



Urban Connected Communities Testbeds Final Report

Document Information:

Document owner:	Professor Delma Dwight
Date of document:	June 2022

Document History

Version No:	Date:	Owner:	Description of Change:
1.0	29/04/22	Delma Dwight	First Draft
2.0	20/05/22	Delma Dwight	Second Draft
3.0	01/06/22	Delma Dwight	Third Draft
4.0	08/06/22	Delma Dwight	Fourth Draft
5.0	13/06/22	Delma Dwight	Fifth and Final Draft

Distribution and Sign-Off

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1. Executive Summary

The aim of this programme closure report for the West Midlands 5G (WM5G) Urban Connected Communities Programme (UCC) is to provide an overview of the programme, drawing together key strands such as results, benefits and lessons learned from across WM5G workstreams. The report complements the workstream specific closure reports¹ – which provide greater detail on each activity - while providing a high-level, evaluation of the overall programme against the ambitions of its original business case.

In line with Department for Culture, Media and Sport (DCMS) reporting requirements, the following pages document the key approaches used and findings of the project and confirm the overall benefits of WM5G.

The 5G Testbed and Trial Programme (5GTT) was launched in 2017. As part of this the West Midlands region was awarded £21m DCMS funding from 2018 to March 2022 to deliver the UCC Programme – which was branded WM5G². The purpose being to demonstrate how 5G will support economic growth and benefit businesses, public services and citizens. The strategic objectives of the programme, outlined in the original business case, were to:

1. Accelerate the deployment of 5G networks and ensure the UK can take early advantage of the applications those networks can enable.
2. Maximise the productivity and efficiency benefits to the UK from 5G.
3. Create new opportunities for UK businesses at home and abroad, and encourage inward investment.

WM5G was the delivery vehicle that was established to deliver this programme. It was incorporated in 2019 with the mission of accelerating the deployment of 5G, while testing and proving benefits from 5G services in key sectors by transforming productivity, creating jobs and boosting GVA, all of critical importance to the economy of the West Midlands. The final value of project investment was £50m, including the leverage of £16m private investment.

Key specific project aims included to:

- Test models for cost-effective deployment of 5G infrastructure in highly populated urban areas and remove barriers to deployment.
- Explore and prove the potential for 5G to enable economic and social benefits, for example through cost savings and service improvements in the public sector.
- Develop and test new applications and services that use 5G capabilities, and commercial business models.
- Inform and test West Midlands and national digital policy and regulation.

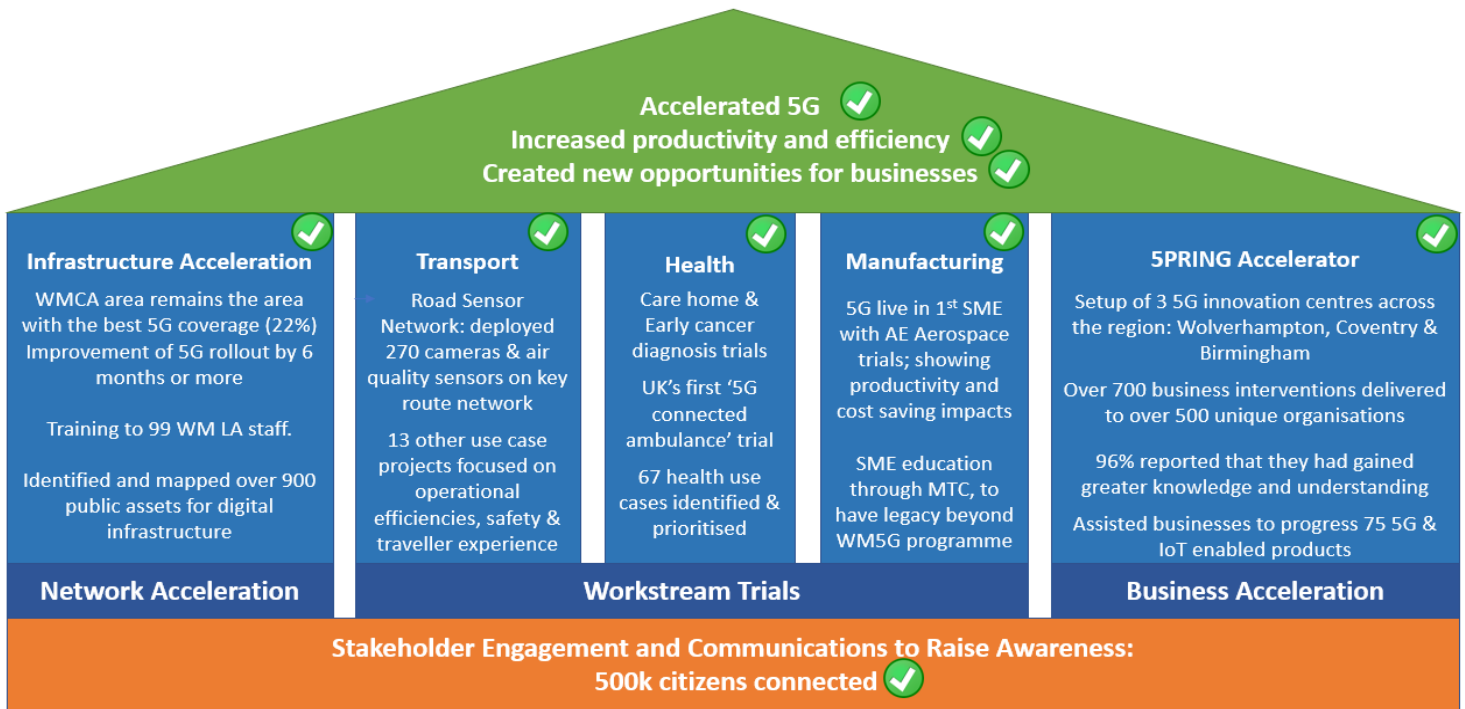
¹ This report should be read in tandem with the workstream specific closure reports, which provide greater detail about each activity.

² For the purpose of this report the UCC Programme is referred to as the WM5G programme.

- Raise awareness of 5G amongst citizens, public and private sector organisations across the region and encourage engagement through the various WM5G workstreams.

Figure 1 provides a summary of the activity that WM5G has successfully delivered against this mission, reflecting major successes against the programme’s original expectations.

Figure 1: WM5G Programme Summary



Together, it was envisaged that individual workstreams would catalyse and create “urban connected communities” in the West Midlands, driving forward the integrated development, deployment, and usage of 5G across the region – to the benefit of communities and businesses for the long-term.

The WM5G programme of activity has helped stimulate the growth and development of the 5G ecosystem in the West Midlands, while delivering some aspects of an urban connected community, even during the time of the Covid-19 pandemic. The projects and trials have demonstrated how a fully-fledged 5G-enabled “connected community” could become a reality in future.

Despite varying levels of success across workstreams, results overall demonstrate a high-level of success within the programme, delivering transformative outcomes to businesses and communities in the West Midlands.

The impact of the WM5G programme’s results is wide-ranging. Collectively, the programme’s benefits can be considered within 4 broad thematic areas as set out in Figure 2 and below. These reflect the tangible economic, social and technological outcomes that WM5G has realised across its workstreams and the interaction between them:

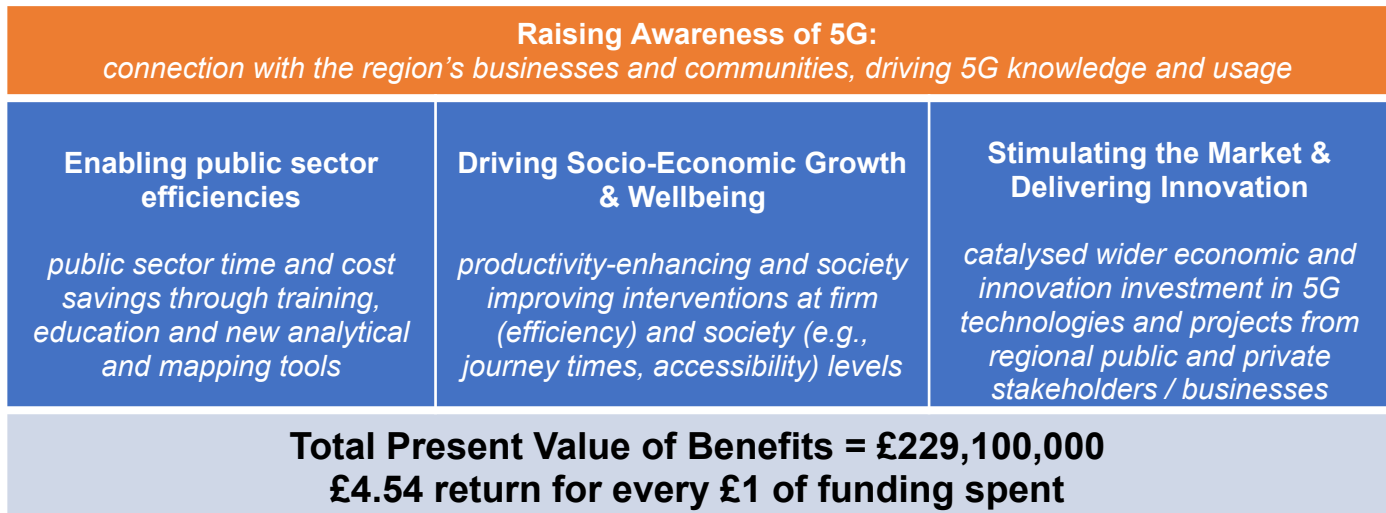
- **Enabling Public Sector Efficiencies:** WM5G's educational, guidance and co-ordinating role with key local partners led to cost and time savings, and more efficient use and delivery of public services. For example, the Infrastructure Acceleration workstream realised the following outcomes:
 - Direct and indirect Mobile Network Operator (MNO) savings worth over £7m over the next 5 years.
 - A reduction in resources costs to West Midlands Local Authorities (LAs) worth over £33m due to sites taking less time to deploy.
 - A faster and easier mechanism for authorities to access assets and deploy 5G sites (via a Connected Map).
- **Stimulating the Market & Delivering Innovation:** WM5G workstreams have catalysed confidence and demand in the use of 5G technologies in the West Midlands, driving innovative practices within the private and public sectors through knowledge sharing and direct business support activities. For example:
 - The development and commercialisation of 5G-enabled technology-based transport products, such as HPOMS - a Train/Tram Pantograph monitoring system that has gone from concept to commercialised product in a short space of time and now expects 5-year sales of £180m.
 - Increasing private sector investment in 5G R&D by an estimated £18m in the next five years through targeted business support interventions (5PRING).
- **Driving Socio-Economic Growth & Wellbeing:** WM5G has led the regional role in making the West Midlands the best region for 5G, drawing investment and economic growth, while also demonstrating the wider social, health and wellbeing benefits that can be realised by the technology. For example:
 - Improving productivity, sales and job creation within companies in the region worth over £14m in the next 5 years through the 5PRING, manufacturing and transport workstreams.
 - Demonstrating the social and health benefits to be realised by 5G, for example through the health use cases and transport projects like Transport Accessibility and Travel XR.
 - Realising wider socio-economic benefits of early deployment of 5G, via Infrastructure Acceleration, worth over £100m to the regional economy.
- **Raising Awareness of 5G:** WM5G's stakeholder and engagement activity has successfully educated businesses, the public and key organisations of the benefits and opportunities associated with 5G, enlightening them to the potential of the technology to make a tangible difference to their lives and businesses.
 - Overall, WM5G connected with at least 500K citizens across the region, supporting knowledge of 5G and its potential usage in people's everyday lives.
 - Claimed knowledge about 5G has increased significantly since July' 2021, with 15% of West Midlands citizens now claiming they 'know a lot about 5G and what it can do', and a further 23% knowing 'quite a lot'.
 - Two thirds of the 2022 business sample claim to 'know a lot about' 5G. This is a significant increase since 2020 and 2021.
- Overall monetisable present value benefits realised by the programme are in excess of **£229.1 million over the next five years³**. There are also

³ As per workstream specific Benefits Realisation Analysis. More detail on the benefits realised is reported from page 27.

considerable qualitative or non-monetisable benefits, as highlighted through workstream specific closure reports.

