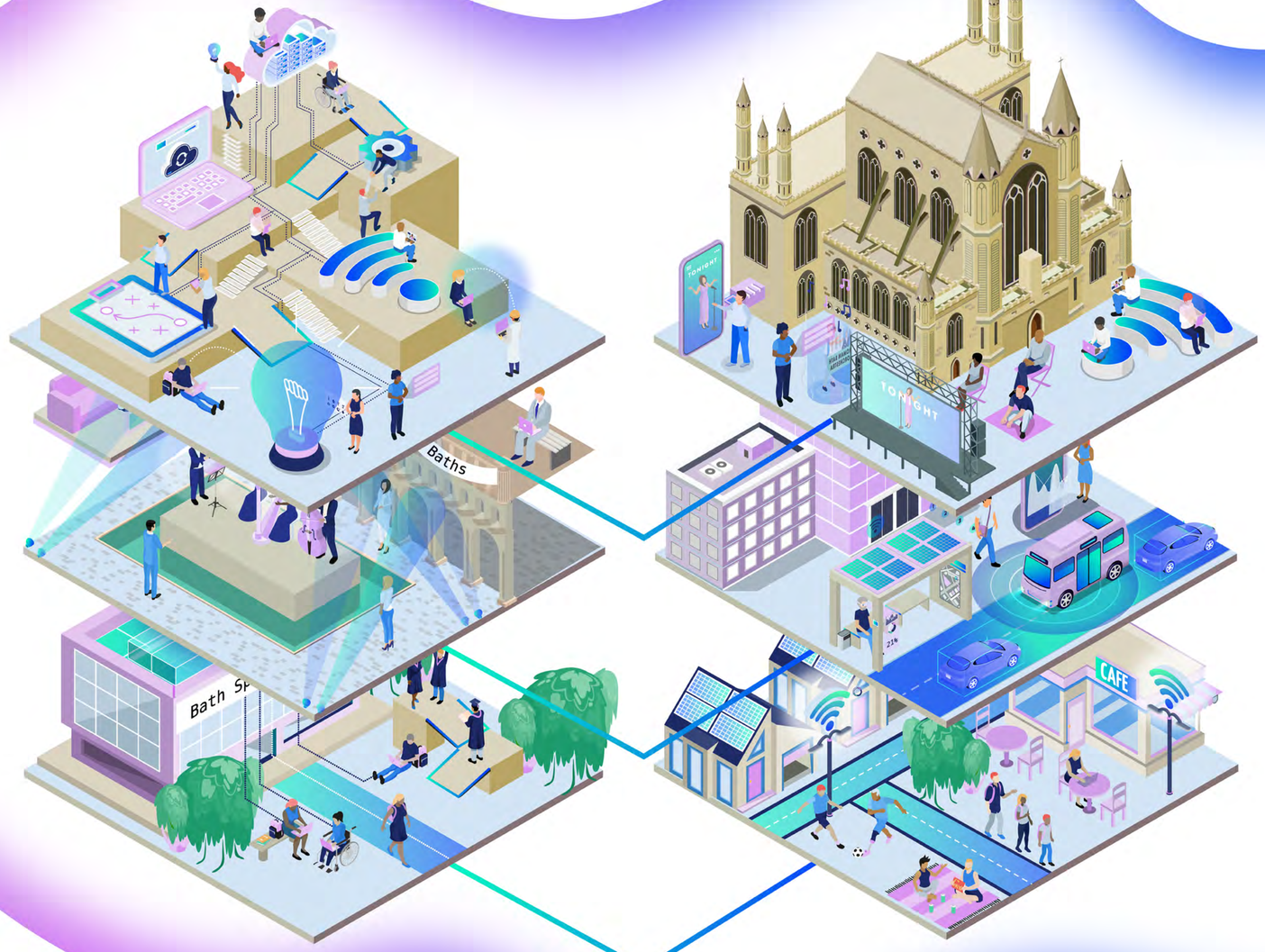
Connecting Bath

Bringing Bath up to Speed with Cutting Edge Digital Connectivity

Sept 2021



City Global Futures

BRISTOL+BATH CREATIVE R+D

Executive Summary

"If you have everything under control, you're not moving fast enough"

Mario Andretti

Bath's strategic position as a crossing point on the River Avon means the city has always been well connected. The Romans arrived and built infrastructure to connect the city to commercial opportunities across Britain and beyond but as participants in this research considered the city's post-pandemic future, it is cutting edge digital connectivity, rather than roads, which is at the front of their minds.

Bath Spa University (BSU) commissioned this study to consider how cutting edge digital connectivity, in particular private networks, might further develop the scale and impact of the creative and technology industries. This is a key ambition of the Bristol+Bath Creative R+D programme, which BSU co-leads.

We deliberately use the term "cutting edge connectivity" to reflect the continual development of networking technologies.

The research highlights that 5G has left the research lab and is now firmly on the sales floor – although the commercial case for specific user-facing applications is yet to be fully proven. In terms of R&D, it is 6G that is starting to excite the minds of the future networks community.

The first part of the report presents findings from an online survey, which was shared nationally. The positive news is that most survey respondents (69%) feel confident that cutting edge digital connectivity is on its way; participants anticipate that the market will deliver good public access to cutting edge connectivity in cities within the next three years.

At the same time, survey respondents are positive about the need for private digital networks, nearly all of the respondents (96%) considered it to be extremely or fairly important for creative technology businesses and researchers to have access to this type of connectivity.

The second part of the report presents findings from one-to-one interviews with key stakeholders. The city of Bath was the focus of the interviews but interviewees included local, regional and national stakeholders.

A wide range of views on the challenges and opportunities associated with the idea of private networks for creative technology businesses emerged from the interviews. Areas of agreement include: the importance and timeliness of the conversation in Bath; the city's need to focus on improving existing "everyday connectivity" for businesses as well as (or even instead of) private networks for advanced users; and the importance of digital inclusion and equality alongside commercial returns.

In contrast, interviewees expressed very different opinions on where networks should be located and how they might best be managed. Some saw the opportunity to boost the capabilities of Bath's existing city centre venues, others were excited by the opportunity of extending the network and footfall into new areas. For some, universities were the natural leaders, whilst others felt such initiatives are best led by the market. Generally, interviewees accepted the benefits of having a range of stakeholders involved both locally and regionally, highlighting initiatives such as the Western Gateway as an opportunity for Bath.

The third part of the report presents five models for Bath to consider when determining how to move forward its ambition for cutting edge networks. They are:

I. Market-led approach: encourage industry to deliver public networks.
II. Smart City approach: creating a holistic city-led vision and partnership.
III. Venue-led approach: meeting the needs of specific venues/locations.
IV. R&D Testbed: making university and business experimentation the key strength.
V. Neighbourhood approach: increasing community engagement by working outside of the UNESCO city centre.

These models derive from a review of projects suggested by survey respondents and interviewees as well as our direct experience. We outline some of the pros and cons associated with each model and include case studies to highlight how they are being deployed elsewhere.

In conclusion, the report recognises the potential value of private, cutting edge digital networks as part of a suite of interventions aimed at building a successful digital place. The question we conclude it is most important for Bath to address is, not which model of cutting edge connectivity to follow but - how to implement them all!

We offer some tangible next steps to help address the complexity associated with moving forward a place based, ecosystem-driven approach. These are,

- Use this research to re-engage the B&NES Economic Recovery and Renewal Board (ERRB) on future digital strategy;
- Revamp the 5G Smart Tourism network at the Roman Baths with a focus on the commercial exploitation of AR/VR services for visitors as well as future 6G research;
- Build one R&D Testbed with two distinct purposes – environmental technologies (University of Bath) and MyWorld innovative screen-based media (Bath Spa University);
- Create a connected neighbourhood, with the Bath Spa University Locksbrook campus at the heart of a new, inclusive, connected digital cultural demonstrator.
- Through all of the above, create a clear offer and ask, to strengthen Bath's position as a successful digital place in relation to emerging digital collaboration via the Western Gateway.

Content

3. Introduction

3.1– Bristol+Bath Creative R+D

Bristol+Bath Creative R+D is a £6.8 million first-of-a-kind collaboration between the West of England region's four universities and Watershed. The aim is to better connect university research and creative business to take the Bristol+Bath cluster to the next level by, forging connections; sharing knowledge and creating new opportunities.

The current/planned roll-out of 5G connectivity and the future development of 6G, in the UK and globally, are potentially significant, disruptive and game changing opportunities, which the Bristol+Bath Creative R+D programme wishes to better understand, particularly in relation to the role that private networks might play.

Under the leadership of Professor Kate Pullinger, Bath Spa University commissioned City Global Futures to undertake this research, including, a national survey; stakeholder interviews and a desktop review of case studies. The overall aim is to explore the feasibility of a private, cutting edge digital network for Bath's Creative and Digital industries.

3.2– City Global Futures

City Global Futures (CGF) specialises in bringing together people, organisations and ideas, across different sectors and spheres of interest. We believe in smart, sustainable and inclusive cities, regions and places that offer a positive future for all. We help create shared vision and purpose and deliver projects that have real-world impact. City Global Futures has significant experience of working on cutting edge digital connectivity and place making projects. Some examples include:

* Managing delivery of the 5G Smart Tourism project - a £5 million DCMS 5G Testbed and Trials-funded programme, involving 20+ partners, including creative businesses in Bristol and Bath;
* sector-based research, publishing Turning on the Lights – a report examining the UK Tourism Sector's readiness and appetite for 5G-enabled technologies;
* advising the West of England Combined Authority on the development of a regional network of Living Labs in support of the Local Industrial Strategy;
* managing the start-up phase of the current DCMS funded 5G Encode project;
* Stephen Hilton (CGF Director) was a Digital Placemaking Fellow on the Bristol+Bath programme, publishing Rebooting the Digital City, which advocated for the further development and use of community networks and edge computing;
* Stephen Hilton and Sarah Toy (CGF Research Director) worked with Bath and North East Somerset Council's Economic Recovery and Renewal Board to develop Ambitious Together a shared 2030 Vision for Bath with NES;
* Stephen is a Fellow of the University of Bristol's Digital Futures Institute (BDFI) developing socially-driven use cases for "nomadic networks" with 5G+ capabilities.

List of projects

* 5G Smart Tourism project
* Turning on the Lights
* 5G Encode project
* Rebooting the Digital City
* Ambitious Together

3. Introduction

3.3 Local Context

As with any new generation of technology, there is a degree of hype but Bath has experienced the benefits of 5G first-hand. As part of the 2018/19 5G Smart Tourism project, the University of Bristol Smart Internet Lab, BBC R&D, Aardman Animation and other partners delivered 360-degree Augmented Reality experiences to visitors' mobile devices with levels of latency so low that they were virtually imperceptible. Achieving this within the constraints of the two thousand year-old Roman Baths is not something easily achieved in historic buildings:

"We were talking to the British Museum a few years ago about developing an AR installation but it didn't happen because we couldn't drill holes in the walls!"
Maria Cuevas, BT

Equally as significant was the indication of commercial potential. The project evaluation showed that 80% of participants in the trial were prepared to pay for similar experiences in future. The potential is genuine but so are the barriers. A lack of business knowledge and capacity within the cultural sector are seen as key issues in Bath and our own research on the Tourism Sector echoes this. A large number of cultural/tourism venues report no senior-level digital capacity, so increasing skills and learning are seen as a key priority:

"One of the concerns I have as a technologist is separating fact from fiction. In order to really make this go, we need the education side of things to go along with it. People don't really understand the potential. Everybody is going to want it because it's a faster connection, but people need to understand the real use cases, the benefits, is where organisations will be able to maximise the potential. How do you convince the SMEs to get involved if most of them don't really understand what it is? That is the antidote to the negative press - the opportunities that it can offer."
Interviewee

New barriers have also arisen since the completion of the Smart Tourism initiative, which are likely to have a significant impact. In particular,

* UK Government's decision to ban mobile network operators from using Huawei equipment is likely to delay the UK's rollout of 5G by at least two years and the cost of stripping out Huawei equipment (predicted to be £2 billion) will ultimately need to be recouped. This is likely to add to the costs for end-users.
* As a brand "5G" has become tainted, all-be-it unfairly, through campaigns aimed at creating/amplifying distrust in the technology. For example, in December 2020, Bath and North East Somerset Council's planning committee voted six to three to refuse permission for an existing 4G mast to be upgraded to 5G following 300 objections from local residents, many stressing the perceived threat to health and nature, with a group called Stop 5G in Bath rallying the opposition[1].

