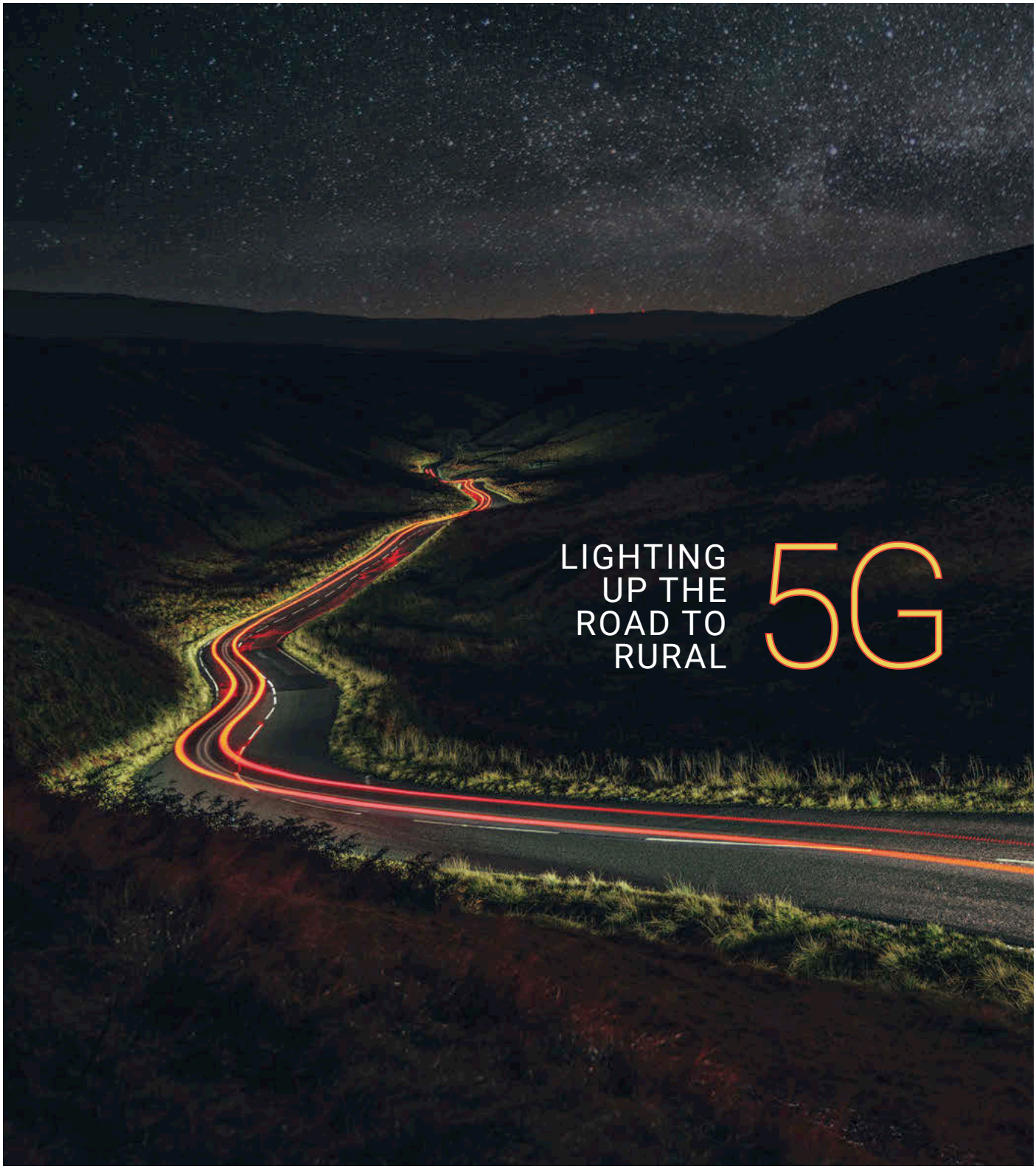
UK 5G

Innovation Briefing

UPDATE
uk5g.org
ISSUE 3

Delivered by CAMBRIDGE WIRELESS Knowledge Transfer Network tmforum



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- Stimulating the links between technology supply and demand across industrial sectors.

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Welcome

GABRIEL BENOIS / UNSPLASH.COM. RETOUCHING STUART BERMAN.

THIS IS THE THIRD edition of UK5G Innovation Briefing, and with each edition, I have been surprised by how much change happens between the publication of each issue. There can, however, be no doubt that the past six months have been pretty unprecedented.

As the world continues to work through the challenges of the Covid-19 pandemic, we've seen an ever greater reliance on communications. With much of the UK working remotely, we're now seeing unprecedented demands on our networks. Despite huge increases in capacity requirements, it's been pleasing to see how the UK has coped. I often find myself reading articles about the UK's fixed and mobile networks that are somewhat downbeat about the position we are in compared with our global counterparts. Naturally, I understand that we have work to do to future-proof our networks properly, and the recent commitment from the government to deliver gigabit connectivity to the whole country is evidence of that. However, I think now is a good time to step back and acknowledge that the UK's networks have stood up extremely well to the recent challenges that we've been facing as a country.

In the 5G Testbeds & Trials Programme, work has continued at great pace during the first half of this year. You'll have noted our announcement back in February, which committed up to £65m to new projects scattered across the country. Two new manufacturing programmes, with Ford and Zeeta Networks, will investigate the use of 5G networks to improve efficiency of electric-car manufacture and productivity and effectiveness of composite design and manufacture. We also have several new projects trialling new deployment models and innovative applications to improve the case for investment in rural deployment and build demand from new use cases. Further details can be found on uk5g.org.

We also announced a brand new competition, 5G Create. This up to £30m open competition is designed to encourage innovative bids from all sectors and industries. Our message to potential applicants is simple; if you have an idea for a 5G project that could genuinely benefit the UK, we want to hear from you!

In the West Midlands, we're seeing our substantial investment continue to bear fruit. WM5G, the delivery organisation for the project, recently announced that it had awarded a contract to a consortium led by Telefonica to deliver application accelerators in Birmingham, Coventry and Wolverhampton. By using the 5G accelerators, businesses and public sector organisations will be able to experience live 5G networks, discover the benefits that 5G can bring to their organisations and work with innovators to take advantage of 5G through new applications and services. At least 2,000 private-sector businesses and public-sector organisations from across the West Midlands and beyond will be able to benefit from using the 5G accelerators over the next five years.

As you can see, it's been an extremely busy period for my team but I'm really pleased with the results we've garnered. Alongside responding to the Covid-19 pandemic, both as a department and by doing our part as citizens, we've managed to launch a host of new projects and a new competition. I hope you enjoy reading all about them here.

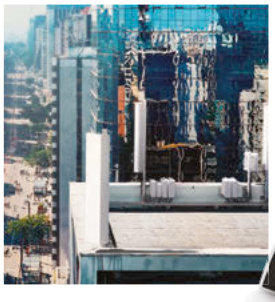
Ian Smith
5G Testbeds and Trials Programme Director, DCMS

Department for Digital, Culture, Media & Sport

Inside

5G UK SUPPLIERS DIRECTORY

An essential resource for all organisations working on 5G projects and for innovative manufacturers looking to promote their products to the UK 5G community.



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12

COVER STORY

RURAL CONNECTED COMMUNITIES

Delivering high-speed mobile connectivity is expensive, and when it has to be done in large areas with sparse populations the business case is challenging. DCMS has backed several innovative projects that are using different ways of thinking to bridge the gap.

34

SECURE BY DESIGN

Thirteen rules provide the guidelines for security. David Rogers explains what they are and why they matter.

36

WORLDWIDE 5G

Collaboration runs at different levels: within consortia, and among projects inside the UK and those around the world.

53

DYNAMIC SPECTRUM

Kenny Barlee sees how mixing 4G and 5G makes the most of a valuable resource.

58

NETWORKING IN ADVERSITY

Bob Driver looks at the challenge of achieving knowledge transfer in lockdown.

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STAR WARS, EPISODE FOUR: A NEW HOPE wasn't called that in 1977. It was just Star Wars. The full name came later. Similarly the Old Testament was just the Bible until the New Testament came along. And 1G mobile phones were never called 1G, they were just cellphones for the best part of a decade until GSM gave us 2G.

So we are in good company. This is the third issue of UK5G Innovation Briefing; except it isn't. The first issue didn't have a name. It was just the UK5G magazine and was supposed to be a one-off. But that went to a reprint and led to a second edition, by which time we had a name. As you read this we are planning further issues.

Over the last year and a bit we've gone from 5G being something for the future to something that's happening. What makes it different from previous generations of phone networks is that we've experimented with it. Of course with the previous versions, we had ideas about what might happen – 3G was going to be all about video calling but it took 20 years for that to be a real thing. With 5G we've had, and have, the Testbeds and Trials, through which we've been noodling with 5G ideas to see what might work. What we've learnt is that 5G will touch every aspect of daily life, so it's great to look at how plans are being put in place to spread connectivity everywhere.

In this issue we look at three ways in which this will be done. The Shared Rural Network is a programme to fill in the total and partial not-spots around the UK. It's brought together the four major networks, and the UK Government is working with them to invest over £1bn on it. This work is starting as a 4G project, but we can expect the network to lay the route for upgrades to 5G. All the major equipment suppliers are building infrastructure with 5G updates in mind. We meet Ben Roome, charged with delivering the project, on page 21.

The second project is the Emergency Services Network. This takes the police, fire brigade, ambulance and customs services off the dedicated Tetra Network and onto 4G. To provide connectivity that's approaching the levels of the dedicated network, BT is working with government to put in extra coverage in the hard-to-reach places. That infrastructure will then be available for all the mobile networks to use. James Atkinson interviews the head of the project at EE, Richard Harrap, on page 26.

The third leg of rural coverage is DCMS's innovation-led approach, the Rural Connected Communities project; this is a follow-on from the Testbeds and Trials programme that is building systems that will enable local areas to determine what they need and researching the technology to deliver it. There are seven projects from Devon to Orkney looking at different approaches but working together. You can read about the intial stages for all Rural Connected Communities consortia in 12 pages starting on page 12.

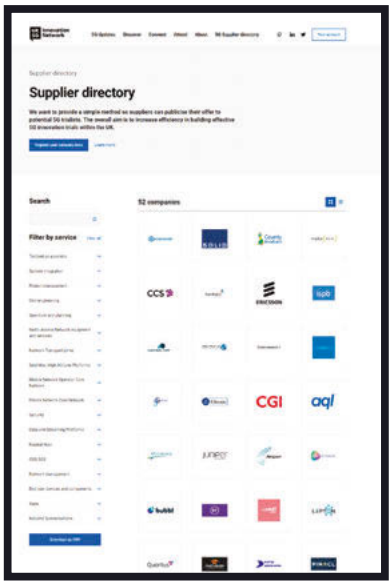
The rural programmes are all part of the government's plans to level up and build a gigabit economy. We are just starting down the 5G road, and UK5G Innovation Briefing will be there to follow the progress. The Star Wars trilogy managed nine main films; the Bible only got to a second edition. We'll see how many generations mobile phones will get.

Simon Rockman
Editor, UK5G Innovation Briefing

Briefing

UK 5G LAUNCHES SUPPLIERS DIRECTORY

Sourcing suppliers and partners is a major challenge for consortia that wish to pull together a 5G project, as well as for the new generation of smaller mobile networks.



It is simple to complete the form on-line through the website. There is no charge for this service, and entries are usually made public within one working day.

UK5G recognised that many organisations considering an application-orientated trial could be confused by the complexity of the technology supply chain, and indeed might not need to build a specific network testbed but could share access to an existing one. Similarly, connecting with those who are looking to create projects is hard for innovative manufacturers of the latest equipment, whether they be large or small.

This new directory addresses these challenges by providing a simple method for manufacturers, integrators and service providers to publicise their offers. The overall aim is to increase efficiency in building effective 5G innovation trials and networks within the UK, as well as a window to the wider world that shows the vibrancy of the UK supply chain.

Users can easily sort the suppliers, which are listed in 44 separate categories. Contact information is provided with a company profile.

The need for the Sourcing Guide is a reflection of how the mobile market is changing in both demand and supply. New spectrum rules for Shared and Local Access Licences have opened opportunities for the formation of new networks, while the adoption of open standards (see p. 46) is seeing a substantial growth in providers of all sizes.

UK5G is now asking relevant organisations to provide short summaries of their offers.

Visit online using this QR code or www.uk5g.org/5g-supplier-directory or mail hello@uk5g.org

MINISTER BACKS 5G FOR LOCKDOWN EXIT

SKILLS IN 5G AND OTHER DIGITAL TECHNOLOGIES WILL be an essential part of the economic recovery from the Covid-19 virus. Secretary of State ***Oliver Dowden*** told UK technology leaders the government would be looking to pass a "GI Bill", new legislation akin to that drawn up in 1944, which retrained American soldiers after the war.

Dowden pledged that he was 'looking at ways to build a highly skilled digital workforce across every region of the UK, so that people can shift into the digital or tech sectors or digitise their own businesses". Central to this is 5G, which will be built on world class, next-generation networks.

Retraining for the digital world, along with a change in the rules on how data is stored so that businesses can "share vital information quickly, efficiently and ethically", will be part of a campaign to turbo-charge the economy. "Right now, our clear priority must be growth - using tech to power us out of the recession, to drive productivity and create jobs in all parts of the tech industry, region by region, and in all parts of our economy," Dowden said.

The initiative has come from looking at how important digital communication has become during the crisis. "With offices closed and shops shuttered during the crisis, tech has kept our economy's engines ticking over. And now, as we enter recovery, tech will put a fresh load of fuel in the tank, driving a new era of growth."

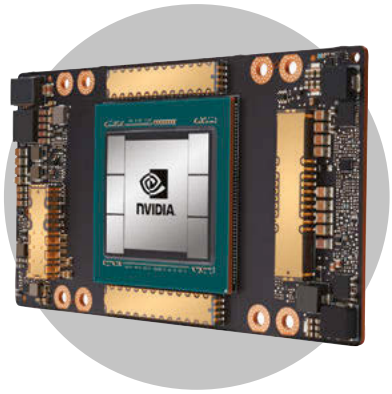
The new strategy will be unveiled in the autumn as one of a number of programmes to retrain people who have lost their jobs as a result of the lockdown.

NVIDIA 5G MOBILE PLANS ARE A GAME CHANGER

TECHNOLOGY DESIGNED for gaming will power 5G networks. Nvidia graphics processing units (GPUs) have expanded beyond gaming to areas such as artificial intelligence (AI), software-defined networks and edge computing.

Nvidia Aerial is a software development kit (SDK) that enables the implementation of cloud-native and software-defined 5G wireless radio access networks (RANs) using Nvidia GPUs and Mellanox network interface cards. The company says that both its platforms and its software enable infrastructure manufacturers to build high-performance 5G RAN to provide AI services such as smart cities, smart factories, AR and VR, and cloud gaming.

Nvidia Aerial SDK is made up of CUDA Baseband (cuBB) and CUDA Virtual Network Function (cuVNF) SDKs. cuBB SDK keeps all 5G physical layer processing (5G-PHY) within the GPUs and is the most efficient implementation of a 5G physical layer in a commercial off-the-shelf platform. CuVNF optimises input/output (I/O) and packet placement on the GPU for 5G packets to be sent directly to GPU memory from GPUDirect-capable network interface cards. This



The latest Nvidia processors are more than two million times more powerful than the one in the original IBM PC

bypassing of the central processing unit improves the efficiency of the baseband unit, making it extremely cost- and power-efficient compared with current alternatives.

The Nvidia platform also offers flexibility to add other functions such as deep packet inspection, firewall and vRAN. Nvidia Aerial's use of existing open-source software such as the Data Plane Development Kit (DPDK) helps developers to add GPU acceleration easily to their existing RAN architecture.

Gaming has a long history of pushing the boundaries in the development of computing, a pedigree that means Nvidia is well positioned to enable a more powerful and application-rich 5G ecosystem.

PHOTOGRAPHY PAUL GROVER

WEST MIDLANDS 5G ANNOUNCES ACCELERATOR WINNERS

WEST MIDLANDS 5G, the largest DCMS-funded project in the UK, has announced details of the organisations that will be creating "5PRING", three 5G accelerators. Telefonica UK will lead the consortium which will include Deloitte, Wayra and Digital Catapult.

Robert Franks, Managing Director at WM5G, added: "The West Midlands has a proud heritage, leading the previous industrial revolution. Through the 5G accelerators that we're launching in partnership with O2 and its consortium, our region is in prime position to lead the next industrial revolution."

The accelerators in Birmingham, Wolverhampton and Coventry will provide innovators with early access to the latest 5G technologies, test equipment and office space. The private networks and demonstration spaces will have large areas of 5G coverage and participating organisations will be supported with the latest devices, professional advice and technical support.

The 5G accelerators are designed to attract businesses and entrepreneurs to solve major problems and find opportunities that can be commercially scaled, when proven. It is anticipated that at least 2,000 private-sector businesses and public-sector organisations from across the West Midlands and beyond will be able to benefit from using the 5G accelerators over the next five years.

Many events and engagement activities run at the 5G accelerators will be sponsored by technology companies or other major businesses, so that small and medium-sized enterprises (SMEs) and other organisations can participate for free. The O2-led consortium is more than matching the public-sector funding provided by WM5G to launch these facilities.

Andy Street, the Mayor of the West Midlands, said: "These new centres will allow thousands of businesses and organisations across the region to experience 5G first-hand, and this will be a great advertisement for the West Midlands as we look to encourage more businesses to relocate here."

For more details of the programme and to register interest see www.5pring.org

SECURITY SUB GROUP ADDRESSES 5G CHALLENGES

A NEW SECURITY SUB-Group has been launched by UK5G to meet demand that was identified by the initial use-case trials of the Testbeds and Trials programme of the Department for Digital, Culture, Media and Sport (DCMS).

Good security is one of the key enablers for the delivery of the economic benefits of 5G, as it ensures that users trust these networks. To deliver a safe, secure and resilient 5G ecosystem, coordination across industry and government will be needed.

A range of 5G security challenges was captured in the 5G Network Architecture and Security report that was published in December 2018. Since then, DCMS has delivered the Telecoms Supply Chain Review (SCR), which highlighted further 5G security challenges and made recommendations for a strategic policy response in the form of a new telecoms security framework. This is currently being developed collaboratively between DCMS, the National Cyber Security Centre (NCSC), Ofcom and industry.

The UK testbeds will continue to be important proving grounds for the development of 5G business models and to carry out research on 5G technologies.

The new group is a sub-group of the Testbeds and Trials Working Group and is chaired by ***Mark Hawkins*** of Qinetiq. The rest of the team comprises:

Woon Hau Chin, Toshiba Research Europe & Bristol University
Stephen Douglas, Spirent Communications
Tracey Sheehan, Utility Technology Council
Francesca Serravalle, Colt Technology Services
Mark Shepherd, National Technical Assistance Centre (NTAC)
Adrian M, NCSC
Anas Tawileh, Systematics Consulting Inc
Saj Huq, Plexal (London Office for Rapid Cybersecurity Advancement)
Ciara Mitchell, ScotlandIS - Scotland's Cyber Cluster
James Cooke, DCMS
David Cuckow, British Standards Institution (BSI)
Darwin, CGI
Greig Paul, University of Strathclyde
Mike Lee, Office of Communications (Ofcom)

Testbeds present a fantastic opportunity to develop and test security principles and policies, at scale, across a range of use cases, as well as to identify security gaps, solve security problems and showcase good end-to-end security practices. This work will lead to increased confidence in 5G networks and support the roll-out of 5G across the whole of the UK.

Aligned to the coordination and influencing activities of the parent Testbeds and Trials Working Group, the security sub-group will have four key responsibilities:

1 To encourage and facilitate secure testbeds through the sign-posting to, and co-ordination of, best practice security approaches that are appropriate and proportionate for research testbeds and their stakeholders.

2 To support testbeds to capitalise on the opportunity to carry out 5G security research in representative environments, at scale. This will lead to identification of security gaps and potential solutions, both generally and focussed on specific use cases and industry verticals.

3 To encourage testbeds to showcase good 5G security approaches. This will increase confidence in 5G technologies and lead to the development of a safe, secure and resilient 5G ecosystem.

4 To coordinate learning on security topics between testbeds and act as a conduit between industry and government via the UK5G governance mechanisms to influence policy, standards and industry best practice.

For more information on the Security Sub Group see www.uk5g.org/5g-updates/research/testbeds-and-trials-wg-security-sub-group/

MOBILE NETWORKS UNITE ON 5G HEALTH

THE FOUR MAJOR MOBILE NETWORKS ARE WORKING together to protect the nation's mobile infrastructure. The organisation Mobile UK, which represents O2, Vodafone, Three and EE, says: "Arson and abuse of telecoms workers is a serious offence, and mobile operators will work strenuously with the authorities to ensure that anyone found conducting these senseless acts will be reported. People need our networks now more than ever and it is vital that the operators' ability to keep Britain connected is not impeded."

Gareth Elliott, Head of Policy and Communications at Mobile UK, told us: ""Mobile connectivity has been critical in underpinning the government's fight against Covid-19. The fundamental shift in the way people work and connect is unlikely to change, and it is crucial that much-needed reforms, such as changes to the planning system to assist network deployment, are taken now to aid the economic recovery." Mobile UK seeks planning reform to help rebuild the economy as it highlights the ways in which the Covid-19 pandemic has changed the use of online services. It says planning laws have not kept up with the demands placed on the networks by the public or with advances in technology. It seeks reform to permitted development rights to ease deployment of mobile infrastructure and increase its economic viability. Mobile UK wants to make it easier to upgrade sites with installation of taller and stronger masts that are better suited to site sharing than those used now.

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Product as a Service in a Connected World

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£1.9m Estimated likely value of new business expected from participants

95% of delegates were satisfied with the event

97% would recommend the conference to other relevant businesses

43% of delegates expected to gain new business

FEEDBACK FROM 2019

"A great event to gain awareness of interesting developments across a range of industries. We do not operate and live in isolation so it is good to connect the dots and have access to the people who can help us learn."

"One the best events around Cambridge to pulse the technology scene, learn something new and network with friends old and new."

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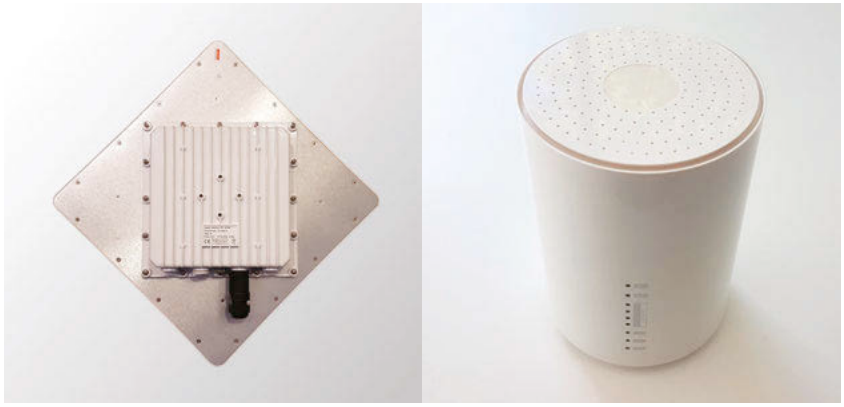


CABLEFREE LAUNCHES 5G INFRASTRUCTURE RANGE

FIXED WIRELESS ACCESS (FWA) expert CableFree has diversified into 5G network infrastructure with a range of 5G base stations and small cells, and desktop and exterior mounted customer premises equipment. All the products are designed and manufactured in the UK.

