



Government
Office for Science

Wireless 2030: Supplementary Annexes

 Foresight

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Annex A - Glossary of terms

Wireless 2030: Exploring the future of UK demand for wireless connectivity, and its implications for public service delivery

Term	Definition
AI	Artificial intelligence.
AR/VR	Augmented reality/virtual reality (mixed reality).
Autonomous Vehicles	Vehicles which use information from on-board sensors and systems to understand their global position and local environment, enabling them to operate with little or no human input for some, or all, of their journey.
Bandwidth	The maximum rate of data transfer across a given path.
CNI	Critical National Infrastructure.
Digital services	A group of services based on communications and information technology which encompasses the services of e-market, web search and/or cloud computing.
Digital twins	A virtual/digital representation of a physical object, entity or system.

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Driver	A current or emerging trend that is likely to shape development of a policy or strategy area.
Edtech	Educational technology: the combined use of computer hardware, software, and educational theory and practice to facilitate learning.
Fintech	Computer programs and other technology used to support or enable banking and financial services.
FVEY	The Five Eyes is an intelligence alliance comprising Australia, Canada, New Zealand, the United Kingdom, and the United States.
Horizon scanning	A systematic examination of information to identify potential threats, risks, emerging issues and opportunities, beyond the Parliamentary term, allowing for better preparedness and the incorporation of mitigation and exploitation into the policy making process.
Internet	A global computer network providing a variety of information and communication facilities, consisting of interconnected networks using standardised communication protocols.
Internet of Things (IoT)	Physical objects with sensors, processing ability, software, and other technologies that connect and exchange data with other devices and systems over the Internet or other communications networks.
Latency	The delay before a transfer of data begins following an instruction for its transfer.
MNO	Mobile Network Operators.

Annex A - Glossary of terms

Mobile broadband	Marketing term for wireless Internet access via mobile networks. Access to the network can be made through a portable modem, wireless modem, or a tablet/smartphone or other mobile device.
Mobile networks	A network which sends communications in the form of radio waves to and from users. It is composed of base stations that each cover a delimited area or "cell." When joined together these cells provide radio coverage over a wide geographic area.
Network capacity	The maximum amount of data that can be reliably transferred between different locations over a network.
Network Slicing/splinternet	The use of network virtualisation to divide single network connections into multiple distinct virtual connections that provide different amounts of resources to different types of traffic.
Private Mobile Networks	A private mobile network features network infrastructure which is used exclusively by devices authorised by the end user organisation.
Public Services	Entirely or partially Government funded services delivered in the interest of the public.
RF-EMF	Radiofrequency Electromagnetic Fields, the part of the electromagnetic spectrum of frequencies between 100kHz - 300 GHz.
RFID	Radio Frequency Identification.
SDGs	Sustainable Development Goals.

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Spectrum	In this case the electromagnetic (EM) spectrum is the range of frequencies of electromagnetic radiation and their respective wavelengths and photon energies.
Standalone 5G	The virtualisation and cloud-based transformation of 5G core networks that does not rely on existing 4G infrastructure.
Telecoms	The transmission of information by various types of technologies over wire, radio, optical, or other electromagnetic systems.
Telemedicine	The remote diagnosis and treatment of patients by means of telecommunications technology.
UAS	Unmanned Aerial Systems.
UK Demand	When, where and how the UK public will want or need to use wireless connectivity in the next decade.
Unicorn	A privately owned start-up company valued at over \$1 billion USD.
UX	User Experience - a process design teams use to create products that provide meaningful and relevant experiences to users.
Wireless Infrastructure	Communication infrastructure that reaches users without wires, primarily via cellular mobile networks, but also including other technologies such as Wi-Fi and satellites.
Wireless technology	Devices which can communicate with each other or communicate with a wired network, without having a wired connection themselves.

Annex B - Long-list of drivers

What forces and factors are driving UK demand for wireless connectivity, and will shape the connectivity landscape in the next decade?

With this question in mind, the GO-Science and DCMS teams conducted a Horizon Scan for evidence of influential change in the political, economic, social, technological, legislative and environmental spheres. The key 'drivers of change' are listed below; they are the result of a xHMG knowledge audit, desk research and 20 expert interviews, and they represent the stimulus for our uncertainties workshop.

	IDENTIFIER	DRIVER	DESCRIPTION	EVIDENCE
POLITICAL	Po01	<i>Strengthening arguments for internet as a human right</i>	The pandemic has resulted in a resurgence and rise of arguments for the provision of the internet as 'utility' or basic right . The requirement of the internet for remote working and learning, and for basic services such as Universal Credit applications or the UK Parliament's online petitions have left segments of the population socially and politically excluded . Citizens expect speed as a result of enhanced connectivity - usually without an increase in cost. Desire for convenience is also driving expectations for integration and interoperability in the digital sphere.	In February 2020, 96% of all households in Great Britain had internet access, up from 93% in 2019 . Internet connections in households with one adult aged 65 years and over have increased by 7% since 2019 to 80%; these households still had the lowest proportion of internet connections (Office for National Statistics, 2020).
	Po02	<i>Potential fragmenting global design and regulation of cyberspace</i>	Whilst multilateral organisations focus on the potential for next generation connectivity (5 & 6G) to deliver on the SDGs , different national/regional governance approaches are emerging and often conflicting . We see the continuing dominance of China in digital innovation and standard-setting within the context of the Belt-and-Road initiative. The UK's future decision-making on standards will also likely be influenced by both EU and FVEY alliances. How these different influences will combine remains uncertain.	UK oscillated between the governance approaches of the EU and FVEY alliance, eventually opting to align with FVEY priorities resulting in complete ban of Huawei equipment with full withdrawal of remaining Huawei network equipment by 2027 (Amon, 2021). Governance approaches moving forward are uncertain .

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Po03	<i>Growing reliance on big data for civic management and service provision</i>	The UK's National Data Strategy confirms government's intent to harness the power of data to develop enhanced products and services to the public . In the coming years public and personal data will become even more critical for anticipating supply and demand and improving public systems.	A 'Data.gov.uk' Platform to find data published by central government, local authorities and public bodies to help build products and services in UK. The UK has a national data strategy which sets out how data can transform the UK (Department for Digital, Culture, Media & Sport, 2020).
Po04	<i>Complexity of infrastructure ownership</i>	The hardware underpinning wireless is a hotly contested asset. Whilst multiple owners (tech companies, telecoms, MNOs, investors, states) barter over transfer speeds and capacities , some of the biggest companies in the world are driving increasingly ambitious infrastructure projects; with ownership comes power (governance and political leverage). This could continue, or issues could be simplified and resolved over the medium term.	80% of recent investments in new cables has flowed from the two US tech giants. Meta now owns or co-owns 99,399 km of cables, Google 95,876 km . Both announced their plans for building a 12,000 km undersea cable, Apricot , which will connect Southeast Asian markets in 2024. Google's Echo subsea cable will span the Pacific . Meta has joined the coalition of telecoms building 2Africa , a 45,000-kilometre-long cord planned to encompass the whole African continent and connect 33 countries in 2024. (Ball, 2021)
Po05	<i>Levels of trust in government</i>	In 2022, the ONS found 35% of the population report trust in the government, although much higher levels are reported in different services provided by government. This could, in turn, mean lower confidence in plans for wireless infrastructure (Office for National Statistics, 2022). This has left individuals more open to misinformation (for example, campaigns about the supposed health effects of 5G masts) and less likely to engage with initiatives to up-skill or decrease the digital divide . There is scope for this to continue or for levels of trust to increase in the future.	Data from 2006-2020 demonstrates a continued low level of trust in the UK government with 34.7% of respondents stating that they have confidence in the government in 2020 . There has been a 0.6 percentage point increase from 2019 (34.1) which was the lowest value since 2008 (32.4%) (OECD, 2022). Building trust in a technology can increase its uptake among the public (AlShahrani, 2019). This stronger public trust, and resulting wider adoption, could unlock the potential for new models of engagement and communication (AlShahrani, 2019) (Tammy Bahmanziari, 2003) (Xin Li, 2008).
Po06	<i>Emergence of new models of citizen engagement & communication</i>	Increasingly ubiquitous connectivity is creating the conditions for a reimagined democracy . The emergence of collaborative platforms and social channels have allowed a new dynamic of ' bottom-up ' governance, engagement, and community expression . Groups build	Taiwan's GovZero Platform which aggregates anonymised perspectives to reach consensus on policy options. gov is a decentralized civic tech community