It seems likely that fear of, or opposition to, 5G will diminish as the technology is widely rolled-out and mobile phone handsets are increasingly 5G-enabled. Measuring the current public perception is out of the scope of this research, however, many interviewees commented that it is not an issue for them, their business partners or customers:

"Our young audiences don't seem bothered at all; the brands we work with don't seem worried about push back. There's some very loud voices, but I'm not sure if they are having any actual commercial impact. I think it's more valuable to define the network by what it does rather than the technology it uses. The fact that it will be a network which works for the city is more important than whether it is 5G or not."
Seth Jackson, Landmrk

[1] As part of this research, we sought to interview two senior B&NES Council officers but unfortunately, neither were available.

3.4 Definition

In this research, we use the term "cutting edge" digital connectivity or networks to refer to digital connectivity that offers the highest levels of speed, minimal latency and ultra reliable quality of service to end users. We are mostly keen to explore the potential of 5G/LTE[2] wireless networks but recognise that for Bath and other cities "gigabit fibre" forms an important part of the connectivity mix. We believe that cutting edge connectivity is an easier concept for non-technical stakeholders to grasp. It also moves away from the emotionally charged dialogue that surrounds 5G.

The report goes on to highlight, from the perspective of Industry and Academia, 5G has moved from the research lab onto the sales floor. Although still at a very early stage of development, it is 6G that is starting to excite the creative engineering minds of the future networks community. This is a timely reminder that the cutting edge is never static. As of yet, the definition of 6G is far from agreed. Engaging at this early stage will allow cities like Bath to frame the future narrative.

3.5 Private Networks

"A private 5G network is a local area network that uses cellular 5G technology to create a dynamically reconfigurable network with unified connectivity, optimised for services and a secure means of communication. A private network, as opposed to a public network, allows far greater control and can be far more cost effective for a business. 5G features, such as neutral hosting and network slicing and splicing, can be applied to transform a private 5G network into a dynamically reconfigurable network able to support a wide range of applications."
Vassilis Seferidis, CEO Zeetta Networks.

As Zeetta's CEO highlights above, private networks offer the promise of secure, bespoke connectivity environments, which can be designed, customised and optimised to meet specific user needs and where network data can be retained locally. They are becoming an increasingly important part of the telecoms infrastructure:

"Private networks are the most successful part of 5G right now. Particularly if there is an owner of a factory type space or exhibition hall - most authorities now allow you to buy a spectrum licence to fit these kind of facilities.... It's a very vibrant idea... It's happening all over the world particularly in ports and airports..."
Paul Wilson, Digital Catapult

Private networks are being deployed in a multitude of settings – from airports to stadiums; conference halls to factories; ports to farms. Site-specific spectrum licenses are now more readily available to support this type of deployment, which is generally seen as complimentary to, rather than a replacement for, public networks. In fact, many mobile network operators are increasing their internal consultancy capacity to support the commercial delivery of private networks. The International Data Corporation[3] (IDC) predicts the market will achieve sales of private networks in the region of £4.2 billion by 2024, a 5-year compound rise of 43.4% from 2019.

[2] Long-term Evolution, [3] As reported in Computer Weekly (15/01/2021)

4. Findings from the Survey

4.1 Survey Method

The on-line survey was designed using the SmartSurvey tool and was kept open to collect responses between 9th July and 2nd August 2021. The 5GUK Creative Industries Working Group promoted the survey nationally and Bristol+Bath Creative R+D promoted it regionally. A total of 27 responses were received during this period. The responses were of high quality providing considered answers and useful additional information for follow-up in the free text options.

4.2 Who Responded?

The survey was designed and disseminated to attract responses from beyond Bath to bring a wider, national or indeed international perspective to the study. FIGURE 1 shows that a good geographical spread of responses was received. Of the 22 people who responded to the question about location(s) of their organisation, their businesses were distributed quite evenly between the city of Bath (27%/6), the city of Bristol (27%/6), elsewhere in the West of England (14%/3), elsewhere in the UK (41%/9) and outside the UK (18%/4) with five respondents (18%) choosing not to give their location.

FIGURE 1

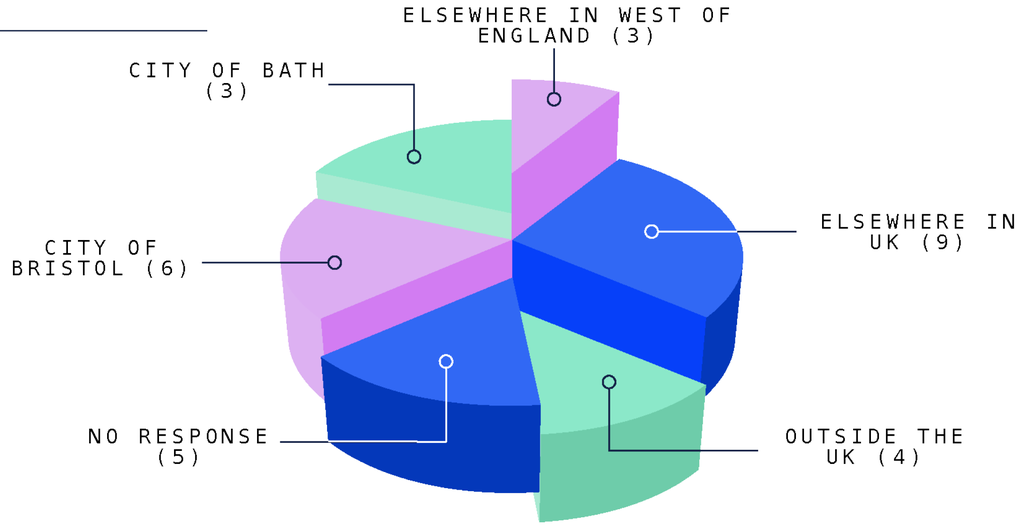


FIGURE 1: LOCATION OF RESPONDENT'S ORGANISATION

FIGURE 2 illustrates the split between type of organisations represented in the survey and shows that, of the 22 respondents who answered this question, the most-represented sector is the private sector (55%/12 respondents) with 3 (14%) responses from the public sector, 4 (18%) from academia and no responses from the voluntary and community sector. Two respondents identified as "other" with one in Arts and one a self-employed artist and educator.

FIGURE 2

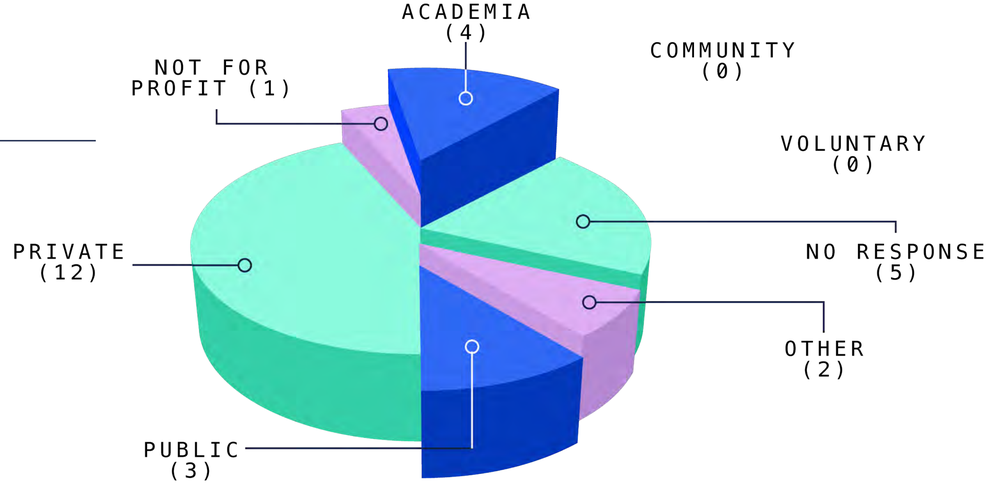


FIGURE 2: RESPONSE BY SECTOR

The geographical and sectoral spread of responses brought some interesting insights, examples of best practices and suggestions for Bath as discussed later in this report.

4.3
What did we Learn?

IMPORTANCE OF CUTTING EDGE DIGITAL CONNECTIVITY:

The majority of respondents (24 out of 26 responses to this question, 89% of the sample) agreed that it is very important for Bath and other small to medium-sized cities to have strategies in place to deliver cutting edge digital connectivity to businesses. 19 (70%) of these respondents felt that cutting edge digital connectivity is as important or more important than having good roads.

BENEFITS OF CUTTING EDGE DIGITAL CONNECTIVITY

When asked to select the top five benefits, all 27 respondents answered with increasing digital inclusion and creating jobs in the creative and technology sectors receiving the most responses (23/85%), followed by developing and testing new ideas and approaches (17/63%). The full range of responses is show in FIGURE 3.

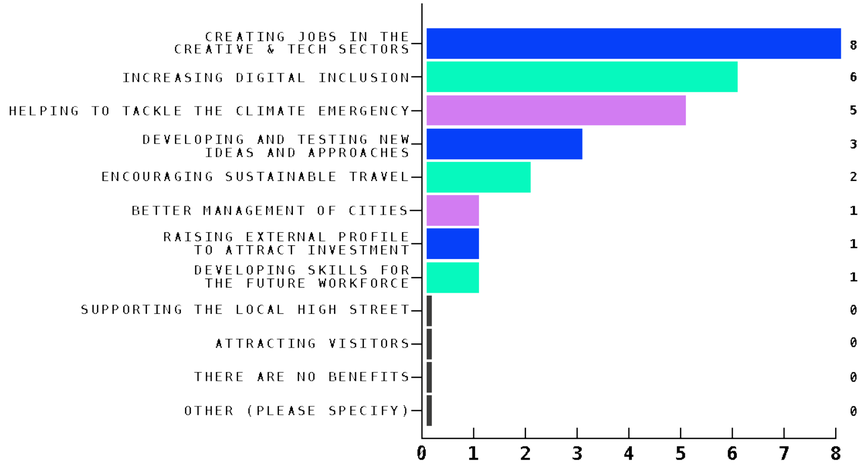


FIGURE 3:
THE FIVE MOST IMPORTANT BENEFITS OF CUTTING EDGE DIGITAL CONNECTIVITY

When asked to select a top priority 8 (30%) felt that creating jobs in the creative and technology sectors is the most important benefit, with 6 (22%) choosing increasing digital inclusion and 5 (18.5) choosing helping to tackle the climate emergency. The full range of responses is shown in FIGURE 4.