The Emerald Advanced Software-Defined 4G & 5G LTE Base Station is designed for macrocells with a transmission power of 500mW to 40W, multi sector cells with 2x2 and 4x4 MIMO for faster data rates.

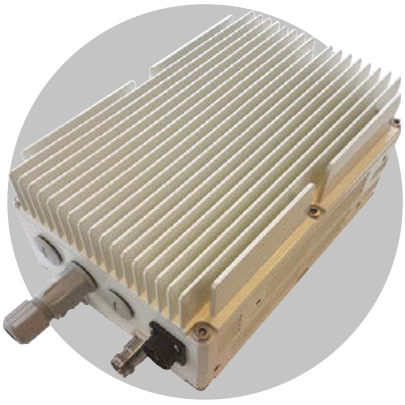
The small cell unit has similar specifications with transmit power of up to 20W. Both support releases 12, 13, 14 and 15, with work to support 5G standalone available today. Both also interface to software-defined radio baseband units, with the small cell version having the option to do this on the mast.

CableFree Chief Executive ***Stephen Patrick*** told us: "With 5G and spectrum sharing, FWA has come of age: users can build a private network for rural not-spots and industrial applications."

The Desktop Indoor 5G-CPE provides a British alternative to offerings from other suppliers. It is available as a full indoor unit, or an indoor unit with additional outdoor antenna for long-distance links. There is an option for a full outdoor, 'carrier-grade' unit if required, with integrated high-gain antenna and ruggedised housing. All units are highly versatile in deployment, with full support for LTE in both time and frequency division duplex (TDD & FDD) as well as multimode wireless capabilities.

The outdoor CPE is ideal for getting broadband to geographically hard-to-reach sites and providing fixed wireless access. It has an option for a built-in high-gain antenna.

For more details see www.cablefree.net



LU JOINS 5G-ACIA BOARD

Following on from last year's announcement of a relationship between the UK5G and 5G-ACIA networks, Sylvia Lu has been appointed to the 5G-ACIA board. As a member of the UK5G board and the International Working Group, Lu's position on both boards will further cement ties between the organisations, which promote co-operation between industries in 5G.

U-Blox's Sylvia Lu and ZVEI's Gunther Koschnick sign MoU

RELIABILITY MORE IMPORTANT THAN SPEED

MOBILE NETWORK testing company Global Wireless Solutions (GWS) has found that reliability of connection is far more important than data speed. In the first study of its kind to combine controlled scientific network testing with a deep analysis of consumer behaviour and expectations of performance, GWS determined that reliability was ranked as more important than speed at a ratio of more than 40 to 1 among respondents, and that 56% of people "usually" encountered problems with their mobile network.

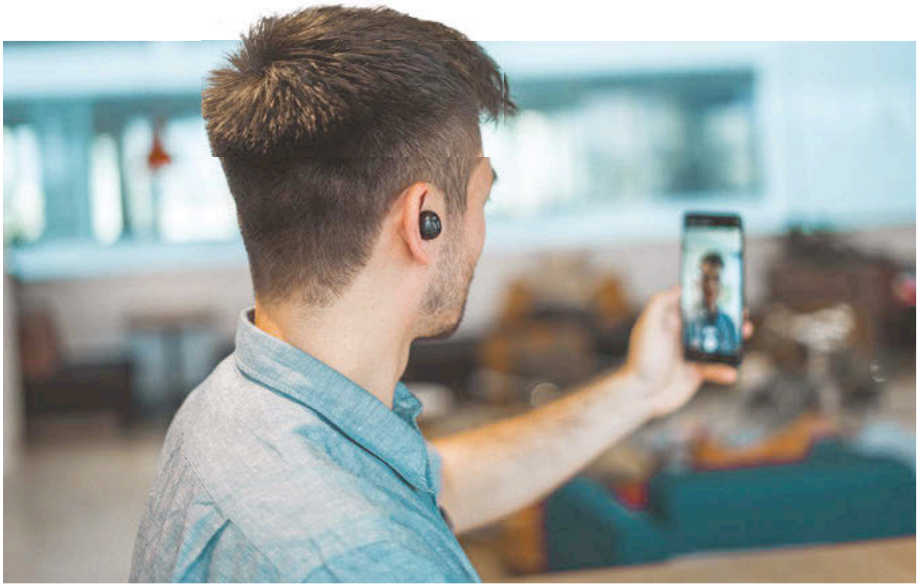
Closely tied to this was the importance of voice. "Making and receiving phone calls" was the most important function of their phone. Nearly half (44%) of respondents said that it was "extremely important" to them that calls always connected when they dialled. Calls dropping infrequently was considered "extremely important" by 37%, while voice-call quality was listed as "extremely important" by 38% of consumers. These concerns related to voice calls were two to three times more important to consumers than data speed.

56% of people usually encounter a problem with their network

Coverage continues to be a key area for operators to improve upon, according to UK smartphone users. When asked to select one area for improvement by network operators, 28% reported the desire for increased network coverage, as opposed to just 8% who wanted to see faster data speeds than they currently experienced. In addition, when selecting a new plan, over half (54%) of people said that network coverage would be an important factor in their decision – more than double the proportion of people who would consider network speed (26%).

For more information about testing and methodology see www.gwsolutions.com

Pinsent Masons



Going Private

Two distinct licensing issues are relevant to operators of private 5G networks. Spectrum and Patents need to be understood.

There is growing excitement around the opportunities offered by private 5G networks. Much of the early focus has been on smart manufacturing, though as the DCMS 5G Testbeds and Trials programme amply demonstrates, the potential use cases – from industrial to rural – are wide-ranging. For private networks, the '5G difference' is in the data speeds, ultra-low latency, massive capacity and reliability on offer, combined with the opportunity to tailor dedicated networks to the needs of the user, around security in particular.

Of course, none of these opportunities can be realised without access to spectrum. This presents a challenge for interested parties that are not conventional spectrum-holding businesses. One option is to partner with a holder of licensed spectrum such as one of the major mobile network operators. However, other routes are available following moves by the regulator Ofcom to open up certain spectrum bands to a wider range of stakeholders. Since late 2019 private operators have been able to apply for a 'shared access licence', to access spectrum to support localised wireless connectivity.

The regulator envisages this form of licence underpinning a wide range of applications including "manufacturers connecting machinery wirelessly, farmers connecting agricultural devices such as irrigation systems and smart tractors wirelessly, enterprise users setting up secure private voice and data networks within a site, as well as rural wireless broadband connectivity using fixed wireless access"[1].

Applications are handled by Ofcom on a first-come-first-served basis and licences are allocated for specific locations, taking into account any interference issues with existing spectrum holders. At the same time, the licence terms contain 'use-it-or-lose-it' provisions which allow the licence to be revoked if the spectrum is not used within six months. Would-be applicants are therefore being encouraged to move quickly, but should also ensure they have concrete plans in place for how the spectrum will be put to use in a short timeframe.

Patent Pressure

Licensing is also relevant in terms of access to 5G technologies needed to operate a private network. 5G is a standards based technology. Standards are developed by businesses working together in collaboration under standardisation bodies such as the European Telecommunications Standards Institute (ETSI). If a patented technology becomes part of a standard and it is mandatory to implement that feature as part of the standard, that patent is termed a standard-essential patent (SEP). The SEP holder can ask implementers to pay a royalty for using that technology. However, a patented technology included in the standard should be available to any potential implementer of the standard and the holder of an SEP must license on fair, reasonable and non-discriminatory (FRAND) terms. The FRAND licence rate is agreed between the parties by commercial negotiation, but often disputes arise as to what constitutes 'FRAND'. If the SEP holder and the technology implementer cannot agree on FRAND licence terms, these will require determination by a tribunal. The courts in England and Wales have indicated their willingness to do this.

Various entities have already indicated that they hold 5G SEPs. Successful 3G and 4G patent licensing programmes have demonstrated that income from patent royalties can be significant. The target market for 5G patent licensing will be much larger than 3G and 4G since 5G will be required across a range of sectors. The licensing of 5G technology on appropriate terms will therefore be an important consideration for smart manufacturing and other private networks where connectivity is critical.

Testing the Framework

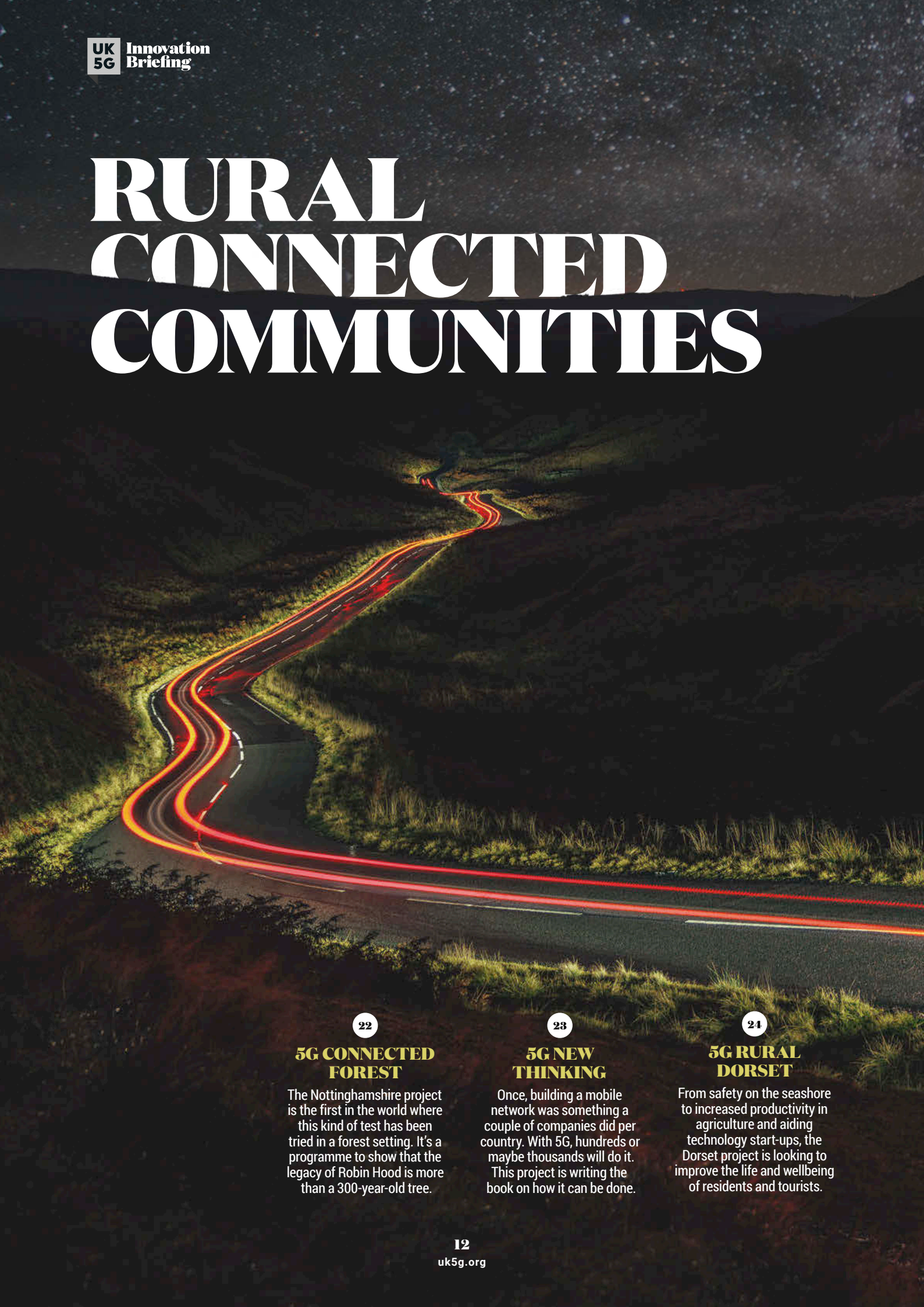
SEP do change hands and patent assertion entities (PAE) often acquire patent portfolios to assert high royalty payments. PAEs use patent litigation as leverage to compel technology implementers license their patents. The story so far with PAEs in the mobile sector has been to target well-funded new entrants to the market and, preferably, the seller of the end product or service, as opposed to component suppliers.

Though commercial private 5G network deployment is still in its infancy, it is plain to see the potential advantages of combining the performance of 5G with the security and configurability of localised connectivity solutions. In the UK, Ofcom has set out its initial framework for widening access to the spectrum needed to fuel growth in this market. Whether this framework meets the needs of industry will now be put to the test. At the same time, industry observers will be watching closely for early signs of how the licensing of SEPs will play out in the 5G arena.

For more information on the licensing issues related to 5G network operators and its legal implications to your organisation, please get in touch with Pinsent Masons' technology and IP law experts: Nick Hutton (nick.hutton@pinsentmasons.com) and Mark Marfé (mark.marfe@pinsentmasons.com).

[1] STATEMENT: ENABLING WIRELESS INNOVATION THROUGH LOCAL LICENSING. OFCOM (25 JULY 2019) HTTPS://WWW.OFCOM.ORG.UK/__DATA/ASSETS/PDF_FILE/0033/157884/ENABLING-WIRELESS-INNOVATION-THROUGH-LOCAL-LICENSING.PDF

RURAL CONNECTED COMMUNITIES



THANKS IN PART TO THE initial phase of the DCMS' Testbeds and Trials programme, the UK is a world leader in 5G. The projects have informed the use cases and the nation has developed a unique level of understanding. But there is a problem. UK coverage by 4G is poor, and the value of 5G will only be realised if the lessons learned in the previous trials can be rolled out to everyone.

Looking for an innovative solution to the problem of rural coverage, DCMS has selected seven trials as winners of the Rural Connected Communities competition, subject to the signing of grant funding agreements these will be awarded funding from the 5G Testbeds and Trials Programme.

There are seven projects in Nottinghamshire, West Mercia, Orkney, Dorset, Monmouthshire, Wiltshire and Yorkshire. All are rural areas that have both unique problems and common difficulties that they are tackling in a variety of ways by using 5G.

Over the following pages, we look at each of the projects, which are in early stages of development, that represent a wide spread of approaches from working with mobile operators to rolling out their own solutions, partnering with major vendors to being test sites for a new tier of small manufacturers. This is a research project and, with the help of funding and a guiding hand from DCMS, the aim is to produce solutions to the problems of getting the best connectivity to the hardest-to-reach spots. New spectrum licensing laws allow Ofcom to grant access to third parties when an operator that has the right to use spectrum nationally has chosen not to do so. This provides opportunities for companies, institutions and communities to build innovative solutions that will bring 5G to the most underserved areas of the UK.

Everyone involved is keen on collaboration and implementing lessons learned from the previous trials. The projects are scheduled to end in March 2022. That doesn't offer a long time to plan and implement solutions that have eluded the major mobile networks for years, but if the results of the initial trials are anything to go by, the Rural Connected Communities project has a good chance of success.

NIGHTS OF THE ROAD

This shot by Richard Pardon was taken in Kielder Forest – the largest Dark Sky Park in Europe. The single 30-second exposure uses the lights on a Porsche 718 Spyder to stunning effect.

25

COCORE

The Welsh valleys are a significant engineering problem for mobile phone networks and many of them are without coverage. Now Monmouthshire council has a plan to install 5G where many people don't have 3G.

26

MOBILE OPERATOR NEUTRAL HOST

In the summer of 2017, the residents of the Chalke Valley in Wiltshire became so fed up with the lack of a mobile network that they started their own. Now, with the help of DCMS, it's being upgraded to 5G.

27

MOBILE ACCESS NORTH YORKS

Many small villages in North Yorkshire have poor coverage. The few residents affected cope day to day. But when the Tour de Yorkshire rolls in, a base station in a kite offers a solution.

29

WEST MERCIA RURAL 5G

The Shropshire and Worcestershire borders present service challenges. This project looks at how the creation of new models and services can bring the benefits of 5G to rural areas.

5G Connected Forest Project

The future is bright, the future is green, with an ambitious scheme to give a techie twist to the tourist trail and environmental protection in Nottinghamshire.

ROBIN HOOD LAST rode through the glen over 800 years ago, but thanks to the 5G Connected Forest, we will again see him among the oaks, birches and sweet chestnuts of world-famous Sherwood Forest.

The plan revolves around the use of augmented reality, supplied by Nottingham app and website developer Gooii, to enable visitors to enjoy the forest and explore not only the wonders of the natural environment but also the myths, legends and history associated with it. This will help to immerse visitors in the history of the forest in a new and engaging way and aid their understanding of the natural and cultural importance of Sherwood and why protection of it is vital. The legendary Major Oak, reputed to have supplied shelter to Robin and his merry men, is around 1,000 years old and precious, but Nottinghamshire County Council wants visitors to enjoy much more of the forest.

Project lead ***Ceren Clulow*** explains that it's all part of a broader plan to use 5G to encourage tourism and enhance the care of the forest through the use of robotic environmental management and live monitoring. The Royal Society for the Protection of Birds (RSPB), which manages the forest on the council's behalf, will use this technology in its work to care for the health of the forest.

Ceren Clulow
5G Connected Forest

The connectivity technology is provided by Swedish company Netmore. It is a neutral host solution based on localised roaming over the top of a private network. The consortium aims to apply for a local access licence for 1800MHz and to use the shared spectrum of 3.8-4.2 GHz to distribute the signal through the forest and then link it to augmented reality headsets over Wi-Fi. The 5G signal will also link to touch-screens in the digital hubs. Any new installation requirement will be agreed with the RSPB and Natural England, which is the ultimate authority for infrastructure installation within the designated forest area.

Netmore's Managing Director ***Stefan Stanislawski*** is on the hunt for the right terminal equipment. He told us: "The tourism concept in the Connected Forest is primarily augmented reality. You don't need any fancy devices, you just need something that works. But on the augmented reality side [through people's mobile phones], we're at the beginning because nobody's phone will support the shared access bands." He expects the solution to be 5G dongles that will be attached to the augmented reality headsets.

Visitor content will be created by Gooii, which will work with the RSPB and consortium partner Parkwood Outdoors. The content will be trialled indoors and outdoors through digital hubs at the Sherwood Forest Visitor Centre and at Rufford Abbey Country Park, where people can enjoy the forest experience whatever the weather.

Various other companies are involved in the project. Bus company Stagecoach is supplying two buses for the project to trial 5G-connected and semi-autonomous vehicles. The aim is to use a nearby office car park, which is empty at the weekends, as a park-and-ride site for the entire area. Semi-autonomous, lightweight vehicles may also be tested to support mobility from the visitor centre car park to the forest.

Harworth Group, a consortium member that is building a housing development close to the forest, is looking at linking the homes to the forest via semi-autonomous vehicles.

Connected Forest is very much about the use-case applications. Stanislawski told us: "We're not building a network just because we can, we're building it to be used for something. And that something is the belief that augmented reality, and other technologies that 5G enables, will add a lot of value to the visitor experience. There are a number of operational problems: the headsets are very expensive and we have got to stop people walking off with them. So there's a whole load of things to be solved. The 5G part is obviously my focus, but it's only part of the jigsaw."

Nottinghamshire County Council leader Kay Cutts summarises the ambition of the project: "Nottinghamshire is once again at the forefront of the latest technology. This will be the world's first testing of 5G in a forest. It will bring the stories of Robin Hood to life in a new way."

5G New Thinking

An important goal for all the DCMS projects is collaboration and knowledge sharing. Cisco and the University of Strathclyde are taking this a step further by providing the tools for any organisation or group that wants to build its own 5G network.

THE MOBILE WORLD IS evolving. It always has, but the step into 5G will see a step change unlike any we've experienced with previous generations. The change is the ability to set up small private networks. In the long distant past, all connectivity came from a state-run monopoly. More recently we've seen two, three or four private companies own licences to run telecoms across whole countries. With 5G we'll see hundreds, perhaps thousands, of networks per country, in factories, campuses and in isolated communities. This change will do for telecoms what desktop publishing did for the publishing industry, and it will change the business forever.

RURAL FIRST, NEW THINKING SECOND

Hence 5G New Thinking: with 5G and local networks the thinking will be different. The people behind the Rural Connected Communities project are old hands at this; the team members were the people behind 5G RuralFirst, one of the initial DCMS-funded trials, and they have extensive rural experience in challenging conditions. 5G New Thinking reunites the University of Strathclyde and Cisco as the major members of the project consortium. Once again, the project takes place in the digitally underserved archipelago of the Orkney Islands, working closely with communities and local authorities in the Borderlands and Northern Ireland, to better understand the challenges that face all the UK's rural areas. 5G New Thinking will provide a practical how-to guide for rural communities looking to invest in local connectivity. It is less about what you can do with 5G and more about turning an advanced technology experiment into a process. By developing a replicable and flexible approach, the project aims to help poorly connected communities to build commercially sustainable, next-generation networks using 5G technologies. Cisco's ***Des O'Connor*** explains: "It will help communities figure out everything that they need to do, whether it's wireless access or a neutral host function or a private 5G network."

Des O'Connor
Cisco

STUART BERMAN

The toolkit will take the prospective mobile network operator through the steps the MNO needs to take, from site surveys and spectrum application to delivery. It can also be used to consider business cases and financing. The 5G New Thinking team is keen to work with the other consortia to help and learn from them. The toolkit is expected to provide details of experts and vendors as well as experiences.

WHAT'S IN A NAME?

O'Connor plans to work with organisations on various models of neutral host, in which a private network lets in visitors who are customers of other mobile network operators. Using neutral host technology, visitors might see the name of their usual network on the phone or the name of the private network. Such a system requires major business, political and architecture decisions. In the version in which the external operator's name is shown, the network is broadcasting that external network's mobile network code, so the private network might have just the Radio Access Network hardware. This requires the private network to have full signalling with the other cells held in the area by the major network. In the version in which the new, private network's name is shown, full infrastructure is needed at the backend. The toolkit will outline the pros and cons of each approach.

All the RCC projects involve spectrum issues, but O'Connor has been there before with RuralFirst: "We used 700 MHz, 3.5 GHz; we even used 32 GHz. One of the things we'll be doing in 5G New Thinking is exercising all of the spectrum capabilities of Ofcom offerings. So we'll be asking for spectrum and then working on a number of different spectrum platform areas. That might be in the 3.8 GHz to 4.2 GHz part, or potentially into spectrum owned by operators that is not in use."

The team has carried out a radio survey over most of the Orkney Islands, and worked with the local internet service provider, CloudNet, to establish backhaul. The project has already proved to be a fantastic testbed for accelerated understanding of 5G and the business model around it. That will feed back into 5G New Thinking.

The General Post Office used to run all telephone and postal services in a monopoly model that can be traced back to the Telegraph Act of 1868. After that, slow evolution led to the formation of two separate businesses, mail and telecoms, in the 1980s. The advent of 5G will be the biggest change in 152 years.

5G RuralDorset brings the future to the Jurassic Coast

A project to go beyond the issues of poor rural coverage, 5G RuralDorset seeks to understand the needs of the local community and harness the power of 5G to make Broadchurch county a technology-led area for residents and visitors alike. Project lead Colin Wood explains.

HOW DO YOU BRING next-generation connectivity to beautiful rural Dorset, with its world-famous Jurassic coastline and most of the county designated as Areas of Outstanding Natural Beauty? That's a large part of 5G RuralDorset's challenge.

Led by Dorset Council, our consortium of local, national and international partners was recently awarded £4.3m as a winner of the Department for Digital, Culture, Media and Sport's (DCMS's) Rural Connected Communities competition.