- The consolidated Benefit-Cost Ratio (BCR) from this across the programme is estimated at **£4.54 for every £1 of investment**, placing it within a high value for money category.

Figure 2: Summary of WM5G Benefits:



In terms of next steps, WM5G are working on their overall sustainability for future years and are now successfully bidding for strategically aligned funds to further position the West Midlands as a centre of excellence around digital infrastructure and technology adoption across public and private sectors.

As a result, the Midlands Engine is now paying WM5G to extend WM5G's network acceleration programme to cover the East Midlands – including broadband as well as mobile – and NHS Digital has recently contracted WM5G to help to develop its national connectivity strategy. In addition, each workstream is currently either determining its future commercial model and possibilities for extension; or closing. A summary of their status is provided in the below table.

Workstream Next Steps / Sustainability Status

Workstream	Status	Notes
Infrastructure Acceleration	Continuing	Further mapping and barrier busting (DCIA), new links to ARI-5G (FRANC) and lease activity
Application Accelerator (5PRING)	Closing	Future commercial model not realised
Transport	Continuing	8 use cases are progressing to commercial / deployment; the rest being developed further
Manufacturing	Part-Continuing	AEA system is self-sufficient, MTC demonstrator shutdown
Health	Continuing	Use cases being progressed to next stage

2. Programme Introduction

Programme Background and Objectives

The purpose of WM5G was to demonstrate how 5G will support economic growth and benefit citizens, using 5G connectivity in public and commercial services.

WM5G was the delivery vehicle that was established to deliver this programme. WM5G Limited is a wholly owned subsidiary of the West Midlands Combined Authority (WMCA) which co-funded the programme along with other local funders and private sector companies. The final funding breakdown of programme investment is as follows:

- DCMS: £21m
- Other Public Sector (Local Enterprise Partnerships (LEPs), European Regional Development Funding (ERDF), Transport for West Midlands (TfWM) etc): £13m
- Leveraged Funding from the Private Sector: £16m
- Total: £50m

WM5G worked in close partnership with the 7 Local Authorities and 3 LEPs (Black Country, Coventry and Warwickshire and Greater Birmingham and Solihull) in the region. All 3 LEPs have contributed match funding to the programme along with WMCA as they recognise the value the investment into these activities will bring to the region. Delivering the benefits from 5G through WM5G has been a manifesto commitment for Andy Street, the Mayor of the West Midlands.

The original overarching aim of the WM5G programme, set out in the business case, was to:

- Increase the rate of adoption and deployment of new technologies needed to support higher productivity growth.
- Act as a large-scale prototype for the UK in the deployment of 5G; evolution of market structures; and development of new business models and services.
- Enable full digital inclusion to accelerate the move towards the digital delivery of inclusive public and commercial services.

These align with the wider DCMS 5GTT programme objectives:

- 1) **Accelerate the deployment of 5G networks and ensure the UK can take early advantage of the applications those networks can enable.**
- 2) **Maximise the productivity and efficiency benefits to the UK from 5G.**
- 3) **Creating new opportunities for UK businesses, and encouraging inward investment.**

Programme Rationale

Accelerating 5G deployment was critical because the cost and time taken to deploy mobile networks has increased significantly over the last decade, due in part to the Electronic Communications Code (ECC) and changes to Town & Planning regulations. This is compounded by a difficulty in finding willing landlords and assets for new site deployment which is manual and slow.

Proving the potential for 5G to boost productivity and create jobs is also critical to “level-up” the West Midlands because the region has long-standing productivity and skills gaps – especially in key sectors like manufacturing and health and social care. GVA per head in the West Midlands⁴ area is £23,471, compared to £29,063 on average in England, representing a productivity gap of £5,592 per person to the England average. Also, the West Midlands area underperforms in terms of qualifications when compared to the rest of the UK, as 10.0% of the population (223,800) people have no qualifications, compared to 6.6% nationally. In order to reach the UK average, 63,167 more people need to upskill.

The original WM5G business case highlighted the potential for 5G connectivity to drive much needed social, health and environmental changes in the West Midlands and beyond. For example:

- Pollution levels in the West Midlands are above legal levels for NOx; something for which the root cause (mainly transport) can be tracked through 5G and then acted upon.
- Using 5G connectivity to reduce admissions to hospitals and early diagnosis can better protect patients and support healthier living. This can support reducing the healthy life expectancy gap between the region and UK overall.

Digitally enabled products and services can support greater inclusivity in the everyday lives of underrepresented or discriminated against groups, especially important in a very diverse region such as the West Midlands.

Summary of Programme Logic Chain

Bringing this together, 5G can play a key role in supporting economic and social recovery in the region, driven through regional competitive advantage that targets business, technological and societal change. Underpinning all of this is the need for greater awareness of 5G and its benefits to businesses and communities in the West Midlands.

Figure 3 provides a summary logic chain for the WM5G programme with each section of the report providing greater detail on the components of the logic chain. It draws from the result of individual closure reports and synthesises results against objectives.

This reflects the WM5G journey, from business case programme objectives through to results and the tangible outcomes of each workstream and the whole programme.

⁴ Defined as the seven Metropolitan Areas of Birmingham, Coventry, Dudley, Sandwell, Solihull, Walsall and Wolverhampton.

Figure 3: Summary of WM5G Programme: Logic Chain

Objectives	Rationale	Inputs	Outputs ⁵	Impacts ⁶
<ul style="list-style-type: none"> ● Accelerate the deployment of 5G networks - <i>Testing models for effective deployment of 5G infrastructure</i> - <i>Reducing risks associated with investment in 5G</i> - <i>Raising awareness of 5G</i> 	<ul style="list-style-type: none"> • Deployment of 5G infrastructure takes too long and is too costly • The commercial and technical models are not yet proven • Fast connectivity has become more important • By reducing costs and time, operators are able to invest more money into their networks • Potential for greater 5G awareness and clearer message 	<ul style="list-style-type: none"> • £4m Infrastructure Acceleration workstream, including delivery of “Barrier Busting”, LA training and input to national policy • Tested-driven deployment of technology: transport, health, manufacturing and 5PRING • Comprehensive stakeholder and engagement programme, connecting with citizens and businesses 	<ul style="list-style-type: none"> • Creation of Connected Map and mapping of 950 assets • Improvement of 5G rollout by 4.5 months; WMCA area remains the area with the best geographic 5G coverage (22%) in UK • Training to 99 WM LA staff • Public / business knowledge and usage of 5G increased significantly 	<p>Enabled Public Sector Efficiencies <i>£46.5m worth of benefits</i></p> <p>Raised Awareness of 5G <i>Cross-cutting enabler</i></p> <p>Drove Socio-Economic Growth & Wellbeing <i>£113.5m worth of benefits</i></p>
<ul style="list-style-type: none"> ● Maximise the productivity and efficiency benefits to the UK from 5G - <i>Informing and testing policy and regulation</i> - <i>Exploring potential for 5G to enable economic and social benefits</i> - <i>Developing and testing integrated models of</i> 	<ul style="list-style-type: none"> • Public sector and societal costs through lack of technology adoption: from the transport network to health systems • Long tail of low productivity firms, with lack of digitisation one key factor; becoming more important through Industry 4.0 	<ul style="list-style-type: none"> • Over £21m on 3 dedicated sector testbeds, trialling deployment and use of 5G technology - Patient Safety in Care Homes - Home delivered Colon Capsule - Transport Road Sensors - 13 additional transport use case trials 	<ul style="list-style-type: none"> • Demonstrated productivity and benefits of 5G-enabled factory: 9 percentage point rise in Overall Equipment Efficiency, higher sales per employee & lower calibration cost • 14 transport use cases generating 15 products to support operational efficiencies, safety and traveller experience 	

⁵ As per workstream closure reports and KPI reports.

⁶ As per workstream specific Benefits Realisation Analysis. More detail on the benefits realised is reported from page 27.

Objectives	Rationale	Inputs	Outputs ⁵	Impacts ⁶
<i>infrastructure and investment to deploy 5G</i>	<ul style="list-style-type: none"> 5G still relatively experimental, with more market certainty required in developed settings 	<ul style="list-style-type: none"> Private network for manufacturing SMEs: AE Aerospace and MTC demonstrator 	<ul style="list-style-type: none"> Creation of a system to deliver commercial, tested colon capsule for cancer diagnosis 	<p>Stimulated the Market & Delivered Innovation £70.8m worth of benefits</p>
<ul style="list-style-type: none"> Create new opportunities for UK businesses, and encourage inward investment. <i>Developing and testing new applications and services that use 5G capabilities</i> <i>Testing early demand for 5G</i> 	<ul style="list-style-type: none"> The average revenue per user (ARPU) for UK MNOs is poor compared to global norms, which discourages early investment in new technology with MNOs WM5G can play a key role in supporting economic and social recovery, driven through regional competitiveness advantage and business awareness / application 	<ul style="list-style-type: none"> £14m on 5SPRING Accelerator Focused around 3 commercial 5G accelerator centres in Birmingham, Coventry and Wolverhampton open to all businesses for learning about / engaging with 5G technologies to grow and develop new products/services Investment in private testbed trials for later commercialisation 	<ul style="list-style-type: none"> Over 700 business interventions, improving knowledge of 5G in 96% Assisted businesses (e.g., Plinx, Net4) to progress 75 5G & IoT enabled products & services across key challenge areas such as construction and green Commercialised products in transport arena – e.g., HPOMS – of which now forecast £millions of turnover in coming years 	
<ul style="list-style-type: none"> DCMS 5GTT programme objectives <i>WM5G programme objectives</i> 				<p>Overall Programme Present Value Benefits = £229.1m</p> <p>BCR = 4.54</p>



3. Description of What the Programme Did

The programme delivered against its mission through 5 core workstreams (including via various testbed trials and use cases), in addition to overarching stakeholder / communications activity:

- **Infrastructure Acceleration:** speeding up the deployment of 5G networks.
- **Application Accelerator (5PRING):** working with businesses and other organisations directly to support benefits of technological innovation.
- **Testbed Trials:** demonstrating the feasibility and commerciality of 5G in the West Midlands across key sectors.
 - **Transport:** Road Sensor Network deployment and 13 other use cases
 - **Manufacturing:** multiple use-cases supporting 5G-enabled factories
 - **Health & Social Care:** use-cases for cost savings & patient outcomes

Alongside these workstreams, WM5G ran a communication programme to engage over 500,000 citizens, public services and businesses to raise awareness of the benefits of 5G and drive adoption, along with a Youth Engagement Programme to encourage young people to innovate through 5G.

About the Workstreams

Infrastructure Acceleration

The Infrastructure Acceleration (IA) workstream was specifically created to identify, evaluate and deliver interventions that would speed up the deployment of public 5G networks. By intervening in a few critical areas, the IA workstream was able to demonstrate that by taking positive action within the Electronic Communications Code, Town and Country Planning, making public assets more accessible, and devising a commercial and technical solution for mass outdoor small cell deployment. The IA workstream was able to reduce the deployment times of both 5G small-cells and 5G macro-cells.

WM5G worked in partnership with the LAs and mobile operators to reduce the time it takes to deploy or upgrade sites from 4G to 5G by 4.5 months. This has saved considerable cost and attracted inward investment, achieved by building a digital connectivity map of the region to pinpoint the areas with poor mobile coverage. WM5G then worked with mobile operators and LAs to identify public assets that could be utilised to address these locations while also transforming the processes, legal agreements and compensation models.