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		and share tools that empower people to evaluate their government and exert their democratic right to decide how politicians act. Will they use it?	from Taiwan comprised of government officials, NGOs, coders, and citizens . Open-source government data and public tools are made available to foster collaboration. (g0v, 2022)
Po07	<i>Polarising views on data sovereignty</i>	As data regimes and policies emerge as more autocratic or more liberal in different parts of the world. The debate surrounding 'data sovereignty' , e.g., ownership and control of personal data and digital identity, rages on . In the UK, some experts argue for total individual sovereignty , whilst others advocate for ' citizen-centric' design in which data is still held and managed by authorities/governing bodies .	Data connects with territories and jurisdictions in multiple ways, producing an ecosystem of overlapping applicable rules and redefining the exercise of sovereignties (Government Office for Science, 2020). To complicate matters, data has unusual properties and data value chains are highly nonlinear (De La Chapelle, 2021).
Po08	<i>Increasing use of wireless technologies in military hardware</i>	The integration of wireless technologies into military hardware , opens new avenues for threats to national security i.e., cybersecurity risks, rogue actors, hijacking of ships or natural resources.	The U.S. Army is developing a Cluster UAS Smart Munition for Missile Deployment that would allow a swarm of small drones to fan out and destroy vehicles with "explosively formed penetrators," or EFPs. Turkey has deployed Kargu tactical kamikaze drones on the Syrian border via remote pilots. In October, China conducted a test launch of 48 "suicide" drones from a truck and helicopter. The U.S. Army plans to build an autonomous charging system that swarm drones could fly to for charging before redeployment. (Hambling, 2020) (Hambling, 2020) (Besas, 2020) (Evans, 2020).
Po09	<i>Trade-off between neutrality and innovation for networks</i>	Increasing interest in network slicing will push boundaries for net neutrality . Each network slice is an isolated end-to-end network, tailored to fulfil diverse requirements requested by a particular application. Net neutrality regulation risks hindering innovation in networks, like network slicing. Uncertainty remains over whether this risk will materialise.	This technical innovation anticipates more effective use of the network by allowing to reach better quality indicators for services where it is vital. At the same time the deployment scenarios and applicable regulation remain unclear . More specifically under the question is whether these 5G network slices would be served for only certain nationally selected service providers and act like a sort of specialized services, or those slices would be adapted for specific type of services ,

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				they would be open to every service provider and would be relevant to Net Neutrality regulation. (Ericsson, 2022) (Demirtaş, et al., 2019)
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	IDENTIFIER	DRIVER	DESCRIPTION	EVIDENCE
ECONOMIC	Ec01	<i>Potential for productivity gains related to 'Industry 4.0'</i>	Industry 4.0 aims to drive digital manufacturing forward by increasing digitalisation and the interconnection of products, value chains and business models. Sensor network data , along with automation and robotisation represent a new era of production power for sectors and organisations able to invest in tech adoption and a reimagined/retrained workforce . Many commentators are predicting productivity impacts from this shift, but it is possible that these won't fully materialise.	Industry 4.0 productivity benefits are expected to be in the region of 90-150 billion Euros over the next 5-10 years in Germany alone (from 2015). While Most UK manufacturers have adopted some form of technology that would fall under the Industry 4.0 heading, with 78% already using sensors, machines and servers in their operations. (Boston Consulting Group, 2022) (IoT Worlds, 2022) (Mordor Intelligence, 2022)
	Ec02	<i>Investment shifting towards tech-enabled 'challengers' in every sector</i>	Enhanced connectivity has enabled the development and scaling of challengers to traditional sector models , be it EdTech, HealthTech, AgriTech etc; the UK remains a magnet for tech venture capital investment . However, the future pace of this shift is uncertain, and some sectors lack these tech players in their field.	The UK tech start-up and scaleup ecosystem is valued at \$585bn - 120% more than in 2017, and more than double the next most valuable ecosystem, Germany, at \$291bn (Tech Nation, 2021).
	Ec03	<i>Continuing commercialisation of personal data and attention</i>	Rise of attention economy and targeted adverts (as business model enabler). Personal data has become a commodity , allowing for targeted advertising, social media/entertainment companies which collect data and provide a platform for advertising are increasingly vying for individual attentions to maximise profits.	A survey conducted by Ipsos MORI on behalf of the Internet Society and Consumers International across US, Canada, Japan, Australia, France and UK - 63% of respondents find connected devices 'creepy' in the way they collect data about people/behaviours, 75% distrust the way data is shared , 53% distrust their connected devices to protect their privacy and handle their information in a respectful manner. (Internet Society, 2019)
	Ec04	<i>Rise of the 'sharing economy'</i>	Increasingly, access is enabled and preferred over ownership. Peer-to-peer markets and sharing/rental platforms are attracting users and growing in value , offering sustainability, affordability and community-building solutions.	New service delivery systems necessitate updates to conventional legal and regulatory structures . The UK's sharing economy enables its participants to make sustainable choices . This has immense value to the economy as we build back better, with experts expecting the UK's sharing economy to grow to an estimated £140 billion in 2025 . But despite its potential and resilience, the sharing economy needs specific support from government to reignite. (Sharing Economy UK, 2021) (PWC, 2016)

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Ec05	<i>Intensifying global supply chain challenges for digital infrastructure</i>	Deployment of digital infrastructure is reliant on availability of components in the global supply chain. Uncertainty in the supply of certain technologies and materials may limit the ability of nations to roll out digital infrastructure projects .	The 2020 5G Diversification Strategy aims to enhance the security and resilience of UK telecoms infrastructure by diversifying the global telecoms supply market , with an initial £250m commitment and a Telecoms Diversification Taskforce to guide the strategy. Three key areas: supporting incumbent suppliers, attracting new suppliers to UK market, accelerating open-interface solutions and deployment. (Department for Digital, Culture, Media & Sport, 2020). See also - Continued uncertainty of semiconductor chip supply.
Ec06	<i>'Tokenisation' of goods and information</i>	In tandem with the evolution of our digital identities, digital twins, and distributed ledgers, any asset, currency, utility or even identity can be 'tokenised' for trade in cyberspace.	Blockchain technology and NFTs (Non-fungible tokens) are being incorporated within gaming . Several games console companies have created crypto and blockchain enabled games to purchase digital goods. Items can be sold and traded at real-world value . In 2017 the collectable cryptokitties from the cryptokitties videogame caused a spike in NFTs with over 200,000 buyers . This spike dropped to around 50,000 buyers on average between 2017-2019, rising to c.150,000 in 2020. NFT trading activity more than doubled between July and August 2021 , according to the number of unique wallets that either bought or sold an NFT. By August 2021 , there were roughly 280,000 unique buyers or sellers due to the game Axie Infinity. (deBest, 2022)
Ec07	<i>Emerging models of payment, pricing and access</i>	New forms of transaction are mainstreaming in the UK; contactless payments evolve to 'check-in' rather than 'check out' points of sale, while subscription evolves to on-demand micropayments for services , informed by demand data in real time. Looking ahead, experiments into micropayments by organisations to citizens (for their time, their ideas or their data) may start to scale.	The digital economy now represents a substantial share of the UK's economy , contributing £148 billion in 2019 (Department for Digital, Culture, Media & Sport, 2021). New business models have emerged , that challenge the status quo. For example, some supermarket chains are piloting checkout free shops , with RFID (Radio-Frequency Identification) tracking being trialled at Tesco, Sainsbury's and Amazon Go, whilst Aldi trials facial recognition technology (Evening Standard, 2022)
Ec08	<i>Decreasing cost of connected devices and appliances</i>	Finances are becoming less of a barrier to personal and household connectivity as hardware (sensors, devices, batteries, appliances) are cheaper and cheaper to make .	There has been a relentless drop in the price of components used in most electronics gear, thanks to things like Moore's Law and manufacturing advances . (U.S. Bureau of Labor Statistics, 2015)

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	Ec09	<i>Emerging market for digital identity (avatar) management</i>	eIDs, or "bring your own identity" (BYOI), is a growing trend in the world of access management and user identification. As personal digital profiles multiply and the economy digitalises, secure ID authentication, verification and management become critical . In the gaming world / in the metaverse, this already looks like a booming avatar management market, with tools, capabilities and environments that can be purchased.	Forecasters also appear to agree that the future of BYOI is bright . Organisations including Grand View Research, Fortune Business Insights and Global Market Insights predict that the Identity and Access Management market will grow to at least 20 billion U.S\$55 dollars by 2026 . (Deloitte, 2020)
	Ec10	<i>Skills gap to support the digital economy</i>	Increasingly digitalised supply chains require skilled workers to build and operate them. As networks become more complex, these required skills become more specialised. There is uncertainty over whether the education and skills systems will keep pace with these changing requirements.	What it means to be a telecoms engineer has evolved - engineers are now highly specialised e.g., in AI. One in three employers say their workforce lacks the advanced digital skills needed (World Skills UK, 2021). Demand for and reliance on digital skills is rising rapidly but participation in these courses have declined in schools and employer investment in skills remains low . Inequalities in digital skills are particularly prevalent when looking at gender (uptake of training and employment are much lower among women) and geography (London has the highest supply and interest in digital skills). (Council for Science and Technology, 2019) (Department for Digital, Culture, Media & Sport, 2021)
	Ec11	<i>Increase in Business-to-Business models</i>	With increasingly connected people, things, places and spaces comes greater opportunity for business-to-business (B2B) interaction and transaction. Intermediaries and sub-sectors emerge to streamline services between businesses, enabling the connected consumer.	In 2020 , close to half of B2B buyers are millennials – nearly double the amount from 2012 . As younger generations enter the age of making business transactions , B2B selling in the online space is becoming more important . (Trust Radius, 2021) (Big Commerce, 2022)