The project will address the cost and design challenges of using common wireless infrastructure at national scale to deliver services to rural communities. This will be evaluated by three service providers – Wessex Internet, Excelerate and Vodafone - and across four different research areas that respond to the needs of those living and working in, and visiting, rural and coastal regions of Dorset and beyond. Part of the challenge will be to use existing communication infrastructure – masts, buildings and fibre - wherever possible, to be sensitive to our environment that is recognised by the United Nations Educational, Scientific and Cultural Organisation.

Four sites will be built in Dorset to trial innovative public, social and business uses of 5G. Applications that will be trialled will help to save lives, boost the local economy and accelerate innovation for Dorset businesses.

FOUR RESEARCH AREAS

Connected Coast – the UK's coastal regions provide significant economic, leisure and health benefits. But the coast can be dangerous. There are serious challenges to communication in such regions. The first responder community and organisations such as the Royal National Lifeboat Institution, the Maritime and Coastguard Agency and the General Lighthouse Authority have very limited access to digital communications services. Excelerate Technology will deploy a 5G services test area along sections of the coastline.

5G RuralDorset will trial digital applications that engage with the public and improve the responsiveness of emergency services to incidents. The project will evaluate the upgrade of existing infrastructure around the coast and develop the social and economic cases for deployment. It will consider additional use cases, from tourism and aquaculture to education and healthcare.

Lulworth Estate – At the home of the famous Durdle Door and the beautiful Lulworth Cove new mobile services will be used to unlock social and commercial benefits. For instance, Vodafone will bring enhanced mobile-phone coverage to the area for locals and the one million visitors who come each year. This should benefit the holiday industry. Additional possible uses in areas such as tourism education and healthcare will also be considered.

Agri-tech – On remote farmland, new wireless technology will be placed on existing masts and fibre that is owned and operated by internet service provider Wessex Internet, enabling rapid deployment on a significant scale. This will unshackle the burgeoning agri-tech market, providing solutions that will bring farmers together to reduce economic risk and improve the rural environment. The collaborative work will show that existing and new infrastructure can be combined to deliver next-generation connectivity affordably.

5G Innovation Accelerator – next-generation connectivity will be provided at the heart of the Dorset Innovation Park, a Local Enterprise Zone and advanced-engineering centre which supports companies that develop innovative products and services. This will be connected to other sites in the UK and focus on wide-area connectivity solutions for rural and coastal regions. It will support businesses that operate in the county and across the supply chain to test and develop products before deployment in a collaborative and secure way in this strategically important location.

Alongside Dorset Council, Vodafone, Wessex Internet and Excelerate Technology, the project is being delivered by Bournemouth University, Kimcell, Hugslock, Telint, Neutral Networks, the University of Strathclyde, New Generation Internet Services and Satellite Applications Catapult.

Colin Wood
Programme Manager

STEPHEN DUNCOMBE SHUTTERSTOCK

5G RuralDorset Programme Manager Colin Wood is a former journalist with many years' experience as a local government and National Health Service Head of Communications. He is passionate about cycling, live music and the power of technology to transform public services. You can follow @5GRuralDorset on Twitter

Connected Communities in the Rural Economy

Communications doesn't always mean data, it can mean physical transport. But in many rural locations that is a challenge. The Welsh consortium is looking to 5G to help bring the multimodal transport experience to the valleys.

MONMOUTHSHIRE has nine castles. Unfortunately, when construction of Raglan Castle was started in 1437, no plans were made regarding ways to get broadband to the building. Nearly 600 years later, they are still waiting for fibre, so the project entitled Connected Communities in the Rural Economy (CoCoRE) is looking to use 5G gigabit connectivity to boost tourism in the region.

The project, run by a Welsh consortium, concentrates on using 5G technology to deliver benefits in tourism, transport and the rural economy around the counties of Monmouthshire and Blaenau Gwent.

One aim of the project is to help with transport issues, with which all rural areas struggle. Multi-modal travel solutions, such as park and ride or car sharing, are common in cities, and CoCoRE wants to bring them to South East Wales in ways that suit the local situations. ***David Warrender***, the project leader from the Welsh Government, told us: "We recognised the challenge of joined-up rural transport; what we want to do is make that experience seamless."

The coverage area the project is looking at implementing takes in the former steel making town of Ebbw Vale, which once housed the biggest steel making site in Europe. This valley, which is so steep it has what feels like a vertical railway, poses a coverage challenge. Even at the site of the local hospital, only one of the UK mobile networks claims indoor coverage. In Monmouthshire the project is looking to fill pockets of poor coverage. Those of us working on ***UK5G Innovation Briefing*** feel a certain affinity to the project as the area is close to where this magazine is printed.

The Connected Communities in the Rural Economy (CoCoRE) project will support rural economies through connectivity, with a particular emphasis on lifestyle and well-being for the population, food security and resilience, with better information across the farm estate.

The tourism aspect builds on the work that the University of Bristol has done at the Roman Baths in Bath.

CoCoRE wants to use mixed reality to transport visitors back many centuries so that they can experience the castles in their heyday, although of course they are not looking to replicate the levels of connectivity that would have been familiar in the 15th century.

Mobile Access North Yorkshire

Poor coverage issues led to the county council urging the major networks to support rural areas. When the networks declined the offer, a consortium approach to the RCC programme came to the rescue.

EVERYWHERE IN THE country, people complain about their mobile coverage, but in rural North Yorkshire 35% of the landmass has no 4G signal. The Mobile Access North Yorkshire (MANY) consortium has a plan to change that.

The project is a collaboration between Quickline Communications, North Yorkshire County Council, Cybermoor 5G Services, Flo-culture, SafeNetics, Wireless Coverage and the Universities of Lancaster and York. And yes, the rivalry has continued since the battle of Bosworth Field. It leads to a healthy competition.

Fixing the coverage problem has been tried before. The Local Enterprise Partnership with North Yorkshire County Council offered the mobile networks a £1m contribution to begin to improve coverage. None of the mobile network operators expressed any interest in it. However, the council had a project officer in place who was responsible for improving coverage, and this useful link provided a starting point for the consortium, many of whose members were involved in the 5G Rural Integrated Testbed (5GRIT).

Cybermoor's Head of 5G Infastructure and Services ***Daniel Heery*** explains: "We'd done some work in North Yorkshire and had spoken to the council and LEP about it. They were quite keen to explore further. So when the 5G Rural Connected Communities competition was announced, it made sense that we got everyone together, as Quickline Communications already had some network presence there, to look at the potential of the area, focusing our use cases on local issues."

Those use cases start with tourism, a crucial industry to the general economy of the county. Just being able to provide connectivity to visitors is important. As Heery says: "People visit on from Leeds or Newcastle, often meeting up with friends and family who have travelled separately. When they arrive and are about to call to meet up, they realise they can't connect with each other because they have no signal, making the simple things difficult." It's not just the visitors who need coverage, but those who run the sites. North Yorkshire is full of stunning attractions. But a lack of connectivity means they often can't compete with those that can offer an enhanced digital experience due to the lack of mobile data coverage or Wi-Fi. Heery points out that the situation has always been bad, but in the period of Covid lockdown, during which the only contact with customers has been online, the lack of connectivity has been devastating. Locations need an online presence so that they can attract and keep customers engaged while they are at home, so that they will visit in the future. This is one element on which the MANY project will focus. Consortium partner Flo-culture, which specialises in story-telling apps and websites within the arts, heritage and tourism sectors, aim to develop and test innovative visitor experiences that explore how the use of advanced mobile access networks can support and drive the growth of the tourism economy.

Daniel Heery
Cybermoor

PHOTOGRAPHY

UP IN THE AIR

The second tourism use case is around the Helikite. This apparatus is a combination of a helium balloon and a kite. Like a World War II barrage balloon, it is lighter than air but can use aerodynamic lift to enable it to carry heavy loads. MANY will use Helikites to provide temporary connectivity at events throughout the county. One event that the consortium has in mind is cycling's Tour de Yorkshire. This event runs through lots of small villages which typically have a population of 200; during the course of the event day, 10,000 people arrive and want to get on their phones and upload posts to social media. Helikites enable rapid deployment of extra coverage. Flying at heights of less than 200m, they can provide radio coverage over more than 100 square miles. Some cyclists

SHUTTERSTOCK

send live telemetry and video to motorcycle outriders using proprietary radio systems. This can then be streamed from the motorcycle through 5G. MANY sees an aerial platform as the way to provide the connectivity required to any sort of temporary traders present with stalls. Security can be offered with techniques such as Push-to-talk, and people also turn up who want to livestream the events.

The work to set up the aerial platforms for 5G coverage is being done under ***Professor David Grace*** at the University of York (www.york.ac.uk/chapa), which has customised the Helikite system from Allsopp Helikites (www.helikites.com) to carry various different payloads, along with the trailer that is used to transport them. Grace's team won National Instruments' 2018 Europe, Middle East and Africa Engineering Impact Award in the wireless communications category for the development of a software defined radio-based system to be used on the Helikite.

The technology has to be cleverly designed. It's expected that a fibre-optic cable will run from the base station in the air, down to the ground. Power might take the form of flying batteries or another cable. Which solution is adopted will depend on the application. Tethered aerial platforms are suitable for something like a concert, where connectivity is only needed to fill in when bands are on stage. In the future, for longer term coverage, free flying solar-powered high altitude platforms located at 60 000ft will be capable of regional connectivity that endures.

Beyond tourism, MANY is looking at the work that can be done in wellbeing and mental health, primarily focused on loneliness and people who are isolated, through use of technology such as different apps, voice-activated assistants like Alexa and variations on it, to deliver support to people who are on their own. The consortium wants to add into the mix a support system for doctors who use video links through the accuRx system.

PEAK DEMAND

MANY is keen to address the lack of connectivity in the hills of North Yorkshire, not just so that climbers of the Three Peaks can show off on Strava, but to support the local mountain rescue service. The project organisers are keen to work with the Emergency Services Network to provide a mission-critical layer.

A cell in the sky is an ideal way to cover events

EXPERT PANEL

Kites have been used since the dawn of radio. Marconi used a rokkaku design for the first trans-Atlantic radio transmission. Now MANY is bringing 5G technology to the skies above North Yorkshire.

The social good extends to infrastructure monitoring, keeping an eye on any bridges or roads that are at risk of flooding by putting in sensors that are linked to the highways team at North Yorkshire County Council over a mixture of NB-IoT and LoRa wireless networking. It needs to be robust, Heery notes: "The biggest problem tends to be if you've got a storm, and you get a lot of rain, there tends to be wind with it as well, and that tends to knock out the power supply." Fortunately, Quickline Communications has a lot of experience of running these networks and understands the importance of redundancy and resilience, but there are lessons to learn. Heery is pragmatic about this: "I think one of the important things for us with the actual 5G hardware is to see how it performs on the moors and in the Yorkshire Dales through winter. A lot of this wireless kit that we've had in the past in Cybermoor works great on an industrial estate in Slough, on a bracket on the side of a factory, but when you actually stick it on the side of a hill and you give it 100 mile-an-hour winds with rain, you get water ingress, you get icing, and it stops working. So if we want to actually know how this stuff operates in real-life conditions, then we need to put it through those extremes."

The project has two years to learn these lessons, and to prove that Yorkshire doesn't have to be a place where high-speed mobile data fears to go.

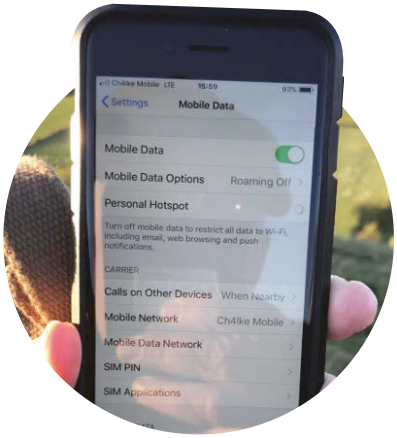
Mobile Operator Neutral Host

The largest contiguous inland not-spot is just south of Stonehenge. Promises of connectivity from big operators came to nothing, so the local community took matters into its own hands and built a network.

MOBILE OPERATOR Neutral Host (MONeH) is one of the most technology-oriented consortia in the Rural Connected Communities projects. Its name reflects the implementation of one of the less talked-about features of 5G. Neutral Host is a mechanism through which a company, community or campus can put in its own mobile network and then provide connectivity for the main mobile network operators.

A FIVE-CELL NETWORK

The Chalke Valley in Wiltshire is a beautiful, small, rural community about 20 minutes' drive from Stonehenge that is distinguished by having its own mobile phone network: Ch4lke Mobile. The 4 in the name is a tribute to B4RN, Broadband for the Rural North, a



community-led project north of Lancaster set up by local residents so fed up with not having decent internet that they built a network themselves. Ch4lke Mobile is a community mobile-phone network which grew out of the frustration felt by ex-Royal Signals officer ***James Body***, a Chalke Valley resident who wanted mobile coverage in his village of Broad Chalke. Body has built international mobile networks in the past and understands the challenges of making a mobile network, including radio, spectrum, backhaul, billing and numbering issues.

MONeH regards Ch4lke Mobile as "phase 0" of its project. The initial phase of Ch4lke Mobile was 4G, operating at 2300 MHz band 40 with an 1800 MHz 2G overlay that offered circuit switched fallback to 2G for voice and messaging, operating on the shared access spectrum of DECT Guard Band. MONeH is ambitious, full-fat 5G that will offer mobile edge computing, network slicing and, in the timescale of the DCMS project, standalone services through release 17.

Body explains: "We are tackling the problem in a two-phased approach. First we will deploy a 5G non-standalone configuration - where a wide-area, narrowband service offers basic mobile coverage - then upgrade to full 5G-standalone, which incorporates a full 5G core infrastructure to fully support multiple network slices. This allows each MNO and slice customer to fully manage and control their own network slice using a common Radio Access Network." He uses the formal Ofcom definition for basic coverage of 2 Mbps data, voice and messaging. But in the case of MONeH, it will be aggregated with a much higher speed 5G-NR signal to provide much higher data rates.

Because it's a small, steep valley with only small villages, covering the area with radio signals is hard, and it is even harder for the mobile networks to justify the cost. It's a problem complicated by the place being an Area of Outstanding Natural Beauty. No-one wants big mobile phone masts.

Residents lament the failure of previous attempts. The Mobile Infrastructure Project promised five sites and delivered none. Ch4lke Mobile Director ***Jonathan Andrew*** told us: "The issue of connectivity in the Chalke Valley is a longstanding one. We have had a lot of broken promises. MONeH needs to make sure it delivers."

ROBUST NETWORK

MONeH's solution to all these problems comes from working with the support of the local community. Rather than having a few tall cells, from which signals then fail to reach into the twists and dips of the valley, MONeH

Jonathan Andrew (left) and James Body (right) met with Margot James MP to discuss their innovative local project.

Antenna installer Ian Newman and Ch4lke champion Nick Birkett preparing a 4G cell to be mounted on a barn at Rookhaye Farm. The complete installation (which included the wireless meshing equipment) was set up on a single aluminium pole, which was then bolted to the steel structure of the barn.

will use around 50 small cells on people's chimneys and barns. These small cells running at low power will provide a much more adjustable level of coverage. They are unobtrusive and welcomed by residents who will get broadband at speeds that previously they could only have dreamed of, in return for hosting them on their buildings and providing them with power.

One issue many mobile phone networks face is local opposition to eyesore towers. The low-key nature of the MONeH implementation has the full support of the Cranborne Chase Area of Outstanding Natural Beauty, the organisation which preserves the rural nature of the region through various initiatives including a Dark Night Sky protection project. At night viewers can see a sky full of stars, and they're not just the celebrities who live in the area.

Only a few of the cells will be connected to fibre backhaul; most will be linked through a wireless mesh. Some will be powered by solar panels. This means the system should be fantastically resilient. In a major storm, even if the mains power is cut and roads become impassable, the 5G network will stay up as long as just one of the fibres, which are supplied by multiple vendors, keeps its connection live. Which will be good going for a place that today has no coverage at all.

SHARED RURAL NETWORK

Fixing British mobile connectivity involves a three-pronged attack. Alongside the 5G Rural Connected Communities project sit two 4G programmes: the Emergency Services Network and the £1bn Shared Rural Network.

Covering the most far-flung and isolated parts of the UK is expensive. To meet the social obligation when the economics don't work needs a new approach, and that has led to EE, O2, Three and Vodafone working together with government to share the costs in a project called the Shared Rural network (SRN).

DCMS is putting in more than £500m to match a similar sum from the operators. This is being done through the joint operator organisations Mobile UK and Digital Mobile Spectrum Limited (DMSL). The networks are also working together, using their own resources, to improve service in partial not-spots.

DMSL is a little-known organisation set up to manage the shift of Freeview from 700MHz to enable the spectrum to be used in a more efficient way for mobile phone coverage. DMSL Chief Executive Ben Roome explains: "We've moved from a position where two operators had coverage requirements to an outcome where we'll see better coverage from all four operators."

Roome says consumers will be most

Ben Roome
DMSL

aware of dramatic improvements in areas of patchy coverage: "The biggest element of change in coverage from this programme will come through the work the mobile operators do to infill partial not-spots."

The success of the shared rural network will be measured by Ofcom, but Roome is looking for consumer input: "We would absolutely welcome hearing from communities who feel they've not got appropriate coverage. We are highly unlikely to see communities, unless they are very, very small, that exist within total not-spots where there's no coverage at all from any operator, but that's not to say they aren't out there. We'd be happy to hear from them and you can get in touch at info@srn.org.uk."

There is a rolling programme to install the necessary infrastructure. Within a couple of years the first live SRN site will be in operation in a total not-spot ,and from then it should ramp up quite rapidly. There is an initial deadline of 2024 for the operators to hit their partial not-spots commitments; the total not-spots deadline comes before 2026. Progress and results will be fed into Ofcom's annual Connected Nations report and the programme's annual reports will be examined for progress by an oversight board, which is chaired by government. There's monthly reporting, and an annual focus on incremental changes.

The Shared Rural Network isn't alone in addressing the issue of rural not-spots. New infrastructure is being added as part of the new EE-led communications platform for the emergency services, and the Rural Connected Communities programme is working to produce innovative solutions to coverage issues.

As DCMS Secretary of State Oliver Dowden says, fixing the problem and delivering gigabit broadband is a high priority for the government.

West Mercia Rural 5G

Worcestershire got a taste of 5G with the industry 4.0 and security-focused testbed in the initial phase. Now hungry for more, the county council is leading a RCC consortium to spread the benefits of enhanced connectivity to local areas with a wider remit.

THE WEST MERCIA Rural 5G programme is one of several to have grown out of the previous Worcestershire project, but while that led on industry 4.0 the new emphasis is on health and social care.

The partners in the consortium are Worcestershire County Council as the lead partner, Hutchison 3G, Airband Community Internet, the universities of Chester and Worcester, the NHS Clinical Commissioning Groups of Herefordshire & Worcestershire and Shropshire, Shropshire Council, and the West Midlands Academic Health Science Network.

Stephen Ashton, the Broadband, 5G and Connectivity Manager at Worcestershire County Council, who leads the project, explains that the rural aspects fit in well with other development goals in the region. "Being a mixture of urban and rural communities means services need to be flexible and operate in both environments. For example, Shropshire is the second-largest inland rural county, with communities spread and displaced across all areas, not just around villages. The topography and sparse population across the Teme Valley and areas around Tenbury in Worcestershire make service delivery a challenge. So as a group we started to think how improved connectivity and specifically 5G solutions could help us. The health partners were interested in overall health outcomes, seeing what could happen across GP surgeries, hospitals and with outpatients; whilst the local authorities were interested to see what could be done across social work and with care homes. Importantly for all partners it is about working together and including community healthcare to keep patients out of hospitals when they don't need to be in them, and promoting independence."

With a population of 11,000, Ludlow is the largest town in South Shropshire, but not one where the mobile operators have announced plans to offer 5G. Without the RCC project, rural coverage in the surrounding areas would be some way off.

WIDER BENEFITS

Improving connectivity in rural areas is an ongoing journey, not just for individual mobile phone users, but for businesses and public sector organisations delivering services in rural areas. Ashton explains: "We recognise it is very challenging for operators, using traditional models, to deploy 5G in rural areas at scale and at pace, so new deployment models need to be found and new revenue streams identified."

There are clearly other applications for 5G in rural areas. For instance, could challenges such as the presence of county lines drugs gangs and theft of agricultural equipment be addressed by 5G solutions and if so, who would pay - farmers, police, insurance companies or all of them? Could some face-

to-face services be replaced by virtual visits, and travel costs and time be replaced by data costs and increased time with the resident?

An effect of the Covid-19 pandemic is that many healthcare professionals have become much more reliant on communications technologies, offering video consultations. Before the pandemic there was little use of such services; in most cases, patients were expected to attend surgeries. Now, realising that connectivity can support some services without the need for travel, healthcare professionals need to be confident in the reliability of the technology, while they have become aware of where the current limits are; this increased awareness could drive innovation further. A rural 5G network could be used to support isolated individuals to manage their physical, social and mental well-being, including those affected by dementia. The network could capitalise on the expertise of the Association for Dementia Studies at the University of Worcester.

NEW APPROACH TO BUILD

Airband is a project partner with a lot of experience in the region. The company has a history in fixed-wireless deployments of broadband to people's homes. Its model is replicated throughout the country, with many local expert wireless internet service providers. The project is investigating a new approach to deployment. For Airband it provides a new opportunity to maximise use of existing assets; masts can be made available to mobile network operators (MNOs) to attach their equipment. This offers Airband a new revenue stream, while the MNOs should gain quicker and more cost-effective deployment.

Landlords are engaged, planning may not be required or the work may be considered 'permitted development', and power and fibre links are present, reducing the need for wayleaves. There are also challenges; masts might not be in the ideal places for radio planning perspective, but most networks make compromises around site location.

The MNO partner is Three. It is keen to recognise these benefits and work with Airband to test other opportunities around training of engineers and new architecture design. Other Three network traffic will be carried over the network to replicate the real world environment. Three aims to work with public sector partners and designers to explore the art of the possible.

Consortia are encouraged to share and enjoy

NEXT STEPS FOR THE RURAL CONNECTED COMMUNITIES PROJECT

Participants in the RCC are lucky. They are part of a growing community of programmes co-funded by DCMS. This gives them an ever-expanding number of organisations to work with. Which, of course, is the idea of the programme; it builds the UK skills base in 5G.

The RCC projects covered here are encouraged to work together. DCMS hosts collaboration meetings to look at all aspects of running a mobile network, from standards and processes to technology requirements and hardware availability. Groups work together on marketing, security and benefits realisation.

The RCC consortia get to work with the companies and knowledge is gained from the six initial projects, the industrial programmes (see Page 42) and the forthcoming 5G create teams, which were finalising their bids just as the RCC teams were starting their programmes.

DCMS has also learned a lot over the past couple of years. There is an emphasis on understanding how each of the projects is using the technology advantages of 5G. DCMS looks to the projects to document and detail the benefits of the approaches they have taken.

But overall these are research projects. The point of research is to find answers to the unknown unknowns as much as the known unknowns.

Working with the previous and subsequent programmes is an ideal way to do this, and somewhat appropriate for organisations that are focused on the benefits of communications.

How Can We Make Scotland a World Leader in 5G?

A Q&A with Paul Coffey, CEO Scotland 5G Centre

There is a broad consensus that the widespread adoption of 5G could represent a significant step change in the UK's digitalisation, delivering enhanced mobility, reliability and more secure connectivity and enabling a new range of opportunities for communities, businesses and public services. From transport and tourism, to education and healthcare, the potential use cases of 5G could be truly transformational for Scotland and the wider United Kingdom.