LOCATION OF CUTTING EDGE DIGITAL CONNECTIVITY:

Respondents were asked to consider the importance of connectivity in a wide range of locations and settings. The top three locations chosen by respondents where provision of cutting edge digital connectivity is

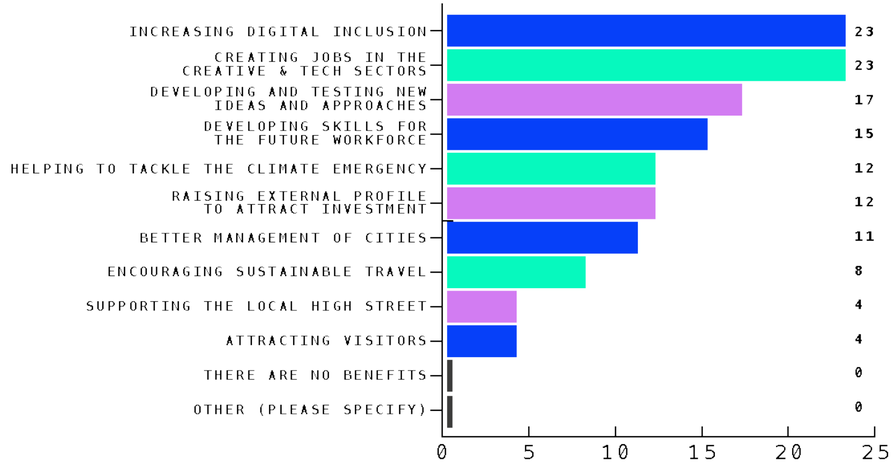


FIGURE 4:
THE MOST IMPORTANT BENEFIT OF CUTTING EDGE DIGITAL CONNECTIVITY

considered to be very important were: hospitals and health facilities (23/85%), university campuses (22/81%) and schools (22/81%). Cultural venues (17/63%) and public transport (17/63%) were also singled out as very important locations. FIGURE 5 shows the distribution of responses. It is worth noting that respondents were given the option to respond "Should not have a cutting edge digital connectivity" but no-one selected this for any of the 14 suggested locations.

FIGURE 5

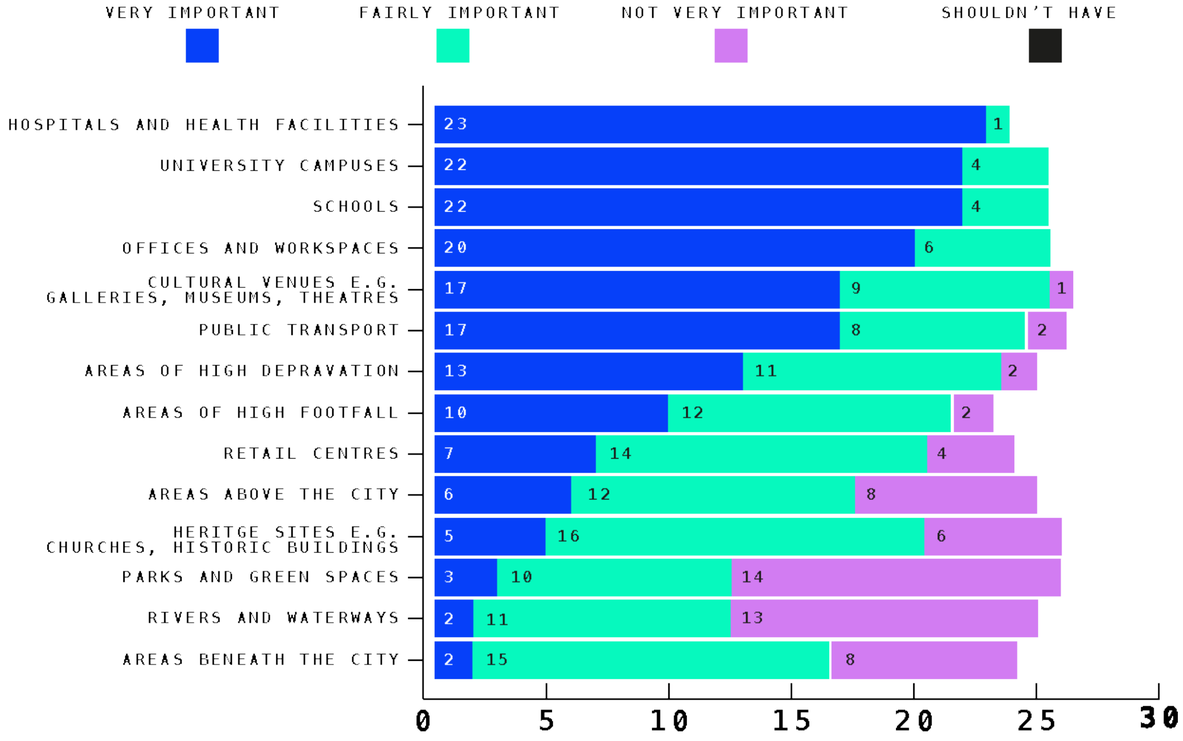


FIGURE 6

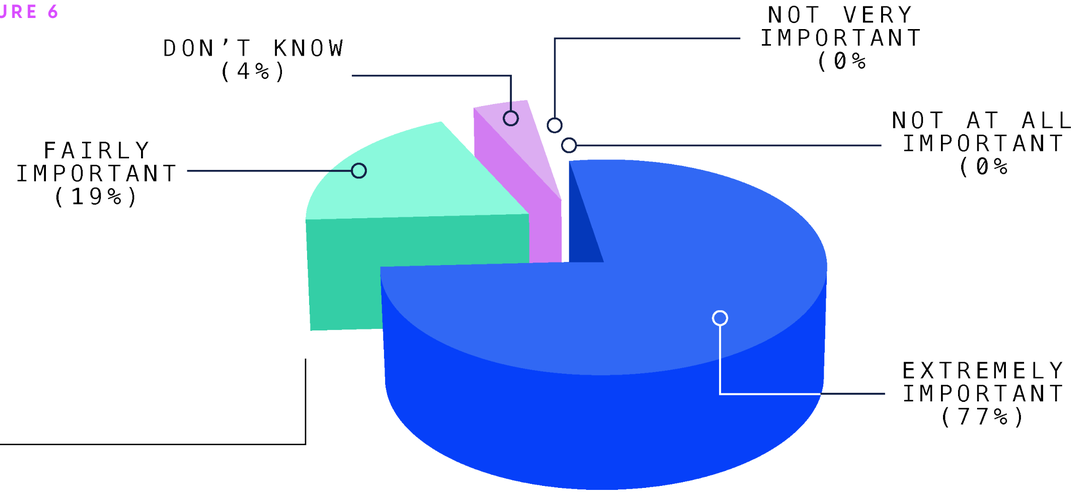


FIGURE 5:
LOCATION OF CUTTING EDGE DIGITAL CONNECTIVITY

DELIVERY OF CUTTING EDGE DIGITAL CONNECTIVITY:

The majority of respondents were either extremely confident (5/19%) or fairly confident (13/50%) that cutting edge digital connectivity would be publicly available in the nearest city within the next three years. However the next question revealed that, despite this optimism for a public network, there is also a real appetite for access to private networks to complement public networks with 96% (25 of the 26 respondents who answered) considering that it is extremely important (20) or fairly important (5) for creative technology businesses and researchers to have access to a private cutting edge digital network. As shown in FIGURE 6 below, none of the respondents thought that access to private networks is unimportant.

FIGURE 6: IMPORTANCE OF ACCESS TO A PRIVATE CUTTING EDGE DIGITAL NETWORK

POTENTIAL APPLICATIONS OF CUTTING EDGE DIGITAL TECHNOLOGY IN BATH:

A wealth of inspiring and exciting ideas for applying cutting edge technology in Bath were put forward by 16 of the respondents. These included:

* Bringing businesses and growth to the city and encouraging tech start-ups and fostering innovation;
* R&D into innovative digital solutions to global and local challenges;
* Augmenting the city with performance and appropriate installations;
* Interventions to reduce climate change impact via real time data (transport, energy and pollution monitoring);
* Research to decrease inequality of access to technology;
* Creation of a hub of digital services (learning from BiO[4]) open to users around the world;
* Making work-life and education more efficient and accessible;
* Getting information about the city attractions in real time; and
* Creating immersive experiences for visitors.

[4] Bristol is Open

5. Findings from the Interviews

5.1 Interview Methodology

We undertook one-to-one interviews with 20 key stakeholders from Bath, Bristol and national organisations. Interviewees spanned both public and private sectors and academia. The purpose was to test and develop the proposition of a private, cutting edge digital network for creative and digital industries in Bath and the questions explored; the need for and relative importance of cutting edge digital connectivity; the role of private networks; the benefits for the creative technology sector and the wider economy and issues of governance and location, as well as examples of innovative practice that Bath might learn from.

The interviews were conducted over Zoom and ran concurrently with the online survey. They were recorded and subsequently transcribed, in part, allowing for the inclusion of direct quotes in this report. A standard topic guide was used for the majority, but a small number required a specific technical or industry focus.

FIGURE 7 (right) includes a list of interviewees and organisations.

INTERVIEWEE	ROLE	ORGANISATION
Sarah Adezzio	Producer, Bristol+Bath Creative R+D Partnership	Bath Spa University (Client)
Catherine Allen	CEO	Limina Immersive
Kevin Blyth	Research Principal	BT Applied Research
Maria Cuevas	Mobility Research Theme Principal	BT Applied Research
Kathryn Davies	Director of Tourism	Visit West
Richard Godfrey	CEO	Rocket Makers
Alison Herbert	CEO	Bath BID
Penny Jenkins	Commercial Manager	Bath and North East Somerset Council
Gavin Johnson	Produce at Clwstwr	University of Glamorgan
David Kelly	CEO	Storm
Freyja Lockwood	Digital Innovation and Transformation Programme Manager	West of England Combined Authority
Sara Pepper	Director of Creative Economy	Cardiff University
Martin Pople	Manager	Former Bristol and Bath Cultural Destinations Project
Kate Pullinger	Director of the Centre for Creative and Cultural Industries	Bath Spa University (Client)
Andy Salmon	PVC (External)	Bath Spa University
Vassilis Seferidis	CEO	Zeetta Networks
Dimitra Simeonidou	Co-Director Bristol Digital Futures Institute, Director Smart Internet Lab	University of Bristol
Jeremy Silver	CEO	Digital Catapult
Charlie Williams	Composer/pianist and Creative coder	Larkhall
Paul Wilson	Chief Business Officer	Connected Places Catapult
Ben Woods	Head of Research, Commercialisation and Enterprise	University of Bath

FIGURE 7: LIST OF INTERVIEWEES AND ORGANISATIONS

5.2
What did we Learn?

CUTTING EDGE DIGITAL CONNECTIVITY IS SEEN AS VITAL TO BATH'S FUTURE ECONOMY:

All of the stakeholders whom we interviewed firmly believe that cutting edge digital connectivity is essential to Bath – not a replacement for the city's roads but equally as important - and as one interviewee noted, also potentially cheaper:

"Getting around the city digitally is just as important as getting around by walking, car, public transport... it's how modern society functions"
Martin Pople, Bristol and Bath Cultural Destinations Project (former)

"I'm not sure they are two ends of the same see-saw [digital connectivity and roads] but digital connectivity is utterly important – and significantly cheaper to set up and maintain, so no excuses"
David Kelly, Storm

