Emerging technologies and their potential impact on the communications industry
BT Response

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1. Executive Summary

1.1. BT sits at the heart of an increasingly connected UK. Earlier this year we committed to roll out full fibre to 20 million premises by the mid to late 2020s, including a commitment to build to 3.2 million premises in harder-to-reach rural areas. We are also rapidly expanding our leadership position in 5G, covering over 80 towns and cities. This underlines our commitment to ensure that as many people as possible share in the benefits of connectivity. BT connects for good.

1.2. We are experiencing a period of unprecedented change and uncertainty. In that world, the importance of a vibrant digital economy has become more apparent. Ultrafast connectivity is no longer an ambition for the distant future. Rapid advances in technology call for the availability of high bandwidth availability both in the home and on the move.

1.3. BT, with its network capabilities and unparalleled experience, is uniquely well positioned to meet the challenge of meeting the demands for connectivity in the UK and beyond.

1.4. Moving beyond the challenges of developing fixed and mobile networks at a national scale, exciting technical innovations will require new ways of thinking from both a commercial and regulatory perspective. It is becoming increasingly clear that the old ways of thinking are unlikely to support the emergence of new technologies and services.

1.5. This submission to Ofcom's consultation on *Emerging technologies and their potential impact on the communications industry* seeks to inform Ofcom's thinking in two ways:

- Providing our views on what the future model for regulation should be in a market prone to rapid change; and

- Describing some of the future innovations we expect to see through a number of case studies. These set out not only the potential opportunities that these new technologies and services could bring but also some of the challenges in realising those benefits. We've also included a longer list of emerging technologies we've identified.

1.6. We welcome Ofcom's invitation to join the discussion and stand ready to fully contribute. As we set out in Section 4 of this submission, we are particularly keen to discuss Network Edge, Open RAN and [✂ confidential], as these technologies may have a significant impact on market dynamics and therefore the regulatory framework.

2. Background

Introduction

2.1. Over the last few decades the UK, as with many jurisdictions, has developed regulatory frameworks focussed on specific sectoral activities including utilities, healthcare, telecommunications, and financial services. Stimulating competition in some parts of the value chain has been a major objective of these regimes, reflecting the belief that markets will, in general, deliver the best outcomes for consumers particularly through innovation. More recently, greater focus has been placed on some of the limits of competition, particularly for customer groups that are unwilling or less able to engage with the market resulting in the introduction of more prescriptive regulatory interventions such as End of Contract Notifications. Nonetheless, the focus has still largely been sectoral albeit that common themes across these sectors have been explored, such as the CMA's work on the loyalty penalty, and some steps have been taken to identify vulnerable customers across sectors.

2.2. Whilst elements of these regimes remain relevant and appropriate, sectoral regulators should reflect real world realities, including the impact of regulating small slices of the value chain with little regard to the wider, often global, market dynamics. Monetisation models often focus on bundling services, often for free, to support loyalty, or to enhance services, in a core profitable market. This has profound implications in those markets that are the 'free' or heavily subsidised part of the bundle, especially where there are very significant barriers to entry in the core profitable market such that it is effectively non-replicable. The 'free' element of the market may be of high value to society and, where investment in that market is harmed, society will, over time, suffer.

2.3. General purpose technologies such as AI and machine learning, cut across sectoral barriers and any issues arising from these technologies, such as biases in algorithmic pricing, require regulatory powers of wider application. In the absence of such an economy wide framework it is likely that the absence or availability of regulatory powers will result in stop-gap measures that attempt to address symptoms rather than targeting the root cause of any harmful practices. There is also a risk that unduly narrow application of regulatory powers will distort competition between those applying the same technology but operating within different regulatory regimes.

2.4. Moreover, regulators should "*find new ways of engaging with innovation as it emerges and evolves, which will equip them to ensure that the economic and social benefits are captured while better understanding and managing the risks*"[1], rather than neutrally observing innovation. Whilst the initial investments that established the digital platforms will have involved significant risk, once the market has tipped in favour of one player, investments are often targeted at reinforcing strength in the core market or raising barriers to entry. Merger & acquisition activity can also remove innovative rivals by absorbing those technologies into an existing ecosystem that prevents innovation that may have occurred had that business developed absent the merger.

2.5. The political environment, and expectations on Government, have changed drastically. Consumer expectations are high, and politicians are under a lot of pressure to deliver, which in turn is passed onto regulators. Regulators will need to be more forward looking, bolder, more flexible and less risk averse if they are to help deliver for society in a challenging fast-moving world. In digital markets where regulators may have to exercise some judgement, so the regulator should set out very clear principles for how it would apply such judgement. For example, in the Competition and Markets Authority's market study on digital advertising, the CMA has proposed a high-level Code of Conduct for firms with strategic market status. These principles have then been adapted for the digital advertising market, so that stakeholders understand what commercial practices are prohibited, and any regulatory judgement when reviewing specific cases is based on the principles that have already been set. The appeals

[1] NESTA, March 2019. Renewing regulation 'Anticipatory regulation' in an age of disruption. p11.

regime will also, of course, need to take account of and enable this evolution in regulatory best practice.

2.6. The role of technology has also been part of international political and trade discussions. The independence of UK regulators from the political system remains crucial to delivering objective regulatory assessments of new technologies. It will be important to ensure that the political salience of issues around regulation of new technologies does not compromise regulatory independence. This would ultimately jeopardise innovation and investment, which rely on clarity and predictability of the regulatory regime.