Following the development of the Scottish Government's 5G: strategy for Scotland - which set out ambitions to establish Scotland as a forward-looking digital nation - the Scotland 5G Centre was established in 2019 to ensure the country is ready for the next generation of connectivity.

As a focal point for 5G in Scotland, the Centre acts as a national interface between the business community, public sector, and academic experts. Here, the Scotland 5G Centre's recently appointed CEO, Paul Coffey, sets out its achievements so far and what lies ahead.

The Scotland 5G Centre has been up and running since late last year – what was it set up to do?

The Scotland 5G Centre was set up in October 2019 as an innovative partnership between the University of Strathclyde, the University of Glasgow and the Scottish Futures Trust, to enable all types of businesses and the public sector to realise the benefits of 5G. Ultimately, as a national centre we want to accelerate the adoption of 5G and support the delivery of its economic and societal potential for Scotland and share this with the rest of the UK.

We are looking to do that in a range of ways, but one of the centre's key roles is providing an interface and platform for collaboration between entrepreneurs, small businesses, corporates, academia, and government bodies. In practice, that means fostering service innovation and cross-industry collaboration by speaking to partners from all areas – not just telecommunications companies.

Collaboration will be fundamental to much of what we want to achieve. It will be particularly important in securing inward investment and bringing organisations and experts from across Scotland and the UK together to facilitate the development of 5G.

Through the Scotland 5G Centre Connect Programme, we offer businesses access to an integrated ecosystem. Not only does this remove complexity and barriers to entry, and reduce time to market, but it provides access to a unique demonstration and development environment where users can test and develop 5G applications and services.

What effect is 5G going to have on businesses? Will it affect some more than others?

Whether you are an SME or government agency, 5G is going to affect you and your customers or service users. In that respect, a big part of our activity is about raising awareness of 5G and the benefits it will bring. 5G has a number of new capabilities to offer, so there is work to be done around supporting the general understanding of what is possible and building a framework to allow business to exploit these new capabilities.

That said, even while it is still in its early stages, 5G is ready to power enterprises. We are already supporting Scotland's implementation of best practice, accelerating infrastructure roll-out, and promotion for inward investment from industry.

Why is 5G important for Scotland?

5G will be massively important for Scotland – it opens up many exciting opportunities and has the potential to deliver significant value to people across the country. To put that in some context, a study by Deloitte estimated that significant changes to wireless technologies in Scotland could increase GDP by more than £17 billion by 2035. That could see tax revenues rise by £5.7 billion, with 3,000 new businesses creating 160,000 additional jobs.

However, it's not just about hard economic data – 5G is as much about improving people's lives. The Deloitte report also highlighted how non-stop connectivity delivered through 5G

networks can improve access to healthcare, education and training; deliver seamless combined transport experiences; and reduce energy consumption and costs through smart, integrated energy grids. In rural areas, businesses can benefit from improved access to secure, reliable networks.

5G will give people more opportunity to choose how they live and work, no matter where they are – which will become particularly important when we consider what the post-Covid-19 world will look like. It will undoubtedly mean different things for different people, but we want to make sure everyone understands the transformational impact 5G can have on their lives.

Why should companies look to Scotland to trial 5G opportunities?

Scotland is the ideal place to develop 5G. It is home to a variety of different sectors ripe for 5G applications – to name a few, there is a vibrant food and drink sector, a manufacturing base that is being revitalised, and the tourism industry is strong under normal circumstances. There is also a good mixture of different geographical settings – large rural areas located next to sizeable urban pockets.

There are world-class universities with top academic expertise, and many are already working with industry partners researching the potential of 5G and how it can be scaled up. Combine that with a broad range of public sector institutions and a strong private sector – including a sizeable engineering and telecommunications industry – and Scottish Government backing and all the ingredients are there to explore what 5G can offer in a diverse range of contexts.

The Scotland 5G Centre is a key part of that offering, bringing all of this together under one umbrella - we can act as a single point of entry for anyone looking to get involved in 5G.

What use cases are already being explored in Scotland?

One of our first projects was the Scotland 5G Rural Testbed. Led by the University of Strathclyde and Cisco, it evolved from the 5G RuralFirst project to provide wireless and mobile connectivity to rural and remote regions of Scotland and other parts of the UK. It encompasses Loch Lomond and the Trossachs National Park, and Orkney, focussing on the development of use cases and business models to help raise awareness about rural connectivity.

Our 5G urban project led by the University of Glasgow is deploying a Nokia 5G private network to demonstrate connected health and connected built environment use cases. This is a great example of how we can work with industry to test augmented/virtual reality and IoT applications on a pop-up network that has measurable tangible outcomes.

Back on Orkney, we are also currently supporting a project with Heriot-Watt University that is looking to develop a 'digital twin' of the island's decentralised energy system. The tool is designed to help engage Orkney's population and businesses in the delivery of its smart energy system and the ultimate goal of decarbonisation.

Of course, the adoption of 5G is dependent on access to the right assets in the right places and our Infralink project, led by the Scottish Futures Trust, is aiming to build understanding of where the public sector assets are and how to make them available. The initiative will deliver a national asset register, financial guidance for the use of sites, and standardised documentation to streamline negotiations between industry and site owners.

Who can engage with the Scotland 5G Centre and how can they do it?

We're keen to speak to industry, public sector organisations, and academics looking for support with project ideas, and have recently launched a series of online events to help facilitate discussions around 5G over the coming months.

About the Scotland 5G Centre: The Scotland 5G Centre was set up to accelerate the adoption of 5G and realise its economic and societal potential for Scotland. The Scotland 5G Centre has received investment from the Scottish Government and is an innovative partnership between the University of Strathclyde (which hosts the Centre), the University of Glasgow and the Scottish Futures Trust. The Centre is collaborating with businesses, researchers and the public sector across Scotland to realise the benefits of 5G.

To get in touch, or for more information on our webinar programme or opportunities such as the Scotland 5G Centre Connect Programme, visit: https://scotland5gcentre.org/

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How the ESN Will Boost UK Rural Coverage

Richard Harrap, Managing Director of EE/BT's Emergency Services Network division, explains how the new network will boost 4G coverage in rural areas for EE customers, and may do the same for customers of the other mobile operators too.

THE NEW 4G Emergency Services Network (ESN) being built by EE is helping to expand the mobile operator's geographic coverage, particularly in rural areas. EE is responsible for the funding and building of most of the radio access network (RAN). The Home Office is responsible for building a further 300 new-build sites in the most remote parts of Britain under the Extended Area Services (EAS) programme.

Richard Harrap, Managing Director of ESN at EE/BT, says: "We are delivering a significant amount of coverage rurally and in other difficult-to-reach areas like marine. EE is some way ahead of the other operators on rural coverage, thanks to the investment we have made for ESN."

The delivery of ESN involves upgrading around 18,000 existing 4G sites and building approximately 700 new ones. Upgrades usually comprise a mix of swapping out antennas, changing over equipment and upgrading transmission to add capacity to the backhaul. Most of this work is now complete.

Two thirds of the new-build sites are in Scotland, 11% are in Wales and the rest are scattered around different parts of the UK. "Most of that estate is built or very well advanced," reports Harrap. "But we will probably be building new sites for the next few years, either because it is deemed operationally necessary or perhaps because a new road has been built."

The new builds are often complex and challenging to deliver, both in terms of gaining planning permission and actual construction, due to their locations in remote and often environmentally sensitive areas. Harrap says the target date for new-site completions is the first half of next year, which is in line with ESN programme timelines.

The coverage from all EE ESN sites will be available to commercial customers as well as the emergency services, so rural areas will see a considerable improvement. EE will also install its base station equipment on the EAS sites, which again will be available for both ESN and EE commercial customers.

Under the SRN up to 292 EAS sites will be made available by the Home Office. The other operators are entitled to use the EAS sites. However, EE has additionally offered the other operators access to all its 700 new-build ESN sites. This, plus the HO provided EAS sites, will provide a huge boost to rural 4G coverage in the UK, a huge collaborative effort by the UK mobile operators.

"Seven hundred new masts in remote locations are a very exciting asset to have," says Harrap. "Conversations are ongoing with

> 700 new masts in remote locations are an exciting asset to have

all operators that share those sites, and this has been discussed as part of the Shared Rural Network [SRN]. It would reduce the amount of infrastructure on the ground and increase coverage for everyone."

Harrap says there is also an opportunity for operators to share transmission equipment, although this is complicated because some sites have satellite backhaul. But he adds that if all the operators do get involved, installation of fibre backhaul could become a viable economic option.

Additionally, the recent Shared Rural network agreement (which is discussed on page 21) will now provide some funding for EAS upgrades, as well as paying for further new all-operator sites in total not-spots to extend coverage to 95% of the country.

"So, over the next few years everyone can enjoy the benefit of improved rural coverage," says Harrap. "There are still planning challenges, but it should open up rural coverage for all operators." When it comes to sharing masts, he says: "We obviously need to make a fair return on our investment, but we are very open to agreeing terms with other operators to use any of our sites."

Looking ahead to upgrading the emergency services to be able to use 5G, Harrap says the expectation is that 4G mission-critical push-to-talk (MCPTT) services will provide the bedrock of emergency service communications for years to come. He points out that optimisation of voice over LTE took time; in the same way, MCPTT will take time too.

"There is a lot of 4G innovation still to incorporate here; we fully expect ESN to add 5G in time, but currently we see 5G as a complementary service to mission-critical 4G," explains Harrap.

James Atkinson
Technology Journalist

James Atkinson is the former editor of Mobile magazine (2009-12) and Wireless magazine (2010-17). He is currently a freelance journalist and copywriter specialising in wireless communications technology. He has worked for the likes of EE, TCCA and Hytera Communications. He was also recently interim editor of Land Mobile and Critical Communications Today magazine.

Connectivity at Wembley

The famous stadium in North West London will have the most advanced 5G connections in the world, due to EE and BT Sport. But that's only the beginning of what's possible for sporting events, BT Sport's Director of Mobile Strategy Matt Stagg tells Heather McLean.

BRITISH MOBILE operator EE has sponsored Wembley Stadium since 2014. When it took on that sponsorship, it committed to making Wembley the most connected stadium in the world.

This means that it ensures that visitors to the stadium have the highest level of connectivity possible so that they are able to use the internet however they wish – something that does not happen often within UK football stadiums. But more than that, all new stadium technology that EE and its bedfellows in the BT Group come up with, including BT Sport, is trialled within the hallowed stands in North West London.

Beyond the consumer, EE began experimenting with ways in which the network could be used within vertical industries; as consumers rapidly realised that 4G meant they could go online more, watch more, stream more, and upload more, news and sports broadcasters were next.

The first broadcasting demonstration at Wembley Stadium carried out by EE was of LTE electronic Multimedia Broadcast Multicast Service (eMBMS), also known as LTE Broadcast, with BBC Research & Development on 30 May 2015, at the FA Cup Final. ***Matt Stagg***, (right), director of mobile strategy at BT Sport and lead of EE's strategy for delivering 4G and 5G networks for the media and broadcast industries, is a member of the UK5G Creative Industries working group. He says: "We were actually ready to launch [LTE Broadcast] at that point. It was seen as a global showcase for how we should be using one-to-many technologies."

However, the technology was not launched as there were not enough handsets available or within manufacturers' roadmaps that supported LTE Broadcast. This led to the creation of the LTE Alliance, including founding member EE, to lobby mobile-phone handset manufacturers to make their devices compliant.

While some major handset manufacturers were still slow to support LTE Broadcast, EE transitioned its investment into 5G. The new mobile technology could solve some of the problems that LTE Broadcast posed for 4G, particularly around the management of a large number of people watching the same content concurrently.

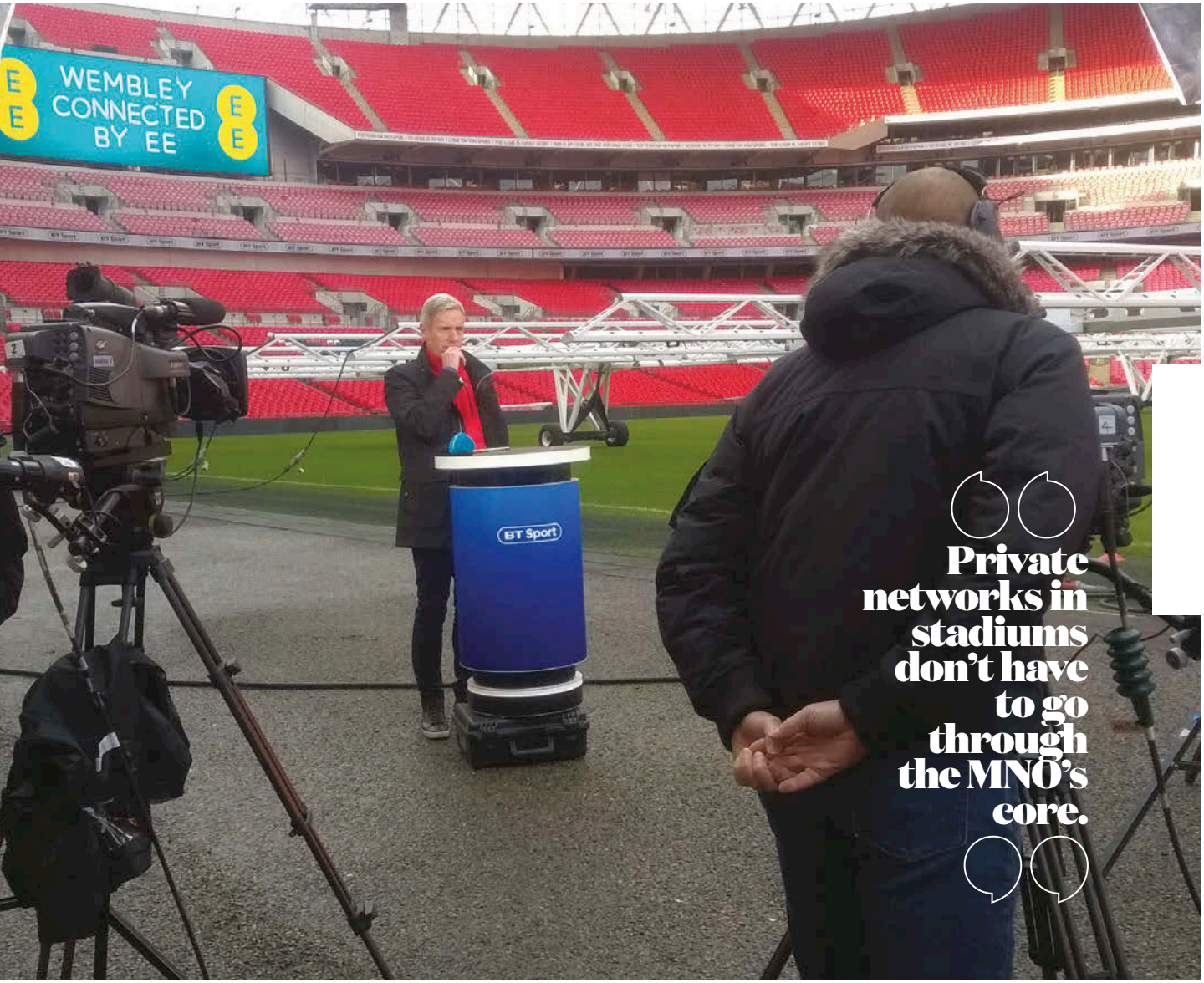
FROM BEST EFFORT 4G

However, 4G was always a 'best effort' network for uses such as sports broadcasting. 5G is the answer, says Stagg: "I'd say broadcasting is the best defined use case of 5G, other than it gives our consumers more bandwidth. The reason is we had a solution that needed one extra thing on 4G and that was the capability to give people something that wasn't best effort. So that meant

having a way of being able to do this. When 5G came in at pre-standardisation I lobbied with other mobile operators in media and entertainment globally to say that in the 5G standards, we need this capability."

Network slicing on 5G will give broadcasters further control over how they use the technology for live transmission from the likes of Wembley Stadium, as it guarantees the broadcaster bandwidth and latency. It is still some way off, however. In the meantime, EE is looking at how to give broadcasters what they need to be able to use 5G effectively.

Stagg says: "For broadcast networks I have a three-year roadmap, and in the end it's going to be a proper, integrated service with a complete wrap-around of service-level agreements and support. But actually what



> Private networks in stadiums don't have to go through the MNO's core.

we can do now are a number of things on the way there.

"It might be that we look at private 5G networks; one of the big things we're looking at now for stadiums is private networks that don't necessarily have to go through our core technology. We may be able to use Edge computing, where we actually give Wembley or other stadiums a private 5G network that's used for the broadcasters in there."

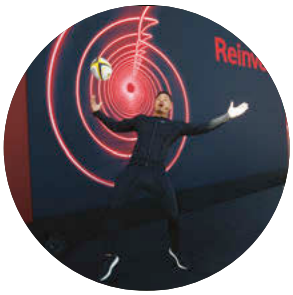
He continues: "There are a number of ways of delivering the requirements of the industry and meeting those key performance indicators in the most technically viable and commercially viable way. It may be network slicing in the end, but there are a number of ways we can increase capabilities and allow broadcasters to use the technology for remote production, untethered cameras, or in areas where trucks aren't viable, including in tier two or three sports."

EE'S FIRST 5G DEMONSTRATION at Wembley was carried out using pre-standard 5G technology. Stagg says: "We did 5G demonstrations. It was one of the first places we put pre-standard 5G in. Then we did the world's first remote production over 5G for the Wembley Cup."

For the Wembley Cup in November 2018, EE began by carrying out a successful live broadcast over 5G using remote production to deliver a two-way transmission from Wembley Stadium to London's ExCeL exhibition centre. The production for the live transmission was carried out remotely at BT Sport's base in Stratford, East London.

To showcase the capabilities of 5G for sports broadcasting, BT Sport organised a live conversation using the technology. Jamie Hindhaugh, chief operating officer at BT Sport, and BT Sport presenter Abi Stephens, spoke live over 5G from ExCeL in East London to Stagg who was at Wembley with Matt Smith, BT Sport presenter.

The transmission used EE's 5G test network in the stadium, plus a first-generation 5G encoded dongle from Huawei. The test network used EE's 3.4GHz spectrum from its 5G antenna in the stadium, connected to a 10Gbps backhaul link. With a throughput of 75MBps at Wembley, feeds from three cameras using 5G at 25MBps each were relayed through the Huawei 5G encoder to the 5G cell in the stadium. From there the transmission was passed onto the EE backhaul network,



SPORTING CHANCE

Telemetry is part and parcel of Formula 1, but other sports are increasingly discovering the benefits of measurement and analysis.

Vodafone sponsors the business lounge at Coventry's Ricoh Arena, home to the Wasps rugby and netball clubs, and has been exploring the use of 5G technology in the sports. One application is virtual reality gaming to allow players to practice. On the field the teams are looking at motion tracking and monitoring. When a player says a tackle was particularly hard it's now possible to put a figure on that; here 5G might have a very different meaning. It's information that would be interesting to fans at home and useful to a paramedic. Training staff will be interested in sleep, hydration, nutrition, calorie consumption, blood sugar levels and fitness performance.

At Vodafone's London 5G launch, it demonstrated the use of a £4,000 suit which would allow players in different places to practice together. The haptic Teslasuit simulates temperature, pressure and touch. Wasps star Juan de Jongh at the launch felt the impact as his colleague Will Rowlands felled a training punchbag in Coventry.

Utterberry, which is part of the Connected Communities in the Rural Economy (CoCoRE) consortium, has worked with cricket teams to put acceleration sensors in cricket balls, and Sunsport coaching in Manchester is using the Moxy Monitor to track muscle oxygen saturation in cyclists.

It's still early days for 5G in sport, but there is one football league that can claim to be the world's first 5G connected football league. It features a crowd-sourced, fan-assisted referee. Equipping an entire league with 5G is, however, less impressive than it sounds when you learn that the league in question is The Isles of Scilly League, which only has two teams: Garrison Gunners and Woolpack Wanderers, who play each other around 20 times over a season. Vodafone, having wired up the five inhabited islands of the archipelago, sponsors both teams.

and from there to the internet. This showcase led to the EE Wembley Cup held on 25 November 2018 becoming the first sporting event to be broadcast live using BT Sport and EE's 5G remote production. This match, recognised by the Football Association (FA), featured YouTube's biggest footballers alongside international football legends. The match was delivered over EE's 5G network live from Wembley Stadium and was shown live on the channel of YouTube star Spencer Owen.

CREATIVE STREAK

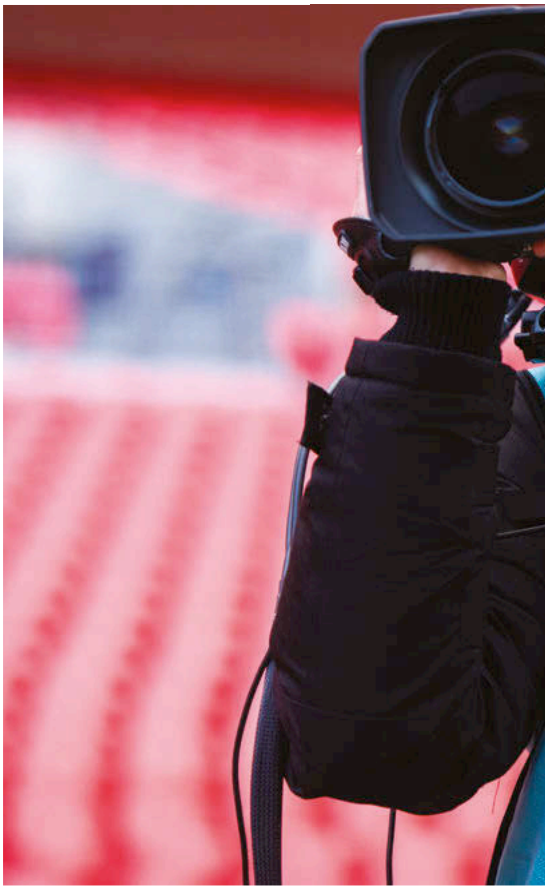
What EE and BT Sport noticed about 5G at this point was the creativity enabled by the technology. Stagg remembers: "The first time we used cameras with 5G, our director said, 'We can just move them anywhere?' 'Yes.' 'OK, so can you just drive it in a car and meet the team bus?' And that was the first really big, massive change in which mobile-connected cameras really changed the way things can be done. It is a big change, technically and culturally.

"The big things that came out of our initial trials – we began looking at remote production before 5G, on 4G – were the creativity and flexibility it gave our directors to be able to send a camera wherever they wanted; to send it on the pitch where the players were warming up. To be able to do that with a tethered camera, even with a radio camera so it can move around, is just not viable."

This creativity led to more unexpected results, says Stagg: "It has always been seen that we would have 5G cameras for where you didn't have an outside broadcast, so really we thought it's unlikely to be used in big stadiums which are all fibred up; it's for places without fibre. But when we discovered the creative opportunities of 5G, we realised that actually, this was going to be a technology for within stadiums, to have that freedom, have that untethered ability, to have flexible cameras that can go anywhere at any time at the drop of a hat."

MAKING 5G A REALITY

Stagg then had to begin thinking about how 5G cameras could work within a fixed, traditional, outside broadcast (OB) environment, with a fibre infrastructure from the pitch to the studio. Edge computing was the answer. It gave EE the capability to connect the 5G cameras from their broadcast 5G network to, as Stagg puts it, "some compute power within that cell or stadium that



enables us to break out that feed and then send that directly to either the OB or directly to the fibre infrastructure. And everything goes back to the studio and everything is in time, because the low latency on 5G means it will have the same latency as the fibre."