	IDENTIFIER	DRIVER	DESCRIPTION	EVIDENCE
SOCIETAL	So01	<i>Work shifting from a place to an activity</i>	The pandemic has accelerated a longer-run change in expectations and patterns of work . An increasing percentage of UK jobs can be carried out remotely, and employee expectations are increasingly for flexibility in location and hours.	The proportion of working adults who did any work from home in 2020 increased to 37% on average from 27% in 2019 . The number of homeworking adverts in May 2021 were three times above their February 2020 average. Of the businesses that had not permanently stopped trading, 24% intend to use increased homeworking as a permanent business model going forward, while 28% were not sure. Of working adults currently homeworking, 85% wanted to use a "hybrid" approach of both home and office working in future. (Office for National Statistics, 2021)

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So02	<i>More time spent in cyberspace</i>	For many, physical identity and activity increasingly blurs with digital . The metaverse (a parallel cyberspace for digital versions of ourselves to exist) attracts more and more citizens to its social, entertainment, creative and commercial possibilities.	Fortnite is a metaverse , as is AmeVRica - a socialising, gaming and cryptotrading world. Facebook has rebranded as 'Meta' and has invested £10bn into 'Facebook Reality Lab' , which will drive innovation into a 'metaverse', an interconnected online world where digital avatars will play out real life. Zuckerberg has stated the technology is not expected to be profitable until the end of the decade . Microsoft and Epic Games have also been found to be investing in AR/VR technology . (Olcott, 2021)
So03	<i>Widening digital divide (generational)</i>	Digital inequality identified between generations . The switch from analogue telephone lines to digital by 2025 will have a huge impact on the users of the health and social care market, with 'non-digital natives' underserved by some mobile services and digital ecosystems.	By 2050, one in six people in the world will be over age 65 (16%) , up from one in 11 in 2019 (9%). By 2050, one in four persons living in Europe and Northern America could be aged 65 or over. In 2018, for the first time in history, persons aged 65 or above outnumbered children under five years of age . The number of persons aged 80 years or over is projected to triple, from 143 million in 2019 to 426 million in 2050 . (United Nations Department of Economic and Social Affairs, 2022)
So04	<i>Widening digital divide (geographical)</i>	Digital inequality reflected in geographical differences, i.e., rural vs urban , where the availability of reliable, fast internet differs widely. Next generation network solutions could make it easier to level-up this divide, but it is currently unclear to what extent a connectivity gap will remain in future.	The average age in rural areas was 45.1 years in 2020, 5.7 years older than in urban areas . The gap in average ages between rural and urban areas widened from 3.4 years in 2002 . The average age in England increased by 1.6 years between 2002 and 2020, but in rural town and fringe areas it increased by 3.2 years and in rural village and dispersed areas by 4.0 years. (Department for Environment Food & Rural Affairs, 2021) Projections suggest that £12-26 billion could be added to the UK's economy by successfully unlocking the digital potential of rural areas (Wilson, et al., 2018).
So05	<i>Widening digital divide (socioeconomic)</i>	Economic inequality reflected in ' digital poverty '. Unequal access to quality internet, and technologies due to difficulty obtaining access, and affordability . Paradoxically, the majority (71%) of mobile customers with a SIM-only plan are overpaying for data they don't use, at a total cost of £800 million per year , according to new analysis from Citizens Advice.	In 2020, one in five households struggle to afford their telecoms services , 6% have difficulties paying for their fixed home broadband, while 5% struggle with their mobile bill. The most common action taken by customers is to cut back on a package to make it more affordable (11%). Other steps include reducing spend on other items such as food and clothes (5%) , cancelling a service (4%) , missing a payment (2%) or changing payment method (2%) . 9% of households containing children did not have home access to a laptop, desktop PC or tablet . (Ofcom, 2020)

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So06	<i>Overwhelming proliferation of digital content</i>	With ubiquitous connectivity and improved hardware (cameras, microphones) the user-generated content landscape is booming . Individuals are exposed to more audio and visual content than ever before; overwhelm and the rise of mis- and disinformation represent the dark side to an explosion of tech-enabled creativity . Increasing connectivity has also been found to impact self-esteem , be a trigger for depression and foster addiction .	Recent data shows that 55% of people have stopped surfing the web for content discovery and purchases and rely on only two or three trusted sites (the top three being BBC, Amazon and Google). 41% of people (and 33% of millennials) claim to feel overwhelmed by the sheer wealth of choice on the internet, preferring friends' recommendations on social media rather than searching for content and products themselves (Go, 2015). In addition, some studies have indicated that certain social networking site activities might be associated with low self-esteem , especially in children and adolescents (Pantic, 2014).
So07	<i>Use of tracking, surveillance and life management solutions</i>	From home security and monitoring systems such as Ring, to tracking systems such as Apple's Find My Friends and health monitoring systems such as Dexcom wearable glucose monitor, life and health management solutions are increasingly prevalent across all generations. This is likely to increase, but by how much?	A poll of 2,400 workers found one in three reported being monitored at work in October this year, up from a quarter in April 2021. Additionally, the number of remote workers who reported being monitored by an at-home camera has more than doubled since April 2021. 13% of remote workers reported having a camera installed in their home , compared with just 5% six months ago. (Urquhart, 2021)
So08	<i>Emergence of new community structures and dynamics</i>	Traditional household and community structures continue to reconfigure over time , with birthplace becoming less of a determining factor in where people live and who they spend time with . Affiliations are forged in communities of interest , and increasingly online . The scale and direction of future reconfigurations is uncertain.	Social media has given alt-right groups easy access to build a network. It can be concluded that social media has been an important basis of the spread of alt-right as the ideology became more prominent with the progress of the internet. As social media became more interactive , the movement subsequently became more interactive as well and the network widened . (Çulha, et al., 2020)
So09	<i>Quality of human-machine interface</i>	UX is the ultimate goal for the software developers, experience designers and tech companies disrupting every sector. It is seen as important to attracting and keeping users, as well as full accessibility, navigating systems and assistive technologies . Companies are combining translation services, image recognition services, and audio transcription services , with the aim of helping people to engage and interact with others and with activities in exciting and easy ways. Will they succeed?	Google chrome language acknowledgement and live transcription and Google Lens' image recognition service . (Katz, 2021) (Google, 2022)
So10	<i>Greater desire for democratised and inclusive design</i>	In response to the inherent biases in systems and service design , a movement towards diversity and inclusion in design processes is gathering momentum. Grass roots groups and start-ups are reimagining the connected experience to ensure wider distribution of benefits .	The Black South West Network are building a decolonised history museum but cannot deliver this service immersively with the technology currently available . They want to build the service themselves to

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				avoid biases (fitting the profile of a 'bottom up' requirement). (Garoës-Hill, 2022)
	So11	<i>Increase in complexity and decrease in public understanding of spectrum</i>	A vacuum of information among citizens gives rise to a lack of trust and traction of misinformation. An increasingly complex communications environment combined with a lack of education and awareness has created a trust chasm between innovators/governing bodies and the public.	Resulting in high instances of misinformation and negative outcomes. MobileUK experienced 160 arson attacks on infrastructure and over 300 physical and verbal attacks on technicians in 2021. (Interviewee, 2021)
	So12	<i>Increasing influence of connectivity on wellbeing, social and economic outcomes</i>	The pandemic and growing capability of the internet have given rise to greater dependency on ecommerce for livelihoods and social media for fulfilment. With greater reliance on networks as CNI (critical national infrastructure), the more vulnerable citizens are if it fails.	As the largest European eCommerce market, the UK is expected to generate close to \$104bn in revenue in 2021, a 7% increase in one year. (Skeldon, 2021)
	So13	<i>Expanding communications landscape beyond traditional telecoms</i>	Social media has been a key driver of demand for connectivity, and internet-based platforms for socialising and messaging - with users opting to use free messaging services over telecoms-based ones e.g., WhatsApp over texts. What will the next big development in digital communications platforms be, and what will it mean for wireless demand?	During the third quarter of 2020, chat and messenger apps recorded the highest user reach with close to 91% of internet users worldwide using these types of apps (Ceci, 2022). An April 2021 report found 23% of consumers worldwide use third-party mobile apps to make voice calls very often, compared to 16% who declared to never use this function of their communication apps (Statista Research Department, 2021).

