.

In order to run a network whether mobile or FWA requires individual billing generation on a monthly basis and also ability to manage monthly financial transactions. As per billing, this is time consuming and not often something associated with a CIC which would further add to resourcing costs.

Maintaining a comprehensive support requirement and Service Level Agreement comes at a cost, predominantly from a resourcing perspective that would make a CIC exceedingly difficult to insure, due to liability (as per above), but also to reach any level of break-even or profitability. With MNOs on a seemingly 'race to the bottom' with regards to data bundles, minutes and calling, an independent provider would struggle to make a valid business case in a small rural setting. It would require a provider to set up multiple instances of a network, plugging not-spot areas across the UK, plus being able to work with local ISPs in bringing together a FWA package. ISPs are structured to provide the support mechanism through resourcing and automation of services and are structured to provide individual billing requirements. A CIC is not.

The recommendation therefore is that a CIC is not suitable to run a local network due to inability to get sufficient insurance but also due to the requirements of the provision of Customer Support, billing etc to manage a true B2B and B2C service correlating requirements to match legal contracts and SLAs.

6.14. Contacts:

James Body, CEO Telet Research jb@tel.et

Peter Gradwell, CCO Telet Research pg@tel.et

Andy Smith, Networks Director Telet as@tel.et

Simon Rockman, Chief of staff Telet sr@tel.et

Matthew McCloskey, CEO Bluesky Hosting matthew.mccloskey@bluesky.co.uk