MANY

Mobile Access North Yorkshire

Project Final Report

October 2023

Contents

1 Executive Summary

The project proved that 5G can be delivered into and will support rural communities in the following ways;

- The use of 5G technology will enable people to remain in areas where previously they would have to leave due to lack of digital connectivity.
- Community engagement is key to success when deploying new technology.
- The use of 5G can also provide residents with an opportunity to work from home, which was not previously available.
- 5G technology will support local businesses enabling them to grow and diversify their offerings.
- 5G will support video GP/Hospital appointments saving patient and clinical time whilst also making environmental savings with reduced travel.
- It is possible to deploy 5G fixed access wireless broadband to properties within line of sight of the radio mast.
- No individual use case will make a 5G network sustainable, however by looking at multiple use cases and benefits to an area then it becomes viable.
- The learnings from the MANY project can be taken and used across several council services showing the benefits of the use of technology.
- The use of Internet of Things (IoT) sensors connected to a low powered Long Range Wide Area Network (LoraWan) can provide early warning of flooding and damage. They can also be used for monitoring air quality, footfall, traffic flow and congestion providing information to influence decisions made by councils.

The project also identified operational difficulties those being;

- Once the technology is deployed monitoring of the network has enabled further developments to be made and also realise that the licences Ofcom supplied are too low powered for rural settings.
- It is difficult to develop and deploy new technology during a pandemic when manufacturers and suppliers cease to operate.
- The Telet private telephone network installed is currently not stable enough to offer to residents in the area. Further work is required on this to enable it to be a commercially viable service.

All project partners have learned a lot from the MANY project and are keen to use these learnings collaboratively in future projects to support broadening of the UK telecoms ‘ecosystem’.

2 Background

The 5G Testbeds and trials (5GTT) programme at Department for Culture Media and Sport (DCMS) was set up as a centre of excellence in 2017, to press forward the work within 5G. The programme is to encourage and fund the creation of a series of Testbeds and Trials in a range of geographic and vertical market segments. It explored the benefits and challenges of deploying 5G technologies in line with the following key objectives:

- Accelerate the deployment of 5G networks and ensure the UK can take early advantage of the applications those networks can enable;
- Maximise the productivity and efficiency benefits to the UK from 5G;
- Create new opportunities for UK businesses at home and abroad and encourage inward investment.
- Testbeds will help the industry understand the challenges of deploying new technologies according to the developing international standards for future 5G networks. Testing 5G applications will help prove different applications ('Use Cases'), bringing ideas closer to commercial viability for future markets.

Through the 5GTT Programme, Government coordinates pilots and trial activities to identify potential deployment and technical challenges for 5G, seek to remove barriers to deployment, reduce commercial risks associated with investment in 5G by stimulating demand for new services, and help to inform future policy. As part of a Government investment of over £1bn in digital infrastructure, £200m has been allocated to support 5G Testbeds and Trials.

In March 2018 the first phase of the 5G Testbeds and Trials competition funded six schemes of between £2m - £5m each. The schemes were;

- 5G Rural First
- 5G Smart Tourism
- Worcestershire 5G Consortium
- Liverpool 5G Testbed
- Auto Air
- 5G Rural Integrated Testbed (5GRIT)

These schemes were completed in the summer of 2019. The following schemes have also been funded.

- Urban Connected Communities Project (West Midlands) £50m
- National Cyber Security £10m
- Road & Rail NPIF £35m
- Industrial Testbed and Trials £25m

Following the above programs DCMS announced the 5G Rural Connected Communities Project. DCMS made available grant funding ranging from £2m - £5m each for approximately ten projects, totalling up to £30 million.
The following schemes have been funded through this programme

- 5G Connected Forest
- 5G New Thinking
- 5G Rural Dorset
- 5G Wales Unlocked
- Mobile Access North Yorkshire (MANY)
- Multi Operator Neutral Host (MONeH)
- West Mercia Rural 5G

3 The MANY Project

The MANY project is made up of a Consortium of members with Quickline Communications being the lead partner. The Consortium members are;

- Quickline Communications Ltd (Lead Partner)
- North Yorkshire County Council
- Cybermoor 5G Ltd
- Flo Culture
- SafeNetics
- Wireless Coverage Ltd
- University of York
- University of Lancaster
- Aql ltd

3.1 Project Objectives & Responsibilities

The project will develop the 5G ecosystem around a number of Use Cases and develop a neutral host model for delivery of mobile coverage in North Yorkshire by:

- Building small networks in the target communities using macro and small mobile cells connected to the internet. These will be supported using fibre and wireless backhaul. These will use Mobile Network Operator (MNO) spectrum and allow calls to be made and received within the target areas using localised roaming;
- Work with tourist attractions to develop innovative mobile 5G apps to improve the visitor experience and encourage visitors to spend longer in the area;
- The project aim was to look at the effects 5G connectivity can have on the health provision in a rural community, specifically GP/Hospital appointments and Mental Health and Loneliness.
- Monitor the effectiveness of the network for Mission Critical Communications; and
- Provide environmental data to NYCC and partners to provide early warning around flooding.

The consortium was created based on the requirements to deliver the outcomes and consists of carefully selected partners that can cover all the required expertise as well as infrastructure.

Table 1

Commercial Org	Role & Responsibilities	Experience	Experience of target area
Quickline QL	Building a 5G network and providing links to nodes in mobile not spots in North Yorks.	QL designs, builds and operates wireless networks around the North of England. It successfully delivered networks for DCMS Market Test Pilot and 5G Testbeds & Trials phase 1 project	QL manage wireless networks in the area including those from 5GRIT
Flo culture	Augmented reality - visitor interpretation incorporating rich media	Designed tourism augmented reality apps for North Pennines AONB on the 5GRIT project.	Previous work with National Trust destinations in North Yorkshire
SafeNetics	Provision of Mission Critical services to emergency services users on the testbed	Active involvement in coordination of pan-European procurement of MCX services and applications, including regular attendance at 3GPP SA1, SA6 standardisation activities of MCX.	Working knowledge of the UK Home Office Emergency Services network and provision of service by their lead contractor EE
Wireless Coverage Ltd	Rapid 5G and TV Whitespace (TVWS) mapping	WISDM has been used to map 5G and Fixed Wireless networks for over 35 operators in the UK and Ireland. We have also supported companies and the Scottish Government in several aspects of R100.	Wireless mapping of the area for BDUK submissions
Cybermoor	Project coordination and community engagement support and managing testbed. Through sub-contract, design, monitoring and evaluation of use-cases.	Experience of delivering projects with DCMS on 5G Testbed and Trials and Market Test Pilot. Sub-contractor has extensive rural experience.	Advice and support to communities in North Yorkshire on broadband provision and illustration of use cases
aql	Responsible for delivering the tank monitoring solution	Experience in 4G/LTE network deployment and hosting of services	Company local to the area based in Leeds with experience of delivering in the area
Academic			
Lancaster University	Network monitoring	Experience of monitoring network performance and user experience	Monitoring performance of QL wireless networks in the area
University of York	Delivering temporary 5G service using a helikite aerial platform at events.	Experience of 5G and delivering communication applications using airborne platforms.	Have trialled a range of 5G services in North Yorkshire
Public			
North Yorkshire County Council	Public engagement, communications and delivery of support for health and wellbeing use cases.	Delivering broadband interventions in North Yorkshire and delivering services.	Local Authority for the target area.

The project was successful in securing £4.4m of funding via the Government's Rural Connected Communities Scheme with a further £2m financed by the SMEs' partners.

North Yorkshire County Council (NYCC) identified six of locations across the county that would benefit from the connectivity.

After the completion of a feasibility study and successful meetings with the Town and Parish Councils benefiting from the project, the North end of Coverdale was confirmed as the first location the project would work in.

3.2 Community Engagement

The restrictions brought by Covid slowed the engagement with the community and methods have had to be adapted to ensure the project followed the changing guidance set out by the government and, also, individual organisations.

Engagement meetings took place with Leyburn Town Council; Middleham Town Council; Carlton Town Parish Council; Melmerby Parish; West Scrafton Parish and West Witton Parish Council. Telephone and email contact has been made with Caldbergh with East Scrafton Parish. These events took place throughout August and September 2020 with the project committed to maintaining dialogue with the community throughout the duration of the project. These parishes are supportive of the project as confirmed by the parish clerk following discussions with parishioners.

A further meeting took place with Coverham and Agglethorpe Parish Council in December 2020. Nineteen people attended this meeting, of which six were within the parish and the rest were from outside of the parish. Clear support was received from three in the parish although formal support was not given at the meeting.

After initial meetings, NYCC's Stronger Communities team and Community First Yorkshire's team were brought on board to work alongside Lancaster University Management School to commence interviews with residents and businesses who have come forward or have been identified as potential end users of the use cases.

Communication continued with the Town and Parish Councils to ensure that an open and honest dialogue continues throughout the project.

A wide variety of communication tools were used to engage with the communities which fall within the signal area and the surrounding areas. These included:

- Community video introducing the project and the use cases and a call to action to become involved.

- Fact Sheets which were used at Town and Parish Councils. These focus on: Background to MANY; Fact Check – the appearance; Fact Check – 5G; Rural connectivity – the benefits; and Part of a wider community – Liverpool 5G. These were produced following meetings and reacting to questions asked. These are available to view on the MANY website

- Press releases were sent out announcing Coverdale, which was picked up by several regional and national media's

- A 4-week local digital champion campaign began the week commencing 19th October 2020. Using a local resident of Coverdale with 45 years+ experience in telecommunications, weekly blogs are highlighting the project and the benefits of connectivity in the Darlington and Stockton Times and Northern Echo both online and in print. The first two articles can be viewed here (23rd Oct and 30th Oct). https://www.darlingtonandstocktontimes.co.uk/news/18815293.digital-connectivity---available-everyone/

  a) https://www.darlingtonandstocktontimes.co.uk/news/18824444.5g---connecting-challenging-locations/

- Mail drop within the proposed signal area
- Monthly blogs across the MANY website and social media platforms
- E-newsletter

In depth research interviews by Lancaster University Management School were carried out with twenty five members of the community. Case studies were produced alongside these highlighting how a lack of digital connectivity affects lives. These can be found on the MANY website.

Some correspondence not supporting the project was received. These centred around concerns over; exposure to EMF, ICNIRP guidelines, mm wave technology and the project not carrying out a full consultation with the community. Those who fell within the signal coverage area were asked to take part in a research interview to fully understand their concerns and issues. These were then fed back to DCMS as part of the project findings.

The project followed the UK Government and Public Health England guidance which uses the ICNIRP and WHO guidelines.

Engagement continued throughout the project to listen and understand all feedback received. This led to Lancaster University Management School producing a best practice guide and toolkit for engaging in rural communities.

3.2.1 Early findings from community interviews

Patterns around experiences emerging from the data include poor, unreliable connectivity and time wasted when connections drop out when doing something for work, business, or everyday life, making life difficult and frustrating. Table 2 below provides some illustrative quotes:

Table 2 : Experiences of rural connectivity.

EXPERIENCES
‘With better connectivity I could actually spend time on growing the business rather than sitting here taking three, four, five times as long to do things’ (Business owner)
‘The broadband is really slow or drops out completely. It can literally take 2½ hours to do an online grocery shop because the signal’s dropped out and we’ve lost our order and have to start again’ (Homeworker)
‘We live in a pretty isolated place. A big restriction is not having a mobile signal. For example, when I last contacted the Dr’s surgery, they said they would get the Dr to call me back. But because I don't have a mobile signal I was tied to the house and had to wait. I ended up waiting all day for a phone call.’ (Retiree)
‘My child has had to sit in the car up the hill [to get a mobile signal] to take part in school online Zoom lessons so’s not to miss out’ (Parent)

Interestingly while these findings illustrate how poor connectivity makes life difficult for those living in rural communities, the findings also reveal a significant difference in the quality and speed of broadband connectivity in Coverdale. This in turn highlights the fragmented nature of the infrastructure currently in place. For example, while some members of the community have high speed broadband or Fibre, other properties in the Dale have very poor broadband largely due to where the property is situated or the quality of the copper phone line in place.

Interviewees also revealed external pressures which impact their connectivity experience. For example, the requirement to have mobile connectivity for energy provider smart meters, dual-factor authentication for online banking, or for support from service providers, was seen by interviewees to be considered a norm by such organisations, causing frustration for those residing in rural communities without mobile phone connectivity. Furthermore, the UK Government’s *digital by default* agenda and the movement of services going online were revealed to be a particular problem for those with poor connectivity who would struggle to complete online forms and audits for their work, business, or household. Social norms as an external pressure are also beginning to emerge from the data in relation to balancing a traditional rural way of life with technological innovation and having a choice of whether to participate using digital technology.

Patterns around hopes emerging from the data include reliable mobile connectivity; how connectivity attracts and keeps people in the community; and how 5G could future proof the community. For example, interviewees talked about how improved connectivity can attract people to the area or keep people in the community, thus avoiding the notion of what is commonly called ‘hollowing-out’ where young people feel there is no work for them or are unable to work from home and are left with no other option but to move away from the area. Table 3 provides some illustrative quotes:

Table 3: Hopes related to 5G and improved connectivity.

HOPES
`We would just like to have the reliability and consistency of being able to be connected, for our home and family, our business, but also the wider community, for example local farmers. Farming is a very lonely occupation, and probably one of the most dangerous' (Homeworker)
'Having reliable connectivity for future residents will make the appeal of living in Coverdale much greater. It would help the community cohesion, the children living here, the schools, and everything that goes with it.' (Parent)
'It's mainly to safeguard the future of the younger generations. I think with technology not being put in place, that is one major factor that would potentially push them out of the dale because how can you expect young people to work and live in this area' (Parent)

Interviewees emphasised the importance of reliable and consistent connectivity for their work and everyday life but also for them to realise future aspirations and to future-proof the locality. We recognise that software packages are being improved all the time and take up more energy and data space, so there's this notion of future proofing where digital infrastructure is in place that can support future technological changes.

Patterns around questions and concerns emerging from the data include the need to gain a more thorough understanding of 5G, concerns of how 5G could impact the aesthetics of the countryside, and the impact 5G and improved connectivity will have on community cohesion. Table 4 provides some illustrative quotes:

Table 4: Questions and concerns about 5G and the MANY project.

QUESTIONS/CONCERNS
'I don't know if 5G is the answer. I'd be happy with 4G and a decent broadband. I'm not in a position to decide what the answer is so, yeah, I'd like to know more about it because it's very vague in what's being described at the moment' (Retiree)
'I think we've got to be really conscious of the impact that we have on the beautiful environment that we live in….. there's a balance between people's requirements and preserving the landscape' (Homeworker)
'There is this cohesiveness and cross-generational togetherness I've not seen anywhere else. I think it's partly… to do with the community activities. I would be interested to know where mobile technology figures on that one' (Homeworker)

Interviewees referred to their lack of understanding of, and aspiration to know more about 5G, and specifically about how the MANY project was to use 5G technology. Interviewees were also concerned with what the 5G equipment would look like and the visual impact this would have on the aesthetics of the national park in which they reside. Some interviewees were also concerned about how the improved availability of mobile phone reception would have on their rural community, fearing transition to an 'eyes-down' community where everyone is looking at their phones instead of looking up, communicating, and speaking.

These questions and concerns emphasised the need to take a responsible, reflexive approach to the project research, and for the research team to act as a conduit by ensuring questions and concerns raised by interviewees are shared with the technical team but also the wider project. This resulted in the development of a spreadsheet with NYCC for those members of the community that want to participate in the project that lists their technical and support requirements but also their questions and concerns so these can be considered when moving the project forward. For example, questions were raised about the location of 5G masts and their size, and how the technology would be monitored. How the project responds to such questions demonstrates to the community that the project is listening. This approach also highlights the important bridging role that NYCC plays in connecting the research team with the technical team and the two-way relationship.