As a result of this work the West Midlands is now independently recognised as the region with the best 5G coverage. Over 40% of 4G mobile sites have now been upgraded to 5G and around 50% of the population now have access to 5G through at least one operator.

The project enhanced perception of the West Midlands as a leader in 5G, meeting wider programme objectives of enhancing the reputation of the West Midlands as a centre for developing and applying 5G technologies. From the last Umlaut

benchmarking data report (Dec 21), the WMCA area remains the area with the best 5G coverage (22% geographic coverage) in the UK.

An additional set of varied activities within IA included:

- *Digital Champions and Coordinators group*: the IA team helped set up and facilitate this group, which met on a regular basis, ensuring local stakeholders were involved and engaged.
- *Barrier Busting Team*: also set up by the IA, this team focused on helping LA's overcoming common barriers experienced around full fibre deployment, utilising public assets, issues around mobile phone masts, navigating legal hurdles from the Electronics Communication Code, and in providing guidance around consistent application to Town & Country Planning.
- *Small Cell Trials*: investigating new commercial and technical models for outdoor small cell networks and pilot in the West Midlands.

Application Accelerator (5PRING)

Most of the innovation associated with 4G and smartphones over the last 15 years has come through start-ups successfully developing apps – i.e., open innovation – including social networking, productivity, photo, gaming, and many others. Against this context, WM5G pioneered the establishment of 5G Accelerators to accelerate open innovation from start-ups around 5G capabilities – recognising the criticality of open innovation for 5G, IoT and data services, and recognising that the West Midlands has a disproportionately low number of start-up accelerators in the region. This is despite the fact that Birmingham is the second most popular city for start-ups outside of London.

3 application accelerators were identified to be located in Birmingham, Coventry, and Wolverhampton and, following a competitive tender process; WM5G partnered with O2, Deloitte, Digital Catapult and Wayra to deliver an extensive array of accelerator programmes. These programmes involved demand-side organisations leading challenges which start-ups competed to participate in solving – supported by 5PRING (the brand name for the accelerators). Each of the accelerator venues had a state-of-the-art private 5G network which enabled start-ups to innovate with advanced 5G features in a sandbox environment.

The workstream, “5PRING”, delivered a vast array of engagements at scale, intervening with hundreds of organisations during the time of the programme. Types of engagement included:

- Direct business support in the form of webinars, panel discussions and introductory sessions, to improve knowledge and understanding of 5G.
- Longer-term Innovation Programmes aimed at facilitating the introduction of new to firm products and services.
- Demand-led challenges themed in specific markets – including green, construction, smart cities, manufacturing transport and events.
- Demonstrating how 5G can unlock opportunities in other key activities, such as extended reality, robotics, computer vision and Internet of Things (IoT).

5PRING provided a mechanism to bring industry, particularly SMEs involved in application development, into the 5G ecosystem. Businesses, typically SMEs, made

up most of the partners on each project. Many of these businesses were new to working on 5G R&D projects, though had often previously worked with other technologies (4G, Wi-Fi).

The purpose of 5PRING was to help demand-side organisations understand the benefits of 5G and help SMEs to develop new 5G enabled products and services. SMEs spoke positively about the difference this made, together with the funding, to the delivery of their use cases and also in the strengthening of their organisations. This included building the capacity of organisations as well as supporting SMEs to improve their ways of working.

In particular, 5PRING:

- Delivered a capability which enabled organisations of all types and sizes to understand the opportunities of 5G.
- Helped put the West Midlands on the map as the place to go for 5G innovation and expertise.
- Helped to create industries of the future by enabling businesses and public sector organisations to access dedicated facilities – in Birmingham, Coventry and Wolverhampton - to experience 5G and work out the benefits it could deliver, as evidenced by positive results from surveys of participants.

Transport

In transport, WM5G partnered with Transport for West Midlands (TfWM) to launch the UK’s first 5G Road Sensor Network (RSN). By installing 5G sensors (video cameras & pollution) at key road junctions, WM5G could prove the opportunity to reduce road congestion and pollution, saving 29,576 hours and 155,572 kg CO2e per year respectively. However, investment in the RSN was expensive and overall has thus far delivered negligible levels of value for money (see Section 5).

Greater potential and value has been realised through several of the 13 other transport use case trials that explored transformation opportunities for public transport productivity gains, improvements to public safety and customer experience and projects in both road and rail infrastructure in the region. Specific details and benefits of these projects are outlined in the table below.

Issue Being Addressed	Use Case - Trialled Solution
<ul style="list-style-type: none"> • Pantographs are special devices mounted on the roofs of electric trains, collecting power from contact with the overhead wires. Maintaining proper contact allows for a safe, cost effective and reliable train service. Excess of impact can cause damage to overhead wires, pantograph wear and failure, deteriorated wire stagger, carbon wear and possibly even extensive damage causing breakages and safety concerns. The longer the issues go undetected, the more catastrophic the damage and the more costly to repair. 	<p>Holistic Pantograph Monitoring Systems (HPOMS) offers an affordable camera monitoring system that provides visual footage to detect impacts and measure pantograph height, wire stagger and carbon wear and can send automatic alerts to train operators. This allows proactive maintenance work to take place, with significant benefits arising from cost and time savings for train operators and reliable services for customers.</p>
<ul style="list-style-type: none"> • Bus companies and service operators can often lack access to live data from vehicles advising 	<p>Occupancy offers a CCTV product with incorporated artificial intelligence to analyse passenger occupancy</p>

Issue Being Addressed	Use Case - Trialled Solution
<p>occupancy at any given time, making it difficult to determine how many vehicles should be deployed for particular services during the day or week. This often results in dissatisfied customers due to overcrowding or poor bus availability.</p>	<p>via a live feed, with the data transmitted to customers via a mobile app. This can improve existing services, giving bus operators the information needed to provide an efficient and cost-effective service, encourage uptake in public transport, reduce emissions and improve customer satisfaction through reduced waiting times.</p>
<ul style="list-style-type: none"> Currently, public transport companies struggle to stay abreast with what is happening on their services and do not receive regular feedback. This means issues can often stay undetected, resulting in more customer complaints which compromise both trust among passengers and costs transport companies' money. 	<p>The Passenger Management product is an artificial intelligence (AI) based real-time, micro-surveying tool which interprets customer feedback using a model that tags and detects context and sentiment. It identifies trends and key issues to be logged and then groups inputs into severity of feedback – generating alerts for situations where a customer may be in distress. The tool can be applied to tram, train and bus operators.</p>
<ul style="list-style-type: none"> Delayed rail services often arise from difficulty with regular and swift maintenance - stuck junction points, missing track brackets and deflection of track leads can lead to safety issues, reduced train speeds or service downtime. Railtrack monitoring is carried out through scheduled asset condition days by specialist vehicles and manual inspection. It requires workers to be on the track, it is dangerous and time intensive due to the sheer scale of train tracks across the region and country more broadly. 	<p>Polytrack aims to address these issues by providing insights for better informed track maintenance and renewals, leading to lower rail infrastructure costs. The sensors are fitted to trains or trams providing data signatures related to track degradation and performance using movements such as shock, accelerations and displacement. These data points alongside time, position and weather information enable train operators and maintenance to identify maintenance concerns and respond efficiently and swiftly to minimise service delays.</p>
<ul style="list-style-type: none"> Struggling urban centres and high streets cite parking as a significant challenge, with the stress associated with finding and paying for parking often linked to people avoiding local shops. Similarly, concentrated periods of peak commuter rush can mean that employees struggle to locate available on-street parking which in some cases could extend commute times by up to 20 minutes. On average, the time spent looking for limited parking in urban areas is approximately 6-8 minutes per day, adding to increasing congestion and tailpipe emissions. 	<p>Predikt offered two potential technologies to detect available on street parking spaces. Both approaches used 5G services to relay data on available parking spaces to a central, aggregated service. The first of these technologies offered kerbside scanning using cameras in passing utility vehicles with GPS location tagging and the second was a predictive parking app ingesting real-time data from various sources. These technologies can save users fuel and money as well as reduce congestion and tailpipe emissions, particularly in urban areas.</p>
<ul style="list-style-type: none"> By implementing sensors at key junctions on the West Midlands Key Route Road Network (KRN), Local Authorities and TfWM's Regional Traffic Coordination Centre (RTCC) could better control traffic and congestion – a significant problem in the area. 	<p>The Road Sensors Network project began in January 2020 with clear objectives – to harness the benefits of 5G to generate better data collection of road users. Deployment of road traffic monitoring sensors across junctions and locations in the West Midlands as well as IoT based emission measurement devices at locations in the region has provided new and critical data collection to significantly improve road management and emission control.</p>
<ul style="list-style-type: none"> Accessibility on public transport networks has long been a barrier for persons with impairments and disabilities. There are 2 million people in the 	<p>To help improve transport accessibility for people with visual impairments, GoMedia's App based phone guidance uses voice, haptics and large displays to</p>

Issue Being Addressed	Use Case - Trialled Solution
<p>UK with a visual impairment, many of whom do not use transport given the existing barriers to full accessibility and inclusion. Partially sighted people in the UK report a lack of confidence along station platforms as well as confidence concerns getting on and off the right vehicles, safely and at the right time.</p>	<p>enable users to better navigate stations and vehicles. By doing so, partially sighted transport users can achieve a greater level of independence and empowerment using public transport networks.</p>
<ul style="list-style-type: none"> The COVID-19 pandemic has had a significant impact on public transport – 70% of passengers who used public transport before the lockdown are no longer doing so. The public needs reassuring that public transport is safe – however as it stands, many passengers, including medically vulnerable passengers, are avoiding busy public transport hubs. Passengers need better information ahead of time to pre-plan journeys knowing where and when hotspots of congestion may be. Operators lack access to congestion and optimal passenger flow data. 	<p>The Travel XR product helps tackle this issue by providing operators with accurate, real-time data enabling them to anticipate over-crowding and re-route passengers dynamically and efficiently.</p>
<ul style="list-style-type: none"> Currently roads are monitored periodically, often using specialised vehicles to scan and assess road condition. Road assets can deteriorate rapidly or be damaged, which will be heightened through increasing levels of urbanisation and population growth. There are therefore benefits to increasingly regular assessments of road asset condition, which include proactive detection of potholes, identification of obstacles or obstructions and other damage. In addition, autonomous vehicles require good road assets, and so good detection of repair and maintenance needs is an enabler for any future adoption. 	<p>Vortex IoT introduced a Continuous Urban Scanner (CURBS), which is a specialist camera that can be retrofitted to existing vehicles and enables effective road management through utilising data to create a real-time 3D mapping and dynamic monitoring system. The trial involved attaching the camera to a fleet of 8 buses. Data that can be monitored includes potholes, road markings, road signs, bus stops, lamp posts, traffic lights, rubbish, pavement degradation, kerbs, pedestrian spillage, detection of near-miss traffic incidents and safety assessments at crossings.</p>
<ul style="list-style-type: none"> Congestion of the West Midlands road network is an extensive issue, with the root-cause identified as planned roadworks and incidents. While the root-cause is sometimes outside of control, the outcome in terms of traffic management and congestion is variable dependent on the operator experience and the tools available to them. 	<p>Capacity Manager uses 5G traffic sensing data for traffic management, providing an almost real-time view of the road capacity available and also the impact of roadworks, incidents and events. This data can inform operators and support their traffic management decisions. Data collation will enable modelling and scenario testing of congestion impacts of events, for example planned roadworks, and therefore more informed future traffic planning.</p>
<ul style="list-style-type: none"> Congestion and traffic around events and venues in urban locations can result in negative travel experiences for customers. 	<p>Urban Tourism uses 5G technologies to deliver a 'Travel Assistant' service. Using 5G-enabled sensors at stations and major venues combined with booking and travel information, it enables personalised integrated multi-modal door-to-door travel planning by merging identity governance technology with a unique, easily integrated 'Travel Assistant' user experience. This supports and incentivises advanced journey planning.</p>
<ul style="list-style-type: none"> There are a number of cities and communities that do not have the funds to improve their urban transport with a rail-based transit system such as 	<p>5G CAT. The autonomous control system on Very Light Rail (VLR) Trams is a way to reduce the infrastructure and operating cost as the crew is the</p>