	IDENTIFIER	DRIVER	DESCRIPTION	EVIDENCE
TECHNOLOGICAL	Te01	<i>Use of 'digital twins'</i>	Use of digital twins (in the widest sense) for mapping and decision making, for example through intelligent autonomous systems, may become more and more prevalent. Where buildings, home interiors and individual identities have real-time digital equivalents, commercial opportunities and ethical challenges will arise. There are uncertainties in the future uptake and impact of this technology.	Blackshark.ai has raised \$20m to develop and scale the digital globe used in Microsoft's Flight Simulator into a planetary digital twin, using satellite imagery to sustain up-to-date 3D representations of every building on the planet. Market engagement with government customers for disaster relief and smart cities is high on the firm's agenda. (Crowley, 2021)
	Te02	<i>Growing number of devices per person</i>	We've seen a sharp increase in recent years in personal computing and sensing devices, from smartphones, tablets and wearables to emergent embeddables, lenses and ingestibles.	The number of connected wearable devices worldwide has more than doubled in the space of three years, increasing from 325 million in 2016 to 722 million in 2019. The number of devices is forecast to reach more than one billion by 2022. (Laricchia, 2022)
	Te03	<i>More players joining the Open-RAN movement</i>	Current RAN (Radio Access Network) technology is a hardware and software integrated platform. The multi-supplier ambition for Open RAN is for open interfaces and virtualisation, and hosting software that controls and updates networks in the cloud. The promised benefits include supply	The O-RAN Alliance is a group that is defining specifications for radio access networks. It is a global alliance founded in 2018 and it is now comprised of close to 30 operators and more than 200 vendor companies. (Ericsson, 2022)

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		chain diversity, solution flexibility, and new capabilities leading to increased competition and further innovation. However, there are doubts related to O-RAN's effectiveness in dense urban areas.	
Te04	<i>Development of connected industry ('Industry 4.0')</i>	Traditional methods of working in industry are being replaced with connected and technologically enhanced solutions : see Agri-Tech, smart manufacturing, transportation (CAVS road and rail). How widespread will this be by 2030?	86% of manufacturers believe that smart manufacturing initiatives will be the main driver of manufacturing competitiveness in 5 years while 83% believe it will transform the way products are made in 5 years. (Wellner, et al., 2019)
Te05	<i>Rise in plans to develop connected public spaces</i>	Development plans for public spaces increasingly include becoming connected via smart cities and smart tourism. Services, utilities and communications are implicated in these developments.	Neom, UAE - the first cognitive and smart city. 'The line' will link the coast of the Red Sea with the mountains and upper valleys of the north-west of Saudi Arabia. (NEOM, 2022)
Te06	<i>Level of fragmentation of connectivity market</i>	The connectivity market is being flooded with satellite, fixed and wireless market innovations . Governments, individuals and businesses have more options and take varied approaches to balancing investments in e.g., standalone masts or Low Earth Orbit satellites for optimised coverage. This fragmentation is starting to happen, but the end state in 2030 is unclear.	The development of 5G enabled phones, the automation industry's dependence on 5G and the use of satellites to monitor forests - satellites reduce our interface with the natural environment. (CB Insights, 2021) (Lynch, et al., 2013)
Te07	<i>Increasing monopoly of cloud-based technology</i>	Rise in the use of cloud-based platforms and cloud computing for data storage, operations and service delivery, so much so that the vast majority of businesses around the world will be at a significant disadvantage without migration to cloud.	90% of all organisations will be running cloud-based core business applications by 2020 . By 2021, 94% of workloads and compute instances will be processed by cloud data centres ; 6% will be processed by traditional data centres. Market share of cloud-based technologies is dominated by a handful of US based companies. (Cisco, 2018)
Te08	<i>Increasing sophistication of 'edge' computing and IoT sensor networks</i>	Outside of central 'clouds', there is a growing 'fog' of less powerful servers (connecting hubs back to the cloud), and then a proliferating 'edge' of sensors (both static in places and spaces, and on things and people). This is often described as the Internet of Things (IoT) . As 5G mainstreams, this vast array of sensors will enable ultra-low latency computing 'at the edge' of data.	The number of IoT devices in the UK is projected to grow to over 150 million in 2024 from 13 million in 2006. Consumer wearables and the white goods market account for over 40% of all IoT connections . However, most of the projected future growth will be in the automotive, consumer electronics and utilities sectors (Ofcom and Cambridge Consultants Ltd., 2017). In addition, reducing the need for data transfer has implications for CCTV and emerging technologies such as LiDAR (light detection and ranging) will enable IoT use cases such as CAVs and robotics. (Butt, et al., 2022) (Hemmati & Rahmani, 2022)
Te09	<i>Advancing data capture, processing and analysis in real-time</i>	Exponential growth of data will continue, with ever growing reliance on always and instantly available data for operations and innovation. This will be tempered in part by the need for	Average monthly data used per mobile data connection was 4.5GB in 2020, up 27% from 2019 (fixed was 429GB, up 36%). Based on previous OFCOM reports,

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		profitable business models and net zero, which will require a balance between performance and energy saving.	this follows a year-on-year increase in personal mobile data usage. (Ofcom, 2021)
Te10	<i>Growth in the LiFi technology market due to its comparable security</i>	Light fidelity (LIFI) technology is internet which travels through light waves as opposed to radiofrequency like WIFI does. We see recent and promising advancements in this emergent space.	The global Li-Fi market size is estimated to show tremendous growth (\$8bn) as the frequency of cybercrimes escalates worldwide. Li-Fi solutions can address all major concerns of wireless systems and their security, ranging from devices to networking protocols. As Li-Fi offers an enhanced wireless infrastructure, enabling extraordinarily high peak data rates, at the same time ensuring energy efficiency, the global market for Li-Fi is set to gain considerable revenue through 2030. (Globe Newswire, 2021)
Te11	<i>Emergence of the quantum internet</i>	The quantum internet is a network that will let quantum devices exchange some information within an environment that harnesses the weird laws of quantum mechanics. In theory, this would lend the quantum internet unprecedented capabilities that are impossible to carry out with today's web applications.	E-crime is estimated to cost the UK retail sector £205 million each year. The UK National Quantum Technologies Programme intends to tackle internet fraud using quantum technology to develop an unbreakable digital signature. (Quantum Technologies Strategic Advisory Board, 2015)
Te12	<i>Ongoing challenges related to the commercialisation of innovations in the UK</i>	The UK upholds its reputation for great research, but studies reveal a relative weakness in bringing those new innovations to market.	A University of Birmingham study found that academics are generally good at research but 'not good at business'; they have other incentives and key performance indicators. Therefore, although some might be connected commercially, they normally do not have a remit or incentives to deliver commercial success. For academics, research funding is often seen as a key outcome, rather than an input to create something that adds value elsewhere. (Billing, et al., 2019)
Te13	<i>Gradual convergence between wired and wireless</i>	There is a shift occurring away from technologies that use wired networks towards technologies that use wireless networks, such as the landline telephone.	26% of homes don't use their landline telephones and 35% only have a landline because it is needed for their broadband connection. Less wealthy consumers are more likely to rely solely on mobile connectivity. (Price, 2021) (Ofcom, 2022)
Te14	<i>An increase in the use of private networks</i>	Rise of the splinternet and small private networks as rivals to using bigger internet providers and public networks. Network security will have to be well managed.	The introduction of private 5G networks using spectrum made available by Ofcom. The City of Liverpool are attempting to use private, standalone 5G networks to lessen the digital divide and tackle health inequalities. (Department for Digital, Culture, Media & Sport, 2018)
Te15	<i>Advancing mixed reality (VR/AR) technologies</i>	There will be greater adoption of mixed reality and deeper interaction with connected devices. 5G capacity will bring 3D video - AR and VR. The technology does not yet offer high-definition video but will if commercially viable. Dominating traffic for next ten years will be the use of AR and VR in	92% of some 200 surveyed organisations expected their spend on immersive technologies to grow year on year. (Immerse UK and Digital Catapult, 2019)