He goes on: "And that really, really will be a massive gamechanger to have that mix, as you'll have the creativity combined with the fixed-fibre infrastructure, so you have the best of both worlds. And that will be really, really interesting when we start to move along that route."

EE has shown the uses of 5G other than at Wembley. Last September, EE and BT Sport brought live feeds from three stadiums in the UK –Stamford Bridge in West London, the Emirates Stadium in North London, and the Etihad Stadium in Manchester - to the International Broadcasting Convention (IBC) in Amsterdam. The feeds displayed FA Women's Super League matches that were being played at the stadiums by Chelsea FC, Arsenal FC and Manchester City FC. Reporters at each stadium were connected over EE's 5G consumer network via BT Sport's production hub in Stratford, East London, then the feeds were channelled out to the broadcaster's OB

van at the IBC where reporters and guests viewed the world-first, live four-way broadcast.

Stagg notes: "People ask why 5G cameras? Remote production on its own has a huge advantage moving forward to how we do things now. It's not necessarily a cost thing; even if it was cost neutral, it would still be much better to do remote. It's the ability to have a work-life balance. When we did a demonstration of 5G remote production into our marquee at IBC, one of our directors, Gemma Knight, was asked what did it mean for her personally; she answered: "I get to have breakfast with my son every day." I think that's very powerful in terms of the work-life balance, and especially where we are at the moment with COVID-19. It's already allowing us to rethink the way we do things. There is also the carbon footprint reduction that remote production provides us with."

LOOKING AHEAD TO EURO 2021

More was expected from EE and BT Sport at the Union of European Football Associations (UEFA) Euro 2020 tournament; however, that event has been postponed until 2021 due to the coronavirus pandemic. EE and BT Sport's plans for Euro 2020 have been put on hold, and the focus has moved to continuing to make sure that Wembley Stadium remains connected with all the bells and whistles EE can throw at it. Stagg says: "We were looking at everything we could do at Euro 2020. One of the biggest things was the investment that we are already putting into Wembley, and we will continue to make sure that everybody in that stadium has the best connectivity they can to do whatever they want whenever they want. So the number one priority is still to make that the world's best connected stadium."

GOING FORWARD, EE WILL continue to work on 5G within the stands of Wembley Stadium. Stagg says: "At each stage of the evolution of the 5G technology we will be testing it at Wembley and other places. BT Sport will be using 5G from next season, whenever next season is, in various places and in various sports.

"We will have, inside and outside of stadiums, the ability to have a full broadcast-grade network. If there's 5G coverage, there'll be no need to use satellite, and within stadiums we will have private 5G networks."

The possibilities for the future in stadiums are exciting, says Stagg: "When you start to look inside stadiums, there's a lot of technology that 5G brings to the experience."

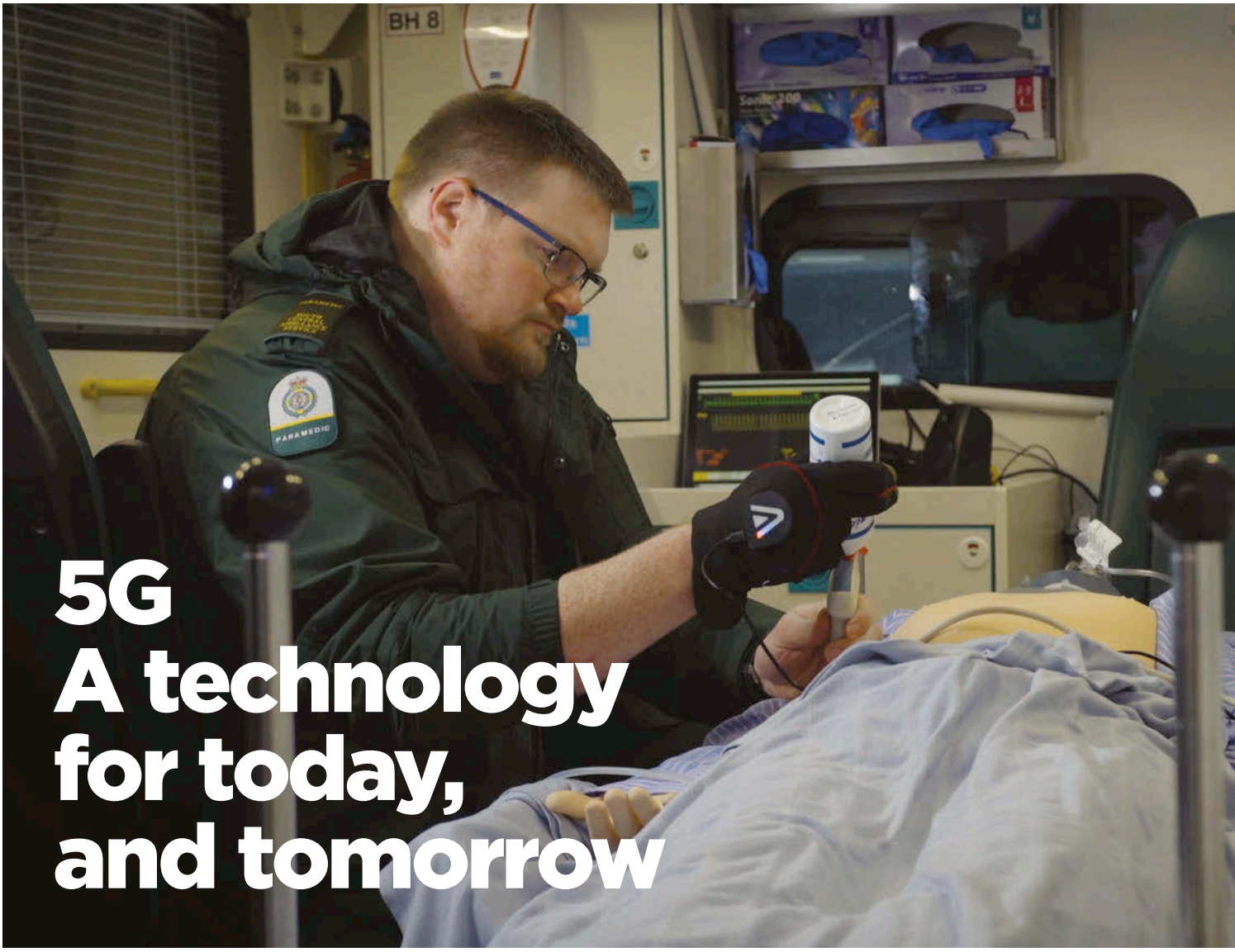
For instance, he is excited about augmented reality (AR). "You have AR opportunities to enhance the stadium experience," he says. "When you look at season-ticket holders only ever sat in one seat, it might be quite nice if they could see a penalty taken from the other end for once, and to have some of that capability that we bring out already through uses of our app, like multiple 360-degree cameras and multiple camera angles. In the stadium today people don't get that [because of lack of mobile network strength] but with 5G, they will.

"They'll be able to access the BT Sport app when they're in the stadium because there will be enough connectivity. Long term we can use AR second screen to enhance their experience, and we can also use it for stadium security, communications, videos, and for marshals, with the ability to monitor where crowds are. The really interesting one is where we move into the new data we get from sensors. We'll have sensors all over the place and [over the 5G network] you'll be able to collate all that data and compute it within the stadium for real-time analytics."

Reflecting on the circumstances in which the UK finds itself today because of the spread of COVID-19, along with the rest of the world, Stagg concludes: "We are looking at how we can use technology when sport starts to come back on. We are looking at everything we have as a group - BT, BT Sport, EE - to try and make things as good as possible, and when everything's back to normal, we have lots of innovations planned, not just for football."

Heather McLean
Freelance Editor & Reporter

Heather McLean has been writing about telecoms since 2001, specialising in mobile. She has been a freelance writer and editor since 2002. She currently concentrates on the areas of sports broadcast and mobile tech, and has written for numerous titles including Sport Video Group (SVG) Europe, The Guardian, The Independent, The Times, The Daily Telegraph, and The Economist Executive Briefing. She heads SVG Europe Women, an initiative to support and inspire women working in sports broadcasting.



5G A technology for today, and tomorrow

If you think about the conversations you've had about 5G, and the narrative you've read, it's likely much of it is characterised by a focus on what the technology will enable in the future – in five, ten, even twenty years' time. It's a really exciting thought, and one I'm excited to see play out. But 5G is here now, today, and there's plenty for us to already be excited about.

5G is the technology that will help us stay better connected to the things that are important to us, our friends, families, entertainment. It's also the technology that will change everything from healthcare and education, to media and broadcasting. It will, and is, changing the way we live for the better.

The first 5G mobile network launched in the UK last year, when EE switched on 5G technology in six major cities. In only a year, we've seen some truly extraordinary ways 5G is already being used.

John Vickery, Principal Technology Partner, BT

5G in action – healthcare

In this era, virtually every business is a digital business, which means 5G will arguably impact every part of business life – from the way employees operate and communicate, to the way businesses interact with customers.

One of the areas 5G comes into its own is healthcare. It's been a focus of ours at BT, and the current worldwide situation shows us more than ever just how critical the work of health professionals is. The industry is facing unprecedented challenges, which technology can, in part, help alleviate.

- Connected healthcare has the

▲ A 5G connected glove allows a remote clinician to direct the paramedic's hand with nudges to guide an utrasound sensor.

potential to transform both the way health organisations run operationally, and the way patients are cared for. A fast, reliable 5G connection offers the potential to achieve this by:

- Enabling high quality video, audio and diagnostic services to run in real time, connecting remote patients and field staff to hospital and clinic based experts. No delay means faster, more effective treatment
- Reducing unnecessary hospital admissions and ensuring patients get the appropriate treatment on arrival at hospital by linking experts with paramedics
- Facilitating secure and flexible information sharing and collaboration across health and social care providers, local authorities, and the voluntary sector

This undoubtedly has the ability to positively change the way healthcare organisations and practices run, and it's something we're already seeing develop.

Working with partners at University Hospital Birmingham, we demonstrated a remote-controlled ultrasound scan using haptic technology over a live 5G network. This was followed with a 5G connected ambulance solution which combined haptic technology with 5G virtual and augmented reality, enabling hospital-based medical staff to help paramedics decide the best course of action remotely and in real time before making a hospital admission, if one is needed.

5G has a real power to change the healthcare industry. We're at the cusp of the 5G revolution, with many advancements to come.

Education

One of the many advantages of 5G as a technology is its potential to improve, enhance and add value to not just one industry, but many of them. The industries can be very different in what they do, but they all share a common factor – the need to effectively and reliably connect people to information and expertise when and where they need it most.

Just like we have with healthcare, we've seen 5G in action in education today. In collaboration with Glasgow University, we showcased the potential 5G has in the sector, by allowing students and businesses to visualise an operations site from anywhere in the world. Crucially, and in the same way as healthcare, removing the need for people to be physically present in one location, enabling easier access to knowledge and facilities.

Media and broadcast

Another industry to call out is media and broadcasting, both for the benefits it brings to the broadcaster itself and its audiences. 5G technology offers broadcasters the reliable, fast connectivity which is critical to successfully deliver live events – whether that's a live sporting broadcast, breaking news, or prime time entertainment.

For a business, that's crucial to gain and keep a competitive edge, and for a viewer it means uninterrupted viewing of your favourite content. We first demonstrated this back in 2019, through the broadcast of the world's first live sporting event over 5G using remote production.

Looking forward with 5G

4G revolutionised the way we communicate and behave – enabling us for the first time to reliably shop, bank, and watch entertainment outside of the home. 5G is the next generation of mobile technology, and will take us one step further. It has the potential to transform industries and services, large and small, by enabling them to work with greater agility and flexibility.

Connectivity is key to every industry, regardless of size, and 5G will be a key turning point in what can be done. Businesses will be able to capture, analyse and share information in a way never before possible, enabling smarter, real time decisions. There's a lot for us all to look forward, and as we've seen, lots that's already happening for us to get excited about today.

To find out more by visiting bt.com/mobile/5g/
Learn more about the West Midlands connected ambulance project at newsroom.bt.com/university-hospitals-birmingham-bt-and-wm5g-demonstrate-uks-first-remote-ultrasound-over-a-public-5g-network/

Secure by Design

David Rogers discusses the UK's world-leading work on securing future connected products and networks and some of the challenges ahead.

HOSTILE ATTACKS upon UK cyberspace were designated a Tier 1 threat to national security in 2010. This unlocked funding for the National Cyber Security Strategy. In its second, current, iteration, to 2021, the government seeks "to significantly reduce the ability of our adversaries to conduct cyber-crime in the UK by ensuring that future online products and services coming into use are 'secure by default'". An over-arching goal is to make the UK the safest place to live and do business online.

NATIONAL SECURITY

As a result of the 2014 report *The Internet of Things: making the most of the Second Digital Revolution* by the Chief Scientific Adviser, Sir Mark Walport, it was recognised that, along with the immense benefits of the Internet of Things (IoT), there were huge risks. These could be broken down into two main aspects – issues that caused consumer harm directly (for example someone's webcam being accessed and viewed), and those that caused wider harm, often without the user's knowledge.

The second of these was potentially a national security risk. This was driven home with the appearance of the Mirai botnet direct distributed denial of service (DDoS) attack in 2016, against individuals and organisations, notably the NHS. More widely it was recognised that there were potential physical-safety, harassment and child-safety issues.

In 2017 I joined an expert advisory group that comprised people from industry, government and academia and that looked at the problem. In March 2018 we produced a report laying down a code of practice designed to address the fundamental problems faced, particularly around IoT devices.

The project was led by ***Emma Green***, DCMS Head of Cyber Security Incentives and Regulation, and ***Peter Stephens***, Head of Secure by Design. As the author of the code of practice I can say that it was a massive team effort. Each group member brought a particular focus to the project. This, along with the support of politicians, industry and consumers, meant something was delivered.

In collaboration with the National Cyber Security Centre (NCSC) and the Information Commissioner's Office (ICO), the code was refined, developed and prioritised. Consultation took in views from the security research community, those in industry who were already demanding better security in the IoT, and loose-knit organisations from the hacking community such as IAmTheCavalry.

It was recognised early in the process that there were ongoing unacceptable practices in the IoT development ecosystem, whilst there were other good practices that were in desperate need of adoption. Priorities were set in the top three items of the code: no default passwords; action required on and implementation of a vulnerability disclosure policy; and ensuring that software updates were available for devices. The code settled on 13 guidelines that aimed to raise the bar in cyber security, not just regarding devices, but in the surrounding ecosystem. Particularly, the security burden was shifted from consumers to device manufacturers and the companies responsible for the products. Supporting studies were conducted by the PETRAS IoT academic research consortium, for example into product labelling.

DCMS is not a standards organisation and there were already multiple recommendations from around the world, so the approach was to keep standards high, not to redefine them. A detailed plan was likely to have been over-specific and could have significantly constrained innovation. It was also realised that the ability to inspect items externally and the transparency of their security features (or the lack of them) was crucial. This was much easier for the priority top three items, since consumers themselves could see default passwords, they could check whether it was possible to report vulnerabilities to the manufacturer through a webpage, and they could discover whether there were updates available. The top three served as 'insecurity canaries' – if an IoT product failed to meet these guidelines, it was likely that all was not well in the rest of the product.

The success of the code is down to multiple factors. There was demonstrable market failure with IoT products being easily hacked, causing damage and with the real potential of a death. The market was ready; companies had already been developing recommendations, but not at the pace that was necessary. Recognising the global nature of the IoT and its supply chain, the code took an international approach and was translated into seven languages. The government published an extensive mapping to IoT recommendations and guidance around the world, provided as open data so that anyone could use it. International alignment continues and the code was submitted to the European Telecommunications Standards Institute (ETSI), becoming ETSI Technical Specification 103 645 in January 2019. This work is well on

IoT SECURITY CODE OF PRACTICE

1. No default passwords
2. Apply vulnerability disclosure policy
3. Keep software updated
4. Store credentials and data securely
5. Communicate securely
6. Minimise exposed attack surfaces
7. Ensure software integrity
8. Ensure personal data is protected
9. Make systems resilient to outages
10. Monitor system telemetry data
11. Make it easy for consumers to delete personal data
12. Make installation and maintenance of devices easy
13. Validate input data

The full report is available at www.gov.uk/government/publications/secure-by-design-report

The report and code of practice were published in October 2018. L-R David Rogers; Martin Sadler (ex-CEO HP labs Bristol); Dr Ian Levy (NCSC); Margot James MP (then Minister of State, DCMS)

its way to progressing to a full European standard (EN) by July 2020.

Following further public consultation, the UK has stated that it intends to legislate on the top three concerns in the code of practice – the banning of default passwords, enforcing the ability for security researchers to submit vulnerabilities to IoT companies, and ensuring that there is greater transparency around software updates.

Other countries and states have followed suit, such as Australia, Finland and Singapore. Some have approached the challenge differently: the US has a large-scale project within its National Institute of Standards and Technology (NIST). These projects will converge at the International Standards Organisation (ISO), but that takes a long time. The UK's proactive stance addresses the issues now rather than in 10 years.

MANAGED RISK

Risk can never be eliminated, but it can be reduced and managed. Trust is something that needs to be gained and relied upon. It is not simply about technology. Between businesses and governments, trust is about keeping promises and whether statements or actions are truthful and verifiable. Large businesses have been affected by ransomware attacks that have crippled operations. Governments are finally beginning to acknowledge cyber-crime and take it seriously.

The 5G vision of a collection of technologies, including different types of IoT devices across multiple sectors, opens a new set of issues around the 'cyber-physical' space: attacks no longer stay in the virtual domain. Cyber attacks can interact with real-world objects or systems, with catastrophic consequences. In farming, for instance, this could mean the loss of irrigation; in a heavy industrial company, the complete destruction of a blast furnace; and in the automotive sector, it could mean cars stopping in the middle of the road. All such disasters could halt the economy.

Hostile nation states are already seeking to take advantage of the weakest links, which can be the most effective points of attack. In addition, networks are shifting from a world in which individual hardware boxes make up a network, to a virtualised one with all the functions now built into software. This provides greater speed and reliability but means that you're exposed in new ways.

Increasingly, a drive to reduce costs has meant that security is often at the end of a long list of requirements. Government has a role here – to level the playing field such that everyone must provide an acceptable bar of security for entry into the market, affording every citizen a certain guarantee of protection.

Companies are also increasingly relying on open-source software – that is, software that is developed by a community of individuals openly and collaboratively and released for anyone to use under a licence. Although open source is visible for peer review, attackers aren't going to submit a fix for security flaws they find! This concern, combined with companies' lack of attention to keeping up-to-date with open-source libraries in their products and services, can be a real issue for security.

Risks mean extra attention has to be paid to the fundamentals of how networks are built from the ground up and how to make them more resilient. That means building defence-in-depth, persuading mobile network operators not to rely on single vendors so that they spread the risk, and validating that what is being built doesn't contain known security vulnerabilities and flaws. It isn't possible to create a flawless system or to design software and hardware without the possibility of security vulnerabilities; however, acknowledgement of this fact leads us to the conclusion that companies need to stay on top of security research and have systems and processes in place. While the country-of-origin of a product or service is clearly a security consideration for both companies and governments, if the product or service can be validated thoroughly and meets a good level of product security together with other cyber security measures, the source country matters much less. If a product or service supplied from anywhere in the world is fundamentally insecure, any country could theoretically attack it successfully; it doesn't matter where it originally came from.

There are many factors in the telecommunications supply chain to consider, including hardware security, cryptographic key management, logistics, testing, auditing and work on security vulnerability management. From an industry perspective, many of these areas have been opaque to mobile network operators for some time, with vendors supplying products that have had little-to-no security. Operators have not been willing to pay more for security and have squeezed vendors for lower-priced products. They've not really questioned the delivery of products with basic security flaws. Throughout the world, there is a shortage of security-focused engineers. Security must be a core component of modern technical degrees and training, but companies also need to ensure that, as part of their efforts to increase security, they invest in their existing staff to train them on product and cyber security.

David Rogers MBE
CEO, Copper Horse

David Rogers is a security specialist who runs Copper Horse Ltd, based in Windsor, UK. His company is currently focusing on security and privacy research for the Internet of Things as well as future automotive cyber security. He chairs the Fraud and Security Group at the GSMA and sits on the Executive Board of the Internet of Things Security Foundation.

5G: The Lingua Franca of International Communications

Mohammad Lari, Head of Cross-Government and International Coordination, 5G Testbeds and Trials Programme, DCMS, looks at how lessons learned from the initial stages of the programme have been shared.

GLOBAL BRITAIN IS A major governmental aspiration, and with the UK mobile networks, universities and projects that are funded by the Department for Digital, Culture, Media and Sport (DCMS) having led the way in 5G, it's an excellent way to open the door to international collaboration.

The success of the 5G Testbeds and Trials Programme has led to significant national and international interest. The projects have developed and experimented with the technology and use cases in a way that is of value to the whole of the UK and the world. DCMS is committed to work as closely as possible with industry, investors, regulators, users and researchers to better understand the opportunities that 5G presents. These opportunities will enable us to meet the objectives of the UK's industrial strategy: creating new growth through enabling business on the move, unleashing dynamic business models and opening new markets.

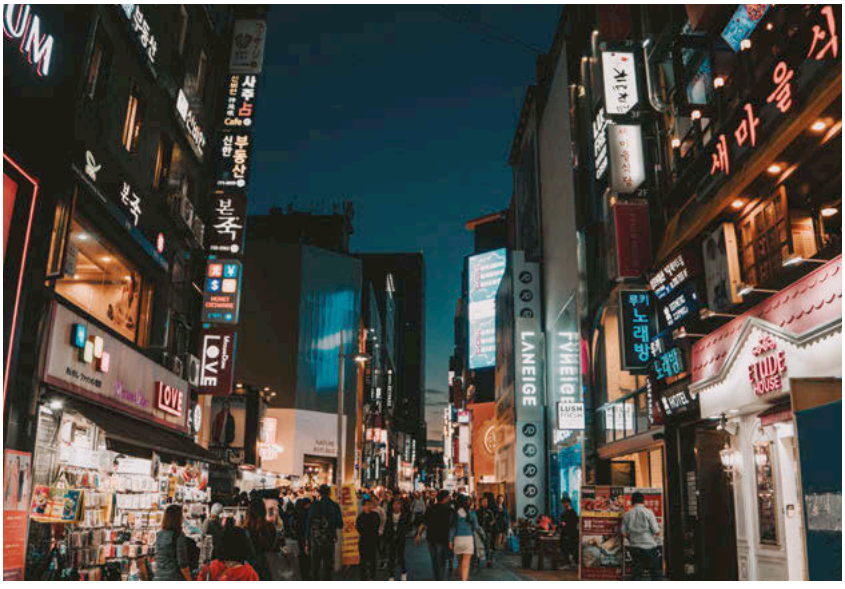
No industry co-operates as well as mobile telecoms. International co-operation is essential to set the standards necessary to build scale. As we head to 10 billion mobile customers globally, the economies of scale that bring down the unit costs of devices become ever more important to growth. Establishing a UK lead in setting the standards is of major value to British industry.

The UK has a proud position as an early adopter, but many lessons can be learned from other countries and their deployment of 5G. This has proved particularly valuable as we look to the fresh ideas in mobile and supplier resilience that we have learnt during Covid-19.

The standards we develop with our international partners need to take into account that not all 5G markets are the same: China has an industrial strategy for volume; South Korea has a population of early adopters and global leadership in devices; Japan, so long a leader in new communications technologies, offers open radio access network experience at scale and Olympics demonstrators; while the United States has particular experience with fixed wireless access.