Issue Being Addressed	Use Case - Trialled Solution
a tram. These costs are driven by high initial infrastructure costs and operating costs.	largest cost for operation. The products being developed are a tram's autonomous control system "remote supervisor" and a door detection system that will be connected remotely via 5G and its control system monitored. The benefit being that there will be no need for drivers on the vehicle creating a large cost saving and a more efficient operation of the line.
<ul style="list-style-type: none"> The 5G Enabled Smart Train Station Rover (5GER) project aimed to develop the first UK 5G-enabled smart train station robot/rover through the state-of-the-art 5G technology and mobile robotics for the applications in large and complex railway stations like Birmingham New Street. 	5GER. This product was to provide an intelligent, 5G connected, and highly secured robotics solution for station operators to improve their operational efficiency for cost savings, enhance passenger's experience and health protection, and disseminate real-time passenger information. The aim was to integrate the 5G-enabled smart train station rover with the TrainFX well-developed next-generation Passenger Information System (PIS) through the 5G network. The data would then have been available before or during journeys and provide a feasibility demonstration of robotics in a real train station.
<ul style="list-style-type: none"> The current CCTV platform on trams does not provide live, targeted, pro-active information to the tram / train operator. Leading to security and accessibility issues on the transport network and revenue loss from inaccurate passenger counting. 	Tram Safety. The use of 5G data fed AI detects people and objects and provides real time safety and security improvements along with business information. This allows for on board/off board analysis of CCTV and provide real time alerts for operators using existing CCTV and on-board connectivity (requires GPU/Control module).

8 transport use cases (including the RSN) are progressing to commercial / deployment; with the remainder being developed further prior to roll-out.⁷

Manufacturing

The Midlands is one of the main industrial heartlands in the UK. Industrial output across the Midlands is around £38 billion in GVA and the region accounts for over a fifth of manufacturing jobs in the UK. In the West Midlands, manufacturing represents 14% of GVA and 10% of employment with over 304,000 jobs. It is a key sector for the region.

However, it is commonly recognised that businesses in the manufacturing sector face major issues when it comes to production, which include the following:

- Accuracy of delivery.
- Lack of transparency within the production process.
- Lack of any insightful data across of the production process.
- Length of time required to validate machined parts.
- Length of time taken by sub-contractor processes.
- Time and processes required to achieve engineering tolerance.
- Inability to increase productivity due to lack of data insights.

⁷ These are listed and detailed in the Transport workstream closure report produced by KPMG.

With the 4th Industrial Revolution (digital) well underway, a connected factory is becoming a necessity for most manufacturing sectors. Higher performance wireless connectivity technologies, such as 5G, with a wider range of digital capabilities, offer reliable communication links that enable critical communications for 'real-time' control and safety applications. As per WM5G's business case, the opportunities for West Midlands manufacturing and 5G are therefore huge.

WM5G worked to implement the first 5G private network at a SME manufacturing business and test use cases to deliver an improvement in productivity. The programme also worked with the Manufacturing Technology Centre (MTC) to help hundreds of SMEs understand and adopt the benefits from 5G as part of its REACH programme. Given SMEs account for over 90% of the manufacturing GVA in the Midlands, this business base is critical. The 5G "connected factory" implemented at AE Aerospace demonstrated the ability of 5G to improve productivity, driving a 9 percentage point increase in Overall Equipment Efficiency (OEE).

The principal reason for the workstream was to assess if the use of 5G in SME manufacturers would enable significant improvements in productivity, profitability, and allowing customers and suppliers improved visibility of the manufacturing process. The use-cases looked at 3 different questions in the manufacturing process: how to increase machine/operative efficiency by gaining access to greater machine data; can time spent locating equipment be reduced by a tangible amount with the aid of location tracking devices; and will an advanced vision system allow for improved quality control and a more concise product audit trail.

As a result, this testbed aimed to deliver a smart factory use case demonstrator using 5G connectivity and multi edge computing applications with a Stand Alone 5G network (at the MTC), and extensively with AE Aerospace on the following use-cases:

- **Establish a 5G private network** capability in the MTC factory workshop.
- Deliver an initial **smart factory demonstrator** using 5G connectivity and multi-edge computing applications.
- Complement and enhance the influence of **MTC's Core Research Programme and Digital REACH SME Programme**.
- **Establish a roadmap of future use cases (MTC)** that exploit 5G connectivity to deliver improved production applications, processes and efficiencies.
- **Machine time servitization (AE Aerospace)** – this would provide real time accurate measurement and reporting, which would make it possible to sell machine and engineering time as a service to allow business diversification. Providing customers greater visibility of products in the production process.
- **Mobile asset location tracking and tracking (AE Aerospace)** – providing the ability to location track gauges via RFID, both improving process and reliability, and improve employee time efficiency.
- **Product Quality Assurance (AE Aerospace)** – use of 4k video imagery to improve product assurance. Allowing improved monitoring of the quality of work provided by 3rd party subcontractor.

Health and Social Care (Citizen Wellbeing)

The wider role health initiatives play in an integrated, urban connected community approach are pivotal. Health, mobility and transport are bound closely together with transport choices affecting healthy lifestyles and transport pollution having a direct impact on health conditions. Similarly, health and economic growth go hand in hand since a mentally and physically well workforce is more productive and happier.

WM5G's health and social care workstream aimed to demonstrate the value of 5G in supporting remote diagnosis applications in three testbed settings: care homes, at home, and on connected ambulances; and to do so explore the sufficient scale and duration to underpin sustainable adoption by the NHS, other care providers and citizens. The following 3 use cases were trialled:

- **Care Homes** – The purpose of this project was to enable remote diagnosis and monitoring of conditions/treatments for patients in care homes, thereby enabling faster, quicker, better and safer diagnosis. A key aim of the project was to make a substantial step-forward in quantifying and documenting the benefits of the 5G-enabled solution and supporting commercial deployment. The testing of 5G use found less than promising results for this project, in part due to a lack of masts and imperfect frequency levels in the local environment. Despite this, there was promising feedback from GPs and patients when the technology did work.
- **Colon Capsule Endoscopy** – The colon capsule endoscopy (CCE) project set out to develop a home-delivered solution to enable patients to carry out a capsule endoscopy in their own home whilst connected to a nurse-led virtual clinic. The purpose trial was to prove the opportunity to enable – via 5G connectivity – cheaper, quicker, and more accurate diagnosis of bowel cancer. WM5G commissioned the development of a “Smartbox” to deliver this objective, trialling with healthcare providers and patients. Following successful small-scale trials and good feedback, a 20-patient trial has been funded and conducted at University Hospitals Coventry and Warwickshire NHS Foundation Trust, which is currently underway and will be a pre-cursor to a larger rollout of the trial following separate funding from the NHS.
- **Connected Ambulance** – The purpose of this trial was to diagnose patient problems at first point of contact to enable better treatment and more efficient allocation of resources. The trial in 2019, in partnership with University Hospitals Birmingham NHS Trust and BT, was the UK's first showcase of how 5G and virtual augmented reality could offer remote diagnostic solutions for the healthcare sector. Using a commercial 5G service, a remotely located clinician was able to conduct an ultrasound using a haptic glove worn by one of the medical responders on site and could interpret the findings seen in real-time.

These health use cases are now being progressed to the next stage, including further trials and possible wider deployment / commercialisation beyond their limited adoption thus far.

4. Description of the Results

Programme deliverables have been achieved and KPIs delivered on successfully. This has driven a set of interesting, valuable and worthy results from WM5G, which can be demonstrated in respect of all DCMS and programme-level objectives. Importantly, they demonstrate a high-level of success within the project, delivering transformative outputs to businesses and communities in the West Midlands.

Results to Support DCMS Objective 1: Accelerate the deployment of 5G networks

By testing models for effective deployment of 5G and reducing risks associated with 5G investment, WM5G has supported the accelerated deployment of 5G networks in the West Midlands. This was principally through the enabling and facilitative role of the Infrastructure Acceleration (IA) workstream, working to promote better relationships between LAs and MNOs while identifying public assets in a more timely and resourceful way. Outputs of this activity – as a result of just under £4million worth of public and private investment - include:

- MNO surveys and MBNL 5G site progress data confirm the WM5G-induced improvement of 5G rollout by 4.5 months in the West Midlands.
 - From the last Umlaut benchmarking data report (Dec 21), the WMCA area remains the area with the best geographical 5G coverage (22%) in the UK.
 - Going further, the project also developed a view of how to use public assets to drive more full fibre deployment across the region, to support 5G development.
- The creation of a “connected map” with LA assets listed provides data to MNOs and Infrastructure Providers (IPs) in an easily digestible format.
 - Over 400,000 public sector assets were identified and mapped via various sources; while the overall number of public assets identified to host mobile / digital infrastructure has reached 958, exceeding the programme target.
 - It was stated by some IPs that the use of the map saved them between 3-6 months in time and effort.
 - DCMS have now taken this concept further by launching a competition for 8 Pilots to develop a ‘market place’ platform that will not only offer the assets up in map layout, but will also aim to create the transaction between the two parties. More details on this follow up program – Digital Connectivity Infrastructure Accelerator (DCIA) - can be found [here](#).
- “Barrier Busting” and wider education from WM5G has supported relationships between LAs and MNOs, while boosting the knowledge of 5G deployment across the region.
 - Across the West Midlands LA’s WM5G have provided training to 99 LA staff. Outside of the region they have trained 66 LA staff.
 - LAs in the West Midlands were some of the first in the UK to sign up to ECC compliant code agreements with multiple Infrastructure providers/MNOs.

IA is continuing in a number of forms, some Government funded and some commercial. For example:

- DCMS' Digital Connectivity Infrastructure Accelerator (DCIA) is a continuation of some of the mapping and barrier busting work.
- The Accelerating RAN Intelligence in 5G (ARI-5G) project is aligned to the IA workstream, with WM5G as a partner in making infrastructure available for the OpenRAN equipment.
- Barrier busting commercial propositions are being offered to both LA's and MNO's/Infrastructure Providers.
- Lease completion activity is taking place on a commercial basis, after being trialled as part of the IA work.

More detailed information about this, the results and outcomes of the Infrastructure Acceleration workstream is provided in its specific project closure report.

Individual trials and testbeds harnessed the outlined assets and knowledge to accelerate trials and deployment of 5G-enabled technology – aimed at benefiting West Midlands communities and businesses. For example, the Transport Road Sensor Network project has deployed 270 cameras and air quality sensors throughout the West Midlands' Key Route Network (KRN), while 5PRING created three innovation hubs across the region, providing participant access to cutting edge 5G technologies.

These initiatives were critical to another important aspect of this objective – WM5G raising awareness of 5G in the West Midlands. Results suggest success on this front too with the following evidenced regional impacts, captured in surveys undertaken by WM5G⁸:

- Claimed knowledge about 5G has increased significantly since July' 2021, with 15% of WM citizens now claiming they 'know a lot about 5G and what it can do', and a further 23% knowing 'quite a lot'.
- Use of mobile applications is at its highest since the survey began, after a dip during the pandemic, suggesting citizens are once again mobile.
- Two thirds of 2022 business sample claim to 'know a lot about' 5G. This is a significant increase since 2020 and 2021.
- Over two thirds of 2022 business sample know that 5G is available in WM, and almost half have a 5G phone themselves. These are all significant increases since 2020.