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			connected vehicles, smart manufacturing and healthcare - not just entertainment.	
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	IDENTIFIER	DRIVER	DESCRIPTION	EVIDENCE
LEGISLATIVE	Le01	<i>Legislation and regulation continuing to lag behind technological advancement</i>	The rate that technology evolves, and new technologies appear cannot be kept up with by legislation and regulation. This evolution may fall outside of current regulation/legislation and by the time regulations have been adapted to cover a new technology, further advancements may have been made, creating a constant cycle of legislation chasing development. Criminals may exploit unidentified legislative/regulatory loopholes as technology evolves, abusing the system to avoid detection.	A World Economic Forum article in 2018 cited social media as an example of the 'cat-and-mouse game between regulators and economic actors' , stating that as they 'use advanced technology in innovative and fast-changing environments, and are therefore almost impossible to define with enough specificity to allow the lengthy regulatory process to run its course. By the time that a regulation is finally approved, the product or service has changed.' and citing the Cambridge Analytica scandal as an example of how regulatory loopholes can be exploited. (Malan, 2018)
	Le02	<i>Volume and variety of cybercrime and cyberthreat</i>	The nature of cybersecurity threats is becoming more diverse due to the increasing range of connected devices. There are also more cybercriminals in operation, with varied motives. The direction of travel is clear, but the scale of the problem remains uncertain.	Ecommerce, mobile payments, cloud computing, big data and analytics, IoT, AI, machine learning, and social media - all increase cyber risk for users and businesses, such as: Distributed Denial-of-Service (DDoS), ransomware, Advanced Persistent Threats (APTs), viruses, worms, malware, spyware, botnets, spam, spoofing, phishing, hacktivism and potential state-sanctioned cyberwarfare. There were a total of 1,272 breaches with a total of nearly 163 million records exposed as of November 2019 . The number of records exposed per data breach averaged 128,171 year-to-date in 2019. (Cisco, 2020)
	Le03	<i>Level of responsibility placed on companies for maintaining high quality, secure services</i>	MNOs and Big Tech companies are increasingly accountable for failures and vulnerabilities in the complex, scaled infrastructure they manage. The extent to which legislation enforcing this accountability keeps pace with rapid developments in technology platforms in the coming years remains uncertain.	The 2020 Telecommunications (Security) Bill introduced legal duties on telecom firms to improve the security of the UK's 5G network, including the electronic equipment and software at phone mast sites and in telephone exchanges. Ofcom have been given new responsibilities to monitor telecom operators' security with finances of up to ten percent of turnover or £100,000 a day for continuing failure to meet standards . (Department for Digital, Culture, Media and Sport, 2020)
	Le04	<i>Increasing integration of wireless technologies into the criminal & justice system</i>	Wireless connectivity is increasingly relied upon for legal decision-making - through identification, geolocation and, at the leading edge, intervention and sentencing via AI	Durham Constabulary has developed with Cambridge University the Harm Assessment Risk Tool (HART), a machine learning system which analyses 34 categories of data to predict the likeliness of reoffending . The tool

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				is not used to determine bail or sentencing decisions but only to inform the selection of candidates for a rehabilitation programme. (Allen, 2020)
	Le05	<i>Uncertain appetite for refreshed regulation of spectrum governance</i>	Some industry experts claim stringent regulation , combined with consumer expectations for affordability continues to pressure MNO profit margins and reduce available funds for research and development. There is uncertainty over the current extent of this issue and whether it will continue in future.	Higher performing mobile broadband networks demand greater investment. Regulation should work to exchange spectrum for investment, creating new service revenues and greater profit margins for MNOs to innovate. Currently, regulation bars entry for competitors, while Net Neutrality allows drain-off revenue. (Interviewee, 2021)

	IDENTIFIER	DRIVER	DESCRIPTION	EVIDENCE
ENVIRONMENTAL	En01	<i>Intensifying efforts to curb emissions and improve efficiency of digital infrastructure</i>	Multiple private and public sector players are striving to reduce the environmental impact of their connected operations - including for energy-intensive connected mobility solutions and industrial automation.	Enhanced connectivity of the UK's transport sector could allow for a 27.8 megaton reduction in CO2e emissions between 2021 and 2035 via more efficient journeys, greater adoption of hybrid working arrangements, and better on-board train experiences. (Assembly, 2021)
	En02	<i>Energy demands for connectivity and data management</i>	Keeping a sensing network functioning e.g., from wireless charging of devices to data storage centres and data transfer demands significant power. However, advances in energy efficient technologies might offset increases.	Servers, cooling systems, storage drives and network devices of some of the world's largest data centres consume more than 100 MW of power, the equivalent of 80,000 US households (Muggah, et al., 2020). Increased energy consumption from networks may offset efficiency improvements. Mobile data traffic is projected to grow by 6.2x between 2018 and 2024 in emerging economies and 3.1x in developed markets. By 2025, 100 billion connections are forecasted , with 85% of enterprise applications occurring on the cloud and 86% of global companies adopting AI. Data utilisation rates (% of data available that is used/analysed) have jumped to 80%. (Analysis Mason Limited and Huawei, 2020)
	En03	<i>Demand for natural resources for digital infrastructure development</i>	Competition is intensifying for the critical natural minerals needed for wireless hardware and device supply chains. Many of these are concentrated in a small number of locations and are becoming rarer. The future balance of supply and demand is uncertain.	Cobalt is a vital mineral used in the building of rechargeable batteries found in laptops, phones and EVs. The price of cobalt rose significantly from \$32,000 per metric ton in January 2017 to \$94,000 per metric ton in March 2018. This increase saw more miners enter the industry. Majority of cobalt is mined from the Democratic Republic of Congo bringing about negative social and environmental impacts. In an effort to curb

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			exploitation, the mineral has entered the EU's Conflict Minerals Regulation. (Davies, 2020)
En04	<i>Hardware, materials and emissions contributing to overheating urban areas</i>	Building design , coupled with heat emitted from electrical devices is contributing to a higher average temperature in cities over sub-urban and rural areas. Regulators define 35°C as the internal temperature above which there is a significant danger of heat stress.	The urban heat island effect occurs through the replacement of natural surfaces with hard impervious surfaces that are generally dark and absorb large amounts of solar radiation . Urban hard surfaces are significant in the built environment in the form of roads, paved areas, roof tops and so on. (Designing Buildings, 2022)
En05	<i>Rise of sensor networks for environmental monitoring and management</i>	We have seen, and continue to see exponential increases in numbers and networks of sensors monitoring the built and natural environment (e.g. connected agriculture, climate, weather and adverse events monitoring .)	Mobile technologies can play a significant role, with research showing smart connected technologies are already enabling carbon reductions 10x the footprint of the mobile industry . This impact is expected to double by 2025 with more machine-to-machine connections. (GSMA, 2021)
En06	<i>Increasing frequency of extreme weather events</i>	More frequent flooding, along with coastal erosion in the UK challenges the resilience of physical infrastructures and heightens risk of blackout and disconnection.	A 2021 report projected high-impact rainfall on at least 1 additional day per year at a 1.5°C level of warming and up to 8 additional days per year at a 4.0°C level of global warming . Suggesting more frequent river flooding having widespread severe impacts across the UK. (Met Office, 2021) (Hanlon, et al., 2021)
En07	<i>Greater public emphasis on 'green' behaviours</i>	Increased awareness and scrutiny from citizens seeking low-carbon solutions for day to day living. Personal carbon scoring and offsetting mechanisms are mainstreaming, from which many are deriving a kind of 'eco-status'.	Commitments made by the GSM Association (GSMA) trade group that helps the wireless industry attain net-zero emissions by 2050 (GSMA, 2021). The emissions reduction target sets downward trajectories over the rest of the decade for each telecom sub-sector. For wireless operators, the goal is to lower emissions by a minimum of 45% through 2030. (GSMA, 2022)
En08	<i>Increased number of devices responsible for power/charging purposes</i>	We see the proliferation of technologies that support the electric vehicle industry - devices that offer charging as well as telemetry.	On 1 July 2020, there were 18,265 public electric vehicle charging devices available in the UK. Of these, 3,206 were rapid devices. Since 2015, the number of public charging devices has grown by nearly five times to July 2020, with an 11% increase in the year to date . Rapid charging devices have also grown quickly, increasing by 363% since 2015. (Department for Transport, 2020)
En09	<i>High instances of obsolescence across more devices</i>	As the volume of devices/objects with embedded technology increases (i.e. smart surfacing), there is a risk of increased tech waste . When upgrades are available devices may be thrown away (as with mobile phones) leading to increased waste and a lack of sustainability in behaviours. In cases of relatively cheap items which have sensors	In 2020 Apple was fined \$27m by France's competition watchdog (BBC News, 2020) and, also agreed to pay up to \$500m (\$25 per iPhone) to settle claims regarding the slowing down of older iPhone models (The Guardian, 2020). Global e-waste is predicted to reach 74 Mt by 2030,

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			embedded within them, they may be thrown away and replaced when batteries run out or when broken but fixable.	almost double the 2014 figure, fuelled by higher electric and electronic consumption rates, shorter lifecycles and limited repair options (Global E-Waste Statistics Partnership, 2020).
	En10	<i>Increase in smart/meta surfaces in the built environment.</i>	Novel technology that intelligently directs a beam to mobile users reduces the need for masts. The dynamic engineered metasurface recycles existing electromagnetic (EM) waves without emitting new EM waves. This technology is expected to be widely deployed in the future - using buildings to improve coverage, capacity, and lower power consumption.	The ETSI ('Standards People') have launched a new industry specification group to review and establish global standards for Reconfigurable Intelligent Surfaces (RIS) technology. (Turner, 2021)