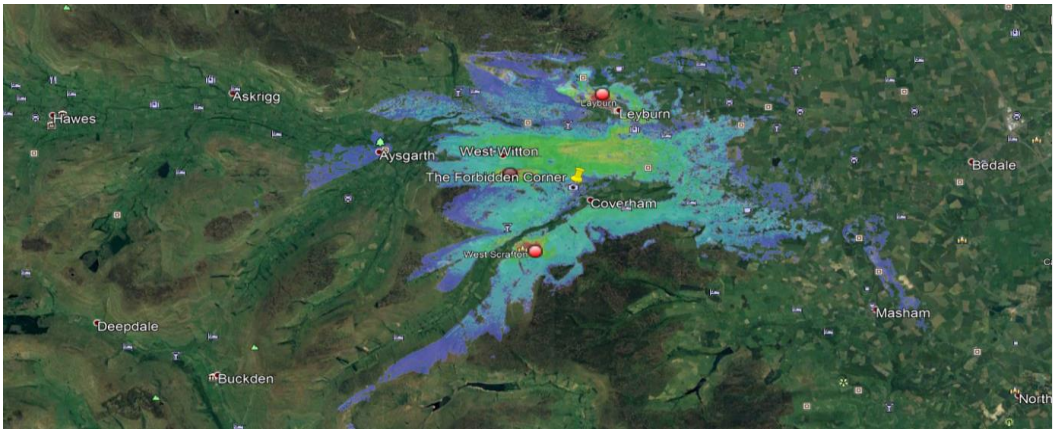
Other emerging findings support the three aggregate measures of well-being, safety and resilience, and business innovation. For example, interviewees repeatedly highlighted the need for mobile phone reception for improved safety and reassurance when working outside, such as in farming or equestrian activities, or when partaking in outdoor pursuits. Evidence of potential business innovation is also beginning to emerge from the data. For example, some interviewees highlighted how improved connectivity and 5G could fast-track their entrepreneurial and business diversification plans. Finally, considerations of wellbeing were also raised by interviewees in respect to social connections lost and made through lockdown and COVID restrictions and the use and potential future use of video conferencing

3.3 The Technology - Network Build Phase

The project looked to deliver an Open Radio Access Network (ORAN) which means that any suppliers equipment can be used removing the dependencies on a single supplier i.e. Huawaei. This meets one of the Government's objectives as it strives to open the 5G supply chain.

At the start of the project there was not a wide range of possible 5G technical solutions available but the exact choice of equipment and services depends on the availability of 5G equipment, its interoperability, the suitability of the solution for use cases and the environment in which it will be deployed. Balancing all of these competing requirements, while working closely with rural communities, and maintaining a commercial focus on the sustainability of the network, is a challenge. The project is time limited and it is important to test out the equipment in real life with the different use cases to demonstrate the benefits of 5G. This requires making decisions on network technologies when not all of the pieces of the jigsaw are in place such as an exact knowledge of radio performance and thereby coverage.

To assist with this element the project used WISDM's mobile planning tool which showed the estimated coverage based on the antenna size and output.



3.3.1 Backhaul

Quickline used multiple steps in order to reach the final masts at Leyburn, West Witton and West Scrafton. This involved building a fibre backbone into BT exchanges between Leeds and Darlington with multiple breakout points along the distance.

The new fibre routes are part of a major investment by Quickline into an Openreach style transport network which will be capable of delivering 100Gbps services.

Typically Quickline are aiming to deliver fibre to a mast site in order to provide the most robust connection possible, however, in areas where this is not feasible Quickline will leverage Microwave radio, typically using mm Wave frequencies (where distance permits) and dropping to lower frequencies where required.

In addition to this spectrum licences from Ofcom had to be applied for and negotiated along with planning and land owner permissions.

3.3.2 Network Build

The Quickline network was first built and tested in a lab, this allowed the team to test out all equipment and it's interconnecting. An Alpha test site close to Quickline's offices was used to further test the laboratory findings and understand the range of the equipment before deploying to the beta test sites on the infrastructure.

As the network build phase began, a number of issues were encountered.

- **COVID- Delays** - Due to COVID delays impacting global manufacturing and shipping, compounded by Brexit delays, Quickline were unable to obtain all the hardware required to deploy the live network.
- **Customer Premises Equipment (CPE) Issues** - Most customer premises equipment (CPE) today utilise the Qualcomm SDX55 chip. When this chip was launched, there were no test networks available running 5G Stand Alone. Therefore, Qualcomm had not enabled this functionality at launch. When Quickline began CPE testing, it was discovered that no CPE could attach to the 5G Standalone (SA) network. Firmware upgrades for the SDX55 chip later resolved this issue when the functionality was enabled by Qualcomm.
- **Supply chain issues** - Due to the combined impact of Brexit, COVID and Tier4 lock down, CPE and Radio Access Network (RAN) hardware manufacturers have had huge issues obtaining components for production of hardware. Quickline has experienced this across all products being imported to the UK including fibre-optic cable, subducting, cabinets, radio equipment, and network hardware. This had a direct knock-on effect on the ability for Quickline to deploy network assets to date.
- **GPS and Sync vulnerabilities** - During the testing with the Telrad hardware, a GPS outage was observed, which resulted in the site stopping transmitting and causing interruption of service to the users. To minimise the risk of this occurring in production networks, Quickline worked with ADVA to investigate the potential of having a distributed timing system with sources generated from various points in the country, additionally supporting large holdover times. As well as the ADVA solution, the CableFree radios support multiple GPS services providing resilience against all but a total GPS blackout.
- **Lease agreements on Ministry of Defence (MOD) land** - To extend the network from Coverdale into Swaledale and Arkengarthdale, a mast is required on MOD land. Despite multiple email requests, escalations to the DCMS barrier-busting teams and meetings between the barrier-busting team and MOD, the MOD took a long time to respond to our requests.
- **Obtaining frequency from Mobile Network Operator (MNO)** - To provide 5G Non-Standalone (NSA) / Standalone (SA) connectivity, Quickline requires spectrum supported by commonly used handsets. It has taken many months of negotiation with Vodafone and Ofcom to obtain this spectrum. 2.6GHz spectrum has been secured from Vodafone for Coverdale, however, this is not a viable solution commercially as the cost per site is £10,000 for a 3-year licence agreement on top of standard Ofcom licensing costs.
- **Access to the 1800MHz spectrum has been rejected by Vodafone**. 3.5MHz of the 1800MHz spectrum in the guard band has been secured and is suitable for a trial, but it is not permissible for a production environment.
- **Handsets locked to MNO networks for n77 5G networks** - It appears that mobile handsets are restricted to access only the MNO networks in the n77 spectrum.

Although they report support for n77, they are unable to connect to private networks.

This shows the difficulty in designing and building a communications network and the reasons why the delivery of the network was delayed. The network was finally delivered into Coverdale in November 2021 some 9 months later than was initially expected, with the first resident connected in early December 2021.

Initially, we were in collaboration with Cablefree (https://www.cablefree.net), but this presented many challenges in on-time delivery and appropriate functionality of the relevant hard- and software. As a result, the project collaborated further with Mavenir (https://www.mavenir.com) to try and establish a functioning network. This was eventually achieved, but so late in the project that a three-month extension had to be secured to enable us to at least test some of the use cases.

Whilst the network was delivered and the first users were connected further issues on the network were discovered through the monitoring carried out by Lancaster University. These issues related to the stability of the connections and the speed of the network.

The issues have been overcome with the network now stable with users connected and testing out the network. The connected users are experiencing speeds of up to 200Mbps. The backhaul services will provide coverage for a lot of remote users throughout North Yorkshire not just those connected via the MANY project.

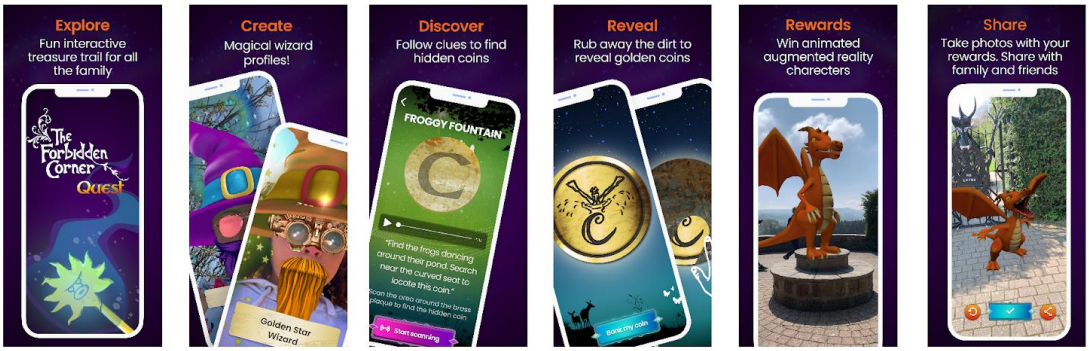
3.4 Use Cases

The project was to be use case driven and the lockdown situation - paradoxically - presented us with a lot of time to be able to discuss and formulate the right use cases for the region. We started with a list of personas we felt would best benefit from the intervention and tested our hypotheses with residents who matched these personas. By doing so, and with the lockdown situation forcing us to take our time, we were able to develop a short list of 5 main use cases we wished to develop.

3.4.1 Tourism

Forbidden Corner (https://www.theforbiddencorner.co.uk) This popular tourist attraction near Leyburn receives over 100,000 visitors per year. The goal was to use 5G or enhanced wireless communication to improve the visitor experience by enabling them to upload photos and videos in real-time. By doing so, the intention was that through social media postings, new visitors will be attracted to the site. In addition, we hope that existing visitors will remain longer at the site and spend more per head at the location. The main focus was a newly created Wizard Quest where visitors can interact with beacons hidden along the trails. An innovative augmented reality app enables participants to gather rewards and create interactive images on their phones.

Working together with the team at Forbidden Corner. We have successfully implemented an enhanced visitor experience centred on a ‘quest’ whereby visitors find hidden beacons along the trails which then interact with their phones. As a reward for ‘finding’ a beacon, an augmented reality feature appears via an app downloaded at the beginning of the trail. This enables special features such as animated creatures and wizardry to be incorporated into the visitors’ own photos.



Visitors are then able to share these experiences in real-time with friends and family, as well as on social media in general, thereby increasing the ‘digital footprint’ of the tourism attraction itself.

We have successfully tested this application with visitors and with students who performed a targeted assessment.

3.4.2 Health & Wellbeing

3.4.2.1 Health

Working with the local GP service in Leyburn, the project aimed to show the benefit of video GP appointments, saving not only the patient time and money with travel but also the clinical time required within the surgery. This could then be expanded into hospital appointments and, given the rural nature of the clients, there is the potential for larger savings in time and transport with the nearest hospital being over 60 minutes away. This became further apparent during the pandemic when appointments and triage were moved to the telephone, with only essential cases being seen.

The process is as follows. The GP sends an SMS to the patient with the link for their video appointment and at the appointed time, both the patient and the GP click on the video button creating the video connection. There is also an option for the GP to use a PC/Laptop. The patient can either connect their phone via a suitable mobile network or broadband service (Wi-Fi).

There is no need for the patient to install anything on their device (Phone/Tablet/PC/Laptop) as the electronic appointment from the GP contains an internet link that the patient simply clicks to accept the video call. No data is stored on the end user device.

Once individuals who have agreed to partake in the use case have connectivity, appointments were scheduled to test the MANY connections, user experience, and benefits of using this technology.

The MANY project team pilot tested the solution from a connected resident's home with great success. The team managed to make a call with the GP practice manager, which was of the highest quality and no jitter. The quality was good enough for a GP to view and assess a wound, although this would be checked with the clinical team during further tests. During the call we also brought into the consultation two further participants without any degradation to the call. This will enable clinical staff to get second opinions of colleagues while remaining on the call.

The second phase of this work was to test the solution with the patient and with a Junior Doctor. This would give us both the patient and clinical perspective on how the solution worked and help shape how it may be used in future.

However, due to workload issues within the Medical Centre and the lateness of the network supply, an adjusted methodology had to be used. The medical centre staff were unable to assist with the trial any further, therefore we used the interviews with our participants to ascertain the level of confidence in having video consultations.

Researchers from LUMS arranged second interviews with five members of the community in Coverdale connected to the MANY project. These second interviews were conducted face-to-face and in-person in the participant's home through three interviews. The interviews provided participants with the opportunity to reflect on the installation and use of the new digital connectivity and to take part in a video call test in the presence of the researchers, with support from a member of the team from Community First Yorkshire. It should be noted for some of the participants the new connectivity had only been installed the week previously and so had little time to experience the new connectivity.

Following introductions to the team, video call testing commenced followed by in-depth qualitative interviews. The video call testing was designed between LUMS and NYCC. The video call involved a researcher emailing a video link via Teams to the participant. The researcher would be in one part of the house while the participant sat in another part of their home. A second researcher observed and took field notes of the participant undertaking the video call. The video call lasted a couple of minutes where the researcher would ask the participant to observe the quality of the picture on the screen, the sound and general quality of the connectivity. This would involve the participant showing their hand on the screen as if to show an injury that could be viewed by a GP.

Once the video call had been terminated the participant was asked to reflect on their experience by grading each of the statements below based the following Likert scale:
[1 = strongly disagree, 2= disagree, 3 = neither agree or disagree, 4 = agree, 5 = strongly agree]

- I had a positive experience using this technology
- I feel like I could have a clear conversation using the technology
- I feel like I could rely on video appointments to speak to a medical professional to access the support I need
- I would feel happier if I knew that I had access to video health care
  [as an indicator of life satisfaction/quality of life]
- Reliable digital access has enabled me to benefit from more health and wellbeing activities
  [as an indicator of digital readiness/confidence to use online services]
- Digital access has enabled me to benefit from family/friends and local community support [as an indicator of increased social connectivity]

These questions were developed between LUMS and NYCC and built on collaborative work on rural well-being measures with The Centre of Thriving Places.

3.4.2.2 Wellbeing & Loneliness

This use case has evolved during the project especially following the pandemic and the involvement of a Mental Health Practitioner in conjunction with Northumbria University. The project were advised that discussing and using the technology with mental health patients at this stage of the trial would not be the most suitable way forward due to the vulnerable nature of the patients. The potential adverse effects of using and then potentially removing the technology was weighed against the welfare of the participants and the decision was made not to use it.

Therefore, this use case is exploring the experiences of mental health practitioners using remote working in the pandemic. This allowed the exploration of the use of digital technology in practice, including consideration of the challenges and opportunities in improving mental health and wellbeing.

Data was captured through both interviews with individuals utilising the MANY 5G connectivity (coordinating with the work Lancaster University Management School are undertaking) as well as through interviews with a sample of Qualified Mental Health Practitioners. In addition, a member of the MANY team tested the difference using 3G, 4G and 5G mobile connectivity with feedback captured around their experience.

A detailed literature review to support and frame the findings from the interviews with a detailed report including (but not limited to) key findings, benefits and challenges of remote working with mental health services, historical impacts/barriers of poor connectivity on mental health service provision, and further research required, has been compiled within a separate report. 5G in rural health & social care provision (uk5g.org)

3.4.2.3 Results

Below is a brief overview of what the participants said in relation to each of the statements asked by the researchers.

[I've had a positive experience using technology – statement 1]

"I would give it a five with a, I think the technology is fantastic and it has really, really helped. It's difficult because I'm not a paying customer [as part of a test & trial], but I'm trying to put myself in the shoes of a paying customer so that we can hopefully help future paying customers. The communication [with Quickline], I'd give it a three at best. The initial setup didn't happen as promised, at the time that it was promised and they never answered my emails"

[I feel like I could have a clear conversation using the technology – statement 2]

"Yes, four because sometimes it can go a little bit...That's the problem with it, it drops out. I've not had a big issue but with some things, sometimes, I can freeze. So, yes, I wouldn't put five, I'd put four."