The Infrastructure Acceleration piece was the baseline we needed to fix...and that has been a resounding success. We are doing eight other pilots built on the success of that workstream in particular so I am delighted. DCMS

On branding, communications and understanding and educating the market and the SMEs and the sectors, they delivered on that. DCMS

Results to Support DCMS Objective

2: Maximise the productivity and efficiency benefits to the UK from 5G

⁸ As noted in the 5PRING workstream closure report, detailing full survey results

The use of 5G trials and use cases was critical in demonstrating the feasibility and commerciality of 5G in the West Midlands, and its ability to drive productivity gains but also wider economic and social benefits. Specifically, tested models of 5G infrastructure and investment demonstrated value and potential in:

Transport

- A wide portfolio of results was achieved through the 14 innovation projects grant funded – and a total public and private investment of over £18m - which has generated significant interest and commitment from Transport Operators.
- Transport grant projects covered 3 main areas:
 - 1. Road infrastructure: 5 projects with 6 products
 - 2. Rail infrastructure: 3 projects with 3 products
 - 3. Passenger experience: 6 projects with 6 products
- Collectively, the projects:
 - explored and delivered operational efficiencies and safety improvements on road and rail.
 - provided improved integrated and effective transport & encourage use of public transport.
 - improved traveller experience while travelling in leisure and work productivity services.

7 of the use case products have either commercial order, market commitment or have enhanced existing products:

- “Transport Accessibility” helping partially sighted people navigate stations and vehicles (Go media) - final trialling at Euston prior to Network Rail deployment.
- “Passenger Management” gathers customer verbal feedback and interprets to provide continuous monitoring of service (Wordnerds) - multiple businesses in transport and outside of transport (retail) are in advanced contract negotiations to adopt.
- “HPOMS” a Train/Tram Pantograph monitoring system (JR Dynamics) - contracts with Angel Trains has already been signed at the end of the project for initial implementation on 21 trains.
- “CURBS” a road infrastructure monitoring service e.g., potholes, white lines, kerbs, lamp posts, traffic lights etc (Vortex IoT, now merged with Marston Holdings) – Marston aim to commercialise within 6 months. TfL are interested in this also.
- “Urban Tourism” event (getting to) venue travel assistant (You Smart Thing) - enhanced features for the travel assistant used by venues and events organisers. This has been commissioned for the Commonwealth games by TfWM and is embedded in the BBC Radio 1 Big Weekend event in Coventry.
- “Capacity Manager”, the road maintenance planning tool, has enhanced capability with the ability to interface with simulation tools and is being offered as part of its upgraded platform. TfWM’s Regional Transport Coordination Centre (RTCC) is interested in this product.

The Road Sensor Network project was expensive (around £8m), which outweighs the overall benefits. However, the 260 traffic and emissions sensors deployed across the busiest roads are continuing to help manage traffic and emissions & provide

insights for future road investments. Measuring continues in order to understand the full range of benefits.

More detailed information about the results and outcomes of the transport workstream is provided in its specific project closure report, undertaken by KPMG.

They have done a lot with transport and had some good success. Now some things are being looked at commercially and that's a great success measure. DCMS

Manufacturing

£2m public and private funds were invested in the manufacturing workstream, demonstrating the following headline results:

- The development of an SME factory showcase has created knowhow in deploying 5G technologies with an SME.
 - The project has also generated a White Paper style & practical documentation that presents 6 step-by-step “How-to” guides for SMEs to understand how to source/implement digitalisation efforts in their environment⁹.
 - This helps fill gaps in business knowledge and time to digitise; related to skills, focus, access to capital and confidence.
- The network has been fully and successfully implemented at AE Aerospace (Birmingham), is stable and working. It demonstrated the following business-level results, reflecting significant productivity and time impacts
 - Overall Equipment Efficiency – Risen from 28% in November 2021 to a demonstrated 37%.
 - Sales per employee – risen from £5,610/month to £16,452/month per employee on these 5 machines.
 - Variance to cycle time – improved from 38.5% to 19%.
 - Reduction in value of lost machining hours looking for parts (an 80% + improvement).
 - Cost of Calibration: lower frequency of calibration by testing.

The company specific system at AEA is live and therefore continuing to benefit the business.

More detailed information about the results and outcomes of the manufacturing workstream is provided in its specific project closure reports.

Health and Social Care

⁹ Available to access here:

<https://www.wm5g.org.uk/projects/manufacturing/the-manufacturing-digital-journey/>

The health workstream had the least investment of all WM5G programmes, totalling just over £1.5m. The activity explored products and processes of great potential though:

- Trials of a more efficient, home-led system for colon capsule endoscopies delivered through a “Smartbox” led to the creation of a commercial and streamlined product that is trialled and tested, with the potential to upscale and create huge NHS cost savings and earlier diagnosis.
 - The initiatives funded supported the ability to scale the solution by demonstrating to clinicians and their Trusts the ability of the product to scale rapidly and be operated safely and effectively. Prior to this, there was no home-delivery solution available to the NHS therefore reducing in-clinic endoscopy waiting lists was an ambition that had little chance of being realised.
 - The project has therefore successfully supported the development of a game-changing, potentially life-changing solution, catalysing wider-scale trials of the product across the NHS.
 - However, whilst an onboard 5G router maximises the chances of a good connection and offers the potential to perform in-transit data transfer of the images taken by the CCE device, 5G coverage was limited in the areas where testing took place.
- The care home trial was exploratory and in part showed the potential of a solution that could, in future, deliver the types of benefits it planned for medical staff and patients – namely reducing unnecessary ambulance callouts and reducing unscheduled hospital referrals.
 - However, the main finding of testing 5G signals at the care homes has been that 5G is not widely accessible in most areas where it would expect to be working. Due to higher / frequency bands used for 5G, although there are sites (care homes) with masts within 500 meters, there is still failure to get a sustainable indoor signal in many of the care homes.
 - As a result, possible benefits were limited and little evidence was reported of a tangible impact on usage in emergency services.
 - Technical advisers from WM5G and Vodafone have said that this project was a few years ahead of the connectivity being available as expected.
 - This is reflected in some of the trialled care homes reverting to their original connectivity infrastructure.
- WM5G also ran the UK’s first 5G “Connected Ambulance” trial, a demonstration of how 5G technology can improve the range of diagnostic procedures available to paramedics and ultimately improving patient care. It was proved that the greater speed, low latency, capability and bandwidths of the commercial 5G network makes real-time, remote assessments possible. This innovation, if scaled, could enable the creation of ground-breaking 5G remote controlled ultrasound demonstrations and enable major possibilities for the future of healthcare technology.

More detailed information about the results and outcomes of the health workstream is provided in its specific project closure reports.

Trial activity in these specific sectors has gone some way to making the case for 5G investment and boosting productivity in public and private services, with several use

cases continuing to commercial deployment. This largely fulfils original business case objectives, despite challenges across the trial cases and some project closures.

Results to support DCMS Objective 3: Create new opportunities for UK businesses, and encourage inward investment.

In addition to the enabling network changes that create a good environment for business, WM5G also successfully engaged directly with businesses about the integration of 5G in their operations. This, underpinned by cross-activity communications and knowledge sharing, was a key part of all workstreams and has created new opportunities for growth, productivity, and investment for some businesses, even in the context of Covid-19 – which naturally limited the face-to-face reach that WM5G business engagement had.

The core business engagement vehicle of WM5G - 5PRING (Application Accelerator) - delivered successfully in this regard. Through its three 5G innovation centres and wider business engagement, 5PRING's outputs have been the following from over £14m of public and private investment in the programme.

- Over 700 interventions delivered, involving around 500 unique organisations, considerably exceeding targets. Within this, 5PRING was very successful at supporting start-ups/SMEs.
- 96% of engaged businesses reported that they had gained greater knowledge and understanding of the technology and the benefits for their own organisation.
- Assisted businesses to validate the application of 5G & IoT technology in 80 Use Cases aimed at addressing real-world challenges.
- Assisted businesses to progress 75 5G & IoT enabled products & services on their journey towards commercialisation. For example:
 - Plinx¹⁰ commercialised a 5G network in a box, successfully securing a commercial relationship with a construction contractor.
 - Net4¹¹ used 5PRING to demonstrate the use of video analytics to detect the use of face masks and footfall within a defined area. They have since had commercial discussions, including with a regional homes provider.
- Increased the likelihood of organisations adopting 5G technology (driving both demand and supply), with 84% of demand-side organisations reporting a likely increase in commitment to adopt new products or services reliant on 5G, and 94% of supply-side businesses reporting a likely increase in commitment to commercialise new 5G based products or services.
- Successfully delivered six 3-month-long theme-based Innovation Programmes, the main vehicle for delivering interventions to project beneficiaries. Key to the success of the Innovation Programmes was the engagement of high-profile demand-side organisations who shaped the challenges based on their own experiences. The involvement of the Challenge Owners attracted supply-side businesses to participate, resulting in each programme – including themes around sustainability, construction, manufacturing, transport, smart cities and events - being oversubscribed.

¹⁰ <https://plinx.io/>

¹¹ <https://net4.io/>

5PRING has, in addition to technical expertise, provided organisations with access to a state-of-the-art Private 5G Testbed. The Standalone (SA) network delivered a maximum throughput of circa 900 Mbps in the download direction, and circa 100 Mbps in the uplink (UL). Whilst download performance reached expectation and supported a wide spectrum of businesses, upload performance was slightly lower than expected.

At the outset of the 5PRING programme there was a collective stated intention by the Consortia to reach commercial sustainability by March 2022. However, despite the concerted efforts of all stakeholders, commercial sustainability has not been achieved in time for this project to continue. This is for several reasons including predominantly the impact of COVID-19 which could not have been anticipated. The pandemic and associated rising costs of doing business has required businesses to focus their efforts internally. This, alongside the maturity of 5G, delays from the lack of widespread availability of Commercial 5G services due to the Huawei ban, and feature availability, have had an impact. Ultimately a change of mindset is needed for organisations to understand that 5G has been designed and developed with IoT and Industry 4.0 in mind and this project successfully laid those foundations across a wide range of West Midlands organisations.

More detailed information about the results and outcomes of the 5PRING workstream is provided in its specific project closure report.

The application accelerator is good, anything that brings innovation into Coventry is fantastic. WM5G doing all the hard yards in terms of showcases and getting the right speakers around the table and generating that incubator environment puts the Midlands on the map in terms of digital innovation.

Coventry CC

Work with the MTC has also educated and engaged with manufacturing SMEs specifically; helping over 100 through the SME Reach programme to see how a private 5G network can benefit their business.

While high revenues are already being reported and forecast for several of the transport-based products developed – notably through the HPOMS project – of which expected 5-year sales are £180m – among other use cases. These developments which are a result of the 5G technology and catalysed by WM5G, reflect exciting business and investment opportunities; something which is also characterised by the colon capsule product in addition to its obvious potential health and systems benefits.

Moving forward, while the MTC demonstrator is no longer present, WM5G continue to work on commercial models for supporting SMEs and other businesses sustainably into the future, while tracking the success and benefits of existing MTC, 5PRING and transport project cohorts.

5. Impact of the Results Including Benefits

The impact of the WM5G programme's results are wide-ranging, captured in individual project closure reports and Benefits Realisation (BR) returns. From these, the programme's collective benefits can be considered within **4 broad thematic areas**:

- **Enabling Public Sector Efficiencies:** WM5G's educational, guidance and co-ordinating role with key local partners led to cost and time savings, and more efficient use and delivery of public services.
- **Stimulating the Market & Delivering Innovation:** WM5G workstreams have catalysed confidence and demand in the use of 5G technologies in the West Midlands, driving innovative practices within the private and public sectors.
- **Driving Socio-Economic Growth & Wellbeing:** WM5G has led the regional role in making the West Midlands the best region for 5G, drawing investment and economic growth, while also demonstrating the wider social, health and wellbeing benefits that can be realised by the technology.
- **Raising Awareness of 5G:** WM5G's stakeholder and engagement activity has successfully educated businesses, the public and key organisations of the benefits and opportunities associated with 5G, while busting the myths.