From its origins in the 3GPP standards set up by the European Telecommunications Standards Institute (ETSI), the UK is well positioned to influence the future direction of mobile and internet standards, for applications and use across many markets.

With English as the lingua franca of the



SHAWN ANG/UNSPLASH.COM

international communications industry, we have a proud history of leading the discussions in international standards and coordinating international spectrum policy. A notable example is the liberalisation of the 3.8-4.2 MHz spectrum, also known as Band N77, which has been adopted in Japan and for the Citizens' Broadband Radio Service (CBRS) in the US. This builds a virtuous circle around scale and low prices for community access.

The DCMS 5G programme is committed to ensuring that the UK seizes the opportunity to be a world leader in 5G, but we are realistic about the fact that other countries may have an inbuilt advantage, such as in the development of 5G hardware. That is why we have taken a targeted approach that builds on the UK's strengths - in particular, enabling the 5G ecosystem by focusing on systems integration and interoperability, and leveraging UK expertise in cyber security and artificial intelligence (AI).

LOVING EU, LOVING 5G

As the UK forges a new partnership with the European Union, we work closely with our neighbouring countries and collaborate with other world-leading countries such as the US, South Korea and Japan. This ensures that the UK both contributes to international discussions and benefits from global 5G developments. A key objective is to facilitate and develop international links to maximise the benefits for the UK from collaboration and learning.

Our international engagements throughout 2019 and early 2020 focused on building stronger bilateral relations through collaborative research and development, and helping to foster a wider 5G ecosystem to align regulatory and security standards. We have been examining early trials and deployments, to share best practices and lessons from our initial portfolio of trials.

A great example of our work is how we linked South Korean businesses to pilot 5G technology across the Seoul and Glasgow metro systems. The joint project supports businesses in the two countries to develop and test 5G applications that explore new experiences for tourists and commuters on public transport.

Ericsson headquarters in Stockholm, where a UK DCMS delegation met with company representatives and had a tour of its technology showcase.

The UK-based 5G RailNext consortium, which is leading the project, is furthering trade opportunities for UK companies in South Korea, increasing investment chances in the UK and providing greater access for UK industry and academia to South Korean technology, hardware, software and intellectual property. These efforts are underpinned by an annual government bilateral ICT Forum, which focuses on advancing 5G and AI research.

AI will deliver huge benefits for the telecoms market

Other examples of our international engagements include working with partners in Dresden, Germany, where the programme connected colleagues from the Department for International Trade (DIT) with the 5G Lab Germany. The conversation focused on opportunities, challenges and pathways for collaboration related to the industrial internet of things (IIoT) for 5G. Attendees emphasised the need for more dialogue between 5G stakeholders. We also discussed consolidating testbeds through partnerships and working towards standards harmonisation through associations such as UK5G and the 5G Alliance for Connected Industries and Automation (5G-ACIA).

WE SHARED LESSONS from our rural trials at Mobile World Congress in Los Angeles, US, where we focused on business models for rural coverage based on the work of our consortium partners to disrupt traditional inputs and reduce deployment costs through innovative solutions. We used this opportunity to demonstrate the UK's continuing expertise in the creative and media industries, highlighting the use cases from our Smart Tourism testbed. It was clear throughout the exhibition that 5G and other technologies such as augmented reality/virtual reality would benefit the everyday activities of businesses and consumers. More importantly, it was evident that AI would deliver huge efficiencies across telecoms, contributing to network balancing, optimisation and risk management while reducing overall energy consumption.

At 5G Techritory in the Latvian capital Riga, programme representatives established global partnerships with the countries of the Baltic Sea region (Germany, Sweden, Denmark, Finland, Norway, Latvia, Estonia, Lithuania and Poland). This area accounts for more than 150 million inhabitants. Here, we shared details of the work from the AutoAir consortium and the research undertakings of the Centre for Connected and Autonomous Vehicles. We reinforced our commitment to accelerating the

Salmon farmed in the fast flowing sea around the Orkney Islands have less fat than those reared in other farms

development of solutions and standards for future transport systems and demonstrated how the 5G connectivity models tested at the Millbrook Proving Ground could be transferable to road and rail, especially as construction begins for the Rail Baltica project.

BEYOND 5G

In Helsinki and Oulu, Finland, a range of UK representatives met Finnish stakeholders to discuss their efforts for 5G deployment, including aspects of security and the roadmap to future mobile networks. The delegation met with Finnish Ministry of Transport and Communications officials, Aalto University and VTT Technical Research Centre researchers, the University of Oulu 6G research group, as well as leading companies including Nokia, Tieto and Ukkoverkot, now known as Edzcom. Discussions focused on the convergence of communications networks and distributed computing, which will rely on terabit capacity.

Then, programme officials along with other UK representatives attended a roundtable discussion in Copenhagen, Denmark, that was focused on the energy and agri-tech sectors. The discussion revealed several shared interests, including how 5G could support the UK and Denmark in their aims to meet targets of net zero carbon emissions. Project partner Cisco Systems showcased the achievements of the 5G RuralFirst testbed, demonstrating what 5G could do for a connected salmon farm and the benefits of installing 5G-connected weather sensors on a windfarm in the Orkney Islands. Meanwhile, Cybermoor demonstrated achievements that had been made in the 5GRIT project, and showed how an unmanned aerial vehicle in real-time could identify grass and soil conditions to help farmers improve the applications of fertilisers. Such innovations alongside other emerging opportunities for industrial use of 5G will help to improve our environmental footprint.

In Stockholm, Sweden, the UK delegation discussed 5G network research and future use cases of the technology with Ericsson, the Swedish Post and Telecoms Authority, the Swedish Infrastructure Ministry and the Royal Institute of Technology. Project partner, Real Wireless, showcased ways in which the AutoAir testbed had used 5G to accelerate the UK's infrastructure for connected and autonomous vehicles. The then Chief Executive of the Worcestershire 5G Consortium, ***Fiona Piercy***, discussed how productivity had been increased at Bosch and Mazak factories by using robotics, big data analytics and augmented reality powered by 5G. We identified opportunities to integrate further the countries' 5G ecosystems through

INDUSTRY COMES HOME

Getting together people who have different experiences is an important part of collaboration. This led to UK5G hosting 5G-ACIA at an event in Coventry in February.

ACIA stands for Alliance for Connected Industries and Automation. This organisation is focused on exploiting the power of 5G in manufacturing, with an emphasis on automotive.

5G-ACIA is an international organisation with a headquarters in Germany. So why the UK and why Coventry? The reason is a reflection of the UK's leadership in 5G; not many countries have 5G rolled out from all their networks, and, in part thanks to pioneering work done in the West Midlands on planning permission, Coventry and the surrounding areas have lots of 5G sites.

The purpose of the event was to look at the work done by ACIA on defining future 5G standards to meet the needs of industry. Robert Bosch's Andreas Mueller, the Chair of 5G-ACIA, explained that 5G was an essential enabling technology as factories transitioned from the use of static production lines to that of dynamic and flexible manufacturing environments in order to improve productivity and efficiency. The factory environment requires the ubiquitous wireless connectivity of 5G to connect sensors, actuators, mobile devices and the workforce. While looking to the future, Mueller paid tribute to the history of the location, explaining that the West Midlands was "the region where more than 200 years ago the first industrial revolution started. It is impressive to see how many 5G-related activities are already happening in the UK".

The impressive roster of presenters included Michael Bahr of Siemens, Jose Prats from Robert Bosch, Atte Länsisalmi from Nokia and Uwe Rüddenklau of Infineon.

Bhar explained: "This work is only possible if there's a dialogue between operational technology or manufacturing companies and networking IT companies from the technological or communication area. It's really interesting to see how different the ideas are that we're seeing short term and long term, and there are at least two different opinions on what is really necessary, what is possible and what the real needs of the industrial automation applications are."

You can find the presentations from the event on the UK5G website at:

www.uk5g.org/5g-updates/research/5g-

ARTUR KRAFT & RAMON VLOON/UNSPLASH.COM

> Glasgow metro is sharing lessons with the Seoul train

academic collaboration on topics that ranged from the use of 5G in smart factories to optimising network performance through AI.

WHAT WE HAD LEARNED was carried forward to Vilnius, where UK representatives laid foundations for collaborative opportunities as 5G is deployed in Lithuania. The timing was excellent, as Lithuania's national 5G roadmap was being finalised to be adopted in 2020. We discussed how innovation and uptake of 5G stemmed from a nurturing, thriving ecosystem, which incorporated a variety of stakeholders to influence national strategy and policy. We highlighted how deployment of 5G hinged on availability of spectrum as well as the underlying infrastructure. This led to discussions on how to build a trials programme, the challenges the UK had encountered, and how trials fed directly into a 5G strategy and wider government initiatives.

In the freezing winds of Reykjavik, Iceland, we showcased the UK's 5G development of health and social care applications. Officials from the Ministries of Health, Welfare, Finance and Transport, national health practitioners and members of the emergency services and telecommunications companies all showed great interest in the UK's experience.

Separately, given the explosion of tourism in Iceland, delegates discussed how to incorporate some of the successes that had emerged from the UK's 5G Smart Tourism testbed, in which visitors to the Roman Baths in Bath, Somerset, experienced mixed-reality simulations to add to their experiences. The visit provided insight into how UK businesses could aid Iceland on its 5G journey.

LIVING THE 5G FUTURE

As we open the door to technologies such as automated cars and advanced manufacturing, it is crucial that the UK's 5G networks are supported by a vibrant and diverse ecosystem of suppliers. To this end, the programme continues to engage with industry and other governments to enable development and testing of innovative solutions. Such solutions are being tested in the UK, but are widely being deployed by the likes of Rakuten in Japan. The programme continues to monitor these efforts. These large-scale deployments, similar to those we've seen across the UK, will provide further insight into performance and feasibility of architectures based on open and interoperable systems.

After a year of events and engagements, it is no secret to the global community that 5G is a priority for the UK Government. We have created a strong partner network and have identified plenty of research and business opportunities to help the UK grow its 5G ecosystem. While industry is best placed to respond to market demand and determine the scope of 5G, government has an important role to play.

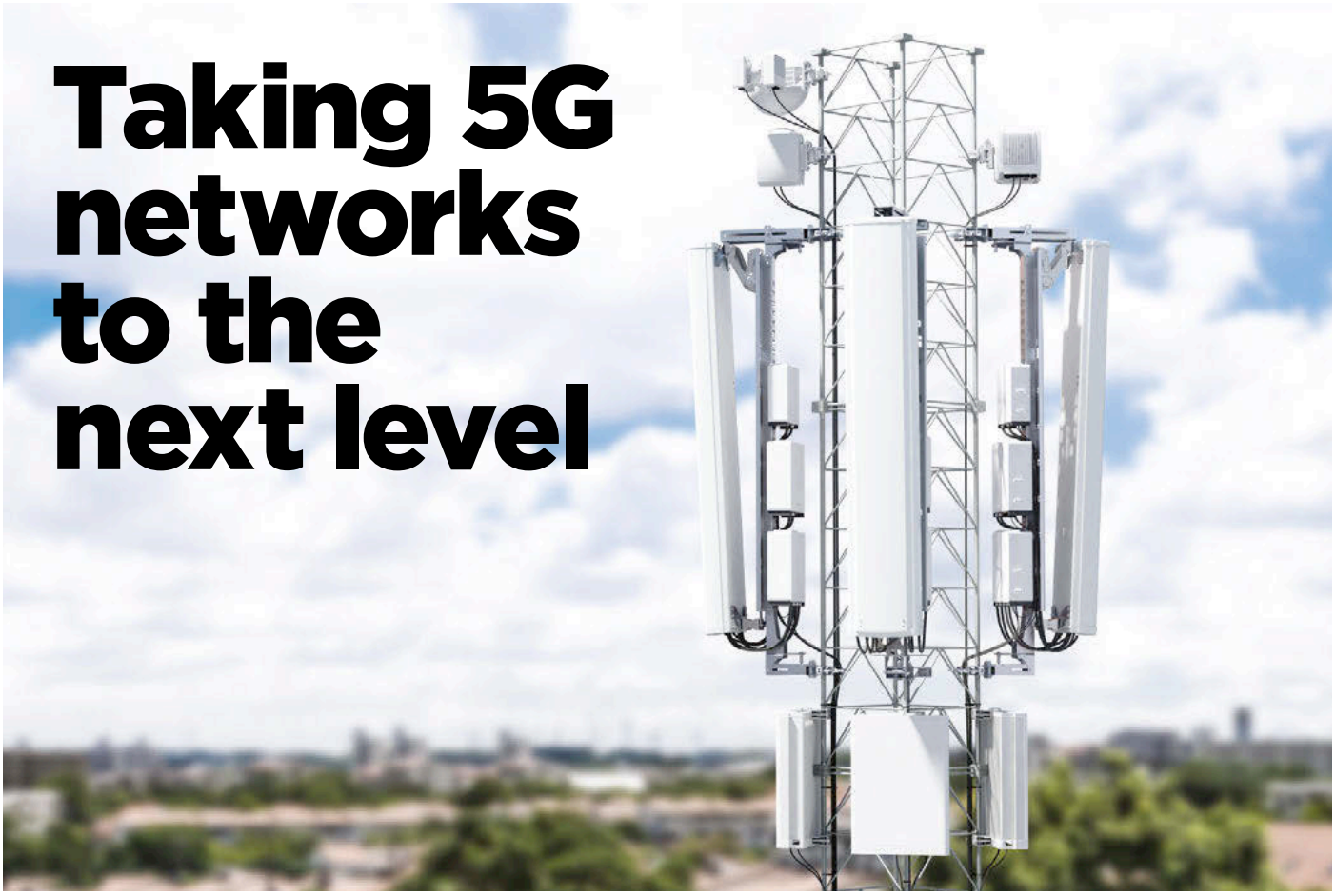
The testbeds and trials have put the UK in the lead when it comes to development of technology, applications and use cases for 5G. They are supported by the international working group at UK5G to identify benefits from those technologies to improve the well-being of society and ensure UK prosperity.

Mohammad Lari

Head of Cross-Government and International Coordination, 5G Testbeds and Trials Programme, DCMS

In his role at the Department for Digital, Culture, Media and Sport (DCMS), Mohammad Lari is responsible for the strategic coordination of cross-government and international activities for the UK's 5G Testbeds and Trials Programme. This includes working with stakeholders to facilitate and develop links to maximise the benefits for the UK from 5G research and development.

Taking 5G networks to the next level

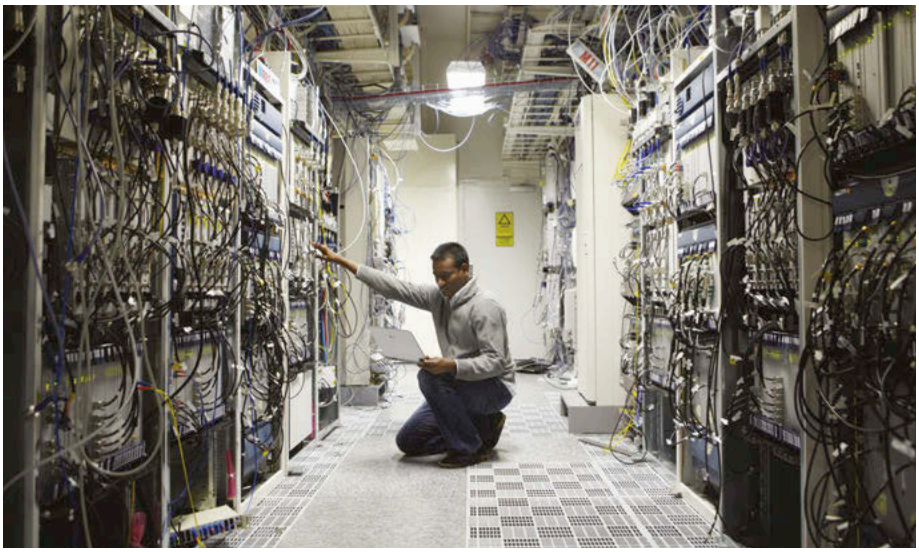


While it's true to say that 5G is here, we are only at the dawn of the age of the new technology. The stepping stones of 5G technology are rich in opportunites. Each new release of the standards opens up possibilites for operators, corporates and consumers. Ericsson is pioneering progress through the stages from the non-standalone technologies which have been rolled out across the world to the newer technologies of standalone.

Apps for Networks

Within standalone networks there are opportunities for new business models which come from the move to a 5G core. Ericsson's service-based architecture is as revolutionary for networks as the ability to run apps has been for phones. It allows the developer ecosystem access to the functions of the network in a secure and efficient way. Developers can use standardised links to the software in the network to create new services. Mobile operators move from a model where data travels through the network, to one where data is processed within it. This opens up opportunites for increasing revenue and reducing operating expenses. Ericsson is the first vendor to have launched a cloud-native Mobility Management Entity, moving part of the network which traditionally relies on custom hardware to an operator cloud environment, reducing cost and adding flexibiility. It is now in service with Verizon and Telstra.

Closer to home, Ericsson has signed a deal with BT to provide its 5G core. Whilst in most cases operators deploy separate platforms to support non-standalone first and then standalone, the Ericsson solution will do both and allocate technologies as BT and its customers require, eliminating the need to maintain a legacy system.



Sliced Airwaves

One of the key features that standalone provides is enhanced network slicing. This virtual-network-within-a-network technology opens many opportunities for the operator, developers and ultimately customers.

Where once an operator had one level of quality of service for all its customers it can now offer multiple levels of network performance as a value proposition. Each slice can have it's own metrics. Andrea Spaccapietra, Vice-President of Digital Services UK and Ireland at Ericsson, envisages a scenario in which a single user might be attached to multiple slices. A connected car might have a high-priority slice for vehicle-to-vehicle communication and accident prevention, a lesser slice for route management and a low-priority slice for infotainment.

Spaccapietra sees opportunities for operators in healthcare, utilities and lifestyle applications, and particularly highlights the possibilities for immersive gaming using location-based services.

In manufacturing, the mobile industry is exploring the potential for replacing cables in applications which previously used fibre and Ethernet and where radio reduces cost and improves flexibility to areas where fixed connectivity was either difficult or impossible, such as autonomous-guided vehicles and mobile cranes. The ultra-low latency of 5G is essential when machines are working together.

Audi and sensor manufacturer SICK have become testbeds for this. The introduction of 5G private networks is having a profound effect in the automotive sector with many factories around the world having already deployed dedicated private networks. A major benefit is the reduction of downtime. One of Ericsson's industry partners can build a digital twin of a deployment and then conduct "what if" experiments to optimise the production process without the costs of losing production.

The tight margins in manufacturing mean that even a very small efficiency improvement can make a significant difference to the bottom line.

The economic benefit of implementing these new technologies cannot be overstated. Research conducted for Ericsson by management consultancy Arthur D Little looked at the impact of 5G on manufacturing, energy and utilities, public safety, healthcare, public transport, media and entertainment, automotive, financial services, retail, and agriculture. It concluded that in 2030 the value of providing 5G across these industries would be around £44bn in the UK and US$1.5 trillion globally: the top three industries being healthcare, manufacturing and automotive, which between them would account for over half the revenue.

Spaccapietra also believes that higher levels of automation through connectivity will lead to the creation of high value jobs.

The sky is the limit

Combining different features offered by standalone technologies provides an opportunity for mobile operators to win back control of applications from the over-the-top players and processing from the cloud-service providers.

Combining communications and computing, mobile network operators can offer the solutions and services their corporate customers need and end users want. Clustering use cases through the platform approach makes it very powerful.

A major asset that mobile networks have is their closeness to their corporate customers; close both in terms of understanding customer need, and close in terms of having physical network infrastructure near the customer locations. This allows the operator to perform data processing at the edge of the network in an optimal way to meet customers' needs.

The architecture that Ericsson has created enables a flexible split between edge and core. It also integrates many functions that would previously have required space and expense. The result is a significantly more powerful, more agile, solution, with reduced capital and operational expenditures.

Ericsson is working with partners, its customers, and their customers, to install a wide variety of solutions. The ability to harness a standards based ecosystem which can deliver bespoke solutions combined with the speed and resiliency of 5G is a far more powerful proposition than anything we've seen in mobile communications before.

The extensive platform potential combined with the features of standalone 5G, which will come over the next few years, are so huge we cannot begin to envisage the difference they will make. Yes, 5G is here, but there is so much more to come.

For more information on Ericsson 5G digital services, EPC and OSS/BSS see www.ericsson.com/5g.

5G at the Port of Livorno

CASE STUDY Ericsson is the preferred equipment vendor for many mobile network operators that are installing private networks. In the Italian port of Livorno, west of Florence, Ericsson is working with Telecom Italia (TIM), the ENI Enrico Mattei Foundation, the Port System Authority of the Northern Tyrrhenian Sea and the National Inter-University Consortium of Telecommunications (CNIT) to supply and deploy an ambitious smart harbour project.

The port participates in the "5G for Italy" programme, a collaboration platform founded by Ericsson and TIM.

Over 30 million tonnes of cargo, 780,000 containers, 7,000 ships and 2.5 million tourists travel through Livorno every year, making it one of the largest ports in the Mediterranean.

A container can "choose" which vehicle it wants to use to continue its journey to customs or warehousing. This requires the bandwidth and latency of fibre with the flexibility of wi-fi. Only 5G cellular can deliver this.

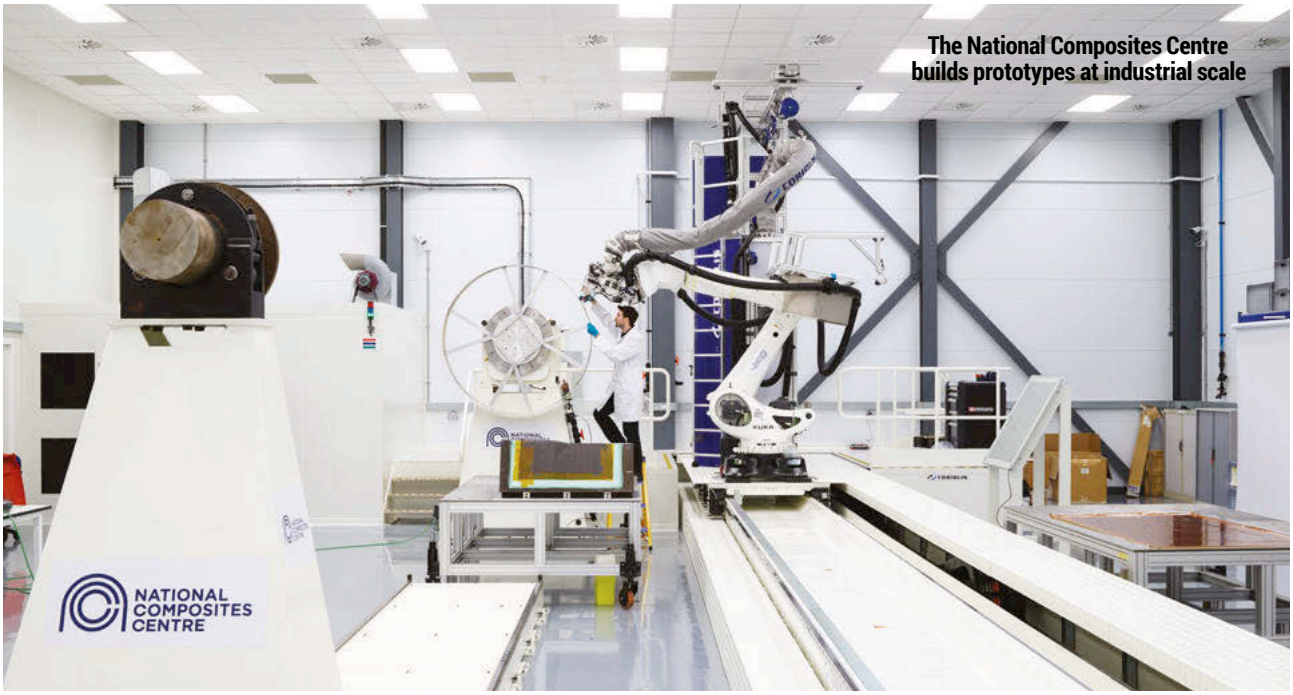
A stable connection with low latency is needed to provide remote control of cranes and autonomous vehicles, while bandwidth is needed to cope with the data traffic from an array of sensors and high-definition cameras. The 5G network provides physical security, geofencing autonomous vehicles. The expectation is that the robots will cooperate by working in swarms, exploiting technology developed for the military and leveraging cloud and distributed computing.