[I feel I could rely on video appointments to speak to a medical professional to access the support I need – statement 3]

"Definitely, Five"

[I would feel happier if I knew that I had access to video health care – statement 4]

"Five -Yes, I'm keen on it. Keen on the idea. I'm keen on it because at the moment we're getting telephone calls and that's less personal and, as you say, you can't show symptoms over a telephone call, so that seems to me a next best thing other than actually seeing a doctor face to face. And we have been using... we have been in contact with the health services by Zoom quite a bit"

[Reliable digital access has enabled me to benefit from more health and well-being activities – statement 5]

"Four - I do an online exercise class through an app. I subscribed to it during lockdown, it's a girl that does all her workouts from home and it's easy to do, I couldn't go to the gym and in lockdown it was a nightmare because it was buffering, I'd be like jumping around and she'd be stopped and I'd be like, 'I'm going to have to this for longer now' and it was a nightmare. So, now, I never get any buffering, it's straight in, straight on and 45 minutes of just exercise. So, that has made a big difference to me, yes."

[Digital access has enabled me to benefit from family, friends & local community support – statement 6]

"Yes, Five, I would say definitely. None of our family live nearby and we have family all over the world. That actually means, for me, personally, I use it on a daily basis, maybe to call my mum over video, because she lives in Kent. My brother lives in Dubai and our daughter has recently moved back from Saudi Arabia. We've tested the system in terms of connectivity for video calls and obviously being able to upload photographs of grandchildren has been really lovely..... loading photographs is important for me, so yes, it's helped enormously. I also do market research for agencies, which involve, quite often, uploading videos and/or photographs. I used to have to really be careful about committing to those, whereas now I don't even have to think about it, because I know that we can. I can take on the task, whereas before it was a bit, not sure."

However, an important result of visiting participants and conducting the video call test was that Community First Yorkshire and the LUMS team were able to feedback connectivity issues raised by participants directly to Quickline who could then act on this information. It should be noted that Community First Yorkshire has taken an important role in maintaining communication with participants in the community in relation to connectivity surveys and installations throughout the project.

In summary, participants overwhelmingly agree and strongly agree with the benefits of video calls for online healthcare support. However, as described above, there were caveats to some of their statements.

In conclusion, important themes around connectivity and connection have arisen from the research. The study has indicated that there are issues of inclusivity and education and training that need to be addressed in order to inform future digital healthcare provision and support patient and practitioner experience. The understanding of what is 5G and its capabilities will enable users to see its full potential benefits. However, there is an understanding that technology has its place, but it can not replace all the functionality of face to face clinical visits.

3.4.3 Environmental

This theme explored how the use of 5G can enable monitoring of key aspects of rural infrastructure, such as roads and bridges, and key aspects of environmental monitoring, such as air quality, river levels and temperature.

This theme included:

- River level monitoring
- Smart Leyburn (which included):
  1. Air Quality monitoring
  2. People Counting
  3. Traffic Counting
  4. Vivacity Traffic flow monitoring

The trials and use of sensors managed to capture a range of data that was previously not available to rural communities. Data capture has provided insight which has been found to be of significant interest to local communities and interest groups, and all levels of local government including, the local Town and Parish Councils, as well as District and County Councils.

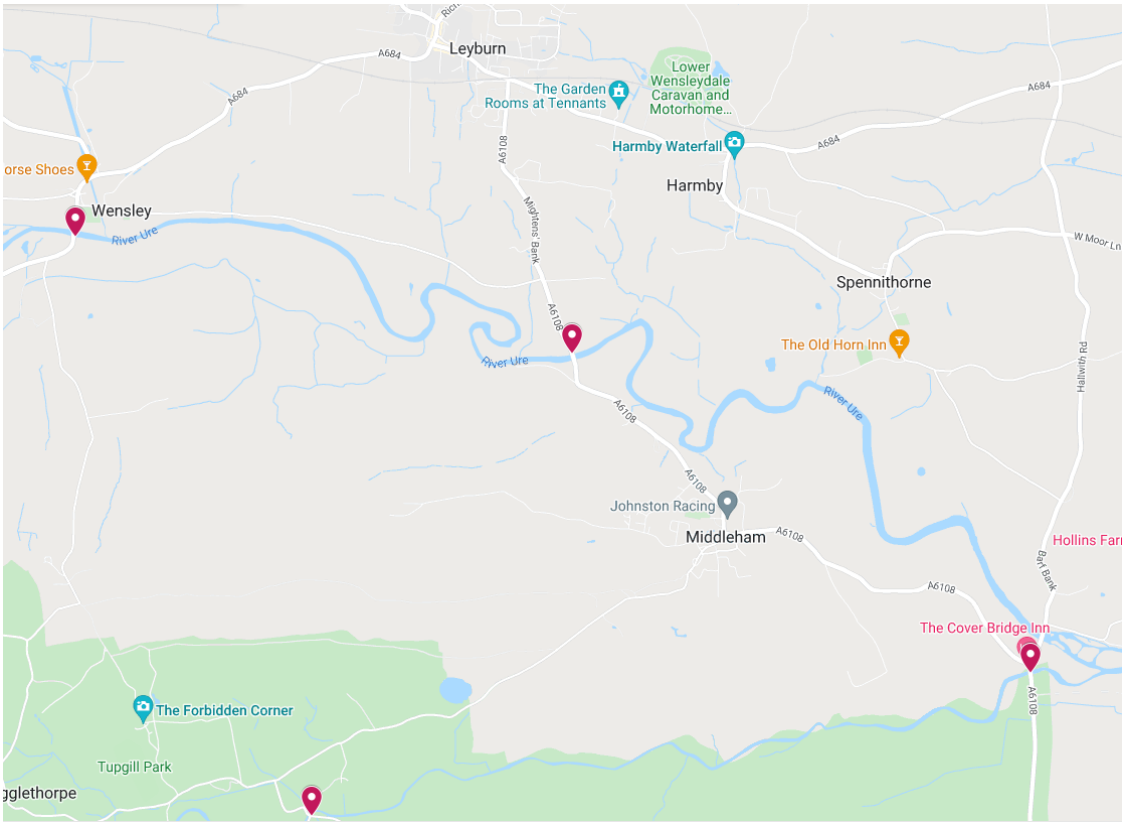
To remove the constraint that the 5G mast provided (relatively short distance and line of sight), a LoRaWAN Gateway was attached to the 5G mast, utilising the 5G connection for backhaul. This opened up the potential size of the trial area available for trials, and enabled the use of LoRaWAN sensors to capture data for the benefit of the local area.

LoRaWAN provides a wireless network across a wider area using low power meaning it is generally affordable and can run on batteries for up to ten years. This is well suited to enabling connected places utilising the Internet of Things (IoT) approach.

3.4.3.1 River Level Monitoring

There have been historical flooding incidents in and around Leyburn, impacting local businesses, residents and infrastructure. The need for remote monitoring of infrastructure flooding has been recognised by North Yorkshire County Council as per work undertaken (outside of the 5G coverage area) to deliver a sensor based flood warning solution using the Government's Safer Roads Fund (News release).

The MANY project utilised the LoRaWAN river levels sensors at 4 key bridges south of Leyburn (as identified in the map below) to create a sensor mesh of data across an area. This use case will aim to provide data and insight to inform a number of teams including the North Yorkshire County Council emergency planning team and the environment agency.



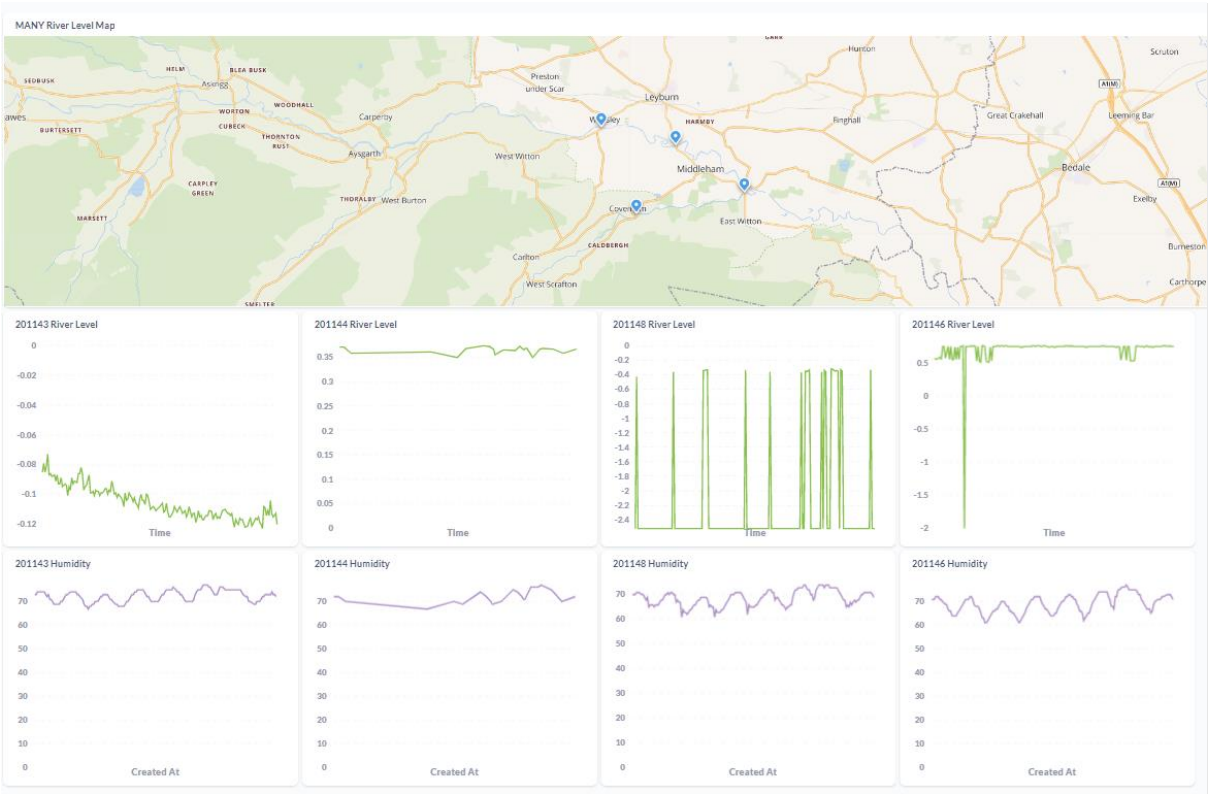
Utilising LoRaWAN connectivity enabled the project to overcome the lack of consistent and reliable 3G/4G connectivity in the area, enabling us to connect to the Ultrasonic battery powered sensors and gather data effectively.

Data

NYCC worked with our Technical Partner, Parallax, to build the infrastructure required to ingest data and ensure it is stored in an easily accessible and analysable format. We overlaid a User Interface (UI) to help present the data in an easily digestible format for our target stakeholders (shown in the screen capture below).

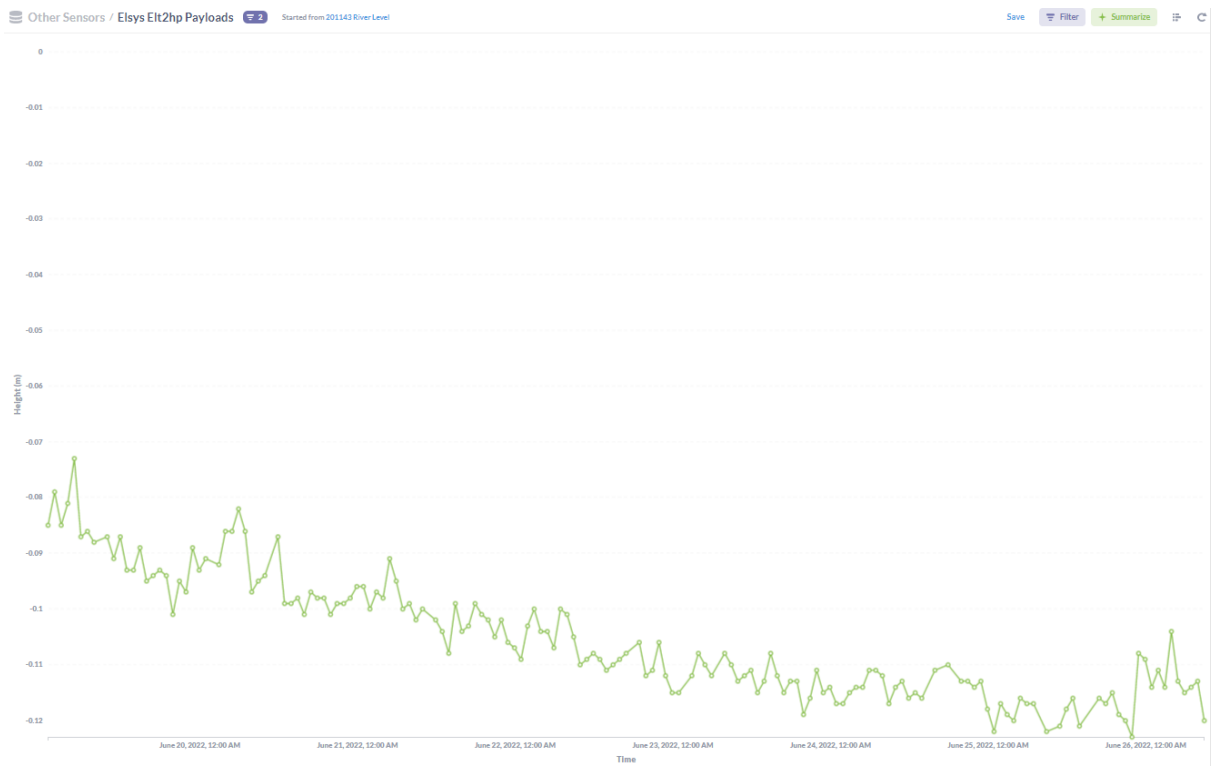
The data each sensor captures includes:

- Distance from the sensor to the surface of the rivers
- Humidity
- Temperature



Web based dashboard built to present river level data

We have also enabled users to undertake trend and longitudinal analysis with access to data from the point at which the sensors were first installed.



Example of river level trend over time

The data is also exportable so it can be shared and analysed alongside external data sets, working with other agencies where required, for example adding additional levels of granularity to existing flood monitoring undertaken by the Environment Agency.

3.4.3.2 *Leyburn Environmental and Movement Monitoring*

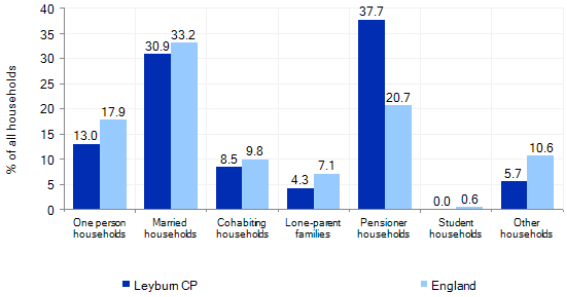
Leyburn is a rural town on the edge of the Yorkshire Dales and demonstrates some very typical rural demography. It acts as a hub town for a number of nearby villages and sits on a busy A road through to Middleham and the dales. It's home for a bustling tourism focussed local economy, farming and agriculture.

Pensioner households	One person households (aged under 65)	Lone parent families with dependent children
396	136	45
37.7% (England average = 20.7%)	13.0% (England average = 17.9%)	23.9% of all families with dependent children (England average = 24.5%)

Married households	Cohabiting households	Student households
324	89	0
30.9% (England average = 33.2%)	8.5% (England average = 9.8%)	0.0% (England average = 0.6%)

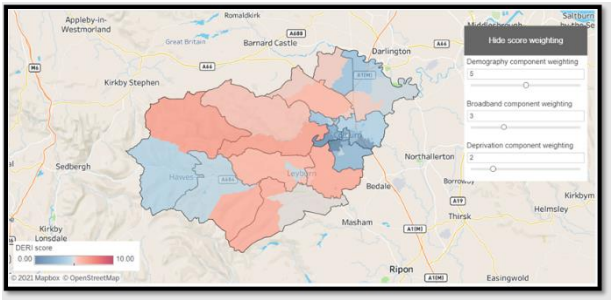
Source: Census 2011

Figure: Population by household composition
Source: Census 2011



Leyburn has a significantly higher proportion of pensioners who reside there.