Many see cutting edge digital connectivity as an enabler of the city's economic future, underpinning entrepreneurship and re-balancing and growing the green economy. It is also seen to enhance the city's reputation as a part of a leading regional, creative digital cluster:

"Thinking about how Bath moves forward, whatever happens next, creative technology and entrepreneurship seem to me to be huge growth areas, so as Bath moves forward into its next phase and creates new businesses... it will be about sustainability and the green economy... creative technology with a strong accent on user engagement and repurposing our economy"
Andy Salmon, Bath Spa University

"[cutting edge connectivity] is really important for Bath for two reasons: you can't claim to be part of one of the leading digital clusters without it and secondly, in order for the city to deliver its ambitions - to be a contemporary city and a great place to live, work and visit – it needs that connectivity to be there."
Kathryn Davis, Visit West

Interviewees noted the opportunity to harness cutting edge connectivity to build on the city's existing tourism and hospitality strengths. One interviewee suggested it was part of the city's social responsibility – using 'tech for good' to make more of its world-class heritage assets:

"Bath's reputation is as a heritage city internationally, so there could be a perception that because of this, its digital infrastructure is also stuck in the past.... From the perspective of public good, it is important that there is a good digital infrastructure to unleash and liberate all the city's fantastic heritage."
Catherine Allen, Limina Immersive

"In terms of tourism, it's about how we present Bath as a more modern city.... People will always come because of the UNESCO World Heritage site but it will be the same people coming all the time. As a city, we should be looking to attract new more diverse audiences, so people who wouldn't otherwise come. It will make us more accessible as a city."
Penny Jenkins, B&NES Council

There is also seen to be potential to make use of a private digital network to help improve Bath's physical accessibility by offering enhanced levels of wayfinding to meet different user's needs:

"I'm interested in digital wayfinding... There are such a lot of stories to tell about Bath. There are so many lost people all the time. The BID pays for 20 people to help at weekends. We could develop layers e.g. a quiet route for people with autism, the dog walkers' route, to make the city more accessible for people."
Alison Herbert, Bath BID

THIS CONVERSATION IS A TIMELY ONE:

Bath has recently agreed a new 2030 shared Vision, which sees the city and wider North East Somerset region as "Fair, Green, Creative and Connected." Work is also underway to create a new Cultural Strategy for the city. The timeliness of this research was commented on by several interviewees who recognise that nurturing and growing the city's creativity is vital to future resilience and that technology will increasingly be the delivery vehicle:

"Covid is really interesting, it looks like the perfect opportunity to rebalance the economy but actually we are all going out again, wanting to fly. The United Nation's SDGs[5] are all interconnected, a huge amount of this is about human behaviour and creativity has a huge amount to do with that. It's not a climate crisis - this is misnamed, it's a human crisis but we're not thinking like that at the moment. Creativity has to lead, and technology will be the delivery mechanism".
Andy Salmon, Bath Spa University

Whether as a consequence of Brexit, COVID-19, or both, interviewees also commented on the changing 'flavour' of digital innovation – with the emphasis shifting increasingly towards demonstrating real-world value and rapid results:

"The testbed's immediate usefulness is the most important thing. The same way COVID accelerated the processes that turn ideas into products on the ground, that is where the government's mindset is at right now. They are looking at innovation deals, regional specialism: they want those ideas out there, where businesses can use them."
Ben Woods, University of Bath

THERE IS AN URGENT NEED TO IMPROVE 'EVERYDAY CONNECTIVITY'

Concern about the poor state of 'everyday connectivity' in Bath – by which we mean the level of digital connectivity that is generally available to businesses – tempered interviewees' enthusiasm for cutting edge networks. For example, interviewees noted that COVID-19 has brought rapid changes to the way all tourism and hospitality businesses operate. Online booking, table ordering, and contactless payment systems have rapidly become the norm and many small businesses in Bath are currently struggling to get sufficient 'everyday connectivity' to support these applications. One interviewee even suggested that due to issues with a local mobile transmitter, "businesses can't even rely on taking phone calls".

"It's absolutely essential, even the smallest café in Bath city centre is reliant on digital connectivity to take orders at the moment... ignoring digital connectivity is like turning your back on the future."
Interviewee

This situation has arisen over many years, interviewees explained. The absence of a central office/business district, combined with the complexity (and cost) of deploying infrastructure in Bath's UNESCO world-heritage setting, has led to the city being seen as low down on Industry's priority list for upgrading telecommunications infrastructure. The perception is that Bath is far behind where it should be in comparison to other UK cities and that this has a persistent detrimental effect on businesses' ability to thrive:

"Compared to other similar sized cities our infrastructure need is acute... Bath has very poor connectivity full stop for businesses... [commercial] networks have not entered the city in the same way as they have in other places, primarily because it is a tourism destination without much of an office base... for tourism and retail it's basically been about can I get good wi-fi for my customers.... For creative, cultural, tech businesses, they suffer as they don't have

[5] UN Sustainable Development Goals

the ability to drive themselves forward with digital infrastructure in a way that Bristol, Oxford, London or Manchester can."
Ben Woods, University of Bath

Some interviewees hoped that 5G might have helped Bath's situation – wireless technologies being generally less disruptive and costly than fibre to deploy – but uncertain city leadership in light of fierce local opposition to 5G led interviewees to fear that Bath has missed out again:

"5G wireless was seen as a solution – but looks like it won't be for Bath – it's all really quite a sore spot"
Interviewee

"Pre-pandemic the council used to have someone responsible for digital connectivity but now there is no one"
Interviewee

The roll-out of high capacity 'gigabit fibre' locally was seen as a great step forward by some interviewees, and it seems clear that many local residents are benefitting from this investment. However, other interviewees suggested that the marketing of these high-speed services is well ahead of availability – and that poor everyday connectivity is likely to continue to hinder business, particularly high-end users, for the next few years or longer.

"You can't call yourself a creative, tech, digital city if you don't have the connectivity, or fibre, to back it up. I know this from personal experience, we are looking for premises at the moment and we are struggling to find places with suitable connectivity…. We were shown one the other day and the agent said, this one is really unusual as it has fibre to the premise – it shouldn't be unusual!"
Interviewee

"The truth is there is really little choice. I was talking to [a Bath telecoms service provider] who are currently laying cable and advertising high speed connections everywhere but they said they are probably two years away from being able to get to our office… and we are right next to the train station."
Richard Godfrey, Rocket Makers

NOT EVERYONE FEELS THAT CREATIVE TECHNOLOGY BUSINESSES SHOULD BE TREATED AS A 'SPECIAL CASE':

A perception that the market will deliver cutting edge digital connectivity in and around Bath colours some interviewees' views on the merits of treating the creative and technology industries as needing special attention in relation to connectivity:

"Why focus on a specific sector – infrastructure should be available for all…. I've got gigabyte here that's 15-year proof, probably. And I know that it is spreading across Bath, it's in Odd Down, Peasedown, central Bath; Both Truespeed and Gradwell offer gigabit fibre locally – so the nag is, I don't know what more a concept like this is planning to offer"
David Kelly, Storm

"Underestimate at your peril the upload speeds needed by a normal business… how lovely for them [creative and digital businesses] but what about the rest of us?"
Interviewee

"Creative and digital industries are the first adopters – they are out in front using the technologies that they are helping to develop but it's just as important for other businesses…."
Martin Pople, Bristol and Bath Cultural Destinations Project (former)

THOSE WHO WORK IN OR WITH THE CREATIVE TECHNOLOGY SECTOR(S) ARE MORE LIKELY TO BE SYMPATHETIC TO THE NEED FOR A BESPOKE PRIVATE NETWORK:

Interviewees who are directly working in or with the creative technology sector have more sympathy for the idea of bespoke connectivity.

The opportunity for testbeds to create private cutting edge networking environments was recognised as potentially valuable for both Bath and the region, providing a space for experimentation and innovation, giving greater control over how networks are configured and optimised, and increasing control over how data is collected, shared and used.

"We are not that typical of most of the digital organisations, we look a bit further ahead than many – but if you think of the need for augmented and digital reality; the needs of internet of things devices... on the internet and speaking to each other, you end up with this mushrooming of need with everything talking to everything.... And you need the connectivity in order to be able to provide that."
Richard Godfrey, Rocket Makers

"Everyone is looking at trying to create a more immersive experience now so having the infrastructure in place is going to become more important now, and that also opens up the skills opportunity. We are seeing massive gaps in skills coming through"
Gavin Johnson, Clwstwr, University of Glamorgan

One important added benefit that was identified is the role creative industries can play in helping to socialise new technologies, allaying public fears about the pace and scale of technological change through active and creative public engagement:

"If you put this type of high speed in the hands of creatives, I would hope that it would allow people to lean into any concerns or trepidation they might have about the future coming along too quickly"
Catherine Allen, Limina Immersive

THE EXACT FOCUS OF A PRIVATE NETWORK (OR NETWORKS) IS A MATTER FOR DEBATE:

Even when interviewees were sympathetic to the sector's need for private networks, the scale and focus was a matter of debate. Some interviewees shared examples of current innovative projects, which could benefit from cutting edge connectivity now, others focused on the longer term potential.

"For creative digital, a 5G telecommunications testbed that enables AR and VR, like we did with Smart Tourism, fits quite well. Equally, from a city perspective, to be useful to the city and to researchers, I think it's about a sustainable, net zero testbed."
Ben Woods, University of Bath

"We've just done an Innovate UK project, which is about dynamically replacing content in virtual reality scenes, so when you think about that – city models, engines, or anything you might be training people on - it's a sort of content management for the internet, 3D, spatial audio, we are trying to stream 3D models with textures etc at run time to change people's experiences – if you are in that type of technology space then this type of infrastructure is essential to stay ahead of the game"
Richard Godfrey, Rocket Makers

"Because we do everything on mobile web, connectivity is absolutely vital. Using mobile web data has presented an opportunity for us and a limitation: it is easy for everyone to use and doesn't rely on the quality of the user's smartphone but one of the issues we run into now, especially with AR experiences, is speed and file size limitations, so even though the handset can do more, we are limited to what the network can handle."
Seth Jackson, Landmrk

THERE IS LITTLE CONSENSUS ON HOW CUTTIVNG EDGE DIGITAL NETWORKS SHOULD BE MANAGED – BUT GOVERNANCE IS ALSO RECOGNISED TO BE ABOUT COMMUNITY ENGAGEMENT:

"Governance? No - that will slow it down. If you leave it to companies, they will get it done but it won't be the fairest way. We should keep our noses out to facilitate

speed and keep the prices lower."
David Kelly, Storm

"Governance is hugely important - who owns and who has control and who has input into them - If it was Google, I would be very apprehensive. Some measure of local control is vital. Get local residents on board and part of this from the word go, so there is no local hostility. The idea that the local community owns it including businesses, residents and not just the council. COVID has emphasised the local, if this is seen as being owned from outside it will go down really badly."
Martin Pople, Bristol and Bath Cultural Destinations Project (former)

The question of how private, cutting edge digital networks should be managed divided participants. Some perceived governance as an overhead that would slow down progress whilst others saw it as essential to achieving local buy-in and success. There were also differences of opinion about the best leader for such initiatives:
"From a governance perspective, I was going to suggest that the testbed would be managed on behalf of the city by the universities... you will be more likely to get university funding for research on it than you would from WECA or other types of public funding. The universities could lease the testbed from B&NES...."
Ben Woods, University of Bath