These reflect the tangible economic, social and technological benefits that WM5G has affected across its workstreams and the interaction between them. Furthermore, WM5G has given the West Midlands a substantial basis to extract greater value from the implementation of 5G, with potential future benefits that can occur into the future. This reflects our developed benefits typology that includes potential benefits (not included in the present value / BCR calculations) as well as realised benefits (included in the present value / BCR calculations). The full typology is as follows:

- Economic
- Cost Saving
- Educational
- Technological
- Health / Social
- *Potential Economic*
- *Potential Cost Saving*

All benefits from WM5G's BR sheets, approved separately as part of the programme closure process, have been categorised against the above benefit themes and typologies, with monetary benefits taken forward as part of Benefit Cost Ratio (BCR) calculations for the whole programme. This helps to determine an estimate of return on investment (ROI) and value added within WM5G.

Monetary benefits are the total realised and projected benefits of each workstream - as per calculation in WM5G's BR sheets – over a period of the next 5 years. The “present value” of monetary benefits is calculated through a standard discount rate of 3.5% over the 5-year period, assuming equal distribution of benefit value in this period where benefits have a lifespan beyond the immediate term.

Final benefit findings have been determined by analysis of final BR sheets provided by the WM5G project team, and, for the transport workstream, via KPMG’s separately commissioned benefit calculations, included within this workstreams closure report. No sensitivities have been applied to indicate the benefits that should be attributed to WM5G solely, nor deadweight calculations. Costs are assumed to be sunk and therefore are not discounted, while any costs of future input are also not included in the assumptions.

Based on this methodology, monetisable present value benefits realised by the programme are worth an estimated **£229.1 million** over the next five years. This value will predominantly benefit businesses, organisations and communities in the West Midlands, but other areas of the country are likely to benefit from spill-over effects and the opportunities of 5G application highlighted through the programme.

To determine a programme-level BCR, the total benefit figure is divided with the programme’s overall spend of just over **£50million**. This represents £34m of public funding (including £21m from DCMS) and the leveraging of £16.2m investment from the private sector – distributed across workstreams.

WM5G Programme Level BCR

Total Costs	£50,500,000
Total Value of Benefits	£247,000,000
Total Present Value of Benefits	£229,100,000
Present Value Benefits / Cost Ratio	£4.54

Following this BCR formula, the consolidated present value BCR across the programme is estimated at **£4.54 for every £1 of funding spent**, placing it within a high value for money category. This reflects tangible benefits realised in the programme and projected across the next 5 years.

Figure 4: Summary of WM5G Benefits:



These monetised benefits are estimated to be allocated across key themes and typologies as per the below table. These present values have been compiled through a categorisation of each monetised benefit against the 3 key themes and major types of benefit by source. As demonstrated, the monetary benefits cut across all theme areas, with the delivery of socio-economic growth and wellbeing benefits being the most valuable benefit area (estimated to be worth over £113m over the next 5 years).

Thematic Benefit	Monetary Benefit Sources	Estimated Benefit Present Value (£)	Total Estimated Benefit Present Value (£)
Enabling Public Sector Efficiencies	<ul style="list-style-type: none"> Local authority <i>cost savings</i> from avoiding tribunals, mitigating appeals and planning application sites turned from likely rejection to approval. 	£2,480,000	£46,500,000
	<ul style="list-style-type: none"> Staff time saved in site identification and deployment, including through <i>education</i> of data analytics such as via Connected Map. 	£1,540,000	
	<ul style="list-style-type: none"> Employee multipliers relevant to enabling public sector efficiencies. 	£4,560,000	
	<ul style="list-style-type: none"> A reduction in 5G acquisition and deployment timescales has created several benefits for both Operators and IPs. Reducing time brings an overall <i>cost reduction</i> – scalable across the UK. 	£37,850,000	
Stimulating the Market & Delivering Innovation	<ul style="list-style-type: none"> Catalysing wider <i>economic</i> investment in 5G technologies and projects from public and private stakeholders: e.g., NHS, local tourism partners, MNOs and business support organisations. 	£4,620,000	£71,000,000
	<ul style="list-style-type: none"> Employee multipliers and operator <i>cost savings</i> from the development and commercialisation of <i>technology</i>-based transport products, enabled by 5G. 	£49,530,000	
	<ul style="list-style-type: none"> Driving <i>innovation and R&D</i> spend in the private sector in relation to 5G technologies – commercialising these for business growth and success. 	£16,650,000	
Driving Socio-Economic Growth & Wellbeing	<ul style="list-style-type: none"> Improving productivity, sales and job creation within companies in the region. 	£8,160,000	£113,500,000
	<ul style="list-style-type: none"> Enabling improvements in journey times (<i>cost efficiencies</i>). 	£1,520,000	
	<ul style="list-style-type: none"> Employee and R&D expenditure multipliers from the development of a 5G enabled road sensor network. 	£5,300,000	

Thematic Benefit	Monetary Benefit Sources	Estimated Benefit Present Value (£)	Total Estimated Benefit Present Value (£)
	<ul style="list-style-type: none"> Improving fuel efficiency and reducing carbon emissions through 5G infrastructure on the transport road network with longer-term <i>health / social</i> outcomes. 	£424,000	
	<ul style="list-style-type: none"> Socio-economic benefits as a result of the 4.5 month increase in 5G adoption.¹² 	£98,130,000	
Total			<u>£229,100,000</u>

Note: Totals do not add up exactly due to rounding and discounting methodology used across transport (KPMG) and the wider programme (BCC). The difference is minimal and insignificant.

It's also important to recognise the "potential" future impact and benefits of the environment WM5G has helped to secure regionally. The long-term benefits of a more 5G enabled economy in the West Midlands are expected to be large, and WM5G has thus far played its part in this. There is potential for monetary benefits to be realised long into the future through accelerated cost savings, the commercialisation of new 5G-enabled technologies and products, and the inclusive economic growth 5G can help drive.

Qualitative or non-monetisable benefits realised within each area are demonstrated below, including information about how each benefit theme has been realised in reality. This accounts for benefits that were unable to be monetised through the programme.

Enabling Public Sector Efficiencies

As reflected in the monetary benefits, considerable time and cost saving benefits to the public sector were realised through the programme. This was largely through MNO / LA / IPs engagement and education by the Infrastructure Acceleration workstream. Further benefits in this regard – not yet to be monetised – include:

- For MNOs and IPs there is a reduction in the required resources and overheads for the sites to be deployed.
- A faster and easier mechanism for authorities to access assets and deploy 5G sites (via the Connected Map).
- Wider knowledge sharing across the UK: the approach has now been shared with over 50 Local Authorities through introduction meetings and knowledge sharing events, allowing some of those LA's to develop similar approaches.

The health and transport trials have reinforced the possibilities of 5G to drive significant public sector efficiency benefits for the long-term, with wider economic, social and health outcomes. In particular:

¹² Taken from WPI Economics report for Vodafone UK
<https://newscentre.vodafone.co.uk/app/uploads/2020/06/Vodafone-5G-Report-final.pdf>

- The potential time and procedure scaling, and overall reduction in endoscopy backlog that could be achieved through a 5G-enabled Colon Capsule type product.
- Time and efficiency benefits of health services through reduced “time to see” patients and overall connectivity.
- Widespread adoption of products developed and deployed in the transport space – e.g., sensors – could also prove to have demonstrable benefits in emergency service, or other public service, response times.

While WM5G has not realised all these benefits within the programme, it has demonstrated the potential for future development and adoption, possibly through further trials.

Stimulating the Market & Delivering Innovation

Investment has been stimulated by the existence of WM5G and its workstreams, above and beyond the scope of the project. This is well demonstrated in some of the transport projects – with 8 products having commercial orders or market commitments.

Future, not yet monetised, benefits will arise from the cohort of businesses supported by the programme – notably via 5PRING and the MTC workstreams.

Market knowledge and investment stimulation has occurred, evidenced by:

- 98% of 5PRING Accelerate Participants (Supply) reported a likely increase in commitment to commercialise new 5G based products or services.
- 93% of 5PRING Accelerate Participants (Supply) reported a likely increase of go-to-market readiness for new 5G based products or services.
- 40 validated use cases were developed through 5PRING (POC, prototype or demonstrator) (Demand), aimed at addressing real-world challenges.

Furthermore, the tracking of technology readiness levels (TRL) across all workstreams has proved the success of WM5G to catalyse shifts in 5G technology and its innovations across multiple settings. The workstreams demonstrate specific benefits of this to key stakeholders, beyond the financial:

- AE Aerospace recorded an increase in the quantity of digital job packs and the quantity of machines live on the factory system.
- Within 5PRING’s survey results, 93% of Accelerate Participants (supply) reported a TRL improvement of at least one level, while 100% of Accelerate Participants (Demand) reported a likely increase in commitment to adopt new 5G based products or services.
- 5G technology adoption in transport has improved the ability to model new schemes or developments in future, while use cases have paved the way for further technology development and deployment. For example:
 - “Polytrack”, a rail track infra structure monitoring system (ESR) – has very encouraging product results and strong interest from Network Rail & WM Metro.
 - “Occupancy”, passenger counting and vehicle service-use monitoring developed by Hack Partners is ready for integration, with strong interest from Transport for London (TfL) and TfWM.

Driving Socio-Economic Growth & Wellbeing

The accelerated deployment of 5G technology can facilitate faster connections which lead to time and cost savings, while delivering productivity gains. Having a regional competitive advantage can maximise the economic benefits of such deployment, as reflected in the monetary benefits calculations and potential. WM5G has demonstrated this potential system-wide and at the firm-level; and while the former considers gains through reduced congestion, R&D expansion and investor attractiveness, the latter reflects:

- Improvements in return on capital employed, demonstrated by the AE Aerospace project.
- Supplier quality improvements, also demonstrated by the AE Aerospace project.
- Future firm-level benefits longer-term – such as increased revenue, job creation or firm-level investment attraction. Engagement with WM5G from companies (via 5PRING and the MTC programme) – many of which based in the West Midlands – is likely to realise some of these economic benefits longer-term, but measurement of these will have to be taken further into the future.

Beyond purely economic factors, social and health benefits were realised – with major future potential. There are multiple patient benefits of the care home, colon capsule and connected ambulance use cases, should their rollout be successful, and identified issues reduced. These include reduced exposure to Covid-19 and other infectious diseases, reduced travel time for emergency services and earlier detection of life-threatening diseases.

Furthermore, several of the transport use cases have demonstrated tangible social and environmental benefits from 5G-enabled products. This is through increased safety for vulnerable road users, reduced air pollution and emissions, traveller comfort and improved traveller information and guidance. All of these benefits generate more accessible and inclusive travel conditions, in turn supporting community wellbeing and more inclusive growth. Strong examples include:

- The Transport Accessibility project involved the development of an app to support partially sighted people navigate the transport network. Individual benefits of the app to partially sighted users are clear – it provides them with a greater feeling of inclusion, positivity and accessibility when using public transport. As a result, 100% of users reported being in favour of extending this app on the full public transport network.
- The Travel XR product gives confidence to passengers to use public transport services as they can actively avoid congested hotspots through re-routing by transport staff. The data provided to operators will enable those feeling anxious about congestion to avoid points of conflict and find areas with better social distancing.