Making services easy to access and supportive technologies such as homecare may have more relevance.



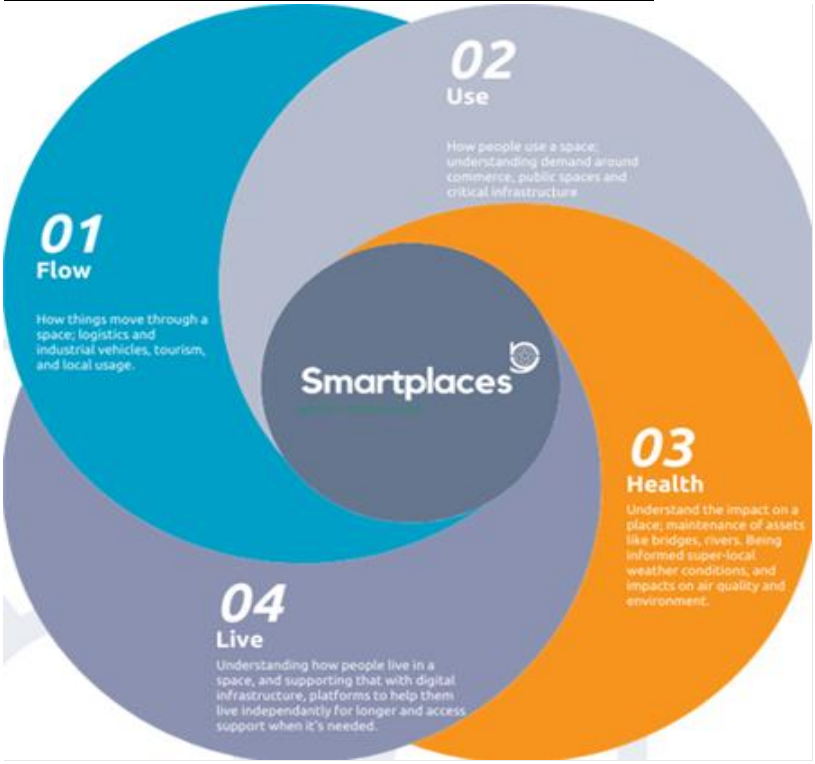
According to the DERI (Digital Exclusion Risk Index) Leyburn sits as a rural centre point around a demographic that is more likely to be digitally excluded.

This makes Leyburn a good opportunity to act as a rural exemplar; which means residents are more to embrace the benefits of a digital twin

Leyburn also benefits from having a 5G mast installed just to the NW of the town centre and so provided an opportunity to deploy a mixture of 5G, 4G and LoRa sensors and solutions to paint a multi-layered picture of the place.

Early engagement took place with the Councillors from Leyburn Town Council who were supportive of this trial and interested to gain access to data from the sensor once a period of data capture had taken place. This is being taken forward as a project legacy action by North Yorkshire County Council.

Leyburn Environmental and Movement monitoring



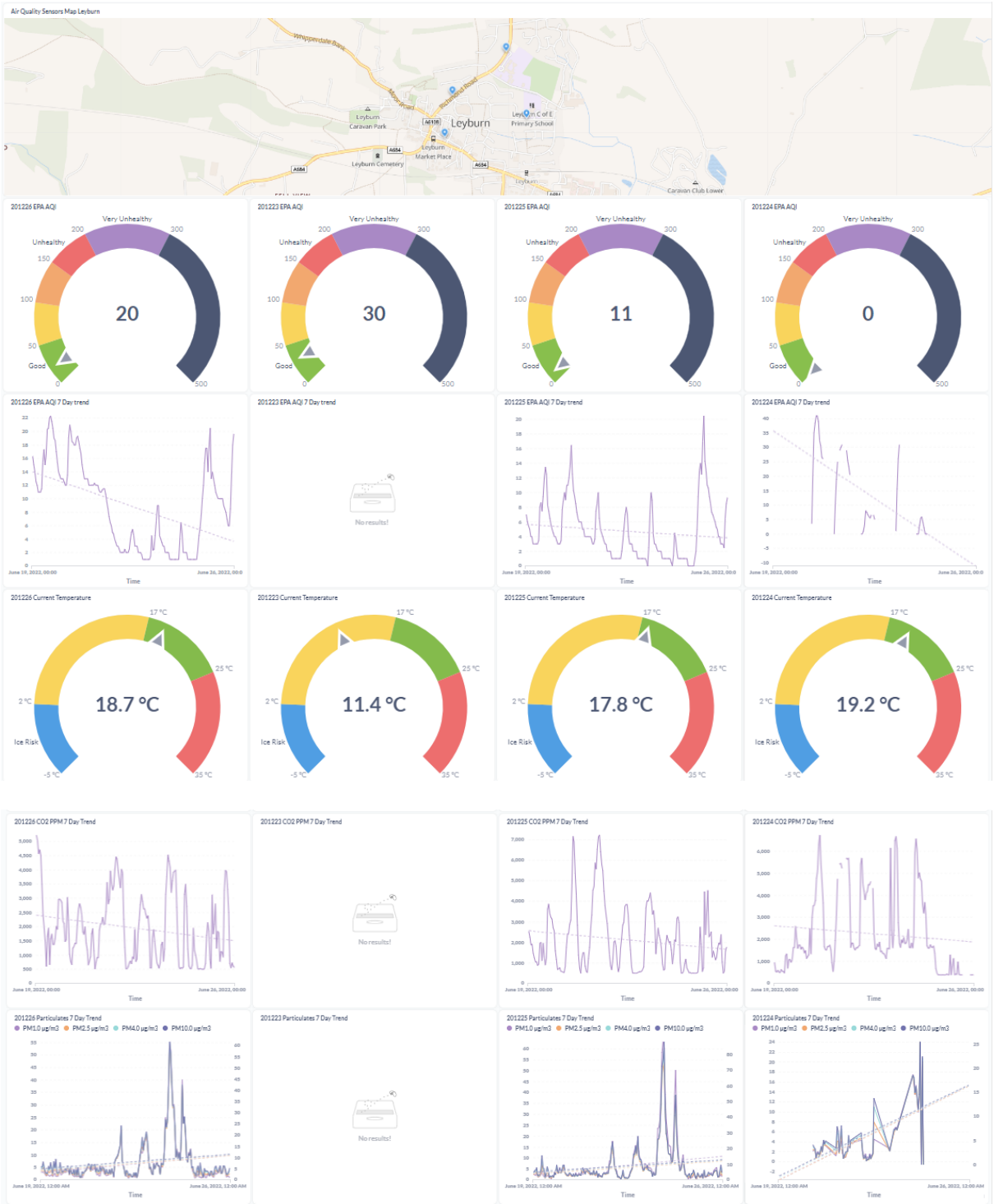
For Leyburn we looked at 4 different categories of data to help describe and inform local residents and stakeholders.

:

Sensor Type	# deployed	Locations	Data metrics captured
Air Quality (LoRaWAN)	4	Wensleydale School & Sixth Form Leyburn Primary School Leyburn Livestock Auction Mart Leyburn Market Place	EPA Air Quality Index Temperature CO2 PPM PM 1.0 / 2.5 / 4.0 / 10.0
Traffic Counter (LoRaWAN + Solar)	1	A684 leading out of Leyburn towards Wensley	Sum of traffic Average speeds Solar Wattage
Footfall Counters (LoRaWAN + Solar)	4	2 x Market Place Up A6108 Along Shawl Terrace (feeder for Market Place)	Count of people past sensor in both directions Solar Wattage
Vivacity (4G / 5G powered via lamp post)	4	Leyburn A684 towards Wensley Leyburn A6108 towards Richmond Leyburn Moor Road towards Reeth Aiskew Bedale Road	Vehicle classification Vehicle count Average Speed Journey times Route / turn count Pedestrian Count Pedestrian path analysis

Air Quality

We used the same technical architecture built for the River Levels sensors (as well as traffic and people counters), including a similar format for the Air Quality UI (screenshot below):



Air Quality web based dashboard built to present data from LoRaWAN sensor

As you can see there are still times at which signal seems to cut out and data is not captured, despite transmitting at the time of install. This could be down to a number of factors including something moving to occlude the line of sight with the transmitter or that an issue has arisen with the sensor itself. This has been captured as one of the lessons learnt and as an outstanding action post project closure to resolve.

Stakeholders

We have an engagement plan in place with four local stakeholders:

- **Leyburn Town Council** – with Councillors to identify any air quality issues in Leyburn.
- **Richmondshire District Council** – Environmental Health Team who are responsible for Air Quality Reporting to DEFRA.
- **Leyburn Primary School** – to support engagement activity with parents and children and to understand the impact of behaviour change on air quality levels
- **Wensleydale School & Sixth Form** – to support engagement activity with parents and children and to understand the impact of behaviour change on air quality levels

There is a significant amount of information about what constitutes poor air quality, but minimal methods to inform residents or users of a place about what a current reading is. Below is guidance from DEFRA about what different levels of PM 2.5 and PM10 mean in terms of severity.

PM_{10} Particles

Based on the daily mean concentration for historical data, latest 24 hour running mean for the current day.

Index	1	2	3	4	5	6	7	8	9	10
Band	Low	Low	Low	Moderate	Moderate	Moderate	High	High	High	Very High
µg/m³	0-16	17-33	34-50	51-58	59-66	67-75	76-83	84-91	92-100	101 or more

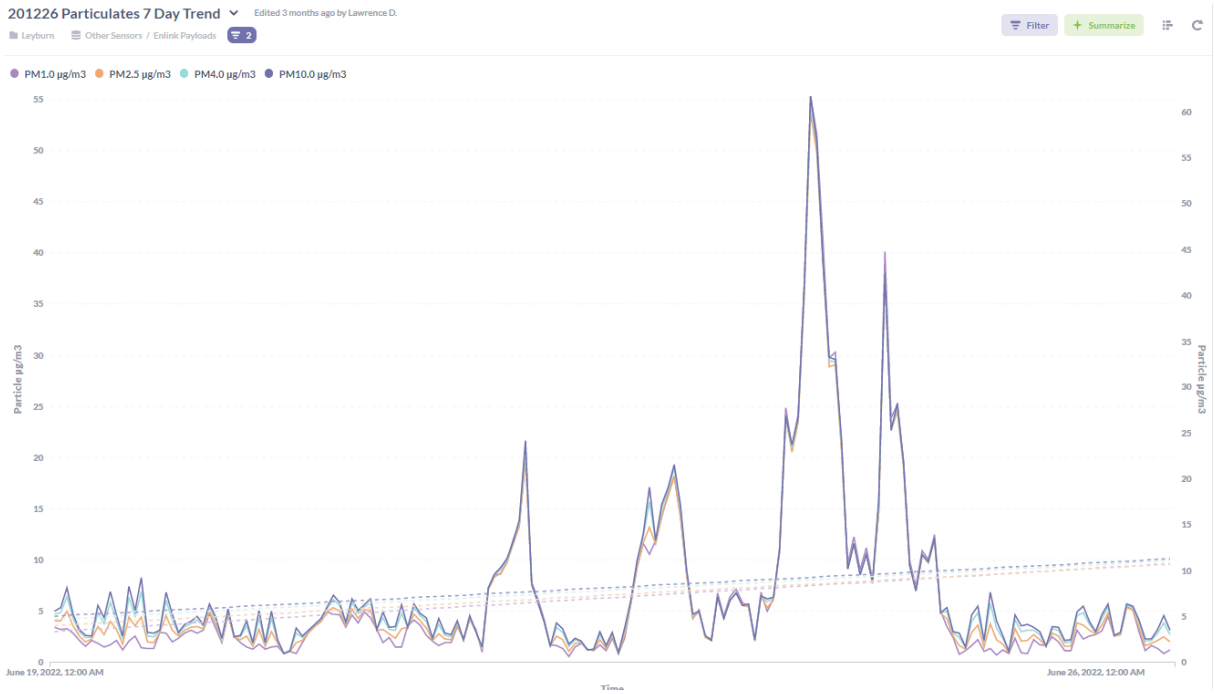
$PM_{2.5}$ Particles

Based on the daily mean concentration for historical data, latest 24 hour running mean for the current day.

Index	1	2	3	4	5	6	7	8	9	10
Band	Low	Low	Low	Moderate	Moderate	Moderate	High	High	High	Very High
µgm^{-3}	0-11	12-23	24-35	36-41	42-47	48-53	54-58	59-64	65-70	71 or more

Source: DEFRA Website

The graph below shows that the overall trends for Particulate Matter on one of the sensors over the past week (June 19th – June 26th) indicate that on the whole, levels are within the low band. However, there are 4 distinct “spikes" over a 2 day period (shown below) that show levels in the Moderate to High Bandings.

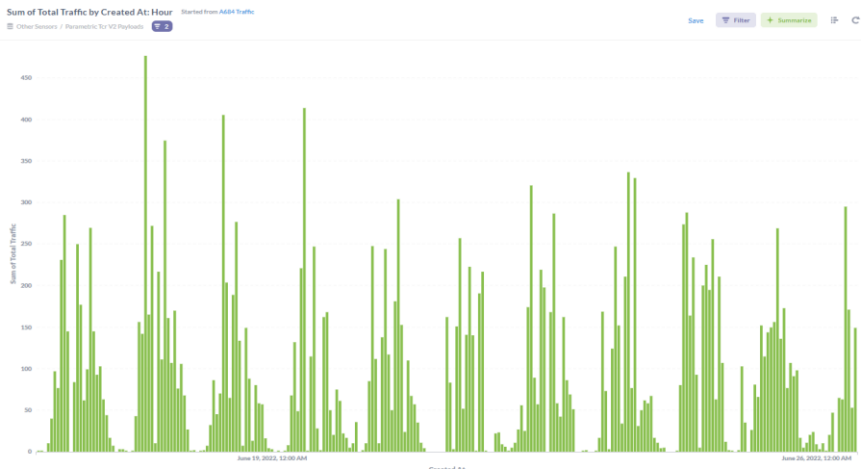


Particulate matter reported by Air Quality LoRaWAN sensor over the period of a week

From our engagement with local stakeholders, the consistent feeling was that air quality is not an issue in Leyburn. On the whole the data corroborates this assumption, but the spikes in Particulate Matter provides an opportunity for the local Council to try to identify if there was an event that took place over 2 days which caused the degradation in air quality. The data also enables this analysis to take place over a matter of time to see if the frequency of poor air quality events increases in frequency, enabling mitigating actions to take place before it becomes a significant issue.

Traffic Counting

A single low-cost LoRaWAN traffic counter was installed to test the hardware and accuracy of the data alongside the Vivacity sensors (high-cost/highly calibrated). The A683 south of Leyburn towards Wensley is a key arterial route out into the North Yorkshire Dales National Park.



Sum of traffic passing LoRaWAN sensor by hour

We are able to show how many vehicles pass the sensors and start to identify any trends or anomalies in traffic volumes through the junction. Over a period of time this will help to create a baseline of volumes and enable regular monitoring to identify when this level is breached, and potentially trigger investigations into why this is the case.