	IDENTIFIER	DRIVER	DESCRIPTION	EVIDENCE
DISRUPTORS	Di01	<i>Failure of systems of democracy</i>	Whilst heightened connectivity represents new opportunities for citizen empowerment and devolution; the benefits of a digital economy and society are unlikely to be evenly distributed. Echo chambers, issues of accessibility and inclusion, and algorithm-directed perspectives all threaten to undermine true democracy.	50% of experts responding to a Pew Research call for evidence said people's use of technology will mostly weaken core aspects of democracy and democratic representation. (Anderson & Rainie, 2020)
	Di02	<i>Worsening variants (or entirely new viruses) of concern creating new pandemic spikes</i>	Continued spread and incubation of Covid-19 across geographies sparks the emergence of deadlier and/or more transmissible variants of concern.	The emergence of the new Omicron Covid-19 variant has pushed governments to re-enforce travel restrictions and re-consider national control measures. (HM Government, 2021)
	Di03	<i>Debt levels rapidly eclipsing GDP</i>	As significant pressures build on health-related spending in an ageing society, pre-existing fiscal pressures on the state are intensified by pandemic shock - triggering financial panic across the UK and global market. This could impact upon public sector spending and available budgets for wireless infrastructure projects.	Debt levels are increasingly expected to continue rising towards 100% of GDP and further shocks are predicted to tip debt levels over 100% of GDP into the mid-2020s. (Resolution Foundation & Centre for Economic Performance, 2021)
	Di04	<i>Mass digital identity withdrawal</i>	Amidst rising concerns about the protection and commercialisation of personal information, and vulnerabilities in connected systems, the next decade could see a mass withdrawal or deletion of online profiles and identities. This could affect the way that public services are accessed and dampen demand for wireless infrastructure or willingness to engage with digitalisation programmes.	Google searches for ' incognito ' and ' personal data ' have increased 4-fold in the last decade (Google Trends, 2020), pointing to a desire for anonymity and potential for increased 'digital cloaking'.
	Di05	<i>More frequent grid outages</i>	Climate and weather events combined with increased demand for charging (e.g. for electric vehicles) exposes vulnerabilities in UK power grids. More people and places will see blackouts to 2030. Such extreme events will test the resilience of wireless infrastructure and, as they become	In the last decade, the " margin " of forecasted energy supply to demand has been tightening - in 2021 supply will only just exceed demand by 5.3% (National Grid, 2017).

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		increasingly reliant on connectivity, increase the vulnerability of public services.	
Di06	<i>Rapid development of game changing quantum technologies</i>	Quantum technology has the potential to revolutionise the capacity of the internet and global cybersecurity . The rate and success of its development is currently unclear, if it were to develop rapidly, demand is likely to be high and it may be necessary to re-think the UK's wireless infrastructure strategy .	In late December 2020 , scientists at the Fermi National Accelerator Laboratory (as part of a U.S. Department of Energy effort) announced they had successfully teleported data more than 44 kilometres (more than 27 miles) with 90% accuracy , a significant achievement for quantum technology. (Prisco, 2021)
Di07	<i>Intensifying concerns around the impact of radio frequencies on environmental and human health</i>	We see increasing calls for research into ecosystem interference ; some evidence has indicated adverse effects of RF-EMF exposure to certain human and non-human vertebrates, invertebrates and plants (through potential dielectric heating).	Recent reviews of lab data on RF-EMFs indicate that exposures can produce wide-ranging effects , including reproductive, foetal, oncological, neuropsychiatric, skin, eye and immunological. It is highly likely that each of these many forms of RF-EMF causes somewhat different biological effects —making sound, comprehensive and up-to-date research on those effects virtually impossible . (Frank, 2021)
Di08	<i>Adverse weather in space</i>	Space weather, like solar storms, cause fluctuations of electrical currents, energising electrons and protons trapped in Earth's magnetic field. These disturbances can cause problems with radio communications, GPS, power grids and satellites .	1.6% to 2% chance that an extreme space weather event could take place within the coming decade. (Jyothi, 2021)

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A set of plausible but extreme scenarios have been generated using a set of established futures techniques. This provided a set of qualitative narratives that describe the key characteristics of each scenario.

In addition, there was a requirement to augment these narratives with quantitative analysis of how demand might vary across the scenarios for a small number of illustrative public service use cases.

The purpose of this analysis was to help enrich the scenario narratives with some additional specific details and compare the scale of demand of each use case across the scenarios. The analysis is not intended to make a prediction of aggregate data demands.

A quantitative model was developed by Decision Analysis Services Ltd, based on the following design criteria:

- Necessarily a “light touch” model reflecting the limited data available, and the uncertainty associated with each scenario.
- Re-use of data/analysis/modelling is beneficial, recognizing substantial work undertaken elsewhere within DCMS and industry - a meta-modelling approach.
- The model focuses on take-up and usage and does not attempt to be an explicit assessment of quality of service.

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- Given high degrees of uncertainty, the approach is to estimate for one scenario, as an “anchor”, and use this as a stepping off point to consider the remaining scenarios by factoring the anchor inputs i.e., “moderating”.

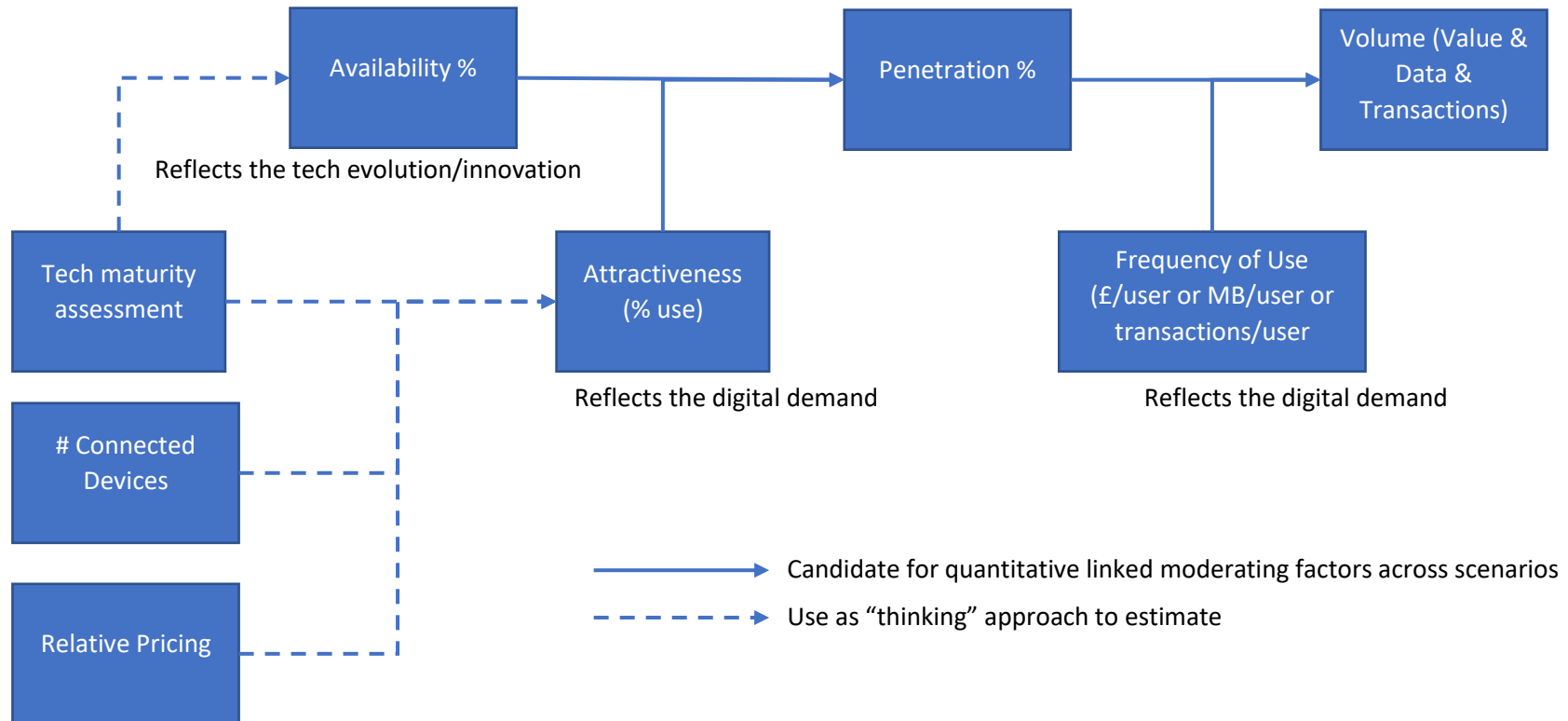
The quantification has been developed through review of existing literature and expert judgement to reflect:

- Generational advancement of the technology for the use case (how mature is it?).
- Availability - this can take the form of a capacity in terms of devices required and/or the underpinning network and reflects the coverage (does not consider affordability).
- Attractiveness - the level of take up for the use case given availability.
- Frequency of use in terms of transactions, value and/or data flows.

In addition, other factors were used to help inform the above. These include numbers of connected devices (associated and critical to the use case), pricing and quality of service. The coverage and attractiveness map onto the scenario axes well and when combined with the level of transactions, has provided a simple approach to estimate demand across scenarios.

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An overview diagram of the approach:



- This approach allows the user to build an estimate of use case demand, using a series of real-world parameters that would influence this demand.
- It also helps, in a logic model, to qualitatively think through the steps to make these estimates.