Raising Awareness of 5G

The final theme reflects a critical, cross-cutting benefit area: the awareness of 5G generated by the programme across West Midlands citizens, businesses and the public sector. Increased awareness, as reported in the previous results section, has the potential to boost investment, innovation and usage of 5G across the West

Midlands. Its key benefit is that it will further enable activity to drive the other five benefit themes, hence its central role within the original business case.

The WM5G programme connected with the region's businesses and communities as a whole through overall stakeholder and communications activity. For example, connecting with at least 500K citizens across the region, supporting knowledge of 5G and its potential usage in people's everyday lives. Furthermore, through varied knowledge dissemination activity (research outputs, events, knowledge transfer etc), each workstream effectively engaged with many organisations and got their message out there. Education was also a major part of the Infrastructure Acceleration, equipping local authority and MNO / IP teams with the right tools.

Benefits by Workstream

Total monetised benefits and costs by WM5G workstream are outlined in the table below, reflective of BR sheets submitted by individual WM5G workstream leads.

Workstream	Total Costs (£) ¹³	Total Benefits (£)	Present Value Benefits (£)	Estimated BCR ¹⁴
Infrastructure Acceleration	3,952,599	150,587,929	140,741,864	35.61
Application Accelerator	14,361,550	23,794,956	22,239,143	1.55
Health	1,509,604	1,840,000	1,719,693	1.14
Transport ¹⁵	18,030,046	67,252,502	61,142,815	3.49
Manufacturing	2,039,132	3,431,520	3,207,153	1.57
<i>Indirect Costs</i>	<i>9,837,309</i>	-	-	-
<i>Other</i>	<i>165,231</i>	-	-	-
<i>Unallocated</i>	<i>610,126</i>	-	-	-
Total	50,505,596	246,906,907	229,050,668	4.54

This highlights the difference of value add across workstreams, with the Infrastructure Acceleration reporting a very high BCR, while the transport workstream had a high value for money too – driven by the use case trials (BCR of 7.2) as opposed to the Road Sensor Network project (BCR of 0.9). Despite the benefits reported, the manufacturing (1.57) and health (1.14) workstreams reported the lowest return on investment; but it's noted that these were largely exploratory trials. The Application Accelerator (5PRING) reported a BCR of 1.55 but with likely future benefits to be realised through the cohort of businesses engaged.

The results suggest 5G is a good fit across sectors trialled, but that in some cases (notably health and manufacturing), more trialling and infrastructure is required to fully understand the potential benefits of the technology. Application in the public sector and public services has provided demonstratable added value even in a short

¹³ Including both public and private investment.

¹⁴ To obtain workstream level Benefit Cost Ratio (BCR), present value of benefits is divided by total workstream costs.

¹⁵ The calculation of transport costs and benefits is replicated from KPMG's workstream closure report.

space of time – reflecting the benefit of 5G to save time, costs and enable efficiencies in society.

Individual workstream closure reports provide more information about each project's 5G fit in the context of workstream BR findings. The table below provides a full breakdown of benefits that have been monetised, as agreed in the BR sheets of each workstream.

Workstream	Benefit Description / Title	Metric Information	Monetary Value of Benefit (£) ¹⁶
Infrastructure Acceleration	Mitigation against costs from tribunal cases	£ Cost mitigated by no tribunals	1,500,000
Infrastructure Acceleration	Mitigation against costs from Planning appeals brought about by lack of understanding of National planning policy	Number (and value £) of appeals mitigated	231,000
Infrastructure Acceleration	Improvement in T+C planning timescales enables faster rollout of 5G by ensuring fewer planning rejections (Acceleration Cost Saving)	Number of planning application sites turned from a likely rejection to an approval	918,000
Infrastructure Acceleration	By creating a connected map showing available public assets Operators are able to quickly establish potential site candidates and have access to contact the correct person in the Council. Timescales for site searches will be reduced for sites.	Time taken to find the required sites on Map and make contact with the council	12,600
Infrastructure Acceleration	Direct MNO Savings	The difference in months between the time taken to deploy a site end-to-end in the WM against other regions with the same scope	250,466
Infrastructure Acceleration	Indirect MNO Savings	Reduction in overall project delivery time	7,050,000
Infrastructure Acceleration	Future Opportunity Saving (e.g. 6G rollout)	Reduction in overhead/resource costs due to LA sites taking on average 4.5 months less than other network sites	33,200,000
Infrastructure Acceleration	By accelerating 5G rollout the socioeconomic benefits are realised earlier than other regions	Socioeconomic value to calculate a benefit of deploying 4.5 months earlier	105,000,000

¹⁶ Not presented as present values (no discounting applied). Reflective of estimated benefits in 5-year period. Full information available via approved Benefits Realisation Sheets and individual workstream closure reports.

Workstream	Benefit Description / Title	Metric Information	Monetary Value of Benefit (£) ¹⁶
Infrastructure Acceleration	Investment stimulation	£ investment stimulated	2,425,863
Application Accelerator (5PRING)	Commitment (or intent) to create new jobs	No. of new or safeguarded jobs	3,600,000
Application Accelerator (5PRING)	Increase in revenue / profitability	% of / total participants reporting increase in turnover / profits from 5G products or services	2,374,956
Application Accelerator (5PRING)	R&D expansion	% of / total participants reporting increase in 5G related R&D spend	17,820,000
Manufacturing Test Bed - MTC	Investment stimulation	£ investment stimulated	672,000
Manufacturing Test Bed - AEA	Productivity Improvements	Overall equipment effectiveness, production time, calibration time, reduction in lost time	1,766,000
Manufacturing Test Bed - AEA	Improved Sales	Sales per employee	953,520
Manufacturing Test Bed - AEA	Cost of Calibration	Change in value	40,000
Health Test Bed - Care Homes	Investment stimulation	£ investment stimulated	870,000
Health Test Bed - Colon Capsule	Investment stimulation	£ investment stimulated	970,000
Transport - Road Sensor Network	Employee expenditure multiplier	ONS composite employee multiplier	922,466
Transport - Road Sensor Network	R&D expenditure multiplier	BEIS R&D multiplier ¹⁷	4,745,414
Transport - Road Sensor Network	Improved journey time (cost efficiencies)	Journey time (via Vivacity sensors / Digital Twins)	1,621,236
Transport - Road Sensor Network	Improved fuel efficiency	Litres of fuel saved	105,305
Transport - Road Sensor Network	Carbon Emission reduction	kg CO2e per year in carbon reduction	348,349
Transport - Road Sensor Network	Operating cost savings	Per year saving from data analytics taken	1,434,981
Transport - Road Sensor Network	Operating cost savings	Time saved for staff	197,335
Transport - Use Cases	Use Case specific benefits (multiple)	Dependant on specific Use Case ¹⁸	57,877,416
Total			247,000,000

¹⁷ Calculated using BEIS R&D multiplier 2.03 multiplied by the total PV expenditure on R&D from original investment, source:

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/897462/macro-economic-modelling-of-2-4-r-and-d-target.pdf

¹⁸ See KPMG's closure report on the transport workstream for detailed benefits information across transport use cases.

6. Key Learnings

Overall, the WM5G programme made strong progress in delivering its intended outcomes. The testbeds it developed trialled numerous technologies, products, and applications. These demonstrations generated a wealth of knowledge and learning for project partners. Use case trials demonstrated if and how 5G technologies can be deployed and if and how 5G functionality (low latency, etc.) can be integrated into products and applications. Importantly, use case trials also identified the limits of 5G technology, and identified where – for economic and/or technical reasons – other technologies are, for now, more appropriate.

WM5G has helped stimulate the growth and development of the 5G ecosystem in the West Midlands. This was relatively immature when the programme launched, but the injection of public funding and the creation of WM5G has had a catalysing effect. The programme also brought together a diverse range of partners from a variety of backgrounds and sectors.

While key achievements can clearly be highlighted from the programme, at the same time there were some considerable limitations and learnings to arise. The following feedback, which is based around themes, provides a foundation for identifying key constructs amongst the different testbeds, and the use cases that were deployed in the WM5G programme.

5G Security / Technical Issues

With its high speeds and low latency, almost all businesses and industries are now in the position to digitise new applications and services. With 5G networks, millions of devices and IoT (the internet of things) are interconnectible. However, the massive potential and almost unlimited connectivity gives rise to many security challenges. The pandemic has only intensified these issues, especially the risk of ransomware-related breaches.

The risk of more sophisticated botnets, privacy violations, and faster data extraction can escalate with 5G. Essentially, more IoT leads to more potential problems, as IoT devices are inherently insecure; security is often not built-in by design. Also, the decreased network visibility along with increased supply chain and software vulnerabilities will only elevate the risk of exploitation on 5G networks.

Feedback from numerous use cases has found that due to the lack of spread of masts and use of frequency that can be picked up from distances and through buildings, it has resulted in less than promising results in using 5G. This was particularly the case in the Care Home project on the Health & Social Care workstream, where none of the original five care homes were able to access Vodafone 5G infrastructure by the conclusion of the first phase of work.

Lessons Learnt:

1. The presence of the WM5G programme in the West Midlands has accelerated the deployment of 5G coverage in the region. MNOs have responded positively to the programme and have brought forward their plans for the West Midlands.
2. While MNOs were mostly focussed on download speeds, the use cases put forward by WM5G relied on faster upload speeds, leading to a slight disparity

between wants and needs of the programme and what could be delivered. Faster download speeds can be seen as a consumer-focused approach, which was not ideal for the use cases. The faster the speed and the lower the latency, the higher the costs became.

3. Barriers were experienced in relation to the laying of full fibre, and in being able to access small cell devices & sensors.
4. The global shortage of 5G chips used in routers, caused substantial delays during the trials. The worldwide chip shortages for the past 18 – 24 months, have caused issues and delays. This resulted in some trial participants opting out of use-cases due to delays.
5. Covid restrictions proved problematic when they presented difficulty in accessing buildings where technical equipment was installed, impacting the development and delivery of use cases due to increased delays and reduced activity.
6. The main finding of testing 5G signals at the care homes was that 5G is not widely accessible in most areas it is expected to be working. Due to higher / frequency bands used for 5G, although there are sites (care homes) with masts within 500 meters, there is still failure to get a sustainable indoor signal in many of the care homes. Technical advisers from WM5G and Vodafone have said that this project was a few years ahead of the connectivity being available as expected. Alongside world shortages of 5G chips needed for routers, the project was faced with substantial delays in getting the connectivity set up in care homes. Nevertheless, the project did proceed with a smaller number of care homes with very tangible and measurable benefits.
7. High staff turnover at MNOs presented a delivery difficulty, as the new staff would need to go through the necessary onboarding process which affected timelines.
8. Plug and play devices: difficulty around the Internet of Things (IoT) implementation was experienced on some of the projects. There was complexity in installing and connecting IoT devices, as it was discovered there was a lack of plug and play capabilities in instances on projects.

Partnership Working / Stakeholders / Public Sector Reform

One of the key appealing aspects of the WM5G project in West Midlands was the integrated aspect of the programme – with proposed large-scale 5G pilot across the region, with hubs in Birmingham, Coventry and Wolverhampton. With support from local partners including LEP's and local authorities, it was envisaged that WM5G would have public service quick wins and have a direct impact on digital leadership in the public sector.

Due to the pandemic, a lot of events occurred that have been labelled 'unprecedented' – this impacted the level of partnership working that was displayed on the testbeds and use cases.

Lessons Learnt:

1. The working relationship with Local Authorities developed over time as the test beds started to materialise. To assist with building rapport and disseminating the latest 5G information, WM5G set up a Local Authorities digital group and secured appointment of Digital Champions and Coordinators in each LA to successfully lead engagement.
2. Testbeds found that some of the organisations they worked with were less experienced in working with public funding and they needed the evidence for the

funding to come through, which slowed down the pace of progress on use cases while documentation and evidence was being gathered.