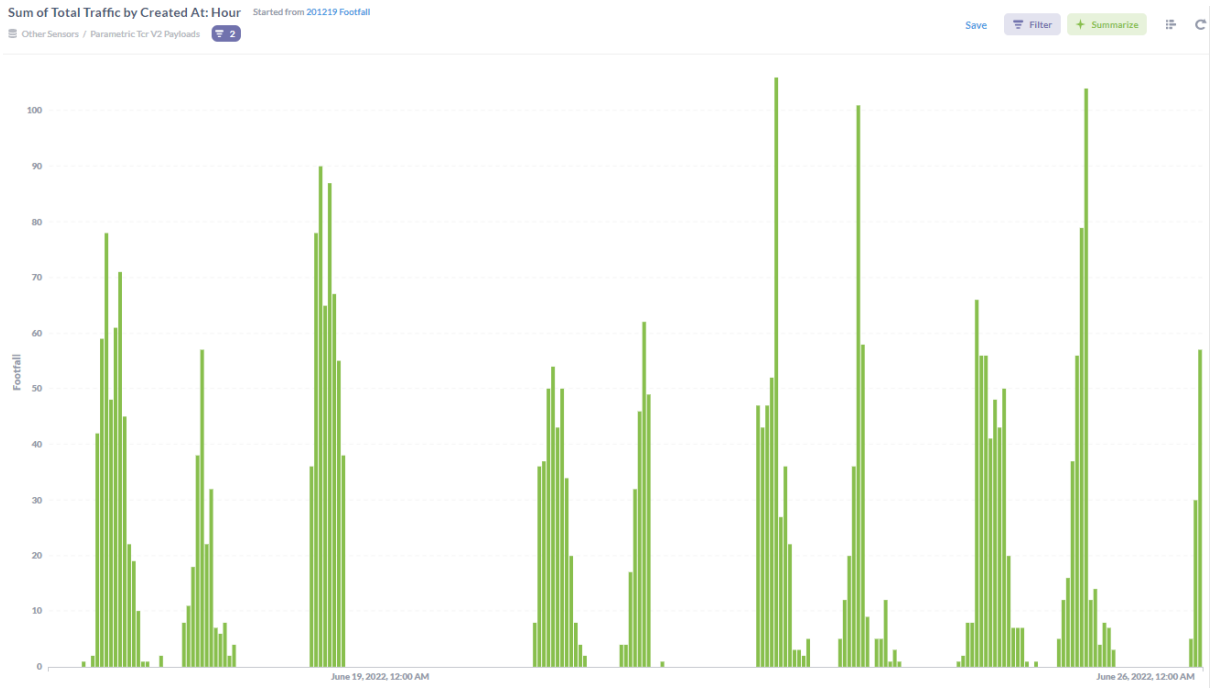
It can help to identify the impact of things like:

- Road closures elsewhere in the highways network
- Construction schemes
- Events taking place elsewhere in the dales
- Efficacy of tourist advertising campaigns

Footfall Counters

Four LoRaWAN People counters were installed by the primary parking area and business space by the Leyburn Market Place as well as by smaller scale car parking areas that feed into the Market Place.

The aim was to start to create an understanding of how busy Leyburn was over each 24 hour period, including when different areas started to get busy and when there are either unusually high or low footfall periods.



Sum of pedestrians passing the LoRaWAN sensor by hour

The aim is to engage with businesses to help them understand when areas are busy and potentially look to make changes in how they operate as a result of the data. For example if it is clear there are significant volumes of visitors on certain days before a business (for example a Café) usually opens, then there may be an opportunity to open earlier to target additional trade.

The data also provides an opportunity to support events such as the Covid lockdowns and ensuring that measures were being observed. The data can also help visitors to understand when busy times are, which they may want to avoid.

This would require additional sensors being deployed to create a more comprehensive mesh of counters to understand volumes of people round a space with a greater degree of accuracy.

Vivacity Sensors

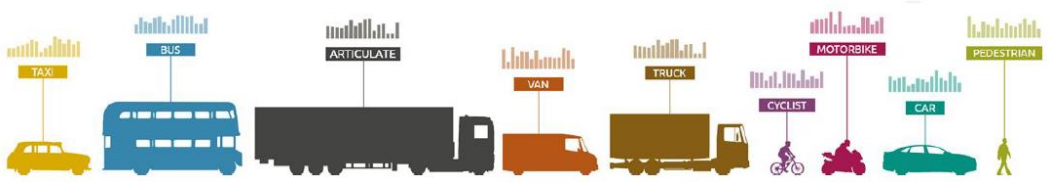
The location of the sensors was agreed through identifying key junctions in and around Leyburn, and understanding where the sensors could gather the most data and insight to inform local communities.

The sensors provide a range of connectivity and functionality. A major benefit of using these sensors is their GDPR compliance, with computing taking place at the edge with images captured, analysed and then deleted on the device itself to capture insight without sharing personal data.

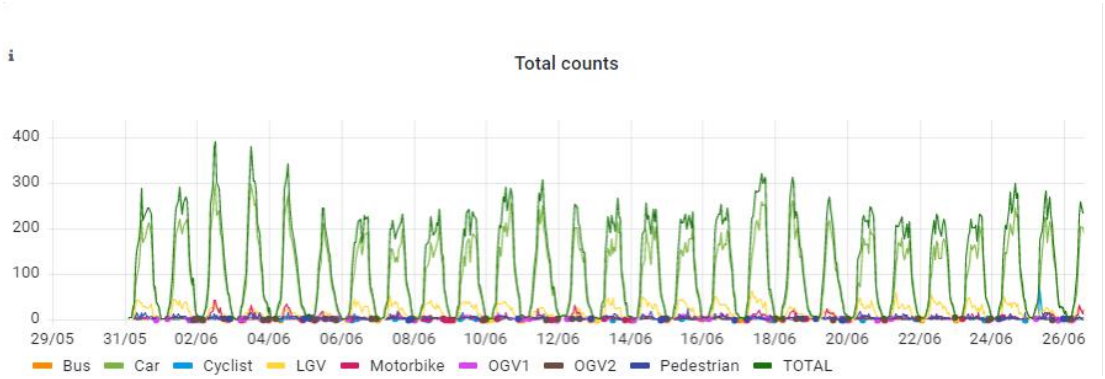
The four locations identified for the install provide insight into the flow of traffic through Leyburn as well as what traffic comes from Bedale in the east across to Leyburn in the west.

Category of road user and count

The sensors can distinguish and count over 9 different categories as outlined below:



An example of this using data capture at the roundabout with the A684 in Leyburn is shown below:



Hourly Count of road user over a period of a month by category

This breakdown of road user type over time can start to identify the impacts of variables such as:

- Road closures
- Planning approvals
- Events
- Weather
- Holidays
- Day / time of day

This kind of insight has never been available in a rural setting in North Yorkshire. Data needs to be ingested over a period of time to enable robust baselines to be established to then identify “abnormal” events or a degradation to the prevailing trend.

Speed of vehicles

Key local concerns that Leyburn Town Council and other Parish Councils had was the speed of vehicles when travelling through their local area. Some feedback from local Councillors was that attempts had been made with the Police and County Council to address their concerns about speeding. The primary feedback received was that there needed to be evidence that this was the case, which would often take a long time to gather and be costly in nature.

When reviewing the data for the sensor on Bedale Road we can view the average speeds of different types of road users.

Average road user speeds over 24-hour period by category

The road has a 30 mph speed limit. From the above chart you can see that, on the whole, the average speed across all vehicle types (using 15 minute intervals) remains within the speed limit. However, there are a number of occasions when cars, LGVs and OGV1 went over the speed limit.

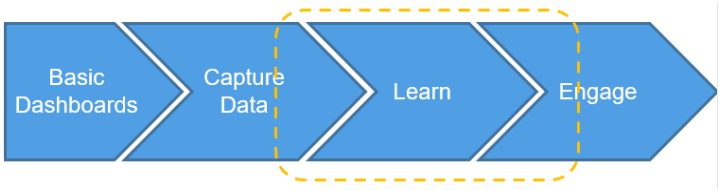
Plans are already in place to share this data with the local Parish council to start to look at whether this matches local concerns and what can be done to address any concerns using the data as a clear evidence base to engage with the appropriate agencies.

Links have also been made with the Highways and Transportation team at North Yorkshire County Council to evaluate this technology and examine other potential applications and value elsewhere in the County.

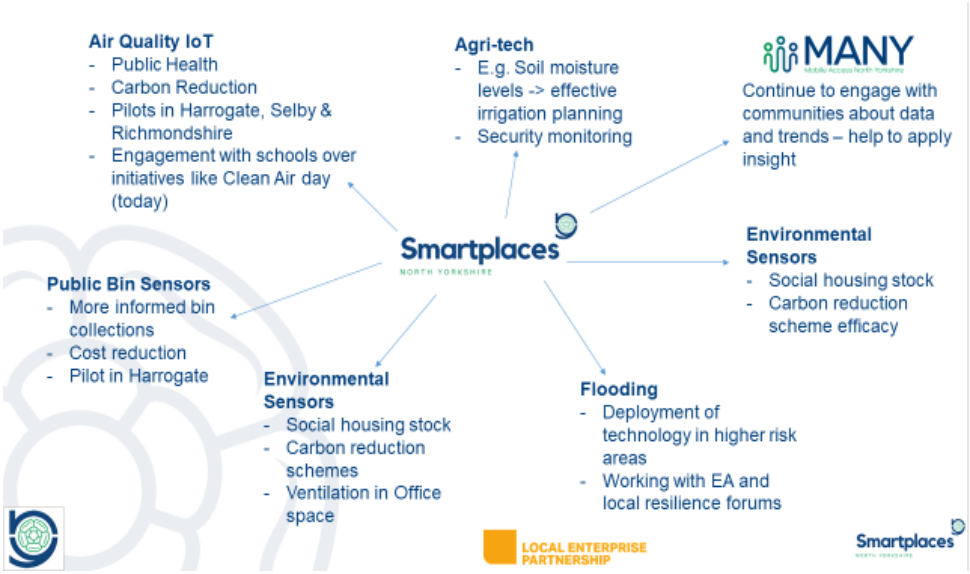
The additional data collected from the wireless sensors on bridges and roads will enable Council engineers to make informed, data driven decisions regarding the repair and maintenance of Council assets. A significant amount of data has been and continues to be collected across all the sensors outlined within this report. This is capturing valuable insight into what the baseline and trends are in different areas of the trial areas – this is ongoing.

Data captured has already highlighted things that were not flagged as part of the early engagement with local stakeholders (e.g. air quality degradation events), as well as started to confirm some perceptions (e.g. regular speeding along residential stretch of Bedale Road).

A standard process has been developed for any new data set / sensor (outlined below). Due to delays in the connectivity to the area this trial is still in the “learn” phase, understanding how to interpret new data sets in the context of where they are located, and engagement has started to share the information with key stakeholders.



This process will be ongoing by connecting into the Smart Places initiative within North Yorkshire County Council, that is deploying IoT sensors across North Yorkshire to support the evolution of Council service delivery and supporting local residents and businesses. Examples of other IoT work underway is shown below.



Examples of ongoing IoT work by North Yorkshire County Council

Learnings from the trials undertaken within the MANY project will be shared across the Smart Place programme of work, some examples are outlined below.

Category	Lesson learnt
Sensor hardware	There was often a period of calibration or “settling” required with the IoT devices, for example the air quality sensors took a week to settle into a trend that resembled an accurate picture of a local area.
Signal quality	There are a variety of environmental factors that can impact on signal strength for IoT sensors. Use of a Field Test Device was implemented to evaluate installation locations prior to install towards the end of the project.
Subject Matter Experts	It would have been beneficial to the project if a representative from (for example) Leyburn Town Council was brought into the project team to help act as a local expert to start the analysis piece for data earlier in the project.
Data ingestion	The development of the technical architecture enabled single device data presentation. Early work to start to layer data would have been beneficial to identify correlation across data types. This will be taken on by the Smart Place programme with North Yorkshire County Council.

Overall the project would have benefited from having the required connectivity earlier in the timeline, to enable 6-12 months of data collection to support the identification of key trends, insights and information to benefit local residents and businesses. However, this trial has proven the technology, identified there is demand for this insight, and identified next steps to help drive value from the MANY project outputs past project closure.

3.4.4 Tank Monitoring

The Tupgill Estate - the same location as our tourism use case, Forbidden Corner - has a number of critical tanks dotted around the estate, which have to be monitored manually at regular intervals. In total, there are 19 tanks as follows:

- 2 x Diesel (1 – red, 1 – white),
- 14 x Oil/Kerosene,
- 1 x Water
- 2 x LPG (Low Pressure Gas)

This use case has focused on using the installed local wireless network to monitor these tanks remotely. To do so sensors, which can wirelessly transmit readings, have been installed in the tanks.

IoT Platform

The aql IoT (Internet of Things) core platform allows differing types of site sensors to provide live data. The platform allows sensors to connect through a variety of protocols including LoRaWAN (Low Power Wide Area Networking), and has a API (application programmable interface) allowing uploads to be processed through the aql IoT API.

This is a very effective and efficient way of transferring data collected regularly to an observation console or personal computer for monitoring purposes.

Data can be reported on the https://iot-visualiser-api.aql.com/api allowing third party systems to view platform and data information. Additionally, the platform provides an access anyway data portal, which allows users to view all connected sensors across the differing connection routes. From within the platform, a user can view the current readings, set alarms and warnings and view historical data. This information can be fully accessed from the api as well.

Site Locations

The Tupgill Estate has a series of Fuel and Water tanks across the estate which prior to the project had to be manually dip tested by the estate team. Their locations are spread across the site.

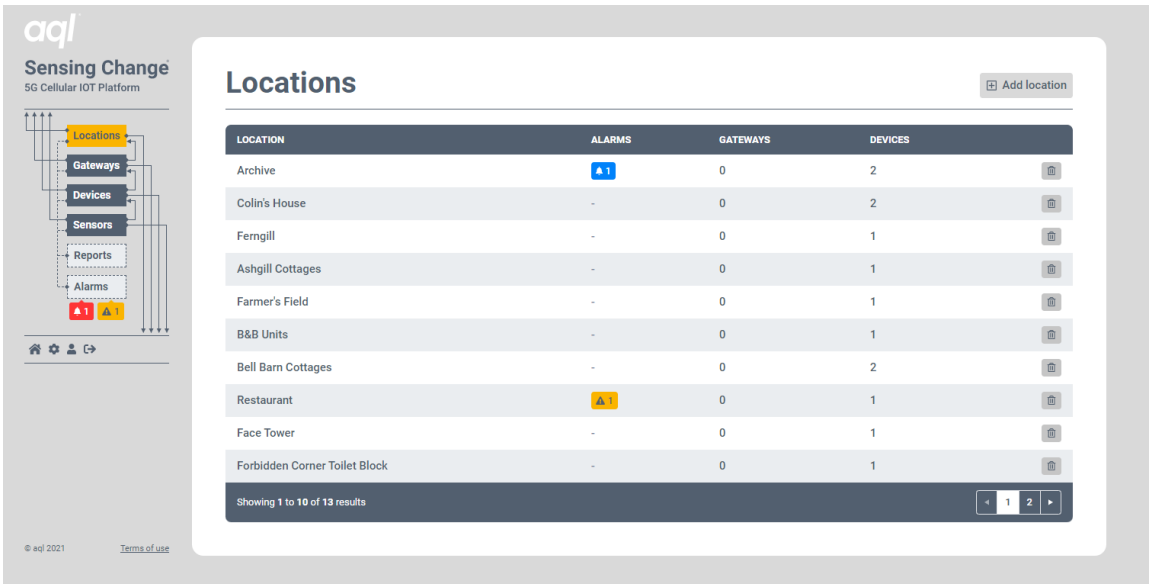
The tanks are often in areas which are not easy to access and due to regulations, are in brick enclosures.