"I would loathe to see it just controlled by the university, because then it would be all about research. I would equally loathe to see it controlled solely by the council or by private companies, because they each have their own specific interests and the network would end up being all about them. Instead, I think its about finding suitable representatives, who understand the industries that want to use the network and their needs, who can communicate and allow access."
Seth Jackson, Landmrk

More generally, there was agreement that having a mix of local stakeholders involved would be beneficial. The opportunity is to think of governance not simply as a mechanism for controlling the network but also as a tool for creating greater democratic ownership and engagement, and ideally for ensuring greater equality of access:

"Maybe you would need voices from all the partners I mentioned previously- government, industry, education, and the general public. The governance would need to be derived from all those potential partners."
Sara Pepper, Cardiff University

"If people are disfranchised, think it is sci-fi, then having local businesses involved would feel right rather than global multi-nationals. How it is run could be a beacon, an inspiration, something you do have a say in."
Catherine Allen, Limina Immersive

"The bit that will make a huge difference is the equity around it. Connectivity should be treated with parity of access to water, electricity, roads. [Digital connectivity] is often shown as a 21st century addition to Maslow's hierarchy and organisations should be subsidising access to it."
David Kelly, Storm
Several interviewees referred to the potential of creating a special purpose vehicle to manage a network – a community interest company (CIC) or local development company. State Aid and procurement were recognised as key issues that would need to be addressed:

"There is one in Ashton-under-Lyne where they developed a workaround in which every time the roads would come up the council would put fibre optic fibre down, which led to roughly 50km of ducting. They then asset transferred that into a cooperative to get around the issue of state aid, so some of that is now used by the universities, some of it is used by commercial companies to accelerate the rate of delivery of their broadband programme"
Ben Woods, University of Bath

"Different form of governance/oversight might be needed for digital infrastructure. Possibly some kind of local development company... it has come up in our Board meetings as something they want to look at"
Interviewee

Finally, interviewees provided a reminder that it is possible, perhaps even likely, that creative companies and practitioners, whilst supportive of the idea of cutting edge digital networks, won't have a strong desire to run them. They will be happy if they are simply available and easy to connect to when needed:

"It makes sense that people want to feel invested in the network, but personally, I would just like a network that requires as little input from me as possible and would just work."
Charlie Williams, Larkhall Music

"I think creative companies are well placed to help co-design network solutions."
Freyja Lockwood, WECA

WHEN IT COMES TO LOCATION OF THE NETWORK, THE CHOICE IS WHETHER TO BUILD ON EXISTING DEMAND AND STRENGTHS OR TO PUSH OUTWARDS INTO NEW LOCATIONS:

We quizzed interviewees about the type of footprint or geography that a private, cutting edge network might need to be effective. Three main choices arose: (1) whether to position a network in already busy locations or use it to disperse interest and stimulate new opportunities and demand; (2) how to build on and support existing digital hubs and (3) what the scale of the network should be:

"not at the Roman Baths - people go there anyway... use it to attract people to less visited places. e.g. beyond Milsom Street... Something outside where people can be socially distanced (while we live with COVID) e.g. the Bath Skyline Walk or closer to city – there are all kinds of small walks around green spaces... The river is woefully underused as well."
Martin Pople, Bristol and Bath Cultural Destinations Project (former)

"It is an opportunity to use spaces that are less used in the city such as former industrial places along river towards the A4. Also, vacant retails spaces around the city - do you convert these to some kind of hub for the 4th industrial revolution?"
Kathryn Davies, Visit West

"In terms of delivery it needs to be places like The Studio, IStart is another obvious manifestation and there will be a whole lot of other connectors and platforms. Spaces won't be the problem."
Andy Salmon, Bath Spa University

"For it to be actually useful, the testbed would need to cover an area that would represent the city, or it would need to be mobile. Take Bristol for example, it would be great to have a network that covered the city centre, but it would be even better if we could take a portion of that network and take it to Hartcliffe or another area to run different things, with the aim that eventually the whole city will be covered."
Seth Jackson, Landmrk

THERE IS A GROWING REGIONAL TELECOMS/ FUTURE NETWORKS SECTOR FOR BATH TO WORK WITH:

The West of England has a well-established Telecoms cluster, which revolves around the University of Bristol Smart Internet Lab and includes innovative SMEs such as Zeetta Networks and Blue Wireless. Local organisations are highly active in 5G demonstration projects, testbeds and trials. The cluster is also going from strength to strength with companies such as BT, Parallel Wireless, as well as Mavenir and Mobileum, who recently increased their presence in the region.

Other cities around the UK (and beyond) are increasingly recognising the capabilities of the region's businesses. Vassilis Seferidis CEO, highlighted that his company, Zeetta Networks, has seen a significant increase in the number of UK cities issuing Request for Information (RFI) documents in relation to private cellular networks

during the last six months. Vassilis sees this as "a response to the buzz created by the DCMS 5G T & T programme" with Local Authorities increasingly keen to explore private cellular/5G networks as "an alternative to Wi-Fi".

The Digital Catapult and University of Bristol announced a new strategic partnership in May 2021. Digital Catapult is a leading innovation centre for advanced digital technologies whose purpose is to help grow the UK economy. The partnership with University of Bristol seeks to boost UK capabilities as well as strengthening innovation in Bristol and the wider region.

A number of funded projects provide a foundation for the collaboration including, MyWorld – a pioneering programme to develop a creative media powerhouse across Bristol and Bath; the Bristol Digital Future Institute - which is pioneering socio-technical approaches to innovation; and DETI – which is accelerating digital engineering skills.

In connection with our research, Jeremy Silver, the Digital Catapult's CEO, highlighted that they have built around seven private 5G networks for city/university clients in the UK, including in Brighton (see case study).

The strength of this growing West of England cluster provides a strong opportunity for Bath to build new local connections, harnessing the private network idea as an opportunity for collaboration.

NEW TECHNICAL CHALLENGES ARE EMERGING THAT A BATH NETWORK MIGHT HELP TO ADDRESS:

Some interviews also reflected on the technical focus of the network. As previously mentioned, 5G has to a large extent graduated from the research lab onto the sales floor with commercial providers actively marketing services. There are, however, new technical challenges and opportunities on the horizon. One that is likely to be relevant to Bath is the interface between public and private networks:

"Standalone private networks are ok for geographically constrained cases (e.g. university campus) but not for public use. In future we can have standalone private networks also providing public network service... a private slice in a public network. The tech is not yet ready for this sort of thing, but we have concepts in the lab, vendors of equipment say it is still a challenge, but a hybrid approach is something operators could and should be able to offer."
Maria Cuevas, BT

Achieving this type of seamless interface could, in principle, address many of the inherent limitations of private networks – their physical and digital boundaries – whilst also retaining some of their benefits – bespoke networking environments, the retention of data etc. From an end-user perspective, the networks would just work seamlessly, with no requirement to log in or out or to switch SIM cards. Developing this type of functionality will create new research opportunities that could add value to any private testbed developed in the next few years:

"It's not reality just yet but the vision is that a mobile device will be able to access multiple slices - public and private, is a win-win, and hopefully it will be a seamless experience for users. Tech innovation needs three things - the network will need to manage slicing (radio), the core needs a network slice selection function. And third, the hardest one, is that the device needs to support access to these slices. This must be in the manufacturers' roadmap. As soon as they are available, BT will be able to start to test. So three innovations needed - radio, core, device."
Maria Cuevas, BT

At a regional level, Bath also has an opportunity to explore the benefits associated with a multi-city or location approach.

This started to be explored within the Smart Tourism project, which linked Bath's Guild Hall and Roman Baths to the University of Bristol's Smart Internet Lab. UoB used their expertise in software and network management to enable very low latency services to be provided – whilst the processing of the AR/video content took place in Bath using edge computing.

This type of virtual network function holds great potential for creative technology businesses and interviewees suggested they would like to see it explored further:

"Firstly, if you want to create for a perfectly connected world, it is worth having a testbed environment that's bigger than one tiny location. I think it is a good idea to create for the future, so you can build something now which most commercial networks will support in a few years' time. Second, 5G Networks provide a great opportunity for edge computing. We're not going to get access to that right now with the commercial mobile networks, they are more likely to go with a company like Netflix over a company like us. But, if we can show compelling test cases for the use of edge computing, then there may be an opportunity for something to be mandated."
Seth Jackson, Landmrk

"I currently use a wired connection for my work as this produces the least amount of latency between a note being played and a visual being rendered–you typically have about 50 milliseconds between when a note is played and something appearing on screen. It would be possible, with a very fast network, to do this remotely or wirelessly, but it isn't something I've looked into because it doesn't seem possible at this point in time."
Charlie Williams, Larkhall Music

Finally, it is important to note that there are also other associated agendas that will benefit from future research. For example, the security of networks and data is an increasingly pressing and serious issue as well as questions of ethics and responsibility to both current and future generations:

"Cyber - it's got to be secure whatever it is. And also data - ethical but I am looking at London's Tech Charter, ethical use of data and tech with regional shared values and principles."
Freyja Lockwood, WECA

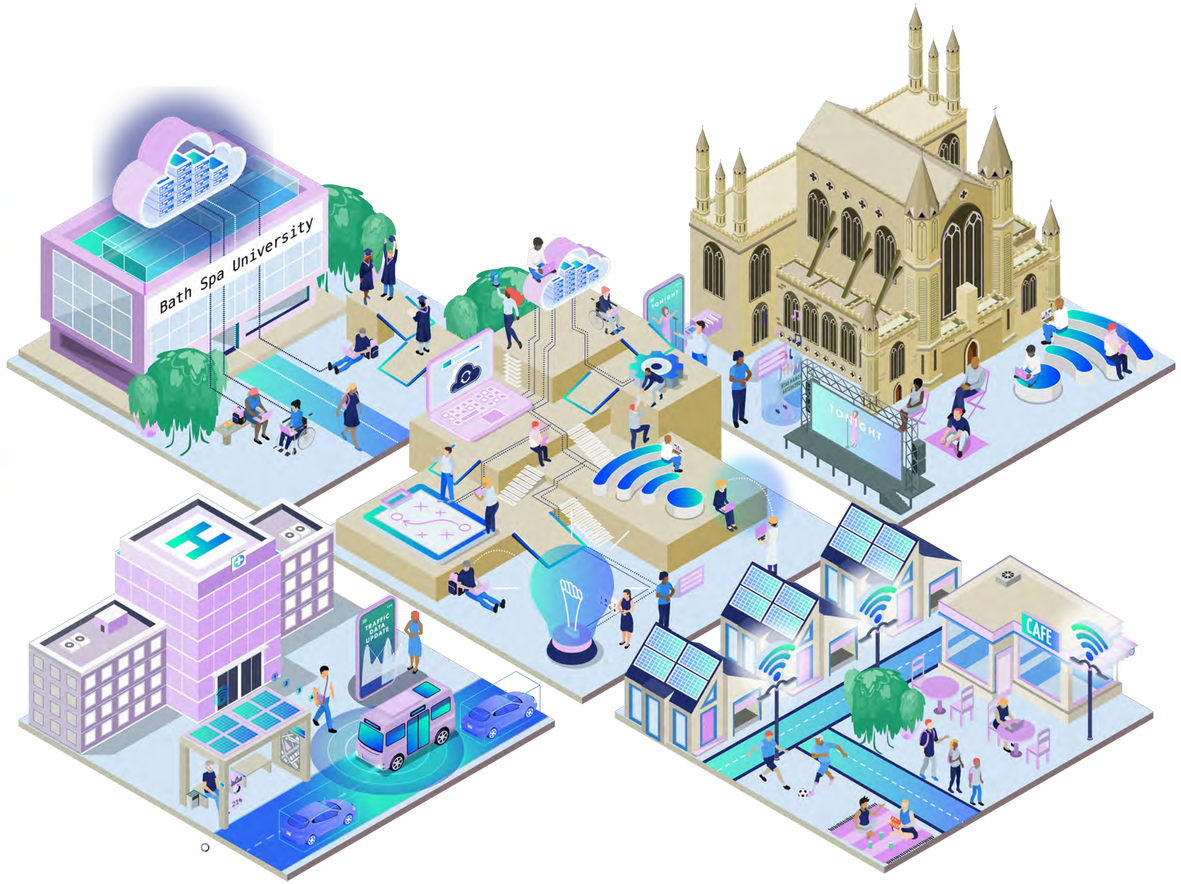
6. Five approaches to Cutting Edge Connectivity