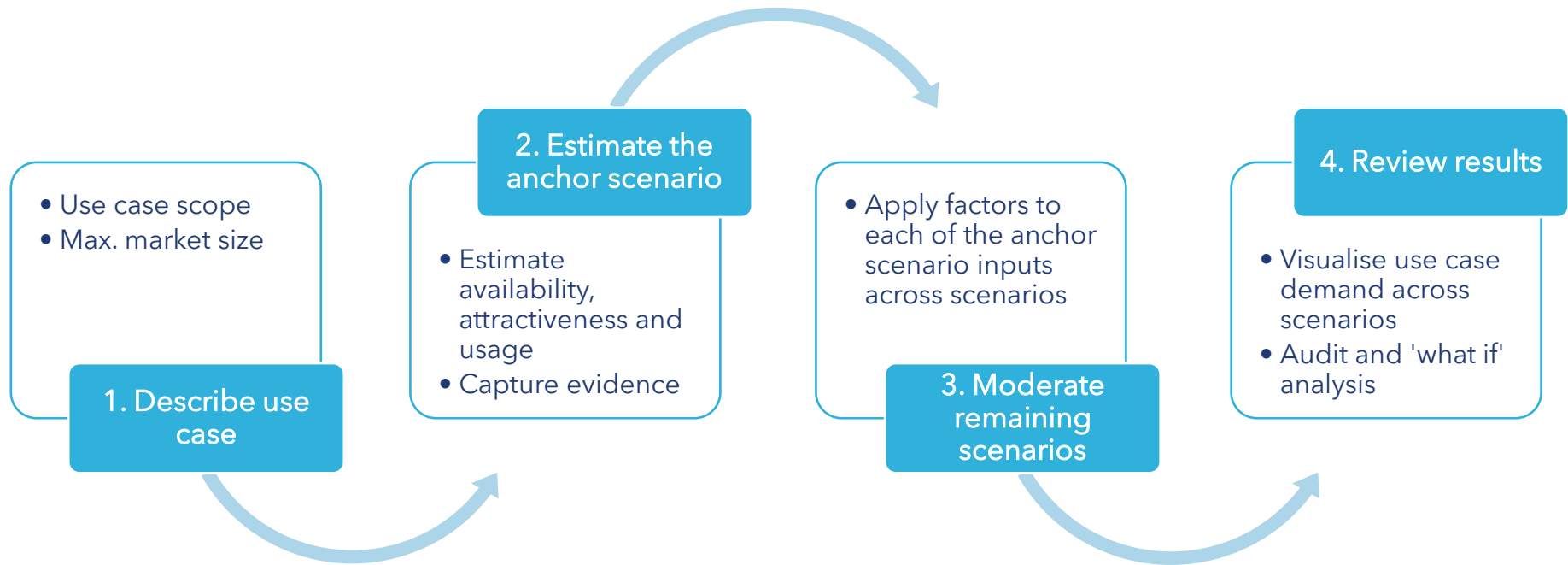
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	Market potential (users or devices)	X	Availability (%)	X	Attractiveness (%)	X	Transactions (/entity/mo)	X	Data/ transaction (Mbits/trans)	=	Data Demand (Tbits/s)
Market potential											
Accessible market											
Entity demand											
Transaction rates											
Data rates											
Penetration											

- The basic calculation is a series of simple multiplicative steps.
- The calculations are undertaken using a geographic segmentation (rural/urban) as appropriate.
- A one size fits all approach has been applied but there is flexibility on how entities and transactions are defined for each use case.

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The approach to completing the calculation - step by step:



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Step 1. Describe the use case scope

- Estimates are made but at each line, an anchor evidence point is flagged.
- Evidence is included to provide audit trail.

2 Healthcare : Procedures			
No errors on data			
Links -> Go to Navigation Go to Tot Output Go to Geo Output			
Sector	Area	Unique Label	Status
Healthcare	Procedures	Healthcare : Procedures	In Progress
<p>Definition: Healthcare in future will have hospitals based on a hub and spoke model. This will create an operating model for outpatient and inpatient surgery delivery. Even in regions such as Scotland, remoteness is not a widespread problem for elective surgery. In this Use Case, senior specialist surgeons can provide a full tele presence in the operating room but NOT undertake the actual procedure. They can guide other health care professionals and access other data resources. This can still include some laparoscopic surgery.</p>			
A Estimate Total Market Potential Size - this is the maximum size			
	Estimate	Anchors	Notes/Refs
Connected Entities (M)	0.005		Assume 4/100 operating theatres in UK
ESX Urban segment (M)	0.004		Will allow for 11 channels to other health professionals @UHCD + 10 data sensor channels
ESX Rural segment (M)	0.001		Assume
Connected Entities Type	Theatres		
User Entities (M)	7.1	7.1	There were 5.7M elective surgeries in the medium/complex in hospitals in 2014
ESX Urban segment (M)	5.92	7.14	Been growing at 2.4pa. [est]
ESX Rural segment (M)	1.21		Note - will be using operating theatre utilisation rather than # ops
Users Type	Operations		

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Step 2. Estimate anchor scenario

B.2 Estimate Benchmark Adoption (based on User Entities)			
	Estimate	Anchors	Notes/Refs
Availability (%)	100%		
Urban segment (%)	100%	100%	
Rural segment (%)	100%	100%	
Willingness to Use	100%		
Urban segment (%)	100%	100%	
Rural segment (%)	100%	100%	
User Adoption	100%		
Urban segment (%)	100%		
Rural segment (%)	100%		
Users Adoption (M)	7.1		
Urban segment (M)	5.9		
Rural segment (M)	1.2		

B.3 Estimate Benchmark Unit Demand			
	Device Entities	Anchors	Notes/Refs
Basis of demand	Device Entities		Do we calculate outputs with devices or users?
Value of Use (£/mo/entity)	0.00		
Transactions/mo/entity	240.00		Assume 8 hr day, 7 day use, use Analysis mason data and data channels described at top - calculate hrs/mo in use
Data Need (MB/transaction)	6280000.00		Assume 200MB/s across UHD channels (10 off) + sensors at 10 off at 10 MB/s. Need to check Analysis Mason work as it suggested v high UHD video

B.4 Benchmark Demand Metrics			
		Anchors	Notes/Refs
User Entities Adoption (M)		7.14	
83% Urban segment (M)		5.92	
17% Rural segment (M)		1.21	
Use Adoption for Connected Entities	Yes		Adoption of devices can be based just on coverage eg base stations or with attractiveness as well
Connected Entities Adoption (M)		0.01	
83% Urban segment (M)		0.00	
17% Rural segment (M)		0.00	
Basis of demand	Device Entities		
Entities (M)		0.005	
83% Urban segment (M)		0.004	
17% Rural segment (M)		0.001	
Entities Type	Threatres		
Value (£M/mo)		0.000	
Transactions (Bn Trans/mo)		0.001	
TB/s (average)		3.908	

- The benchmark scenario is listed. The default is “Seamless Citizen” because this tends to have the highest digital demands.
- Some assessment of the technology advancement is needed. This will typically reflect the scenario narrative.
- The adoption and unit demand feed through to estimates of coverage, attractiveness and level of use.
- Data flow is measured at a transaction level.
- Geographic segmentation is also included.

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Step 3. Moderate inputs for remaining scenarios

- The benchmark inputs are displayed on the left of the table below for reference.
- Moderating factors can then be applied for each of the other scenarios.