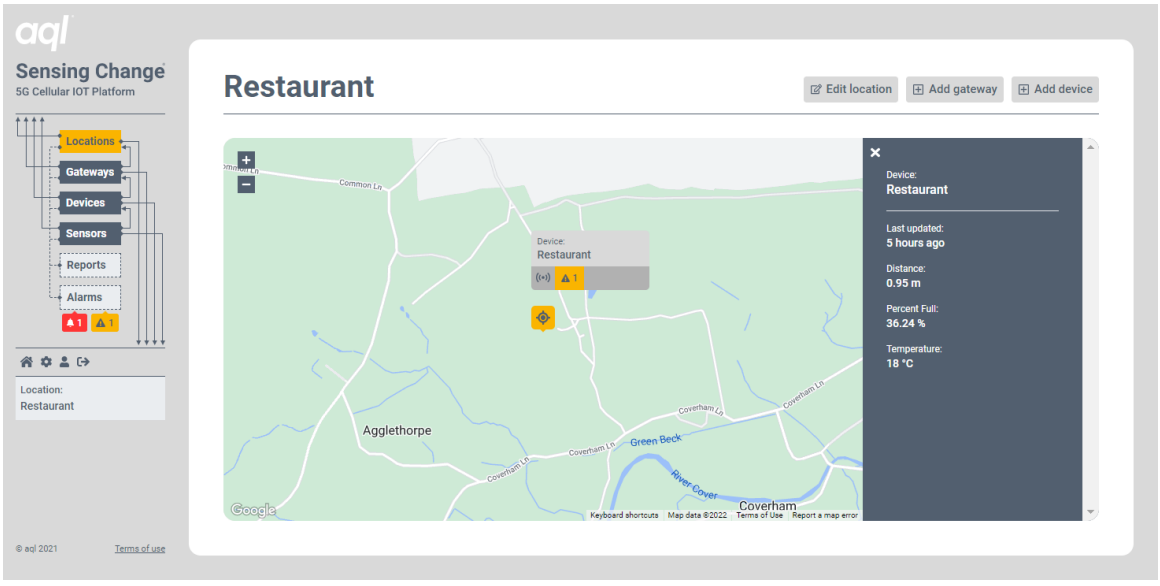
Sensors have been added to each of the main liquid tanks.

Software Platform

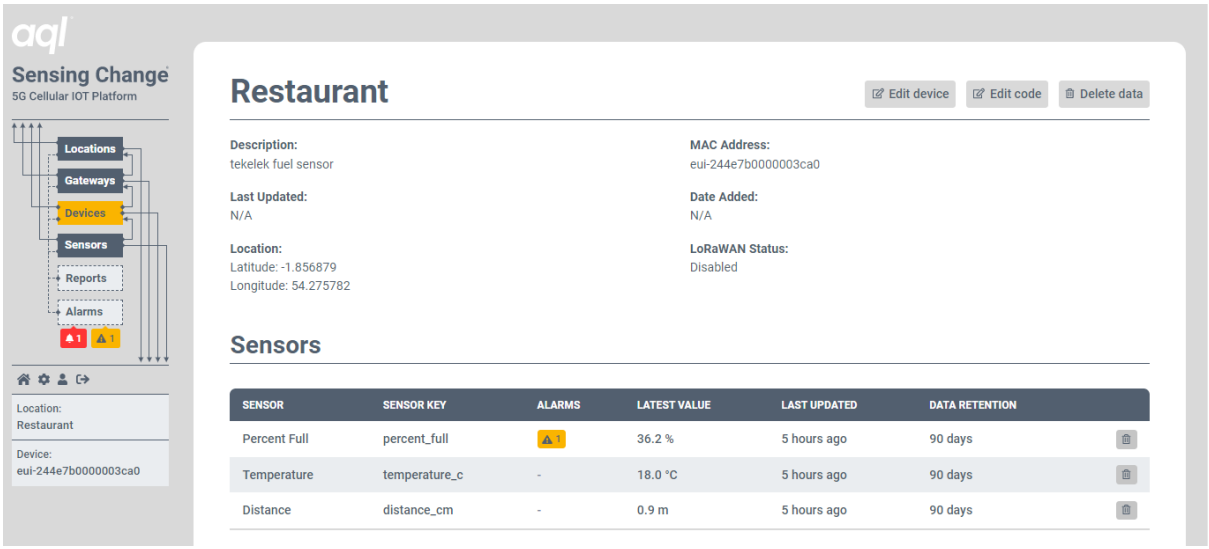
The installation of a new 5G Enabled LoRa WAN aql gateway and a series of LoRaWAN Sensors were installed as part of the project delivery.

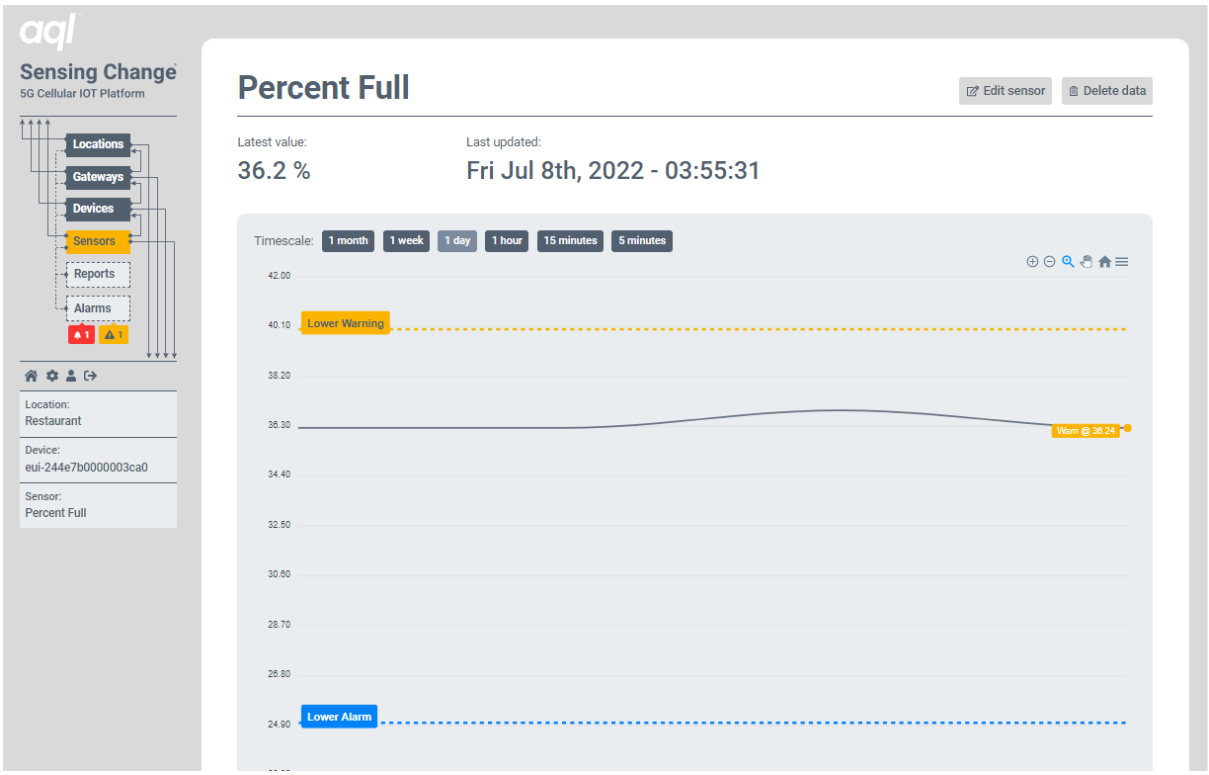
The aql IoT Core Platform allows the Tupgill Estate team to view all 5G enabled sensors across the differing locations. Devices which return GPS location information are displayed within the Location Summary Page to provide an immediate view of the sensor readings. From here a user can easily select a sensor and view its latest readings and be informed if any sensors are currently reporting a state of Alarm.





The aql core Platform allows the Tupgill team to set alarm values which will raise visual and email alarms when sensor readings achieve a specific reading. These alarms are clearly displayed within the alarms section or within the specific sensor summary page.

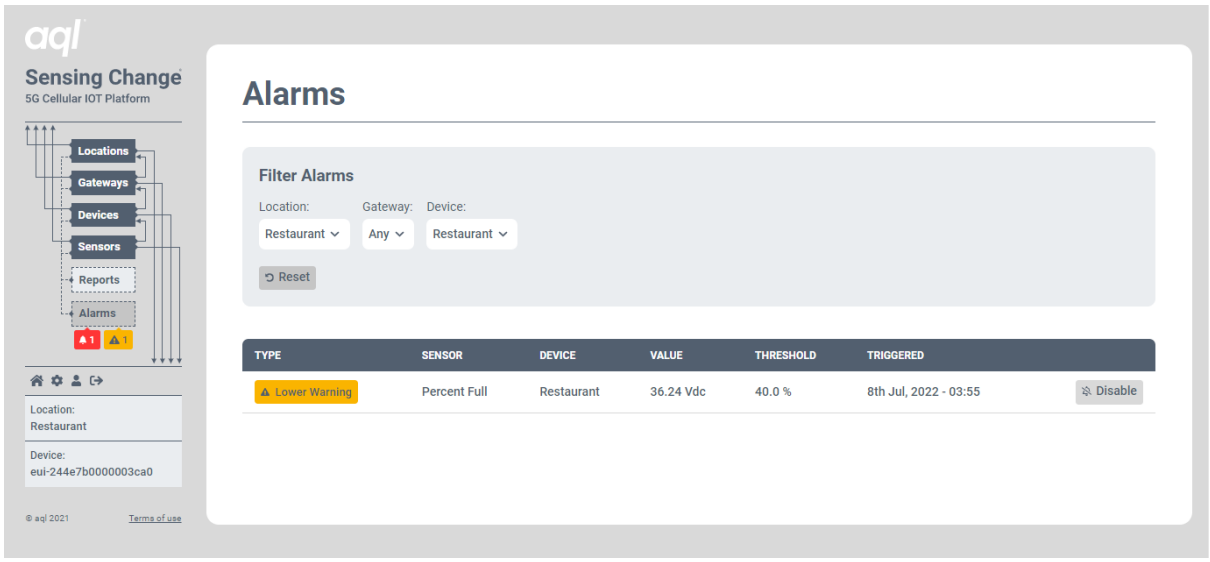




The aql Tank Sensors return a variety of information regarding the site including the level reading in distance and as a percentage as well as the current temperature of the reading of the liquid. Temperature differences can affect the volumes measured in the tanks.

Alarms can be easily managed by the team, and the team can configure the push notifications either as SMS or via email.


Alarms
Upper Alarm Value
0 min
Alarm Trigger Delay
Time elapsed above value before alarm is triggered.
0 min
Alarm Reset Delay
Time elapsed below value before alarm is reset.
Lower Alarm Value
25
0 min
Alarm Trigger Delay
Time elapsed below value before alarm is triggered.
0 min
Alarm Reset Delay
Time elapsed above value before alarm is reset.
Upper Warning Value
0 min
Warning Trigger Delay
Time elapsed above value before warning is triggered.
0 min
Warning Reset Delay
Time elapsed below value before warning is reset.
Lower Warning Value
40
0 min
Warning Trigger Delay
0 min
Warning Reset Delay


aql
Sensing Change
5G Cellular IOT Platform
Locations
Gateways
Devices
Sensors
Reports
Alarms
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Terms of use
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Lower Warning
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36.24 Vdc
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8th Jul, 2022 - 03:55
Disable

Usage & Benefits

Through the automation of this data, the estate team are now able to manage the estate more efficiently and focus on procurement and business efficiencies without the need to manually dip test the tanks on a regular basis. This is reflected in the quote below.

Leo Morris, Tupgil Estate manager said:

“Our work with aql and the larger MANY consortium has enabled huge improvements to the Tupgill Park estate. Innovations include a 5G network, enhanced connectivity and smart data insights. Notably aql has provided a smart platform where IoT sensors can retrieve data from areas all over the estate. Connectivity issues associated with rural areas created their own challenges but utilisation of LoRawan and Bluetooth technologies provided a solution. The data obtained, displayed on a clearly laid out portal, coupled with alerts for key data points, has provided us a much easier and efficient way of completing processes. This adoption has not only saved many hours, making it a useful cost saving exercise, but also allowed accurate forecasting of resources by reviewing historical and seasonal data.”

This system has two main benefits:

- fluids can be monitored without staff having to go out and physically measure the fluid levels of the tanks. The saving associated with this is an "opportunity saving", as the staff time can be allocated to other tasks, but there is no cost reduction. Effectively, staff resources are more effectively employed.

- By collating fluid levels of various tanks, deliveries can be better coordinated, preventing multiple deliveries in a short time-frame. The higher volumes ordered can potentially enable a volume related discount and at least some delivery charges will be saved.

- In addition, the system could be configured in the future to automatically order oil, for example, once pre-set re-order levels have been set. In this way, the risk of running out of fuel, or water, is managed to an absolute minimum.

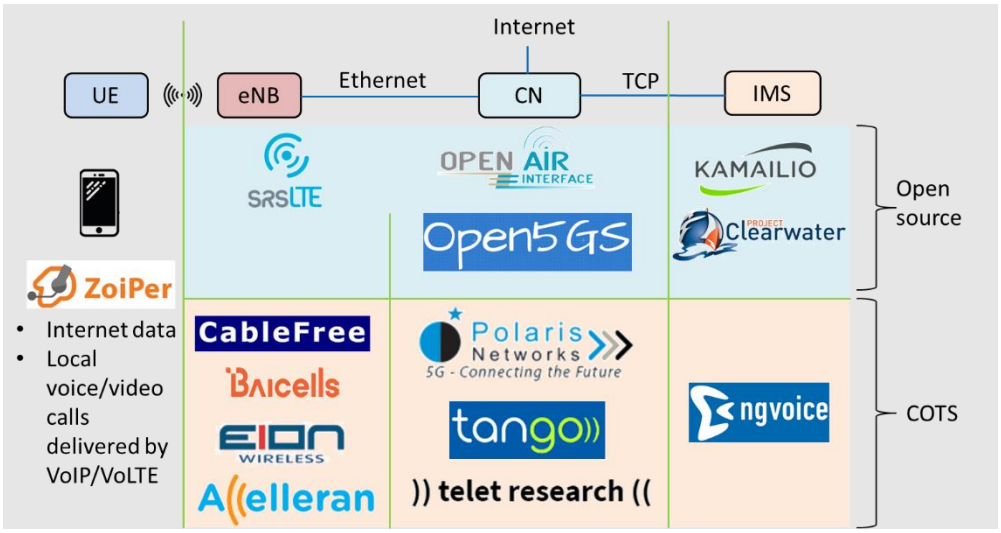
3.4.5 Helikite

The Helikite 5G Testbed has been developed by University of York to demonstrate the possibilities of providing network coverage to temporary events, e.g. planned events such as cycle races, festivals, weddings, or unplanned events such as post-disaster or rescue situations.

The Helikite is a tethered helium balloon-kite, which is capable of carrying small payloads of 10-15kg. The payloads are powered with on board batteries and linked to the ground via a fibre optic cable fastened to the tether. The Helikite system can normally be flown to 60m altitude without the need to seek permission from CAA (except close to airports) or in our case up to a maximum of 400m with permission from the CAA who grant a Notice To Airmen (NOTAM) restricting the airspace to other users around the Helikite. The higher altitudes increase the probability of providing line of sight connections, increasing the quality of coverage available to the end user.

The project has tested a number of options for the 5G payload that are discussed in more detail later. The chosen solution that has emerged exploits a software defined radio-based system, using Open Source Software. While this is experimental so far, it does point to a low-cost solution for 5G provision, which is particularly useful for temporary events, or Tier 2 rescue services which do not have significant budgets for communications. Such Open Radio Access Networks (RAN) solutions can easily be updated, without the need to call on Tier 1 equipment providers. The developed solution has proven very adaptable, so not only can the system be used on the Helikite, it can also be used for ground based deployments providing further flexibility to the end users.