3. Through DCMS engagement, the testbeds were also exposed to other UK5G projects which proved very helpful to the teams directly working on the testbeds.
4. The Draw Down Agreement (DDA) process ensured stakeholders were kept up to date on a regular basis.
5. The impact of 5G projects on Local Authorities often depended on the attitude and personality of the Digital Officer who was engaged with WM5G. Staff turnover didn't help with knowledge retention, and it slowed down progress on the testbeds. This was also found with staff working at DCMS.
6. The DCMS administration process was felt to be over bureaucratic – to the extent that it stifled innovation. Reporting has been considered burdensome, which drew away resources from testbed activities.
7. It was acknowledged that the programme could have done a better job insourcing rather than outsourcing which would have created more local engagement in the testbeds. The use of external consultants has led to much knowledge and expertise that was developed – which sadly left with the consultants when their involvement came to an end.

Funding And Finances

The UCC programme was the first of its kind in the UK, with the West Midlands as the UK's first large-scale 5G testbed through WM5G. This included £21m from DCMS and a further £13m match funding from regional partners including LEPs, the WMCA and TfWM. The programme was also successful in raising over £16m of additional funding from the private sector.

Lessons Learnt:

1. WM5G have exceeded their own targets based on Payment by Results (PBR). Covid could not be foreseen on regular risk registers but WM5G worked closely with funders to address and overcome the challenges it presented. They managed unknown risks through collaboration, which WM5G managed proactively.
2. The importance of match funding was highlighted, and how difficult it can be to meet specific criteria attached to match funding. It was found that it can stifle progress.
3. There is a lack of consistency in funding application processes amongst local partners and Government – so this led to duplication and delays in having to submit multiple businesses cases through different processes.
4. Working with SMEs on the testbeds was sometimes problematic – as some of the SMEs were overly ambitious, for example when one company tried to develop four use cases but only had the capacity to develop two. This led to overpromising, and sometimes under-delivering on results.
5. The 5PRING programme delivered many promising interactions with SME's, however, the ability to develop these into long term sustainable relationships were determined by the availability of funding on the testbed.
6. The importance of ensuring the conditions of the funders is directly reflected to the suppliers. Conditions that were agreed with DCMS were not related to Telefonica (for example) through the 5PRING contract. This created imbalances that were required to be monitored. When trying to achieve too much activity

through a contract, it has the potential to lead to overcomplications and misalignment between funders and creditors.

Testbeds

The original winning UCC application submitted by WMCA had bold scope and ambition, reinforced by the strategic business case. The promise of being able to deliver the WM5G programme at a regional level was progressive and showed a level of integration along with the proposals to reform public sector services.

As the funding for most of the testbeds expired at the end of March 2022, they technically come to an end. WM5G is keen to continue the development of the innovation developed on the testbeds and is actively working on preparing business cases / propositions that also look at the Levelling up agenda. WM5G believes that there is a demand for a physical testbed along with facilities in the West Midlands.

Lessons Learnt:

1. The programme teams were successfully able to pivot to digital delivery based on events being moved online in response to the pandemic. As a result, all 3 5SPRING locations for example were equipped with a 5G private network and 5G public indoor and outdoor connectivity.
2. Testbeds utilised the knowledge and expertise of the staff working directly on the testbeds who brought industry experience with them. Some staff have since gone onto win commercial contracts and raised further private sector funding.
3. The individual testbeds have largely operated as separate, independent, industry vertical projects that were divided geographically, in approach and technology, and with minimum public service improvement impetus. This reflects limited success in the projects coming together as one “connected urban community”, a key aim of the original application and business case.
4. MNOs played a key pivotal role in the programme, as they were required to provide network coverage allowing the testing of 5G solutions as well as support and deliver other innovations. However, it was discovered that some cultural differences at MNOs, lack of prioritisation from MNOs, and a lack of interest in some instances resulted in WM5G not being able to explore all desired aspects such as neutral hosting or network slicing – thus hindering delivery.
5. Many SMEs involved in the testbeds did not have the technical know-how and experience with 5G technology. Hence the technical support provided as part of 5SPRING was critical to enable multiple trials to proceed.
6. The lack of a dedicated single point of contact at the MNO on the testbeds, sometimes presented difficulties to SMEs. As new contacts at the MNO were not familiar with the trial, and in some instances did not prioritise them.
7. In some instances, some projects were impacted by the availability of 5G connectivity, coupled with the lack of 5G hardware and the worldwide shortages of 5G chips needed for routers. This was also one of the reasons the programme was not able to deploy network slicing.
8. During the 5SPRING challenge, meetings were held with regional local body stakeholders across the West Midlands to establish the challenges they were facing within the public sector. These ideas were then screened to determine whether 5G could deliver a cost-effective solution to these challenges (challenge led approach). A number of meetings were held, which then resulted in an open

competition in which SME's applied to join the 5PRING programme to provide potential solutions to the challenges. This approach worked really well.

9. All the testbeds generally ran independently in practice (not out of design), so in repeating the exercise more could be done in collaboration across the various testbeds.

Knowledge Sharing and Communications

Despite the impact of coronavirus, the 5G workstreams have been resilient in their progress and testing. From a marketing perspective, the team have provided very encouraging numbers. Even though initial engagements were fairly generic, the continued efforts of WM5G have led to a range of use cases, products and services.

Lessons Learnt:

1. All testbeds made use of the 5G connected map produced by the Infrastructure Acceleration workstream. The connected map provided useful connectivity evidence, which underpinned activity on the other workstreams.
2. Local Authorities have overwhelmingly provided positive feedback on the support and guidance provided by the Infrastructure Acceleration team specifically around the Electronic Communication Code.
3. WM5G have successfully won Government competitions in recent months, including the Government Digital Connectivity Infrastructure Acceleration (DCIA). This highlights the funding experience, confidence, and capability it has developed from the UCC experience. It has developed a reputation as a successful organisation that can deliver projects and win 5G competitions.
4. WM5G is confident on the continued role of the Infrastructure Acceleration team, and see it playing a pivotal role in a regional & national barrier busting capacity.
5. The programme felt that it should have invested more in adoption of the solutions that were being developed on the various testbeds. Most of the solutions being developed were based around real challenges faced in the region, so it was disappointing that there was limited business interest / deployment of the solutions developed in the region, which had the potential to be scaled up regionally, nationally and internationally. Additional project funding could have helped explore the scaling up of solutions that were developed in the projects.

Conclusion

Overall, the UCC Programme made strong progress in delivering its intended short-term outcomes. The IA programme exceeded its objectives to accelerate the rollout of 5G and contributed to the West Midlands becoming the best-connected region for 5G – measured by independent analysts. This has generated numerous benefits that can be adopted elsewhere in the UK.

The 5PRING accelerators were successfully launched, despite the pandemic, in three city centre locations. 5PRING has supported over 500 organisations and over 100 start-ups to understand the benefits of 5G and develop 5G applications. This is many more than the original targets in the grant agreement. Despite local funding challenges, the testbeds and use case trials funded by the programme successfully demonstrated technologies, products, and applications. These demonstrations generated a wealth of knowledge and learning for project partners. Use case trials demonstrated if and how 5G technologies can be deployed and if and how 5G

functionality (low latency, etc.) can be integrated into products and applications. The UCC programme enabled businesses to test different ideas and models, from use cases focused on Smart Cities around public safety, to Health use cases focused on connected ambulances providing real time information to clinicians. Importantly, use case trials also identified the limits of 5G technology, and identified where – for economic and/or technical reasons – other technologies are, for now, more appropriate.

Additional funding and time could have allowed the IA testbed to test and to explore Neutral Hosting and passive solutions, while the Covid-19 pandemic proved to be challenging for 5PRING, and the future commercial model was not realised which has led to the accelerators closing. A worldwide chip shortage for the past 18 – 24 months had caused issues and delays in accessing sensors for some of the transport use cases – which has impacted trialling them on 5G. Connectivity issues to the care homes impacted the efficacy of the pilot. In the Manufacturing testbed, there were challenges deploying 5G private networks owing to the nascent nature of the technology despite working with leading players. Despite this, the AEA project was good value for money (given its low project cost) and delivered its benefits – despite the team having to deal with the challenge of AEA going into and then exiting administration (for reasons unrelated to WM5G).

One of the biggest challenges that the programme encountered was successfully deploying 5G private networks at 5PRING and also in manufacturing (AEA + MTC). In all three instances there were significant challenges designing, configuring, installing and going live with the technology. These issues highlight the nascent nature of 5G private networks and the urgent need for manufacturers to offer, simpler, cheaper and more productised solutions. Clearly these will take time to develop but until they do so private 5G networks are unlikely to offer a commercially viable alternative or enhancement for SMEs versus corporate WiFi (WiFi 6) networks.

Looking ahead, WM5G has established clear plans for its future. Working extensively with its board, it has given much consideration on its sustainability for future years and are now successfully bidding for strategically aligned funds to further position the West Midlands as a centre of excellence around digital infrastructure, technology innovation, and technology adoption across public and private sectors. The fact that WM5G has raised additional funding to continue its work and move the business to become self-sustaining from 2022/23 is a significant achievement and meets DCMS objective to create a sustainable entity.

Glossary of key terms

5G ecosystem: The system of organisations and activities working on 5G, made up of public sector bodies and regulators, academics and research organisations, and businesses. Encompasses organisations that develop and supply 5G-enabled products and services, and organisations that use them.

Benefits Realisation (BR): The testbeds and use-cases each reported their progress towards delivering against objectives and targets using a BR data collection tool that was developed by DCMS.

Impacts: Impacts are the effects on the outcome that are attributable to the programme over and above what would have occurred in the absence of the programme

Latency: Latency, in technical terms, is a time interval between the cause and the effect of some physical change in the system being observed. 5G is designed significantly to reduce network communication delays (latency). Latency has held back technologies that are otherwise technologically ready for 5G.

Machine to machine communication: A broad label that can be used to describe any technology that enables networked devices to exchange information and perform actions without the manual assistance of humans.

Network provider: Telecommunications providers which own infrastructure which is used to deliver internet services

Network sharing: Network sharing e.g., for MNOs means they are sharing the infrastructure to some degree or other.

Neutral host infrastructure: Neutral host infrastructure comprises a single, shared network solution provided on an open access basis to more than one mobile network operator (MNO). It is usually deployed, maintained, and operated by a third-party provider.

Small cells deployment: Small cells are portable miniature base stations that require minimal power to operate and can be placed every 250 meters or so throughout cities. Global mobile operators will be using small cells to expand the indoor coverage and improve network capacity, improving the quality of telecommunication. Small cells can divert 80 per cent of data traffic in crowded areas.

Technology Readiness Level (TRL): The TRL scale is a commonly used method for estimating the maturity of technologies and is often deployed as part of R&D programmes to measure the progress of funded projects.

Testbed: The term is used to describe research and new product developments and environments.

Use case: A use case is an applied example of what can be done with a technology, in this case 5G technologies or 5G functionalities.

Value for Money: (as defined in the Magenta Book and following HMT Green Book guidance on economic appraisal and cost-benefit analysis)

List of Acronyms

5GTT Programme - 5G Testbeds and Trials Programme

AR - Augmented Reality

BR - Benefits Realisation

BRL - Business Readiness Level

CAVs - Connected and Automated Vehicles

CRL - Commercial Readiness Level

DCMS - Department for Digital, Culture, Media and Sport

IoT - Internet of Things

IP - Intellectual Property / Infrastructure Provider

LEP - Local Enterprise Partnership

MBNL – Mobile Broadband Network Limited

MNO - Mobile Network Operator

R&D - Research and Development

RAN - Radio Access Network

SME - Small and Medium Size Enterprise

TRL - Technology Readiness Level

UCC Programme - Urban Connected Communities Programme

VR - Virtual Reality

WM5G – West Midlands 5G

WMCA – West Midlands Combined Authority

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