First results point to about 60 direct and indirect benefits for the port system, including: increased competitiveness; increased safety for personnel; the sustainable growth of the port city; management of responsible business in logistics; and a positive environmental impact that is estimated in CO_2 savings of 8.2 percent per year.

DCMS's initial Use Case Trial in Worcester showed the benefits of 5G in a manufacturing environment. Now it is doubling down with projects that are aimed at providing global benefits in advanced mass production techniques.

Industrial 5G

TESTBEDS + TRIALS



The National Composites Centre builds prototypes at industrial scale

THE COMPREHENSIVE set of research and development programmes DCMS has funded has helped to build the UK's leadership in 5G. The initial six trials have spawned the Rural Connected Communities programme, the Industrial programme and 5G Create, which is an open call for any kind of innovation projects based on 5G. All the projects benefit from what we have learned in those original six.

The success of the Worcester project, which showed significant improvements in efficiency and productivity at the Worcester Bosch boiler factory, led the programme to partner with Digital Catapult to consider how specific vertical industry sectors could benefit from coordinated innovation investment in exploring the application of 5G technology to their digitisation strategies.

That research and engagement, together with the Made in 5G report (Digital Catapult, July 2019) began the Industrial 5G project and has led to the 5G Enabled Manufacturing and the 5G Enabling Connectivity for Digital Engineering (ENCODE) projects being established alongside the national Industrial 5G Coordination project led by Digital Catapult. Here we look at these projects' plans for the two-year duration.

INDUSTRIAL 5G COORDINATION PROJECT

5G adoption can accelerate digitalisation across a range of industries, but this is not yet a well-trodden path. It's crucial to foster more focused, and seeded, collaborative activities to build an ecosystem of 5G-enabled solution providers focused on meeting the needs and requirements of these industries. To achieve this requires a coherent technically-underpinned coordination to bring together lessons learned across individual projects, trials and pilots focusing on 5G in industry so that they benefit the entire ecosystem.

The Industrial 5G Coordination project, funded by DCMS's 5GTT Programme and run by Digital Catapult, is set up to deliver this programmatic approach for cross-project technical coordination. It is seeding, advancing and sharing technical learnings on the deployment and use of 5G in industrial contexts, and is sharing what has been learnt

about innovation challenges and how to address them across multiple projects. The Industrial 5G Coordination project has now established, in partnership with 5G-ENCODE and 5GEMUK projects, Technical Forums and Innovation Forums specifically to address the need for effective guidance and support for the practical aspects of:

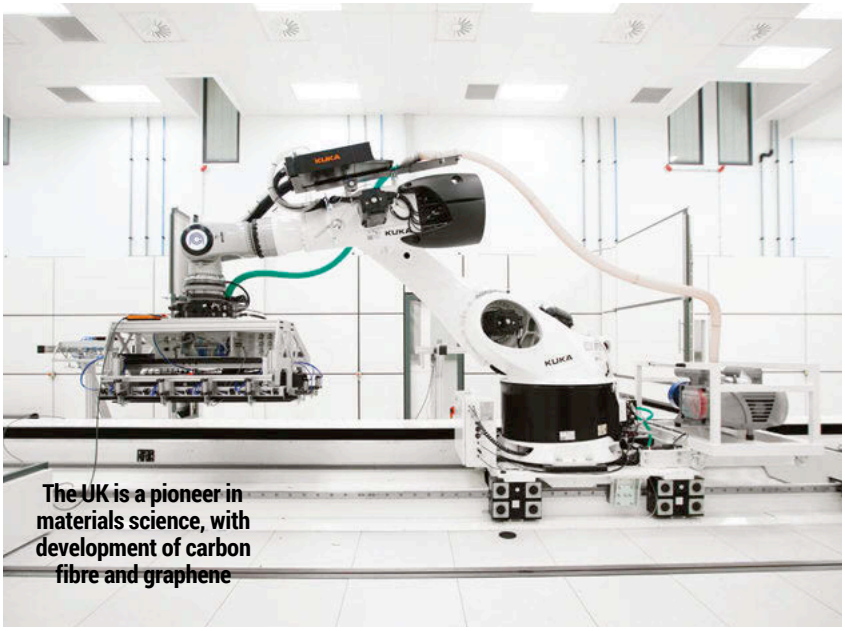
- Deploying 5G in industrial environments
- Exploiting 5G characteristics to create integrated advanced digital infrastructure fit for advanced digitalised processes
- Achieving interoperability and coherence within and between 5G systems; integrating legacy systems with 5G service architecture or operating on top of it; and across regulatory domains
- Ensuring provision for standardised, scalable, high-performing advanced digital infrastructure that can be adapted to numerous applications.

The objective is to approach these publicly funded projects as one programme with national-level outcomes, over and above single projects with individual, however significant, outcomes, in order to enable a faster development of the ecosystem, more impactful interventions, and to de-risk project activities through better sharing of technical and innovation responses to common challenges.

5G-ENCODE

ENCODE is a £9 million project with consortium members that include Zeetta Networks, Cytec Engineered Materials, Siemens, Plataine, Telefonica, Toshiba, Mativision, the National Composites Centre and the University of Bristol.

The programme examines new business models and value propositions that use enterprise 5G networks in an industrial environment and test some of the 5G technologies. In particular it's using some of the advanced features of 5G: network splicing and slicing in a real operational setting. Development work is being done in conjunction with the National Composites Centre in Bristol, which houses a specialist and advanced manufacturing environment for composites research and development. It's one of the country's innovation centres, with links to the concentration of aerospace development that is found around Filton near Bristol. The project is looking to work with



The UK is a pioneer in materials science, with development of carbon fibre and graphene

Airbus and Rolls-Royce, which are big users of composites technology, to improve productivity in composite manufacturing. Running in parallel is the Digital Engineering Technology & Innovation (DETI) programme, which will develop tools, technologies and processes for smart manufacturing and design, underpinned by the ENCODE network.

It is sensible to combine the advanced materials research of the National Composites Centre with the advanced research of the 5G Industrial Trials and Testbeds programme. Thanks to the pioneering work at Bristol University and the initial DCMS Smart Tourism 5G testbed, there is a cluster of 5G companies in the area. There is also backhaul fibre in the ground from the earlier projects.

STEPPED APPROACH

It's early days, and the initial stage is to focus on the solution architecture. But the experienced team has a good understanding of the use cases and need to ensure that the 5G network and the network infrastructure will support those use cases. As with many of the Rural Connected Communities projects, ENCODE is using 4G as a launchpad and will migrate to 5G when the 5G small cells become available: not just 5G handsets but also 5G dongles and devices. They are available today, but they're not cheap. During the course of the project, the team expects prices to drop quite significantly. Initially the specification will be the current standard release 15, 5G non-standalone, although the team is considering when to move to the future specification of release 17 standalone. This may be within the project timescale, before March 2022, but it will happen eventually as the project's end goal is to hand the infrastructure over to the National Composites Centre. A key driver for the DCMS projects is the suitability for transfer into commercial ventures. There is a pragmatic approach to using the right technology, be this Wi-Fi 6 or 4G.

The lead company for the 5G ENCODE project is Zeetta, a spin out from the University of Bristol's High-Performance Networks Group, which was involved in the 5G Smart Tourism and 5G RuralFirst Use-Case Trials. Zeetta is responsible for getting the infrastructure working so that it is ready to support the use cases. ***Vassilis Seferidis***, founder and CEO of Zeetta, told us: "We aspire to make the ENCODE testbed a national asset that will catapult to new heights the application of 5G technologies in the manufacturing sector." Zeetta is providing an advanced network control capability, and has a proof-of-concept multidomain orchestrator that will be developed as part of the project. In the early days, though, the network will be built using its single-domain, NETOS Rapide to manage the baseline private LTE network.

Initially the project managers expect to deliver improvements through use of very high-value manufacturing, much of which is modular, and the company constantly reconfigures the production line. Reducing downtime during configuration and making best use of the machinery and components rapidly pays dividends.

The second use case is around asset tracking. Composites manufacturing involves many time-critical steps, and there are challenges involved in keeping track of assets as they move between sites and manufacturing locations. When something like an Airbus wing is being made, it has to be moved between parts of the production facility, so the ability to hop between network technologies with network splicing is the key to being able to track assets in real time. The ultimate aim is a wireless factory that uses the low latency component of 5G to manage industrial systems. Factories are electrically noisy and experimenters with Wi-Fi have struggled. The expectation is that 5G will be more secure and robust.

An advantage of 5G is the possibility to reduce the carbon footprint through use of augmented reality for maintenance and training. If something fails, there is no need to wait for an expert to come out and fix things; the on-site engineer can be guided remotely to solve the issue. Use of this technique should address around 95% of the problems.

The National Composites Centre has two buildings quite close to each other. The network will run in both of these and in Bristol's Millennium Square, which was part of the Initial Use-Case Trial. The University of Bristol has its own dark fibre between the sites, which helps to bring down the cost. At the moment the internal networks have speeds of just 100 Mb/s but they will be upgraded to 2 Gb/s and engineers hope to move to 10 Gb/s.

While the project is initially framed as a private network that only SIM cards issued by the programme can use, the team is interested in looking at neutral host options that would allow users from any other network to attach and be routed through to their own. This requires interconnect and a billing system. Zeetta expects that the relationship with Telefonica, which is helping the company with the Local Access spectrum and testing development licence, will help.

The project partners include Toshiba, which is serving as a system integrator for an experimental LTE/5G infrastructure from National Instruments. The plan is to have the 4G system up and running very soon, using the Enhanced Packet Core from Druid Systems.

Druid has a lot of experience in private networks and, interestingly, the company's electronic product code is not just 5G ready, it already supports the current standards of 5G New Radio and 5G non-standalone. This will smooth the passage to the coming upgrade.

The private network model works well for access in the factory, but the ability to support 5G in Millennium Square is clearly attractive. This ability would increase the scope of the project considerably, however, as it would need the addition of billing, carrier interconnect, voice and even phone numbers, none of which are a necessary part of a private network. One advantage of having cells outdoors, however, is that they can pull a timing signal from the global positioning system. All phone networks need highly accurate timing; to achieve this via GPS requires a clear line of sight to the sky. The 5G ENCODE project will investigate other solutions for the in-building cells.

Although ENCODE is still in the planning stage, it has assembled an impressive list of industrial players with the right experience and skills to build one of the largest testbeds of industrial, private 5G networks in the UK.

5G ENABLED MANUFACTURING UK

The 5GEM UK project looks at how 5G can improve the manufacture of electric vehicles. For the last 120 years the car has evolved slowly, and while electric cars have been around all that time, the focus has been on those powered by oil-based fuels. In 1886 Carl Benz built what is generally accepted to have been the first car. The one-litre engine developed two thirds of a horsepower. Today's Mercedes-Benz A45S AMG produces 415bhp from two litres. Electric cars have seen nothing like that 300-fold improvement, and yet the governments of the world are mandating a switch to electrically-powered vehicles over a strict timescale.

This comes just as attitudes to personal transport are changing and personal car ownership among some groups of people is no longer considered a necessity, particularly those in cities. Only agile automotive companies will survive the changes in regulation and consumer demand.

Ford offers electric drive with the Transit hybrid

It is against this background that Ford is working with several consortium partners including consultancy HSSMI on various projects, notably one called E:PriME that is investigating ways to scale up some prototype manufacturing techniques and technologies that are suitable for electric vehicles to make them ready for mass production.

Such are the complications and overheads involved with hardwired connections that the move to 5G could pretty much cancel out the installation cost, while its use enables a lot more machines to be connected and a lot more data to be analysed. It has to be 5G because the work needs the low latency that the protocol provides. The project will develop a system at Ford's R&D centre in Dunton, Essex, with a view to rolling it out to sites around the world. Vodafone was a natural partner for Ford because the two firms had an existing relationship.

The kind of benefits that 5G can offer have been demonstrated by the effort that was necessary to reconfigure the factories when in March this year Ford switched from car to ventilator manufacture. While Wi-Fi was flexible enough for this rapid deployment, technologies such as Hololens struggled with bandwidth and reliability on the shop floor.

HSSMI works with The Welding Institute (TWI), a research and technology organisation for the welding industry. Laser welding is an advanced technology and the applications are pretty bespoke. A lot of data are needed from the process in order to understand the final quality of the component being made; in particular, data are necessary to check the welds that are required to make the hairpin stator of high-performance electric motors. This is where 5G comes in.

The stator is the fixed part of the motor, around which copper is wound. It's both the body of the motor and fundamental to the electrical properties. The quality and precision of the stator welds affect the cooling, power and efficiency of the motor. There are 150 connections per hairpin stator, with up to 30 data points per millimetre of weld. That means 600 data points per seam weld. Weld time is 0.86 seconds. Analysis requires heavy data processing in real time so that managers can make instant data-driven decisions. This job

E:PriME lab at Ford Dunton. Steve White (left) and Russ Goodbody examine the hairpin laser-welding equipment

requires incredible, repeatable precision with thousands of welds a minute.

The second area of interest is Midlands-based company Vacuum Furnace Engineering, which services vacuum furnaces, melting and casting furnaces, electron-beam welders, pumps, spark plasma sintering machines and autoclaves. The ability to add remote maintenance to its suite of skills and to monitor parts as they are being heat treated is extremely valuable and makes the process much more efficient.

Satwik Mehta, Engineering Director at HSSMI, explains: "As engineers, what we don't like is uncertainty. We should know what is happening inside. We don't want to be coming back at the end of a two-hour, three-hour cycle only to reject these parts."

Improved understanding of what is happening through manufacturing brings benefits through the lifetime of the vehicle. Knowing the batch in which components were made and the metrics from their production helps with repairs, servicing and recalls.

Applied Tech Systems (ATS) is an important partner. It is an independent solution provider for smart digital transformation. The 5GEM project is using ATS's expertise in sensors and network architecture to implement new manufacturing techniques, such as virtual and augmented reality. The 800 degC vacuum furnace manufactures high-value components and the process can take many hours. The ability to monitor and manage the metallurgical processes is invaluable.

Chris Allen, from Vodafone, sees as serendipitous the timing of the shift to electrification and the introduction of 5G: "Ford is undergoing a massive transformation right now, moving from making internal combustion engines to electric engines. It's having to refit and build lots of factories anyway. So the timing is good because it's a great opportunity to rethink the way they do it."

Connection of the private networks in Ford's factories will reap benefits, and the 5G Testbeds and Trials project will pioneer this work with networks in Essex and Cambridge employing a common core. The infrastructure is supplied by Ericsson, using 3.5GHz spectrum and starting with non-standalone equipment, aspiring to move to standalone during the timescale of the project.

The private network will remain private even when a customer of Vodafone visits the factory: even though it will employ Vodafone SIM cards, no visitor will be able to connect.

A major benefit of the project will be data visualisation. Ford has more than a million connected machines across the world. As the company reshapes itself for the new transport market, the need to understand the data produced by the machines is crucial. The data are also incredibly commercially sensitive. Vodafone and the University of Lancaster are building in security and data management, based on existing university trials.

A key output sought by the Department for Digital, Culture, Media and Sport (DCMS) is repeatability and scalability. The work being done in Essex today is the start of making the project international. Mehta says: "That is the big opportunity that we have, that if we are able to get it right at Dunton with the 5G programme, the opportunity could be to scale it at a much larger scale. Fixed connections take too long. We have to maintain them and they need to be validated most of the time."

Moving to a cellular connection adds flexibility and that leads to a better use of data, which in turn makes the connected machines more efficient. Today, if there is a fault, teams of people have to be onsite to dump the data from a machine. With a connected and interconnected network, the running of the factory improves. The information available also powers the decision making and analysis is better informed. This leads to better planning. Connections and networking can be in place even before machine deliveries hit the shop floor.

The car industry might be more than 100 years old but there is still plenty of scope for it to learn new tricks, many of them from the new upstart: 5G.

Opening Up the Telecoms Supply Chain

Mobile networks have become dependent on a small number of global suppliers. That lack of diversity creates a significant security concern that increases the risk of some form of systemic failure. For some governments there is an additional concern related to high-risk vendors. Steve Unger, former CTO of Ofcom, looks at how new, open standards applied to 5G networks might increase supply chain diversity.

THE TELECOMS supply chain has received a great deal of attention in recent years. Networks are now of critical importance as they underpin our economy and bind society together. Our dependence on these networks has been starkly illustrated by the measures that are being implemented in response to coronavirus.

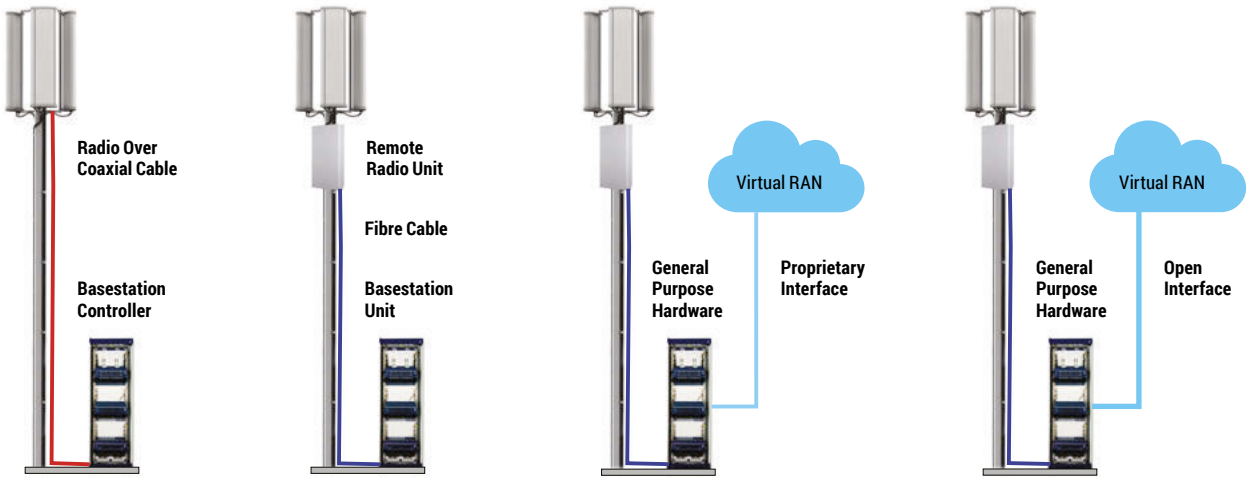
Regardless of your views on the issues around particular vendors, it is difficult to disagree with the proposition that, from a security perspective, a more diverse supply chain would be a good thing.

The same is true from a commercial perspective. Network operators need to be able to source equipment from multiple suppliers in order to keep costs down and to drive innovation. The current situation, in which many operators are locked into existing supply arrangements with few alternative options, is bad.

Over the last couple of years we've seen the emergence of two parallel initiatives:

- Governments have acted to push diversity into supply chains. In January the UK Government announced that "high-risk" vendors would be limited to a market share in the access network of 35% (see www.cwjp.co.uk/hrv). At the same time, the European Commission set out its proposals for a European Union security "toolbox" (www.cwjp.co.uk/security), which contained very similar measures to those that had been adopted in the UK.
- Mobile operators have moved to open their supply chains. They are supporting the development of open standards, which enable different elements of a radio-access network (RAN) to interoperate with each other. It then becomes practical to construct a network that uses equipment from multiple suppliers. For example, Vodafone and Telefonica have collaborated to improve the commercial availability of "Open RAN" solutions.

Substantial practical benefits are likely if those involved in these initiatives work together. Various administrations including that of the UK have made clear that they intend to introduce new regulations designed to improve network security. Those



A
Basestation with integrated controller

B
Basestation with separate radio and baseband units

C
Virtual radio access network

D
Open radio access network

regulations are more likely to be effective if they go with the grain of the market and are implemented in collaboration with industry. Industry and consumers also stand to benefit if measures taken by government to improve security also drive commercial choice and technological innovation.

First I will briefly explain work that is underway. Much of that work deals with mobile, and I will focus on access rather than core networks, since access networks dominate total costs. The diagram above illustrates the key trends in the way that the design of mobile-access networks has evolved over time. Several stages can be identified in this evolution:

- In traditional mobile base stations used in early mobile networks, the antenna was at the top of a mast, and a base station controller (BSC) was at the bottom (Fig 1a). These were connected via a co-axial copper cable, which carried the radio-frequency signal.
- The BSC was subsequently split into a remote radio unit (RRU), located at the top of the mast, and a baseband unit (BBU) (Fig 1b). These were connected by a fibre-optic cable. The advantages of this approach included the elimination of losses associated with co-axial cable, and greater flexibility as to the location of the BBU.
- The next step was to virtualise the functionality provided by the BBU, so that it became a software application that ran on general purpose computer hardware (Fig 1c). The advantages of this approach included reductions in the cost of hardware, introduction of flexibility into the software solution, and the ability to manage multiple sites in a tightly coordinated manner. However, the interfaces between the different components of this system were still proprietary.
- Now there is interest in replacing those proprietary interfaces with open interfaces that have equivalent functionality (Fig 1d). This move will make it possible to procure different elements of an access network from different vendors.

IT IS IMPORTANT TO NOTE THAT a virtual RAN is not the same as an open RAN. Virtualisation has already delivered significant benefits, but open interfaces offer additional benefits, and these are the prizes we should be aiming for now.

Work is underway in the O-RAN alliance (www.o-ran.org) to develop the technical standards that make this possible. This alliance was launched in February 2018, is led by a group of 24 operators, and includes around 130 equipment vendors in its membership. The intention is not to replace existing standards, such as those developed by the Third Generation Partnership Project (3GPP); instead, the alliance will build on those standards to develop new ones, or more specific profiles will be developed for the existing standards, where that is necessary to improve openness.

SKILLS AND STANDARDS

Whilst open standards are necessary as an enabler of greater supply chain diversity, they are not sufficient. Action will be required on other fronts in order to ensure the implementation of more open networks on the ground. I have identified three actions as being particularly important:

Firstly, it will be necessary to establish the skills base that is required to build complex systems from multiple suppliers. In recent years, many operators have lost capability in this area, as they have outsourced much of the responsibility for systems integration to their major suppliers. That trend will need to be reversed if we are to benefit from the potential of open-RAN technologies.

Of course, it is unlikely to be cost effective for operators to maintain all the necessary skills in-house. We are likely to need a new generation of systems integrators who are independent of existing vendors and able to work on behalf of network operators. That creates an interesting new commercial opportunity for the private sector. But it also requires the government to consider what it can do to help, through training and

accreditation schemes, and perhaps subsidies.