5G Non Stand Alone (NSA) Network Build



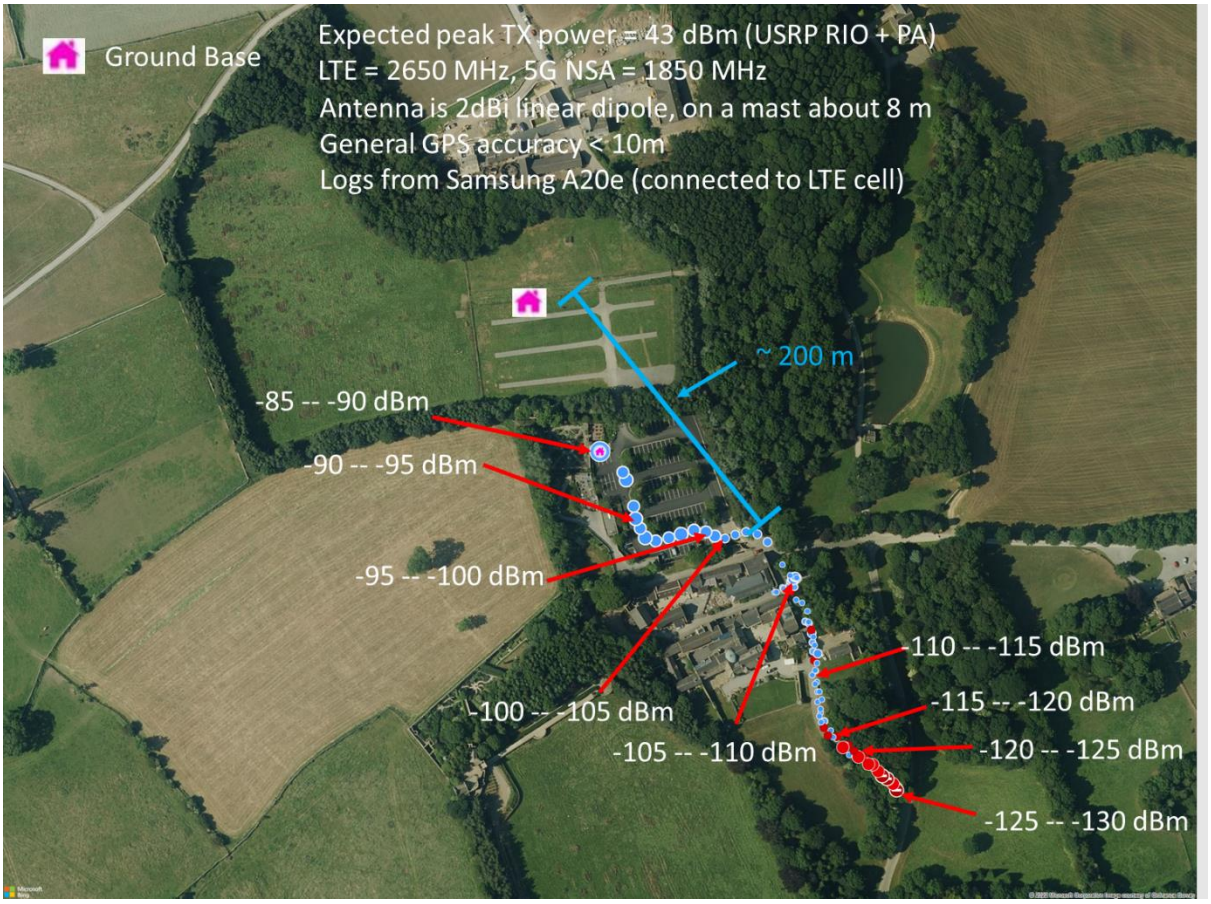
Network software options

Field Trials

Over the period of the project a number of field trials have taken place, each one allowing the team to learn more about the technology and its constraints.

Helikite flights.

Coverage tests were conducted after the live stream was finished to get an initial indication of the possible coverage of a terrestrial system, when the amplifiers were used.



Coverage logs

The picture above shows the coverage test from the logs (LTE cell) recorded on the Samsung A20e handset. The location of the base station offered limited line of site (LoS) coverage at all directions. Although the antennas were on a mast, there were many trees with dense foliage much taller than the antennas nearby blocking the LoS. The RSRP of both cells reduced significantly once the handsets went past the Forbidden Corner main entrance, because the building itself was blocking the LoS path.

The learnings from the Hellkite and the work of YU have led to the enhancement of the Mission Critical solution by converting the payload that was carried by the helikite into a solution that can be easily transported in the back of a vehicle and deployed by a MRT to provide coverage while they carry out their searches.

3.4.6 Mission Critical Services

The Use Case Mission Critical Communications focused on the use of mobile 5G technologies to provide and or enhance communications in extremely rural areas where rescue operations take place. The time taken to remove a critically injured person from the scene of the accident to the medical services is a significant factor for healthy recovery of the patient. Often such scenes are inaccessible by motorised vehicles and patients will need to be carried to safety by the rescue team.

Enhanced communications are critical in these instances for three main reasons:

- the communication between the search and rescue team members is crucial to enable the speedy locating and recovery of the injured person;
- enhanced communications can be used to transmit the injured party's vital signs as they are carried to the waiting ambulance as well as to the recovery team; this saves time as the recovery team will no longer need to pause to measure the injured person's vital signs:
- the transmission of the vital signs to the waiting ambulance enables medical personnel to prepare for the injured person, diagnose remotely possible issues and prepare for the next step after recovery, for example if hospitalisation is required.

Trials and Testing

With such a use case, in which injured people are recovered, it is difficult in real life scenarios to show the benefits of the intervention by the project. Clearly, the recovery of the injured party is the main priority and there is no time to assess new technologies and their benefits. To overcome this, we developed a test scenario to illustrate the benefits of the mobile network technologies.

This test scenario devised was to develop a base line counterfactual and measure against enhanced digital services from broadband enabled mission critical search and rescue. In order to illustrate the benefits, it compares a typical search and rescue in 2 areas of Swaledale in the Yorkshire Dales.

Our rescue scenario envisages an injured mountain biker, with multiple injuries including damaged lower limbs, who needs to be removed on a stretcher from higher ground to a waiting ambulance. This would be a typical search and rescue (S&R) mission for Swaledale Mountain Rescue Team (SMRT) who we've worked with closely on the Mission Critical Use Case.

SMRT covers a large geographical area, in contrast to teams e.g. in the Lake District, who have smaller areas, although they are equally busy if not more so. SMRT were called out 51 times in 2021.

This work generated a great deal of interest and ultimately led to the project being on BBC Click where we demonstrated the work we had been doing with SMRT, implementing a range of apps to help with search and rescue operations. This demonstration took place in Arkengarthdale and required the University of York team to set up a 5G mobile network. The area was chosen as it has little or no mobile coverage. The BBC were keen to show a dog rescue and night vision which are visually engaging and impressive, and we were keen to show a full range of applications including flying a drone and casualty medical monitoring. The technical set up essentially comprised an open source 5G gNB developed by University of York with Starlink LEO satellite backhaul, together with various mobile devices.

For the rescue SMRT had put out a full team of around 10 people, together with a “casualty volunteer” who was to be rescued.

Patch sensors were attached to the ‘casualty’ when she was found and were monitored as she is placed carefully in a mountain rescue survival bag and on to a stretcher, and then brought down the hillside. The advantage of the sensors is that they are low cost and easy to use, as compared to a full ambulance life sign monitoring device. On this occasion we attached ECG, BP and temperature sensors, but on a normal rescue it would be unlikely an ECG would be used, as it is harder to attach correctly, and SMRT advised that the ECG measurement device could interfere if defibrillation was required.

The casualty was successfully brought down and transferred to a waiting mountain rescue vehicle. The Team is regularly called out to assist Yorkshire Ambulance with emergencies in hard-to-reach locations as well as to support casualties from outdoor pursuits. They are trained in first aid and often include clinicians among their volunteers.

The wider *indirect* benefits accrue from implementation of more advanced medical monitoring. These benefits do not accrue directly to the MRT but to the NHS, particularly the Ambulance service, and A&E, and to individuals. Over 50% of SMRT call outs in 2021 were from Yorkshire Ambulance (YAS), plus others from the Police, to deal with medical emergencies. Many of the call outs are for sprains and fractures from trips and falls, but also include support for YAS where they are unable to reach a call out because of adverse weather conditions, or access difficulty.

As a result of the simple testing undertaken, we have suggested a 50% time saving for mountain rescue delivering casualties to the Ambulance service from the use of Bluetooth sensors connected to smartphones.

Health economics is a significant subject in its own right. Concepts such as QALYS and HALE and organisations such as NICE allow for detailed and complex analysis of health benefits (or disbenefits) from interventions, and undertake modelling of projected savings. Such analysis however tends to be disease or adverse health incident specific e.g. stroke, myocardial infarction (heart attack), so does not map readily to the broad range of incidents encountered by mountain rescue.

The speed of response for stroke and cardiac arrest can be the difference between life and death. Ambulance call outs for fractures may be life threatening Category 1 and 2, or maybe Category 3 response, not life threatening but requiring e.g. pain control and transport. “There is limited data on severe sports injury risk, and no national data describing risks across sports” ….however….. “greater severity of injury may be of greater societal consequence, with economic effects of injury, such as time lost from employment, potential time lost from employment for relatives and support providers, and an economic burden of injury assessment and treatment for health service providers”. There is also no current data to support the hypothesis that earlier intervention in sports injury fractures treatment reduces hospital stays etc. However, we can hypothesise that early intervention will reduce the need for visits to A&E and consequent hospital stays, and reduce unnecessary hospital interventions, as recommended by NICE.

It should be noted that the sensors used in the demonstration are not currently approved for emergency monitoring under MHRA medical device regulations. They are approved for home monitoring. For live use in emergency medicine further approval will be required. That approval process would include the need for establishing the clinical benefit of using the sensors for emergency care.

Incremental Benefits

The broad range of other benefits e.g. more information for controllers, sharing drone video, night search video, push to video, GPS for search dogs etc can be described as additional incremental benefits. In the appropriate circumstances they may shorten a search, make a search and rescue safer, but are not a single justification for the additional costs.

Coverage testing was done in situ, and the WISDM predictive coverage tool was also referred to. It was noted that coverage, particularly in valley bottoms, was actually better than the predictive model.

Current system is experimental and needs proven reliability.

The cost of an experimental system is difficult to justify for one MRT but as a shared resource, particularly for training purposes and particularly in the light of future ESN deployment is more justifiable.

The main identifiable direct initial benefit will be improved coverage, but interoperability needs to be addressed.

The greater wider benefit will be in the upgrading of medical telemetry, but this will require a proper evidence base. Savings to the NHS can be estimated and would justify specific investment.

3.5 Mobile Phone coverage by Multi Operator Neutral Host

5G will need a greater number of small cells than 4G to deliver the rural coverage required as part of the UK's wider ambitions for ubiquitous 5G coverage. This requires a larger number of sites going into the heart of rural communities, rather than masts on hills. It is not commercially viable for multiple operators to build these dense networks so "neutral host" sites, which provide services for several operators, will become more attractive. Discussions took place with other 5G projects. There is a recognition that the 5G technology is reaching maturity, but a commercial model which capitalises on 5G's disruptive influence is still elusive.

The neutral host model for the MANY project combines **physical infrastructure (**masts, sites which host equipment), the **technical elements** and **backhaul**. The principle behind the model is that these components can be shared to reduce the cost of deployment in rural areas. There are a number of technical and commercial models which have been developed which involve sharing of different elements.

The project looked to overcome the solution in two ways

- Using Telet network to provide own private mobile network
- Calls via the n77 wireless network

The experience of using the Telet Research "Multi Operator Neutral Host" system suggests that commercial / technical / regulatory barriers need to be overcome ahead of a commercial model being delivered.

Consumer Equipment

The trial service in Coverdale has not been able to deliver a good service for phones, largely due to software maturity issues in the Mobile Core network.

It has been limited to certain models and makes e.g. iPhone 12 with release 15 software, in order to support system compatibilities. It is not available for Android phones due to lack of suitable support on the Telet network, although this is promised for late summer 2022.

A Physical SIM is needed meaning that if the phone is to operate outside of the private network a dual SIM phone is required. The IPhone 12 and many 5G phones only have a single physical SIM slot, with capability to accommodate an eSIM. However, no suitable eSIMs were available for the trial.

Phones which normally connect to EE network struggle to locate the Telet network as the frequencies are close together and the EE phones are steered to prefer a home network signal, even if it's weaker.

In the N77 band, there are very few handsets which support both the N77 frequency and 5G Standalone Mode. Most are configured to benefit from big MNO networks and locked out access to the MANY network. N77 would not work on most handsets.

The N77 service only works close to the mast in direct line of sight, due to the low power levels and weak propagation properties of spectrum in 3800-4200Mhz..

Revenues

MNOs are not sharing revenue for calls made over the networks, ideally via the established "roaming" concept, which makes the value for money business case hard to deliver.

Radio Equipment

The equipment has not worked easily together – as has been the case on other trials. The variety of end user equipment – phones, routers etc. has been harder to manage than on other projects like Liverpool 5G, where the equipment has been controlled to offer an end-to-end solution (which has proven particularly important for 5G SA networks).

Spectrum

The Band 3 / 1800Mhz "guard band" spectrum is close to EE, so phones with an EE SIM tend to "miss" the network and take a while to register. EE is also known to steer their subscribers to reject other networks if there is a small amount of their own service available.

The N77 signal propagation is quite poor and only works in line of sight of the mast over a small area (300m). Higher power is required in rural areas to give greater coverage. It would be unlikely to interfere with MNOs as there will be little 5G mobile coverage in the trial locations.

Licences

The spectrum obtained under the Local Licencing process from Vodafone has been expensive in Coverdale (Vodafone applied a one off administration fee of £10K for 3 sites) – making it unviable across other areas.

OFCOM's process for local licensing has been difficult to work with – it has been slow to get responses on sites, and there is no compulsion for MNOs to say "yes" to an application, even when they are demonstrably not deploying and not likely to deploy the spectrum requested. It is essential that OFCOM moves to a "default YES" position and acts robustly in holding MNOs to account in respect of their spectrum deployment plans.

The solution deployed for 4G was based on the concept of enabling inbound subscribers from other networks to connect via roaming, but was a 4G only solution. However, very few operators globally have rolled out 4G calling, or "VoLTE roaming" and therefore most roaming based Phone calls and texts are currently made over 2G network leaving the 4G network for the data functions. With the announcement of the removal of 2G by 2030, all the MNO's are going to have to operate the calls over VoLTE or develop new approaches which could change the landscape again. Note that we have already seen challenges with this in the USA, e.g. AT&T and T-Mobile have turned off their 2G networks, and many subscribers on holiday now receive an SMS that says they will not be able to make or receive calls whilst visiting.

The performance of the Telet system in Coverdale has demonstrated that this is not a simple plug and play solution. When the end user device is a mobile phone, there are multiple vagaries – the SIM, network configuration, roaming settings and device configuration which all need to be optimised.

3.6 Communications

Communication was seen as a key part of the project, with many different stakeholders to communicate with. NYCC were responsible for this element of the project with the objectives to

- To maximise reach of 5G as a solution in supporting rural lives and livelihoods
- To maximise reach of the findings of MANY to industry stakeholders by showcasing innovative work nationally and internationally of project and partners

There were many different methods communicating on the progress of the project and the values of 5G. These are headlined with the project delivering;-

- Over 400 million reach across all communications. This has included 23 events, 36 press cuts, 4 broadcast pieces (including BBC Click), 39 industry blogs and just under 4,000 attendees at events hosted by or, where MANY were involved
- Press has included hyperlocal, regional, national and international coverage highlighting how 5G can support rural lives
- 28% of attendees at events heard direct from MANY via speaker roles
- Our newsletter had an average of a 65% open rate
- 44 members of the community had an active role in the project (15% approx.)