"I've been involved in several discussions around use of tech but it's not where the conversation begins... take the [proposed] Fashion Museum, we will think about physical location of the building, the collection, but not think about how platforms might be used as well to enable us to experience the city and interact with it in an enhanced way. It isn't our natural beginning. In Cambridge we were forever thinking about the technological capacity we needed."
Andy Salmon, Bath Spa University

The research suggests that discussions of cutting edge digital connectivity and the associated benefits haven't routinely taken place in Bath. There are, however, some signs that the situation is improving:

"There are great signs that working together across Council and anchor institutions in partnership with city and region ecosystems could signal a new era of enhanced social cohesion and value."
Andy Salmon, Bath Spa University

In response, the following section of the report presents a number of different approaches or models of developing cutting edge connectivity for Bath to consider. To develop these models, we considered a number of projects suggested by survey and interview participants, as well as drawing on our own experience. Section 7 of the report also includes short case studies to illustrate how these models are being put into practice elsewhere.



6.1 Market-led Approach

This approach is based on a belief that the market will deliver cutting edge connectivity through industry investment and infrastructure upgrades. Our research highlights that a high proportion (69%) of people believe that cutting edge digital connectivity will be publicly available within their nearest city within the next 3 years. Bath stakeholders drew attention to the increasing availability of commercial gigabit fibre and 5G wireless connectivity.

The main advantage of the market-led approach is that it is perceived to be cost free as end users pay for the services they consume. The main disadvantage is there is no guarantee where or when cutting edge connectivity will become available and, as interviewees highlighted, Bath has previously not been at the top of Industry's list for infrastructure investment.

"The market will deliver what the market wants...[the approach] needs to think a little more widely than market needs, it also relates to sustainability, community cohesion, how can people live in a city like Bath that is divided? It's not just about giving out laptops. Equality, inclusion, diversity, the levelling up agenda: the market won't deal with this.. This is really important, access to digital is something more egalitarian. There are great signs that working together across Council and anchor institutions in partnership with city and region ecosystems could signal a new era of enhanced social cohesion and value."
Andy Salmon, Bath Spa University

Tackling digital exclusion is identified as a particularly important benefit of cutting edge connectivity and as the above quote highlights, 'levelling-up' is arguably more complex than simply providing access to connectivity and laptops. A purely market-led approach will not address underlying structural and systemic digital inequalities – indeed, this is not what it is set up to do!

A market-led approach would also deliver a standard offer to Bath. This brings the advantage of interoperability – the same public networking technology will be deployed in Bath as elsewhere.

However, a hidden cost is that any particular networking requirements associated with innovative or experimental applications may not be met and, perhaps most importantly, the data generated through the use of cutting edge networks will become corporate property rather than something that stakeholders can use to generate local value.

There is also potential to work more actively with Industry to develop a blended model, where the city offers up its own assets and infrastructure and selects a commercial partner to manage commercial delivery of services. As noted earlier, a growing number of UK cities are issuing RFI documents, seeking industry partners to collaborate on the development and in some instances the commercialisation of private, cutting edge digital networks. As a lot of assets in Bath – buildings, ducts, underground chambers, lampposts, fibre – are held in public ownership, actively engaging the market in a conversation about commercial exploitation is an option that could be considered.

In summary, an active market-led approach could open up opportunities to exploit publicly owned infrastructure whilst a passive market-led approach offers no guarantees.

6.2 Smart City Approach

This approach is based on a belief that the creative technology industries are merely a part of a wider strategic opportunity to create a joined up Smart City. Our survey highlights that hospitals and health facilities, university campuses, schools, cultural venues and public transport are all seen as important locations where cutting edge connectivity should be available. Bath stakeholders drew attention to the potential need for all businesses (i.e. not just those in creative technology sectors) to have access to cutting edge connectivity as well as the potential to support innovation, entrepreneurship and the future green economy.

The main advantage of the Smart City approach is that it creates a single, overarching vision, strategy and infrastructure, which can potentially support multiple use cases and realise benefits for a wide range of partners including universities, businesses, the council and other public sector agencies such as health.

The main disadvantage of the Smart City approach is that working at a city scale inevitably leads to increased complexity and potentially significant up-front costs. Consequently, the focus of the Smart City approach often shifts away from blue-sky research, creativity and experimentation, towards return on investment through the digital transformation and streamlining of public sector/city services.

An additional benefit is that Smart Cities often develop a strong focus on capturing and using local data through Internet of Things (IoT) sensors and devices. This might include, automatically capturing vehicle number plate information to help optimise traffic flow; monitoring air pollution in real-time; or looking for patterns that can help predict and prevent health risks etc. The intention is well meaning but this can easily slip into public concerns about surveillance and the ethics of how data is being used and by whom.

In summary, following a Smart City approach would potentially enable Bath to deliver a wide range of benefits for multiple stakeholders. However, it would also rely on a high degree of city leadership and up-front investment.

6.3 Venue-led Approach

This approach is based on a belief that venues should have their own cutting edge, private digital networks. These might be used to deliver enhanced content to customers or visitors, to guarantee mobile payment points are always connected, or to enable better facilities management.

Our research found examples of various venue types that are moving ahead in this way, from sports arenas, ports and airports to conference/exhibition halls and university campuses. Bath stakeholders talked about the potential to augment the city with performance:

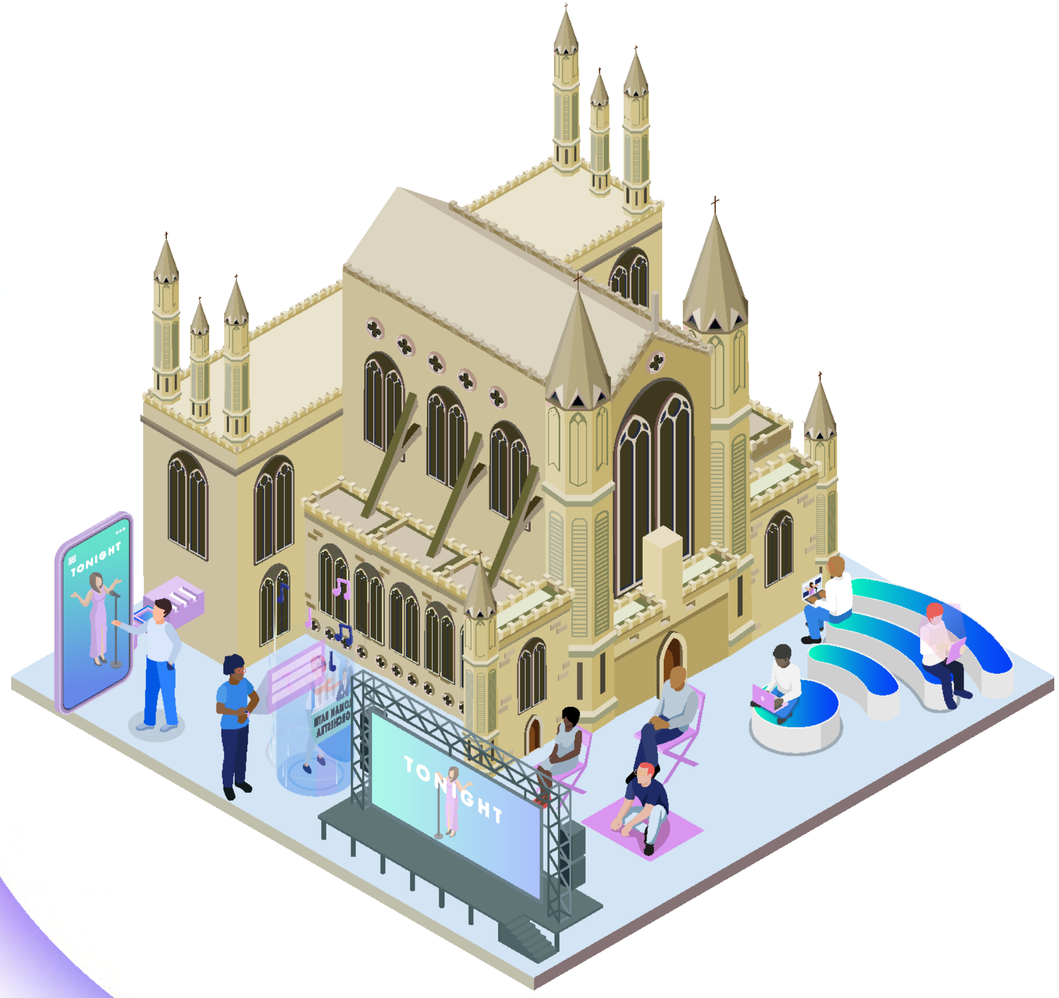
"I would like to see what we could do with expanded performance and time lapse with our Everything is Music Project's ideas of place making in the city, so looking at how you could digitally enhance physical performances and then give them legacy, making them exist once they are over."
Seth Jackson, Landmrk

"I'd like to see the world's first 5G Connected Abbey... I saw Joan of Arc performed by 24 guitars in the Abbey, it was rousing. A 5G Abbey in Bath would add to the cultural and spiritual life of Bath!"
Paul Wilson, Digital Catapult

"The idea of live broadcasting is quite exciting... I've been toying around with the idea of interactive experiences, like an app or a website where many people could interact with the visuals remotely. Another idea is everyone's devices being part of a larger visual, like pixels."
Charlie Williams, Larkhall Music

The main advantage of a venue-led approach is that it is relatively clean and simple to deliver in comparison to other models. The venue owner/manager can create a business case based on their own business needs, such as better data to help manage buildings, and supplement this by providing added value content, services or experiences that customers would be willing to pay for.

In addition, a venue-led approach has arguably taken on a new impetus as a



6.3 Venue-led Approach

consequence of the pandemic, which has forced venues to operate at a reduced capacity to maintain safe social distancing. A cutting edge network might help venues to better monitor and manage usage in real time whilst also exploring how the experience can begin well before the visitor arrives at the destination.

The main disadvantage of a venue-led approach is that it may be too small or limited in scope to enable wider systemic benefits, such as accelerating economic growth or supporting the low carbon economy.

"I play a lot of smaller venues, so if a stronger network was only available at a number of larger venues that wouldn't be the most useful thing for me right now."
Charlie Williams, Larkhall Music

Even in the context of enhancing live performances, interviewees felt that a network located in a single venue, requiring performances to be re-engineered, would not be very desirable. There is potential to create multiple venue-led networks and to join them together, offering seamless experiences for users. It is, however, unclear if Bath has sufficient sizeable venues to warrant this approach – the Roman Baths, proposed Rugby stadium, the Abbey and new Fashion Museum were mentioned by interviewees as possible locations. There is also a question of whom the intermediary body should be that joins the separate networks together and of course, how costs and benefits would be divided.