Secondly, we will need test facilities that can be used to understand the real-world behaviour of complex networks that are sourced from multiple vendors and which operate at scale. It is unlikely to make sense for every operator to establish its own such facility, so this is an area in which there is a strong case for collaboration between operators, potentially with support from government.

Thirdly, it's important that the process of developing and implementing open standards is itself open to as wide a cross-section of industry players as possible, from new start-ups to established vendors. The aim is to create new opportunities for all.

If we get this right, what might we achieve? I can identify three outcomes that we might strive for.

First, and most obviously, we can increase the number of suppliers that are active in the UK supply chain. Of course, it's important to be realistic as to what's achievable. Many of the components of a RAN are commoditised, and their manufacture is subject to significant economies of scale. So the market will always be dominated by a small number of global suppliers. But if we could increase the number of major infrastructure suppliers that are active in the UK to, say, four or five, that would significantly reduce the level of systemic risk to which we are currently exposed. It would also provide operators with a real choice of vendors, and competition would help with costs.

> **we need to grow the UK vendor base**

Secondly, there are several UK-based suppliers of radio systems for which open RAN will create new commercial opportunities. They may not be able to compete in the commoditised part of the network, and they cannot offer the end-to-end solutions that are provided by the major global players, but that doesn't matter - open RAN should mean that they no longer need to do so. There will be scope for systems that address specific challenges in a focused way, and in those circumstances the ability to develop innovative solutions may be as important as unit costs. And there are plenty of small UK companies that have strong track records in wireless innovation – for example, Blu Wireless, CableFree, Cambridge Broadband Networks and Plextek.

Finally, it will be interesting to see whether more open network architectures will enable the entrance into the market of new types of mobile operator. That is unlikely to be a priority for the operator-led O-RAN alliance; but it's interesting to observe the success of Rakuten in Japan, which has deployed the world's first fully virtualised, cloud-native open RAN. It will be fascinating to see whether that example is followed elsewhere.

Steve Unger
Strategy, Technology and Policy

In his role as a member of the board of the Office of Communications, Steve Unger set regulatory strategy for the UK, represented the UK internationally, and led its technology programme. He now holds a variety of advisory and non-exec roles, including on the UK Government's 5G programme board. A common theme across this portfolio is an interest in how markets exploit disruptive technologies, and how public policy can maximise the resulting benefits.

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Remembering the FUTURE for 5G smartphones

Ben Wood has one of the largest private collections of mobile phones (comprising more than 1600 devices). He is in the process of setting this up as a charity to safeguard these important icons of communications history. Here he looks at what lessons 5G device designers can learn from previous generations of tech.

2002
MOTOROLA V70

2008
MOTOROLA AURA

During the last 25 years I've been lucky enough to be part of a remarkable era in mobile communications, having witnessed the birth of the last four generations of technology from 2G to 5G.

The underlying network technology is primarily what makes the magic happen, but the most pleasure for me has come from the handsets. They're the most tangible aspect of mobile communications for people, and the visible indicator of how fast things have changed in the mobile world.

Innovation in devices has come in multiple areas. Engineering geniuses have been able to pack ever more complex technology into phones that are small enough to slip into a pocket, powerful enough to be a computer in your hand, packed with sensors and cameras but still with enough battery life to last all day. The advances have been nothing short of miraculous. The latest generation of 5G devices has added a new layer of complexity. They have to support an eye-watering number of spectrum bands and some of the most challenging antenna architectures yet devised.

2009
SONY ERICSSON PURENESS

But the physical design of the devices appears to have stalled. In fact, I'd argue we've seen little progress in designs since Steve Jobs pulled the iPhone from his pocket in January 2007. Apple's iconic product established what has become the dominant design for all smartphones – a rectangular slab with a touch screen. The past decade has been characterised by what I termed the "sea of smartphone sameness" several years ago.

BEFORE THE SLAB

Outside my day job as a mobile telecoms analyst at research firm CCS Insight, I've quietly established a comprehensive collection of mobile phones spanning the period from 1984 to the present day. More recently, I've decided to use this collection and a wide range of devices donated by others to establish a mobile phone museum, which I'm currently setting up as a charity. While I've been working on this project over the past few months, it has got me thinking about what aspects of the devices of yesteryear I'd like to see in modern 5G smartphones.

The first area would be materials. Currently

2005
SAMSUNG B&O SERENE

2003
NOKIA
N•GAGE

2020
TCL FLEX
SERIES 2
CONCEPT

1997
MOTOROLA
STARTAC
RAINBOW

2003
SIEMENS
XELIBRI 2

2007
iPhone

2003
NOKIA 8910I

device makers seem fixated on using glass as the primary finish on smartphones. There are some good technical reasons for this, especially when you want to incorporate technologies such as near-field communication and wireless charging.

However, I'd love to see a return to some of the more imaginative materials we've seen in the past. They include the gorgeous stainless-steel finish on the Nokia 8800 and stunning variants such as the 8600 Luna, 8800 Arte and 8800 Sirocco editions. Then there's the titanium finish on the Nokia 8910, the carbon-fibre finish used on LG's Black Label devices like the Chocolate, Secret and Shine models, or even the stunning Sony Ericsson Xperia Pureness, which had a see-through screen. A small company called Carbon Mobile is currently working on a carbon-fibre phone, but it's a long way from being a mass-market phenomenon like LG's Black Labels were.

I'd like to see more innovation in form factors too. It would be great to have phone makers come up with something more than the boring black touch-screen monoblocks that pervade the market. You only have to look back at the iconic design of products such as the banana-shaped Nokia 8110, the classic Motorola Razr V3 clamshell, the unique rotating Motorola V.70 and Aura devices or Siemens' collection of quirky Xelibri devices to realise how unimaginative mobile phone design has become.

FLEXIBLE FUTURE

The advent of bendable display technology makes me a bit more optimistic about the shape of phones. We've already seen the emergence of interesting pieces such as Samsung's Galaxy Fold and the beautifully designed Galaxy Z Flip. Many other phone makers are experimenting with designs that take advantage of folding screens; some of the recent prototypes from Chinese manufacturer TCL are good examples of what's possible.

Yet I also need to remain realistic about my expectations. Ultimately there's a reason why the current mobile phones all tend to look the same. It would appear that Apple identified a shape that was optimal for how most people use their smartphones. The technical challenges presented by radio-frequency efficiency, thinness and robustness also place limits on the shape of phones and the materials used to create them.

Perhaps the diversity we've seen in the past merely reflects a voyage of discovery that the industry needed to take as technology matured, materials changed, components shrank and we learnt what we needed about phones and how best to use them. It might just be that we've already lived through the golden age of mobile-phone design. If we really have already seen the most innovative, interesting and diverse examples of phone design, my efforts with the mobile-phone museum are more important than I realised.

You can find more details of the collection at mobilephonemuseum.com. If you have any mobile devices that you think may be of note, Wood would love to hear from you.

Ben Wood
Chief of Research, CCS Insight

Ben Wood is Chief of Research at analyst firm CCS Insight. He specialises in connected devices. With over 25 years' experience in the mobile sector, he has held positions at Gartner, Lucent Technologies and Vodafone and was involved in the launches of SMS and mobile data. Ben is a notable industry figure who is frequently quoted in the media. Follow him at @benwood for rapid reactions to industry announcements.

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Glad To Be Grey: The Power of Shared Spectrum

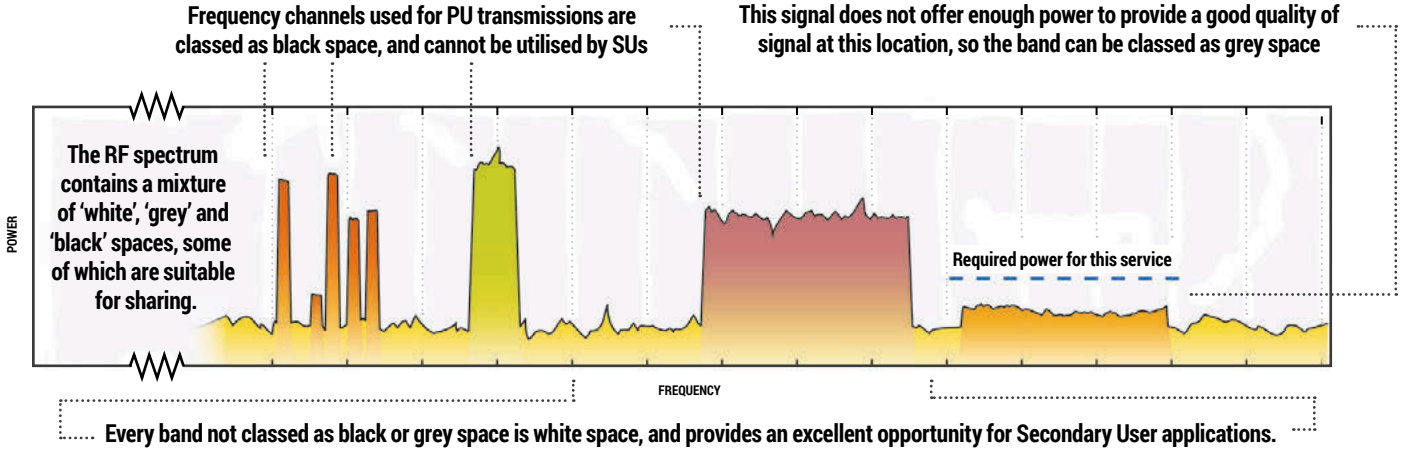
The colours of the spectrum are white, black and grey. That might not sound very dynamic, but Kenny Barlee from the University of Strathclyde shines a light on how, by making nice with the organisations that have the right to use frequencies nationally, small companies can play in the spaces that have been left in the dark.

ANNIE SPRATT / UNSPLASH.COM

WIRELESS DEVICES make use of the electromagnetic spectrum in order to communicate. Traditional spectrum policies have seen regulators such as Ofcom categorise bands of this spectrum for specific applications, and exclusively license these bands to particular entities known as Primary Users (PUs). For cellular applications, in general, the more spectrum an operator has access to, the higher the data rates it can normally offer. Spectrum is a valuable commodity, and therefore licences often cost a significant amount of money. Licence fees at the 2018 cellular frequency auction in the UK (for the 2.3GHz and 3.4–3.6GHz bands) totalled £1.37 billion; an average of £7.2 million per MHz[1]. The average cost of a 20MHz block would therefore be around £144 million. Licensed spectrum is not available to the masses, and is certainly too costly for a small operator to perform any sort of rollout.

These high prices are said to be a result of spectrum scarcity. Yet upon inspection, large parts of the spectrum are actually underutilised or not used at all in certain geographies. Take the rural Highlands and Islands of Scotland, for example – there is very poor mobile coverage in some locations, despite mobile network operators (MNOs) owning licences to broadcast their services there. Where there is no business case for operators to deploy, they don't; the spectrum sits empty and the resources are wasted.

The terms white, grey and black space have been coined to classify the state of any and every band of the RF spectrum[2]. At any particular location, channels that are continuously occupied by PU signals can be classed as black spaces. Under no circumstances should another party, a Secondary User (SU), consider accessing these channels to transmit their own signal. White-space channels are those that are not in use at a particular location. These may be empty because they are being used as guard bands to prevent possible interference with other PU signals, or it may just be that the channels have not been used, even though they could have been. There are white spaces throughout the spectrum (TV, radio, cellular bands etc.), and these are ideal for sharing by SUs, as long as the SU transmissions do not interfere with PU transmissions. Permission to use white spaces may be required from the relevant parties; we will come back to this. Finally, grey spaces are channels that are in use on a part-time basis, or channels where a received PU signal broadcast from a location far away is too weak to provide the required quality of service to customers, as shown (see overleaf). Grey spaces pose the greatest challenge to SUs, because in order to operate in them, SU radios must be highly dynamic and able to reconfigure themselves



to vacate the band whenever legitimate PU signals are detected. Also, if the SU broadcasts over the top of a weak PU signal, it must ensure that it transmits at a sufficiently low power not to cause interference in surrounding areas where the PU's signal can be received.

Over the last 20 years, a number of bodies (governments, regulators and research institutions) around the world have begun to accept that the way in which spectrum is managed needs to change. By developing new policies that incorporate new shared spectrum access concepts, these finite resources can be used in a far more efficient way. With shared spectrum, it is possible to reuse vacant white space (and potentially grey space too), and allow third-party SU operators to deliver wireless services in areas where the PU licence holder has chosen not to deploy.

TV WHITE SPACE

One example of channel sharing that has been adopted in the UK, US, India and parts of Africa is TV white space (TVWS) – white space that is available in the TV broadcast band. A number of TVWS channels have been created in the UK in recent years, thanks to the switch from analogue to digital TV, which compacted the spectral requirements of broadcasting while adding more services

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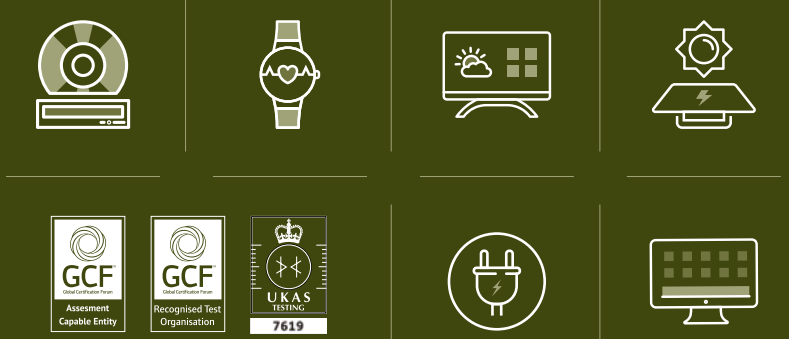

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through the use of multiplexing. Since 2007, Ofcom has been exploring the possibility of allowing licence-exempt SUs to have access to TVWS. The RF propagation characteristics of this sub-1GHz 'ultra-high frequency' (UHF) band are appealing. Signals are able to travel further with the same power as those broadcast at higher (multiple GHz) frequencies, due to the properties of the electromagnetic waves. Sub-1GHz waves are good at diffracting around hilly terrain, so are excellent for non-line-of-sight communications. They also penetrate buildings better than higher frequency waves, which means they are useful to solve indoor coverage issues such as Wi-Fi black-spots.

A SERIES OF PILOTS[3] HAVE BEEN run in several parts of the UK to confirm the feasibility of the TVWS concept. Projects hosted by the University of Strathclyde included provision of rural broadband to various remote communities in Scotland via TVWS, and testing the deployment of new TVWS-compliant Wi-Fi equipment (802.11af) in homes around Glasgow. Ofcom used the findings from the various trials carried out by the university and other UK research institutions to finalise its TVWS policy, published in 2015[4]. This is very similar to the policy adopted by the US's Federal Communications Commission[5].

The end result is that SUs are now allowed to use TVWS bands, free of charge, on one condition: their radios must first contact a regulator-approved White Space Database (WSDB) in order to establish which frequency channels they are permitted to use at a particular location, and at what power levels they are allowed to transmit. The WSDB is 'read only', so all TVWS devices looking to access the spectrum at a particular location are provided with the same list of channels and the same maximum transmit power value for each channel. There is no option of 'checking out' a licence for a particular channel, so TVWS users need to compete with one another when gaining access. While some commercial TVWS deployments have begun, the high cost of specialist radio equipment and the challenges of coordinating TVWS networks have hampered uptake.

SHARING FOR 4G/ 5G CELLULAR

Momentum for shared spectrum has been growing steadily worldwide in the last two years, despite barriers in its way. This has been partially led by the drive to implement 4G and 5G mobile networks. Baig et al.[6] were the first to propose the deployment of unlicensed 4G LTE signals in TVWS shared-spectrum channels. Building on this and past work in shared spectrum and TVWS, the team at the University of Strathclyde worked with key technology partners (such as CloudNet IT Solutions Ltd on Orkney, Cisco Systems and BBC R&D) to design, develop and deploy a 4G/5G mobile network on the Scottish Orkney Islands through 5G RuralFirst[7].

5G RuralFirst was a UK government-funded testbed that was part of the Department for Digital, Culture, Media and Sport's Initial 5G Use Case Trials programme. The project ran from June 2018 to September 2019.

The mobile network that was built for 5G RuralFirst used the UK's pioneer 5G bands: 4G B28/ 5G Bn28 (700-

800MHz) and 4G B42/ 5G Bn78 (3.5-3.6GHz). While test and development (T&D) licences were obtained from Ofcom to permit legal operation of the network, the base stations and mobile network as a whole used shared-spectrum technologies. Available spectrum was entered into a 'pool', and a shared-spectrum manager (based on the standard used for the Citizens Band Radio Service (CBRS) in the US[8]) was used to issue radio spectrum to base stations on demand. Upon receiving new spectrum allocations, the software-defined base stations could be automatically and remotely reprogrammed to update their configurations, and to create mobile cells as required at available frequencies in pseudo real-time. This automated form of spectrum sharing is often referred to as Dynamic Spectrum Access (DSA).

TWO OF THE IMPORTANT KEY deliverables of 5G RuralFirst were white papers that addressed the need to introduce shared spectrum to cellular bands, in order to enable third-party community operators to build and run SU mobile networks in rural areas that were experiencing PU market failure, where no service was being provided[9,10]. Following the release of the white paper, Ofcom opened a series of consultations that focused on the upcoming 5G spectrum auctions and the topics of shared spectrum, local licensing and PU coverage obligations. New shared bands in cellular spectrum were proposed, along with a new licensing model that would support SUs. Stakeholders, in general, responded positively to the proposals. Reactions included this statement from techUK: "Ofcom is to be congratulated for proposing such a radical shift in terms of access to spectrum."[11]

Ofcom has since announced that "airwaves [are being] opened up to support [the] wireless revolution"[12]. From December 2019, Ofcom made parts of the 1800 and 2300MHz (B3, B40) 4G cellular bands, the whole of the 3.8-4.2GHz (Bn77) 5G band, and the 26 GHz (Bn258) mmWave band, available for shared access[13]. Ofcom has also stated that it will consider localised SU-sharing requests for access to other mobile bands in locations where these bands are not being used by the PU licence holder. Applicants will only need to pay a small administration fee to Ofcom in order to gain access to these new shared spectrum bands[14].

CELLULAR SHARED SPECTRUM FUTURE

Using shared spectrum and DSA, a third-party SU, for example a community operator, could access spectrum that MNOs leave fallow, and use it to provide a mobile and/or Fixed Wireless Access (FWA) broadband service in its community. An advantage of this approach over TVWS is that there is a vast ecosystem of 4G smartphones and mobile broadband modems, and a rapidly expanding ecosystem of 5G devices. The business case for this strengthens when it is combined with other technologies such as neutral hosting, in which the physical radio and antenna at a base station are shared. Traditionally in mobile networks, each MNO installs its own equipment to serve its customers. In the UK, this means that four separate networks have been developed, and this comes with about four times the capital cost (albeit with some mast and backhaul network sharing).

With neutral hosting, community operators could build and run their own networks using shared spectrum to provide services in their communities that could also serve the MNOs, increasing the MNO coverage footprint while earning the local operator 'rent' to recoup the costs of capital and operational expenditure. This would probably cost MNOs significantly less than the Shared Rural Network (SRN), which will see MNOs sharing neutral metal-work (i.e. masts) but still having to deploy their own radio equipment at each site[15].

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Kenny Barlee
5G New Thinking

Kenny Barlee is a Research Associate in the Software Defined Radio Laboratory at the University of Strathclyde. He is part of the team that designed, developed and, with the help of partners, deployed a full shared-spectrum 4G/5G mobile network across the Scottish Orkney Islands in 2018-2019 as part of the 5G RuralFirst project. More information can be found at https://www.linkedin.com/in/kennethbarlee

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UK5G in Lockdown

Covid created connectivity challenges for even the most tech-savvy

THE PAST IS NOW divided into two parts - pre-Covid and post-Covid. The time before the virus struck seems distant now. The impact has been profound on every organisation, and UK5G has been no exception. Events and face-to-face meetings have always been a key means of outreach for UK5G, so we have had to remodel our approach.

UK5G is a network of networks that encourages innovation and participation between businesses and organisations. Linking innovation supply (e.g. funding, entrepreneurial talent and knowhow) to demand, whether from government programmes, vertical industries or complex global value chains, is always a challenge. There is a propensity to believe that innovation happens in a logical and linear way, from discovery to exploitation.

But we all know that innovation is far messier than this and takes many forms. Working together can cover a range of intensities, all the way from just sharing information, through to combining resources in formalised partnerships, and ultimately to co-creation between organisations with shared goals and rewards. Whatever the level of intensity, the cliché stands: "Innovation is a contact sport." So how could we achieve this when physical meetings were out of the question? UK5G flipped, along with the rest of the country, to an online model.

We have always operated online. We currently have more than 3000 individuals and 1400 organisations registered on the website. Content continues to appear there. The website contains more than 700 articles and regular e-newsletters. We also have the collaboration exchange, which enables members to ask questions easily and receive their responses online. Whereas previously, UK5G Innovation Briefing had been mainly distributed at events, we now needed to enable readers to obtain their physical copy through the post as well as to check out the latest content online.

The response from the UK5G Advisory Board has been fantastic, and I would like to thank all the members and the working groups for their considerable pro-bono work to ensure this network thrives.

In the early stages of the lockdown, many board members came together to discuss the implications. Lack of connectivity was now a critical issue. The emergency felt like an inflection point in the development of the industry and in the attitude of the population towards technology; in effect, it introduced an enormous experiment in connectivity and resilience. Suggestions were fed into the DCMS both from Advisory Board members and from the Connected Places Working Group, which represented the views of many Local Authorities.

The most significant UK5G effort has been devoted to a series of events with the DCMS team to promote 5G Create. This began with physical meetings across the UK in early March and was completed with five online events that drew large audiences.

A single-view resource page for the competition on UK5G.org helped a lot - with a dedicated on-line 5G Create Collaboration Exchange. We encouraged short pitches from potential partners (44 videos at the time of writing are on the UK5G site). This, along with a great deal of bespoke activity to connect potential partners, led to a real buzz about the competition. We are confident that the DCMS will receive many high-quality bids.

Throughout the lockdown, UK5G Working Groups have delivered virtual events that have covered topics as diverse as 5G in sports, 5G for marketing, 5G for TV and film content training and distribution, training of business advisors on 5G, and demystifying 5G in manufacturing. A Testbeds and Trials innovation workshop that aimed to ensure knowledge transfer from completed projects to those that were beginning was transformed from a single physical event to two online virtual events with follow-up.

We continue to seek means by which a virtual approach can bring folk together. We have launched an online **UK5G Supplier Directory**, to encourage and support 5G testbeds and trials through a shared model by which trial projects simply subscribe to a 5G service provided by one or more suppliers. The directory can also serve as a showcase of the UK 5G supply chain to the world.

SO WHAT IS THE FUTURE OF events? The number of Webinar-type events has exploded. Six major UK events have been shifted to the autumn. Most conferences have become either completely virtual or a hybrid form, in which small audiences and a few speakers can maintain social distancing.

UK5G will support 5G World during London Tech Week from 1-3 September. We are also, with partners, delivering 5G Week over 7-11 September. Many UK5G Working Group virtual events will be available throughout that week, along with the flagship 5G Realised event on 9-10 September. The flagship Cambridge Wireless annual conference, named "At the Edge", is on 23 September, and the TM Forum's Digital Transformation World, "Power to the Edge", will run from 7-9 October.

Meetings and creation of partnerships are all possible online, yet nothing can replace the serendipity of chance face-to-face encounters. We hope that physical events will return in 2021.

Robert Driver
Head of UK5G

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