Sentiment changed from being cautious to supportive although there remained unsupportive residents. This included the MRT team publicly supporting the project, residents highlighting the benefits of the technology and acting as advocates within the community. We saw an increase in awareness of the project outside of North Yorkshire and across other rural areas which increased the numbers attending the final event.

Industry sentiment included being seen at the forefront of engagement and working with and for communities as well as other rural stakeholders highlighting the county as at the forefront of emerging technology, supporting our priority of placing North Yorkshire as a digitally enabled county and included being used as case studies by DCMS in APPG meetings on loneliness.

Planning & Content Creation

METRIC	ONLINE / OFFLINE	ACTIVITY	MEASUREMENT
Content creation	Both	Infographics, videos etc	25 videos 5 x factsheets
Volume of press releases	Offline	No of press releases sent out	7
Volume of SM releases	Online	No of releases to owned social media channels	300 - twitter

The communication activity has delivered the following activity and to the audience reached.

METRIC	ONLINE / OFFLINE	ACTIVITY	MEASUREMENT
Estimate total reach	Both	Aggregate audience reach	400,085,952 (does not include all press reach)
Events	Both	Volume of events	3 x digital leaders 2 x 5G World 1 x 5G Showcase 1 x Connected North 2 x Community event 2 x online community event 8 x parish council meetings 1 x end of project event 1 x Open RAN Europe 1 x 5G Safety in place 1 x Lifting the lid on 5G safety 1 X discussion event Total = 23
Volume of coverage	Both	# exposures	36 x press cuts (up to June 2022) 8 x sponsored content 4 x broadcasts (break local/ national) BBC Click, BBC National news, Look North x 2 4 x Tech UK 31 x UK5G (blogs/ articles) 1 x Lancaster University Mgnt School article 2 x Rural Services Network blogs – website/ newsletter 2 x CLA North – newsletter 21 x Internal articles Total = 106

Estimated total reach (the total number of people available to reach)	Online	Launch Comms - Coverdale	UK Authority Richmondshire Today Telecompaper Northern Echo Government Computing
		Sponsored content – digital champion	Richmondshire Today Northern Echo
		MANY hears experiences	Northern Echo Richmondshire Today BBC National News
		Planning	Richmondshire Today
		Forbidden Corner	The Stray Ferret Gazette Herald Northern Echo Richmondshire Today North Yorks CC UK5G Darlington and Stockton Times York Press Look North
		5G Supports MRT	BBC News/ website BBC Click BBC Parliament UK5G Richmondshire Today Harrogate Advertiser York Press Yahoo Tech Tribune France Daily Advent Communicatistama (Italian) Tech Register Business Fast
			Yorkshire Post

		Go live/ Forbidden Corner case study 5G Showcase – Quickline Newsletter Internal articles	Richmondshire Today Hull Press 80,419 (LUMS an MANY online, printed copies, NYNow) 15,000 audience Over 400,000,000 reach across local, national and international channels
Events	Both	Attendees	600: 5G Showcase event 300: Digital Leaders 100: 5G World 900: Connected North 185: Community events 65: MANY end of project 10: Parish Council 127: 5GTT Collaboration event 1680: Open RAN 23: LUMS Discussion event 75: 5G in place Total = 3,995 attendees
Social media	Online	Owned channels/ Partner channels Twitter LinkedIn	 52,492 Reach 29,020 Reach Total – 81,512

3.7 MANY Sustainability

As part of the 5G testbed and trials the government is keen to understand which elements of the project are sustainable and how this is to be achieved.

This section of the report looks at each element and reviews how it is being used going forward.

3.7.1 5G Wireless Broadband Network

Quickline who are the technical lead for the project have extended the period on free broadband to customers for a further 6 months up to the end of 2022. This has been done as a good will gesture due to the lateness of the delivery of the service. Following this Quickline will offer residents a commercial service at their current rates. The infrastructure is available for any other internet service provider to operate from.

The MANY project has enabled Quickline to gain a far better understanding of how 5G can be used to deliver fixed wireless access broadband – testing CableFree and Mavenir equipment.

The Mavenir equipment is now forming the basis of Quickline's roll out across areas, thanks to the project. This will enable significant improvements in bandwidth for end users over the technologies used previously.

Quickline's clear vision enabled them to raise £50M investment in 2021 to ramp up their growth and the team has grown to take advantage of more projects and opportunities.

The MANY project has allowed Wireless Coverage to develop and prove its WISDM 5G modelling and simulation system at large scale. It has also created an opportunity to develop new features that have never been built in established wireless modelling systems due to the performance of WISDM's GPU-Accelerated engine.

Features that were developed for the MANY project, such as the real-time wireless beam optimiser, which tests the effectiveness of a sector antenna in all directions and at different tilt levels, have now started to give WISDM a fantastic reputation as being revolutionary compared to traditional wireless planning systems.

This has resulted in a number of key achievements which now position Wireless Coverage as a significant disruptor in the 5G planning world: -

- Staff increase from 3 people to 8 during the project - all are high value jobs in software development and AI and Deep Learning. A further 3 staff, including those based in the USA are now planned before the end of 2022.
- Investment from Westbase Group. Wireless Coverage has received investment of more than £500k to grow the business.
- Completed our first commercial AI/Deep Learning project to generate synthetic 3D wireless obstruction data for 5G network planning (for countries where such data is not available), and successfully delivered our first international project for Globe Telecom, who are the largest Mobile operator in the Philippines.

- Launched V1 of our new 5G Small Cell/Mesh design system for Street Furniture network deployment in March 2022. First commercial project success was to use >350 street lights and CCTV posts for a smart cities project across 20 towns in the UK. This has now been purchased for the design of gigabit mesh wireless services for 12 cities in the UK.
- Global partnership has been agreed with Maxar Technologies, which provides access to high resolution 3D mapping data for the entire globe. This has resulted in substantial sales opportunities in the USA, Australia and Africa which are now ongoing.
- We have purchased Gold Sponsorship for North America's flagship Fixed Wireless Access event in October 2022 and will be formally launching WISDM in the USA. We expect to follow up shortly with a similar commitment to NetworkX (formerly 5G World and World Broadband Summit) in October 2022 and Mobile World Congress in Barcelona in 2023, partnering with Maxar Technologies. These activities underpin our strategy to address the FWA market, Small Cell/Mesh and both macro and private enterprise 5G markets.
- New 5G/Private Mobile Network planning system is being released in July 2022, and we already have a substantial sales pipeline at several UK MNO's as well as via partnerships with equipment vendors such as Cradlepoint (Ericsson).

3.7.2 Use Cases

3.7.2.1 Tourism

The Quest app for the Forbidden Corner is being further developed with the team at the forbidden corner as they see it as being a valuable upgrade to their current offering.

Since the beginning of the MANY project Flo Culture has had to change their processes when working with tourism groups throughout the pandemic. They realised there was an opportunity to use the apps to improve processes. These processes can either improve the customers' experience such as the Forbidden Corner app or assist the organisation's processes such as till management or using IoT to assist with staff deployment. Using MANY as a framework for success.

Whilst developing the Forbidden Corner app, Flo Culture had to adhere to new regulations that have affected the deployment of the app. For example, when using camera and facial recognition software they were rejected due to data protection regulations affecting data capture and storage. To overcome this, they had to work closely with the app store to develop a new privacy notice, to clearly state how they will be using the apps data. Flo Culture has realised that the process of capturing data is different when working in rural areas with the tourism sector. They have created new processes to educate and improve internal and external processes because of the MANY project. With this new knowledge, they are able to provide rural communities and businesses digital skills to understand and develop privacy notices, this has become a unique selling point for Flo Culture to use in any future work.

Off the back of the key best practices developed across the MANY project, Flo Culture has developed a digital skills program. Working with Lancaster University's department of Entrepreneurship and Strategy they have developed the program to help digital disadvantaged groups to improve digital skills, especially in rural communities. By using their experience, they will be able to help those working in the tourism sector to improve their digital skills, improving their skillset.

Flo Culture is open to working with the other MANY project partners in the future. They see their skills and experience of designing apps for the tourism sector as well as delivering their digital skills programs can work in other areas of the country where there is 5G connectivity. Flo Culture will use their knowledge to work with different sectors internationally, they're currently investigating the United States as a possibility for pilot work. They believe the collaboration during the MANY project will allow them to use the project partners network to continue to add digital innovation to visitor attractions as well as small villages internationally.

3.7.2.2 Tank Monitoring

The system is being utilised by the Tupgill Estate team and plans for further expansion of the service on the estate are being discussed. aql is a group of telecommunications companies spanning the fixed and mobile space.

As part of the MANY project, aql has created a 5G testbed at RAF Leeming, North Yorkshire. This project has allowed aql to deploy a 5G and 4G innovation network and also an IoT innovation laboratory. This initiative is now a permanent part of the RAFx's technology incubator. The 5G network has been used to connect multiple technologies on-site, including drones, boston dynamics "spot" robots and also Starship (https://www.starship.xyz) delivery robot trials.

Leeming has been used as a base for collaboration, resulting in partnerships on sensor technologies and renewable energy approaches with the Eden project and also the MoD's project VITAL, which is centred around the adoption of circular "cradle to cradle" methodologies to support the carbon neutrality of UK Defence by 2030.

The project has also allowed safe innovation - working with 90 Signals Unit to create sensors and technology to monitor agriculture, crops, beehives and also in wider North Yorkshire, water and fuel tanks to help automate estate management. aql is also the operator behind four other DCMS 5G Create projects and has opened up further collaboration with these other initiatives, resulting in a high degree of overlap.

Whilst towards the end of the project, the new activities between MANY / Leeming and the Solent Marine Enterprise Zone will foster knowledge sharing between the Navy and RAF.

The methodology across all parts of the projects has been to use applicable technology which can be powered in the field by renewables, using modular equipment which can be repaired if needed rather than replaced. aql has also created a low power "Swiss army knife" IoT edge Sensor and developer board which can be used for a myriad of applications from counting bees to monitoring energy usage.

Much of the learnings have also been fed back into the UK 5G Climate and Environment working group, which is chaired by aql CEO, Professor Adam Beaumont. This forms part of a wider aql group project “Sensing Change®” which uses data to positively reinforce the actions and the impact that society is making in its journey towards net zero and beyond.

3.7.2.3 Infrastructure & Environmental Monitoring

North Yorkshire County Council will use the learnings from the project going forward to influence their digital strategy. The council are developing early warning systems using LoRa-Wan technology as well as installing sensors, such as flooding and traffic flow sensors across North Yorkshire as a result of the MANY project. Using MANY traffic & people flow monitoring in Leyburn will be used as an example to be moved into a bigger town or city, the data from Leyburn will be used as a benchmark going forward, this would not have been possible without MANY.

Since the beginning of the MANY project, North Yorkshire County Council have used Lora-Wan as a framework for the future, informing decisions and improving processes. The MANY project has informed them how to discover this data and who to work with to analyse it.

North Yorkshire County Council has developed best practices in regard to community engagement, learning how to better engage with the communities, especially through the pandemic. During the project they had to engage with the community digitally with little to no connectivity, this emphasised the importance of engaging with the community to see how 5G can benefit the community.

The strategy of North Yorkshire County Council has not changed throughout the MANY project. The council strongly believes the projects such as MANY are very important to their strategy, they will continue to discover further funding opportunities to improve connectivity to benefit their constituents and county.

North Yorkshire County Council has future plans to work with York University on a new 6G autonomous project. They will also work with Quickline to install super-fast broadband in the area to further improve connectivity. North Yorkshire County Council are always looking for new opportunities and are keen to work with any partners from the MANY consortia to improve their connectivity.

To support the broadening of the UK telecoms ecosystem, North Yorkshire County Council will continue to work with some partners of the MANY project on projects such as 6G autonomous connectivity as well as super-fast broadband. They will continue to work with the community and local emergency services to understand how they will benefit from improved connectivity in North Yorkshire.

3.7.2.4 Health & Wellbeing

The learnings from this are being taken forward into the health and social care settings within north Yorkshire county council to understand how they can provide further opportunities moving forward. The recent announcement by the health secretary into the further development of the NHS app which will support video consultations will enable the findings of the MANY project to be used further.

3.7.2.5 Helikite & Mission Critical Services

The STARLINK allows University of York to guarantee high speed, low latency broadband internet in remote and rural locations. The connectivity lets the University team the ability to troubleshoot any issues as well as complete analysis and streaming of their activities.

Although the strategy of the team working on MANY has not changed during the course of the project, the new Vice Chancellor has developed a strategy for University of York has developed a greater understanding of how to carry out practical field trials in a rural setting because of the MANY project. The skills they have learned have enhanced the process of completing practical trials away from a controlled University environment. These effective processes will now be taken into future testing when away from the University.

University of York has seen no changes to regulations that will affect their work during the MANY project. However, they have improved their processes when completing spectrum licences for using the Helikite payload.

The MANY project has taught York University best practices when streamlining processes of practical trials in rural areas. They have learned what questions need to be asked, how many team members are required, what equipment is required. Another learning is the addition of a STARLINK. versity research activities to address issues faced by society. The University believes industry related research and projects are very important, especially communications and wireless communication projects, such as MANY.

University of York plans to work on new and different projects, supporting different sectors, but focusing on wireless communications. Using the knowledge and new skills developed on MANY, the University will continue to emphasise the importance of public engagement and outreach. Furthermore, University of York will continue to attend different trial events & conferences to improve their knowledge to develop academic papers for the University. They're very interested in working on projects relating to secure quantum communications and autonomous systems.

Safenetics have been able to use their industry security experience to work with each use case partner to improve the security of all aspects of their business, Safenetics will now use this mentoring as part of their business proposition.

When working with Mountain Rescue, Safenetics realised rugged and durable mobile phones are essential when working in rural locations during pressure situations. Safenetics purchased 16 rugged phones, allowing the rescue teams to use the new push to talk functions without the worry of damaging the phones.

Safenetics business strategy has changed throughout the MANY project. They have developed a new technology platform allowing emergency services to use the software and technology to improve their processes in rural areas. They will also apply their knowledge and work with other practices to improve security at all levels. One of Safenetics main takeaways from MANY project was the benefits of effective collaboration between partners when working on a large scale project.

Safenetics are planning on continuing work with University of York and Swaledale Mountain Rescue, to use the Helikite for further trials. Safenetics & University of York are also planning to work with the Lancaster University monitoring team, allowing them to add their expertise to the trial process.

Outside of the project's consortium, Safenetics are planning to work with other mission critical category 2 providers to use the solution developed during the MANY project in other areas of the UK. They are also planning to continue working on and developing a 5G software solution but with an eye on looking into 6G in the future.

4 Conclusion

- It is possible to deliver a 5G fixed wireless access broadband service which can benefit rural communities, however homes must be in line of sight of the radio mast.
- The Licences from Ofcom for the n77 network should be of higher power to provide greater coverage in rural areas where interference with other frequencies is unlikely.
- All project partners have learned a lot from the MANY project and are keen to use these learnings collaboratively in future projects to support broadening of the UK telecoms 'ecosystem'.
- The current maturity of the technology in the private mobile phone network requires further development and agreed connection to the MNO's networks before it is a commercial solution.
- The Use Cases chosen by the MANY project have illustrated a wide ranging series of applications for enhanced communications in rural areas. We have touched on the areas of tourism, health and wellbeing, Council Asset monitoring and even mountain rescue.
- In all cases, we were assisted by excellent engagement from our potential clients. We made a point of working together with the client in an open, iterative manner, such that they felt included and even ownership of their specific part of the project.
- No individual use case can make the installation of the 5G network viable however by combining a range of use cases then the network becomes cost effective.
- Due to the network going 'live' very late in the program, we have not been able to collect as much data referring to the use case trials as we would have liked. Nevertheless, some data has been collected to illustrate the potential benefits of our intervention.
- Most are trying to use the MANY project as a springboard to further commercial opportunities.