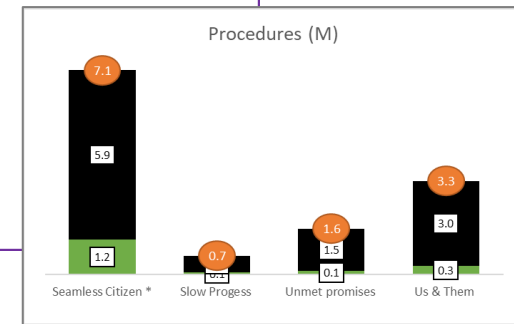
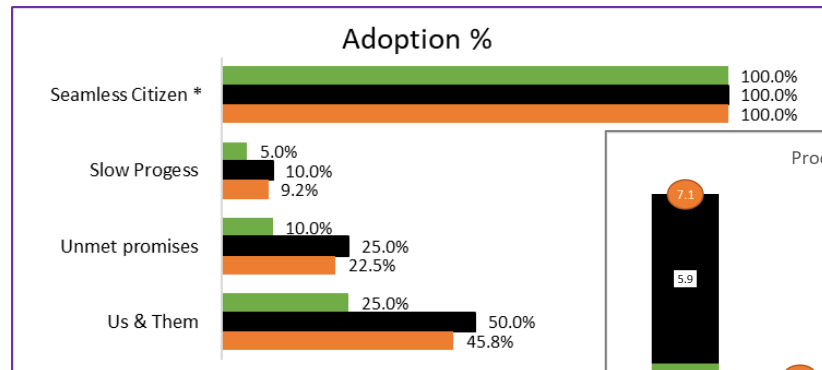
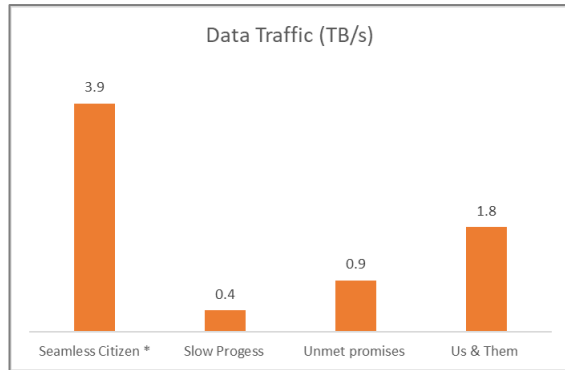
C Assess Scenarios (Factors use i.e. Benchmark Value * Factor, 100% = Benchmark)			NOTE: FACTORS TO MULTIPLY BY BENCHMARK TO LEFT					Notes & Refs
	Benchmark →		Seamless Citizen *****	Unmet promises	Slow Progress	Us & Them		
QoS	100%		100%	100%	100%	100%	Not used in this model	
Connected Entities (M)	0.0	Threatres	100%	100%	100%	100%		
83% Urban segment (M)	0.0		100%	100%	100%	100%		
17% Rural segment (M)	0.0		100%	100%	100%	100%		
User Entities (M)	7.1	Operations	100%	100%	100%	100%		
83% Urban segment (M)	5.9		100%	100%	100%	100%		
17% Rural segment (M)	1.2		100%	100%	100%	100%		
Availability (%)	100%		100%	25%	9%	46%		
Urban segment (%)	100%		100%	25%	10%	50%		
Rural segment (%)	100%		100%	25%	5%	25%		
Attractiveness	100%		100%	100%	100%	100%		
Urban segment (%)	100%		100%	100%	100%	100%		
Rural segment (%)	100%		100%	100%	100%	100%		
Adoption %	100%		100%	25%	9%	46%		
Urban segment (%)	100%		100%	25%	10%	50%		
Rural segment (%)	100%		100%	25%	5%	25%		
Value of Use (£/mo/entity)	-	Device Entities	100%	100%	100%	100%		
Transactions/mo/entity	240.0	Device Entities	100%	100%	100%	100%		
Data Need (MB/transaction)	8280000.0	Device Entities	100%	100%	100%	100%		

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Step 4. Review results

- A variety of visualisations are available (further examples given on the next two pages).
- Outputs are in both tabular and graphical format.

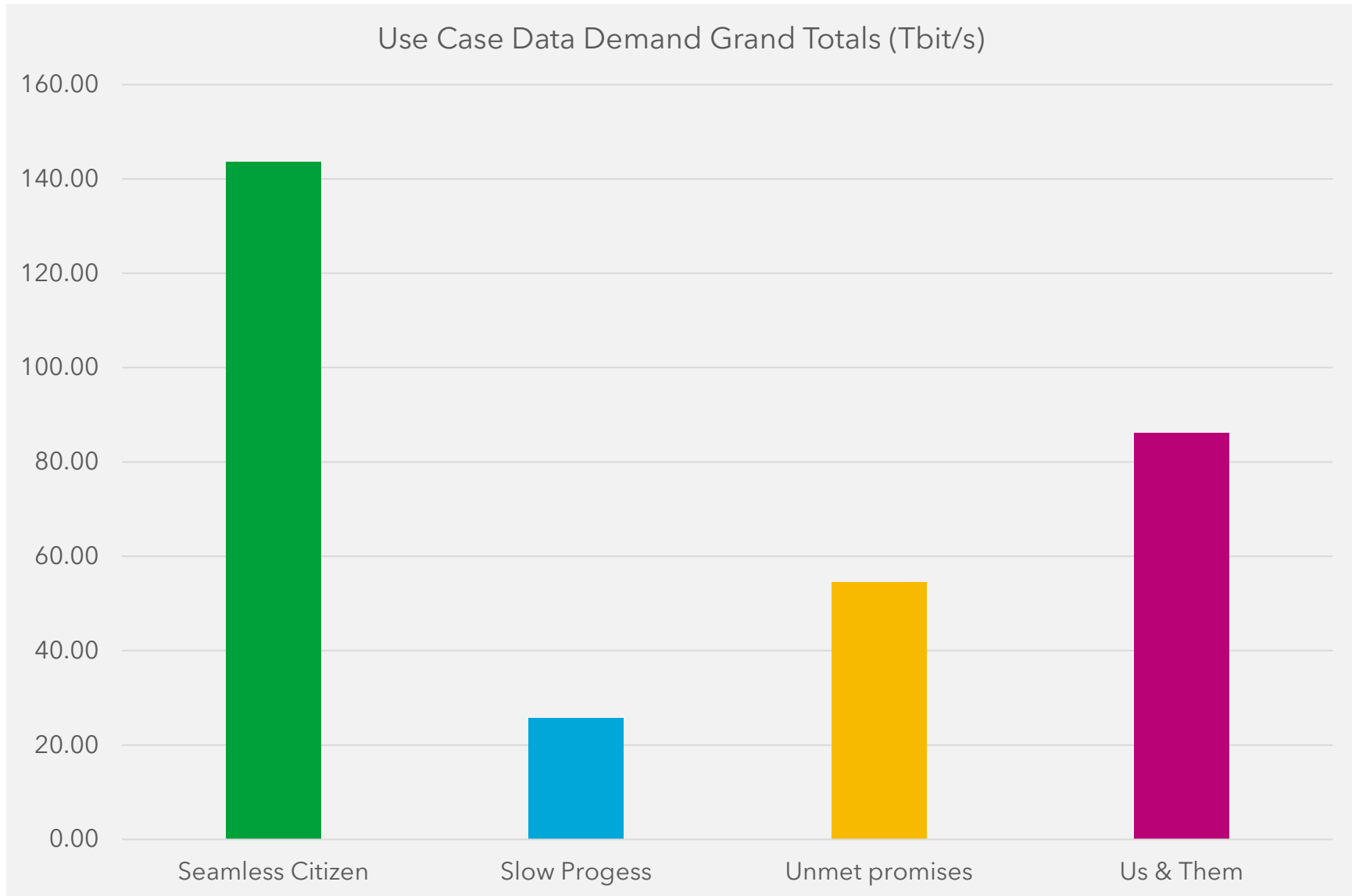
D Scenario Outputs		NOTE: RESULTS ARE METRICS AS SHOWN BY LABELS AT LEFT					Notes & Refs
		Benchmark →	Seamless Citizen *****	Unmet promises	Slow Progress	Us & Them	
User Entities Adoption		7.1 Operations	7.1	1.8	0.7	3.3	
83%	Urban segment (M)	5.9	5.9	1.5	0.6	3.0	
17%	Rural segment (M)	1.2	1.2	0.3	0.1	0.3	
Use Adoption for Connected Entities		Yes					
Connected Entities Adoption (M)		0.0 Threatres	0.005	0.001	0.000	0.002	
83%	Urban segment (M)	0.0	0.004	0.001	0.000	0.002	
17%	Rural segment (M)	0.0	0.001	0.000	0.000	0.000	
Basis of demand		Device Entities					
Entities (M)		0.0 Threatres	0.005	0.001	0.000	0.002	
83%	Urban segment (M)	0.0	0.004	0.001	0.000	0.002	
17%	Rural segment (M)	0.0	0.001	0.000	0.000	0.000	
Value (£M/mo)		-	-	-	-	-	
Transactions (Bn Trans/mo)		0.0	0.0012	0.0003	0.0001	0.0006	
TB/s (average)		3.91	3.91	0.98	0.36	1.79	



Annex C - Quantification methodology

Use Case	Seamless Citizen	Slow Progress	Unmet promises	Us & Them	Grand Total
Cultural	72.08	18.02	36.04	54.06	180.21
VR gaming & Entertainment	48.06	12.01	24.03	36.04	120.14
VR Social/Communications	24.03	6.01	12.01	18.02	60.07
Education	13.29	3.89	7.21	7.21	31.60
Screen based Remote Learning	0.03	0.01	0.01	0.01	0.06
VR Remote Learning	13.26	3.88	7.20	7.20	31.53
Environmental	11.53	2.88	4.32	8.64	27.37
Rural Monitoring	0.00	0.00	0.00	0.00	0.00
Urban Monitoring	11.49	2.87	4.31	8.62	27.30
Healthcare	5.12	0.52	1.15	2.35	9.14
Monitoring	0.02	0.01	0.01	0.02	0.05
Procedures	5.10	0.51	1.15	2.33	9.09
Security	0.76	0.13	0.13	0.76	1.77
Surveillance - Mobile	0.00	0.00	0.00	0.00	0.00
Surveillance - Static	0.76	0.13	0.13	0.76	1.77
Transport	0.29	0.04	0.17	0.15	0.64
Connected Vehicles	0.29	0.04	0.17	0.15	0.64
Transportation	40.58	0.25	5.60	12.94	59.37
CAVs	40.58	0.25	5.60	12.94	59.37
Connected Micromobility	0.00	0.00	0.00	0.00	0.00
Grand Total	143.65	25.72	54.62	86.11	310.10

Annex C - Quantification methodology



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