Agreeing the venues and operating model is likely to be time consuming. The University of Bristol Digital Futures Institute is currently working on the deployment of a "nomadic node" to act as a portable, pop-up cutting edge network. This type of approach could lend itself to a multi-venue approach, although it would operate sequentially rather than in parallel.

In summary, developing a venue-led approach potentially fits well with Bath's focus on tourism and experience in expanded performance. It could be a good way for Bath to dip its toes in the water but it will not in itself significantly deliver the city's wider economic and environmental ambitions.

6.4 R&D Testbed

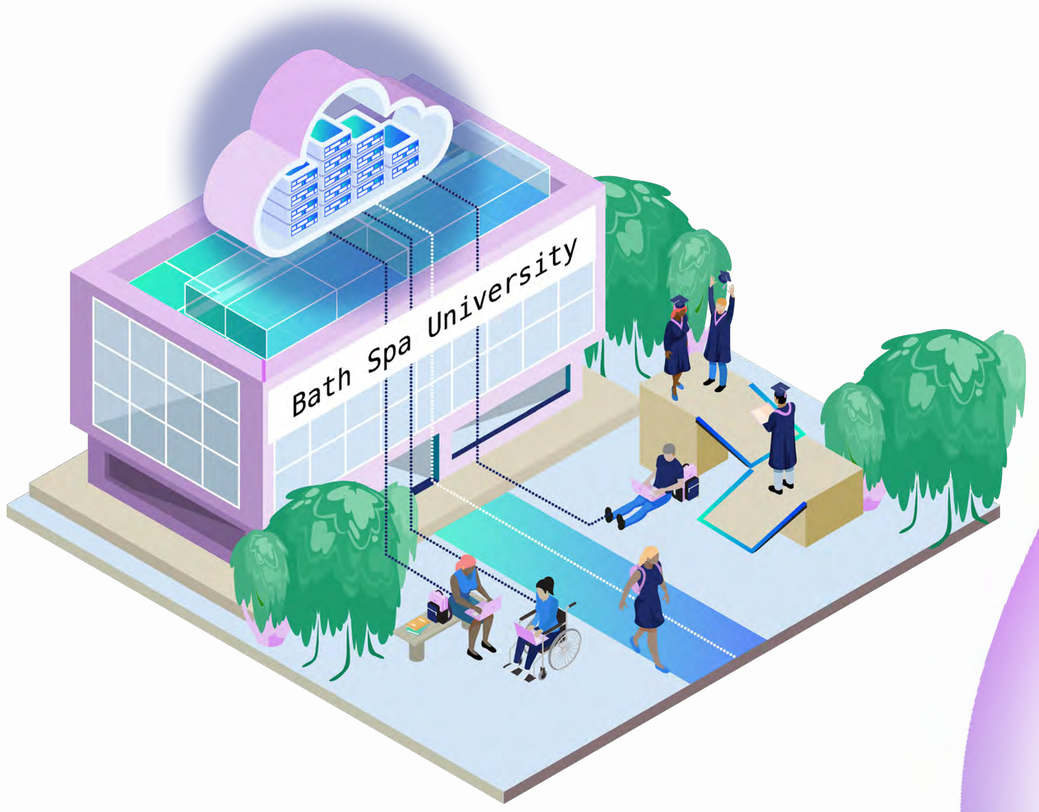
This approach is based on a belief that cutting edge networks should primarily be designed to support university and business Research and Development activities; creating a safe, controlled space where innovative products and services can be developed, tested and refined before being set free on public networks. There is a strong tradition of creating R&D testbeds in the West of England, as exemplified by the University of Bristol's 5G testbed in Millennium Square; the Bristol is Open initiative and the Umbrella testbed in South Gloucestershire, which encompasses the University of the West of England's 'smart campus' and the Bristol and Bath Science Park.

The main advantage of the R&D Testbed approach is that it creates a clear rationale for investment in private networks. The primary purpose is to research applications that are pre-commercial and so not ready for wider distribution via public networks, or to make use of the data generated by networks, for example, through IoT sensors. The main disadvantage is that they remain distinct and largely disconnected from public networks and public audiences. At worst they might be seen as "exclusive" or lacking tangible benefits:

"the council will need to have something to show in two years' time. If we go with 5G as a title, the residents who can't access that infrastructure will think it is something for academics to play with and will feel left out. Then you've got 6G, if we say 6G that's even worse, people will just switch off. They think, we haven't even got 5G and there are places that don't even have 4G, but to our businesses it might be of use."
Ben Woods, university of Bath

R&D Testbeds can offer no guarantees that innovation developed in the testbed environment will be ported across into public networks in the city. For example, an experimental 5G network was created in the Roman Baths to support Augmented Reality and mobile video applications as part of the West of England Smart Tourism project. The experiences that were developed and tested (by University of Bristol, the BBC and Aardman) during the trials proved popular with participants – but the network was decommissioned once the R&D was complete. The challenge is how R&D testbeds can be sustained beyond the end of projects and how the value they create can be experienced and understood locally, beyond those who are directly involved in the research.

6.4 R&D Testbed



It is important to note that neither of Bath's universities has current expertise in research on future digital networks. This is in contrast to Bristol which, particularly due to the work of Professor Dimitra Simeonidou's Smart Internet Lab, has pioneered work on 5G (which Professor Simeonidou feels is now "done") and is starting to develop 6G and associated capabilities. For Bath's research community, the opportunity is to exploit the capabilities of future networks and the valuable data they can produce. Expertise in AR and VR, volumetric capture as well as city architecture, design and engineering, energy systems and circular economy are seen as some of the key opportunities:

"We are increasingly becoming the South-West's hub for sustainable circular technologies. So, if it's a sustainable testbed, we could put down sensors across the city, which would produce data that would make our researchers super excited. For a 5G testbed, neither the UOB or BSU have researchers that specialise in 5G networks, but we do have expertise on what 5G can be used for—AR/VR, motion capture, etc. Beyond 5G and sustainability, there is some interesting work on Augmented Digital twins, we have real specialisms in that from our work with EDF and our architecture and civil engineering team. Again, data emanating from a privately run testbed enables that work massively."
Ben Woods, University of Bath

Building and maintaining a testbed network will require a partnership with organisations such as, University of Bristol; the Digital Catapult or a commercial provider, of which there are a growing number of large and small-to-medium sized providers in the regional cluster.

In summary, the R&D testbed offers Bath an opportunity to build on its existing research strengths and to form new regional collaborations. A partnership approach will be needed to build, maintain and manage the testbed network.

6.5
Neighbourhood Approach

"one of the things it would be a really good challenge to set, is to think of uses for this cutting edge set of products that enable access to communities that currently can't. I'd like to see a deployment of 5G, 6G to grow companies and profitably but also creating things that help those currently excluded to participate, we have to bring people with us."
Andy Salmon, Bath Spa University

A neighbourhood approach is based on a belief that citizens and communities are the beneficiaries of cutting edge digital connectivity, so they need a proper stake in how networks are created and managed. Our survey showed that respondents identified "disadvantaged communities" as being important areas for networks to be deployed – slightly more important than "areas of high footfall". Some interviewees expressed a desire for the network to be based away from the city centre and its already popular attractions. Encouraging people to less frequently visited or neighbourhood locations was seen as a bigger prize.

The main advantage of a neighbourhood approach for Bath would be to secure grassroots buy-in and understanding about the need for cutting edge connectivity. This is important as the city has previously experienced high levels of hostility to 5G. The main disadvantage, perhaps, is knowing where to start. Outside initiative such as Bath Hacked, there appears to be little evidence of a tradition of ground-up digital activism.

In Bristol, Knowle West Media Centre (KWMC) plays a central role. As a neighbourhood-based arts organisation and digital media centre, located in one of the city's least well-off neighbourhoods, KWMC has championed a progressive model of digital inclusion for more than twenty years. A satellite centre – the Factory – has been developed by KWMC as a digitally connected maker space, which supports local businesses and creatives but has also secured investment to build local, sustainable, prefabricated homes through the WeCanMake programme. KWMC works closely with the University of Bristol's Digital Futures Institute and is one of four Community nodes that will be trialling an innovative "nomadic network". This portable cutting edge network will be deployed on a temporary basis to support use cases that the community hubs have identified and co-designed.

In summary, a neighbourhood approach would increase grassroots understanding and ownership of the network. It would be a new and unexpected approach for Bath to try, although there is some exciting potential in and around Bath Spa University's Locksbrook Campus.

7. Case Studies

We have included short, contemporary case studies below to illustrate how the different models are being combined and used elsewhere.

Coventry University (2019):
In partnership with Vodafone, OPPO, Ericsson, Mediatek, and Qualcomm, Coventry University has created the UK's first 'standalone' 5G network, which is totally independent from 4G, to support a state-of-the-art Virtual Reality learning environment that capitalises on 5G's ultra-low latency and guaranteed speed performance. Installed in Coventry University's city centre campus, this technology is used to train student nurses and other healthcare students. This technology has since been expanded to the university's Disruptive Media Learning Labs and their National Transport Design Centre with the installation of the Ericsson 5G Radio Dot System, which is said to deliver a fast, high capacity network to further support innovative teaching and learning.

Felixstowe 5G Port (2021):
Using a private 5G network installed by Three UK, Hutchinson Ports' Felixstowe site became the largest port in the UK to utilise the Internet of Things. Receiving a total of £3,405,776 in funding, this project formed part of the government's Trials and Testbeds programme and ties in with its policy to create a network of Freeports that act as hubs for innovation and global trade. In partnership with Blue Mesh Solutions and Cambridge University, Felixstowe Port's 5G network enables over 100 ship-to-gantry cranes to be controlled and monitored remotely through the deployment of sensors and transmission CCTVs with limited latency, as well as Artificial Intelligence which can determine when a piece of equipment requires maintenance.

Liverpool 5G Create (2020):
Building on the original DCMS-funded network, Liverpool 5G Create and Blu Wireless are upgrading and expanding their independent, private 5G network. In response to the COVID-19 pandemic, this project aims to reduce digital poverty and benefit the local NHS, as well as social care and education services. By allowing for more flexible deployments and environmental protections, the network will provide free and reliable connectivity across the city, facilitating socially beneficial goals such as remote GP consultations via tele-health and other remote monitoring tools, which will improve services for users, reduce costs, and save clinicians' time.

Central St Martins (2019):
For London Fashion Week, Central St Martins in partnership with Three UK installed a permanent 5G network, which premiered at a special mixed-reality show for their MA Fashion course. Created by graduating student Gerrit Jacobs, the event combined physical pieces of clothing such as clip-on ties and shoes with animated overlays that appeared above the catwalk.

Using Magic Leap One mixed-reality headsets, as well as monitors positioned around the building, the university capitalised on 5G's low latency to create a unique event which showcased both their students' talent and the technology's potential.

Brighton 5G Festival (2021)
After a year of lockdown measures, The 5G Festival aims to respond to changes in audience habits by offering a mix of live, remote, and blended experiences. The Digital Catapult in partnership with Warner Music Group, Wired Sussex, Brighton Dome & Brighton Festival and various digital and live streaming platforms, are developing a 5G-powered collaboration platform that helps to enrich audiences' experiences at home and in venue. Using 5G's low latency and ultra-high bandwidth, physically separate artists will be able to perform together at the same time in separate venues. This project aims to create a more diverse, sustainable live music industry which provides more opportunities for a wider range of artists and audiences, helping to future proof the live music industry.

Ericsson Private 5G (2021)
The Swedish company recently released Ericsson Private 5G, a scaled down version of a mobile network which supports 4G LTE and 5G. This platform can be easily integrated into existing enterprise IT systems and supports a wide set of frequency bands and base station configurations. Ericsson currently provides the same radios that it supplies for fully fledged mobile networks and plans to add more specialised radios, suitable for scaled down private networks.

Las Vegas, Advanced Connectivity for Community and Economic Development (ACCED) Network (2021)
In response to the digital divide highlighted by the COVID-19 pandemic, the city of Las Vegas in partnership with Baicells and Terranet Communications have rolled out a 5G-ready private municipal network with the aim of democratising access to broadband connectivity and to transform Las Vegas into a smart city. The network was deployed in only 45 days and due to its success a four-stage plan has been developed that will expand the network across the entirety of Las Vegas and its neighbouring cities, with the goal of improving connectivity for public services such as law enforcement, tele-health, and general IoT infrastructure.

Bournemouth Smart Places (2019)
Bournemouth, Christchurch and Poole (BCP) Council and Dorset LEP have created a 5G testbed. The project was confirmed for start in December 2019 after a detailed public consultation by BCP Council on 5G, which included assessment of public health concerns. Based in the Lansdowne area of Bournemouth, a 5G digital test bed will use the internet of things to improve services, provide free public Wi-Fi and attract new investment, employment, and innovation. The project is expected to create around 200 new jobs at the project site and in the surrounding area in the first two years and 400 jobs by 2025. Dorset will benefit from a gross value added (GVA) of £37.6 million by 2025 and it is anticipated that the project will add £137 million to the local economy over the next 10 years.

8. Conclusions and tangible actions

"The development of the Digital City is not simply defined through global technological milestones. It is easy to measure progress post Facebook, the i-Phone or Twitter. These are important markers but cities do not simply move forward through the next software upgrade. Stories of a Digital City form part of the city's Local History.... It is the spark of excitement and creativity that Digital can ignite, which is at the heart of Digital Placemaking."

Stephen Hilton, Rebooting the Digital City, 2020

We chose to call our report "Connecting Bath" to highlight that whilst cutting edge digital connectivity is important economically, socially and environmentally, the real value is in shaping the identity of Bath as a digital place.

Our research has highlighted that private, cutting edge digital networks are seen to accelerate the impact of creative technology industries. Private networks can be complimentary to commercial investment in public networks and depending on the model/s that are adopted, benefits might be shared by multiple business sectors and city stakeholders.

However, it is also important to recognise that implementing just one connectivity model or approach is unlikely to yield the wider benefits of being a successful digital place. In our experience, and as hinted at by the case studies, successful digital places adopt a mix and match approach. They implement multiple connectivity models, such as those described in Section 6 of this report. This is certainly true in Bristol where a wide variety of interventions have taken place over a decade or more.

This includes, market-stimulation exercises that have sought to exploit city-held assets (ducts, fibre, lampposts etc.); university/ city-led R&D Testbeds, such as Bristol is Open (BiO) and the Millennium Square 5G Testbed; community-led initiatives such as Knowle West Media Centre and The Factory maker space and the Bristol Smart City programme, which has received national and international recognition.

This diversity of approach, whilst not planned by one agency nor delivered through a single strategy, has underpinned the growth of an interconnected ecosystem or "ecology", which is regularly cited as being key to Bristol's success. It has become core to the identify of Bristol as a successful digital place. Learning from this, the question we conclude it is most important for Bath to address is not which model of cutting edge connectivity to follow – but how to implement them all!

In the final section, below, we aim to help address the complexity of following an ecosystem driven approach by suggesting some tangible, near-term opportunities for city partners to consider.

USE THIS RESEARCH TO RE-ENGAGE THE B&NES ECONOMIC RECOVERY AND RENEWAL BOARD (ERRB) ON FUTURE DIGITAL STRATEGY.

The 2030 Renewal Vision for Bath and North East Somerset is called "Ambitious Together for a Fair, Green, Creative and Connected Bath with North East Somerset City Region. It was created following wide ranging stakeholder engagement commissioned by B&NES Council on behalf of the cross-agency Economic Recovery and Renewal Board (ERRB). Several of the recommendations that accompany the Vision relate to the digital opportunity including, further investment in digital skills; the creation of a Chief Digital Officer role within B&NES and the development of a city R&D Testbed focussed on low carbon technologies. A subgroup of the ERRB was formed to lead the development of a Digital Strategy for B&NES. At the time of writing this report, we are uncertain how quickly this work has progressed.

Bath Spa University, as commissioners of this research and Board members of the ERRB, are well placed to table this report for discussion with the ERRB group– giving the topic of cutting edge connectivity the high-level and urgent strategic consideration that this report suggests it warrants.

REVAMP THE 5G SMART TOURISM NETWORK AT THE ROMAN BATH'S WITH A FOCUS ON THE COMMERCIAL EXPLOITATION OF AR/VR SERVICES FOR VISITORS AS WELL AS FUTURE

A bold, practical step would be to upgrade and re-instate the experimental 5G network, which was previously deployed in the Roman Baths for the Smart Tourism trial, moving the focus on to the exploitation of 5G-enabled commercial services for visitors – Augmented and Virtual Reality, mobile HD video experiences etc. as well as paving the way for 6G research.

Professor Dimitra Simeonidou at University of Bristol and Freyja Lockwood at WECA expressed frustration that efforts to sustain the previous 5G network proved unsuccessful, so it was decommissioned and removed at the end of the project. The positive news is much of the hardware that was used is currently stored at the University of Bristol and could, in principle, be reinstated if the fibre connection between Bristol and Bath was re-established.

However, much has also moved on since the 2019 Roman Bath's Smart Tourism trial:

"You have to think well beyond 5G at the moment because if you want connectivity services only with no intention that you are going to drive innovation out of the platform, then commercial 5G is going to give you this" Professor Dimitra Simeonidou, University of Bristol.

From the perspective of Industry and Academia, 5G has largely crossed from R&D into commercial services. As Professor Simeonidou highlights, the research agenda is now moving towards 6G capabilities, advances in radio access technologies and Open RAN. In practice, much of the original Smart Tourism hardware would need to be replaced/upgraded but as Professor Simeonidou points out, it is the network and packet core management that is most difficult to get right – and University of Bristol remains keen to work with Bath partners to provide this capability, as well as using their contacts and position in the market, to help convene Industry interest.

In summary, a Smart Tourism cutting edge digital network could be established in matter of months. So, as one interviewee put it, "there are really no excuses".

BUILD ONE R&D TESTBED WITH TWO DISTINCT PURPOSES – ENVIRONMENTAL TECHNOLOGIES (UNIVERSITY OF BATH) AND MYWORLD INNOVATIVE SCREEN-BASED MEDIA (BATH SPA UNIVERSITY).

The University of Bath (Ben Woods) has done some excellent work on scoping the potential for a university-led R&D testbed. Ben's view, described earlier in this report, is that a testbed focussed on environmental technologies would provide significant benefits both to University of Bath's research agenda and to local people. For example, using internet-connected sensors (IoT) brings potential to monitor air pollution levels more precisely. This and other real-time date could be used to build a Digital Twin for Bath – a sophisticated, data-rich model, to inform future city planning.

Equally as exciting is the MyWorld project, in which Bath Spa University is a partner. This 5-year R&D programme has secured £30million Strength in Places funding from UKRI and seeks to accelerate Bristol and Bath's pioneering reputation for innovation in screen-based media. MyWorld was seen to provide a significant opportunity for Bath to build a strong innovation narrative

relating to the creative use of cutting-edge connectivity. BT, the University of Bristol and the Digital Catapult highlighted the infrastructure requirements of the MyWorld project as a potential opportunity for collaboration. A healthy budget is earmarked in the MyWorld project for digital infrastructure to support the project's research aims. This provides a tangible short-term opportunity to build meaningful collaboration and capacity in Bath.

CREATE A CONNECTED NEIGHBOURHOOD, WITH THE BATH SPA UNIVERSITY LOCKSBROOK CAMPUS AT THE HEART OF A NEW, INCLUSIVE, CONNECTED DIGITAL CULTURAL

The research found little evidence of neighbourhood digital working in Bath but identified some interesting potential. The recent £33million Bath Spa University Locksbrook Campus has state of the art digital connectivity. It is located in a post-industrial area with as-of-yet unrealised ambitions to connect with both the immediate neighbourhood and less advantaged areas in close proximity.

The campus is also next to the river, where an exciting proposition – the Bath Art Depot – is emerging to convert a former light industrial space on an island in the river into a new cultural/arts quarter. Slightly further away is Twerton, an area of Bath that bears some similarities to Knowle West in terms of its disconnection from the urban centre and relatively high levels of deprivation.

An exciting neighbourhood-focussed opportunity for Bath would be to scope a cutting edge connectivity project, which has the Bath Spa Locksbrook campus at its core, powering a network that will bring together all of the above, and more; breaking the mould on how the city often presents its culture and creativity and bringing new voices and energy into the Bath creative ecology.

THROUGH ALL OF THE ABOVE, CREATE A CLEAR OFFER AND ASK, TO STRENGTHEN BATH'S POSITION IN RELATION TO EMERGING DIGITAL COLLABORATION VIA THE WESTERN GATEWAY.

"I would go a step further and say it's not just vital for Cardiff or Bristol and Bath, but the region as a whole. We're talking about the Western Gateway, that is Swindon to Swansea and Salisbury, so we're thinking about city-regions, about our travel-to-work times, about freelancers and where work is happening and could happen in the future, and we are also thinking about Wales as a backdrop for a lot of that happening. When you think about the high-end television and film productions that Cardiff attracts, it's not just the film studios but the locations around them that are attractive, which means that having connectivity out-and-about wherever people are working is fundamental."
Sarah Pepper, Cardiff University

At the same time as the West of England digital cluster is growing, the Western Gateway initiative is gaining momentum. The Western Gateway is developing collaboration beyond traditional regional boundaries in order to promote inclusive economic growth at scale. The geography includes the core cities of Bristol and Cardiff, it stretches across South Wales and Western England, from Swindon to Swansea, Wiltshire and Weston-Super-Mare to Tewkesbury.

"If you are looking at it from a regional perspective, it's about how do you make the individual parts greater than the whole; having something [in Bath] that is distinctive from either Umbrella, or Bristol is Open, would start to build that regional capability"
Freyja Lockwood, West of England Combined Authority

As WECA's Freyja Lockwood highlights, there is potential to better align connectivity initiatives at regional level. Professor Dimitra Simeonidou from University of Bristol highlighted that a new Digital Accelerator is being scoped to support the Western Gateway – with a focus on Creative Industries, Manufacturing, Data Science and Connectivity.

The aim is to create a new innovation platform for designing future networks by bringing together expertise on semi-conductors in Wales with systems and networks from Bristol and the West of England. Interviewees from both industry and academia highlighted uncertainty about where Bath fits in to this.

By taking some or all of the steps identified above, the opportunity is for Bath to showcase expertise in using cutting edge digital connectivity. This will be timely and essential if Bath is to cement the position it deserves within this wider regional ecology of successful digital places.

Thank you.

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