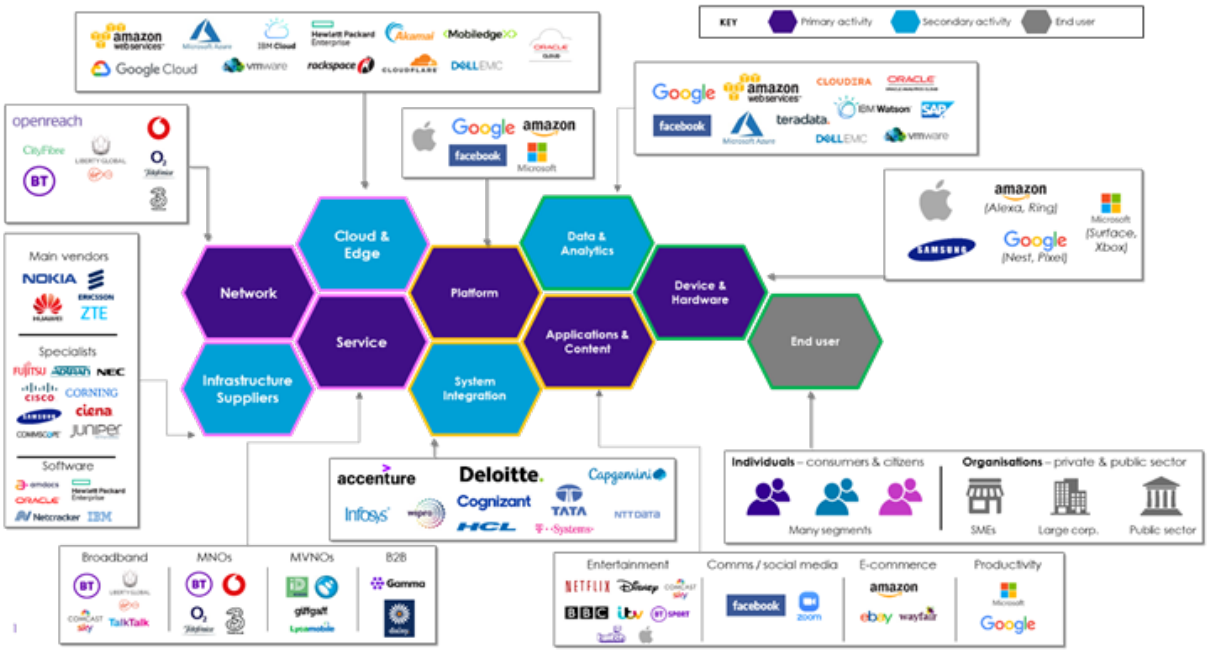
2.7. Against the backdrop of these themes we welcome Ofcom's review of emerging technologies as an important input into the wider debate about how regulation can best drive societal benefits. In the next section we briefly illustrate the wider digital value chain and the monetisation layers for the large technology companies, concluding that it is just as important to understand the commercial models as the technologies that underpin them. This theme is picked up in our final section in some of our case studies. Our second section provides our views on some regulatory themes that Ofcom's review is pertinent to. The final section provides case studies illustrating the important of the commercial models that the technology is used for.

Section 1 – Market Context

2.8. Digital markets are characterised by fast pace of change, an increasing importance of global scale, the importance of data to business models and close proximity between 'markets' with the ability of global players to move quickly into adjacent markets.

2.9. Figure 2.1 shows a depiction of the digital value chain, running from the network infrastructure layer to services, applications and devices. The figure shows how many firms operator at multiple layers of the digital value chain, and in many cases, are firms with an established global presence.

Figure 2.1 – The digital value chain



2.10. Digital markets exhibit strong network effects, derived from economies of scale that are often global, and multi-sided markets where each side of the market benefits from growth on the other sides. Strong network effects in such markets increases the chance of the market tipping in favour of one or few players. The CMA has already found that search and display advertising

markets have tipped in favour of Google and Facebook resulting in entrenched market positions[2].

2.11. Large digital firms operate across an 'ecosystem' of adjacent markets that gives them access to unique data. Unique data is extremely valuable in digital markets because it helps firms build a richer picture of user behaviour and interactions. This helps the firm with market power consolidate its position across the entire ecosystem and leverage into other markets to expand the ecosystem even further, in a way that limits rival firms' ability to compete on fair terms. Figure 2.2 shows how large global technology firms operate across multiple layers of the value chain, making it increasingly easier for them to leverage into new areas by building on their position in their current markets.

Figure 2.2 – Large global technology firms' role in the digital value chain

Section 2 – What does that mean for Regulation?

2.12. There are some key themes which together drive the need to challenge current approaches to regulation:

- **Narrow, sectoral regulation is not always appropriate** – many emerging technologies enable use cases which do not sit neatly into sectoral regulation or sit at the boundaries of the currently regulatory framework, which can result in multiple regulatory barriers to innovation in different sectors. For example, a medtech device (approved by the MHRA) could require the use of spectrum (allocated and regulated by Ofcom) and the use of data (regulated by the ICO) to enable improvements in diagnostics and treatment.

- **Regulators have to respond to emerging consumer issues** - with new technologies and innovation come new consumer issues. Whilst the Covid crisis has accelerated the move online in some consumer groups, differences in digital participation still exist. Such a divide could be exacerbated by new technologies such as the use of algorithms, which enables more sophisticated personalised pricing. Access to consumer data is also increasingly part of the 'transaction' for a service, which challenges current modes of regulation for example in respect of consumer protection and redress.

- **Future uncertainty means regulators have decide when to exercise judgement** - with the scale and pace of change, we can't assume the current market conditions will prevail.

[2] BT Group, July 2020. Response to Digital Markets Taskforce call for information (see annex 2). Section 1.1.1 (p1).

Regulators and industry players alike will need to look out decades into the future to identify the next disruptive event. However, looking into the future comes with uncertainty and less evidence on which to base decisions, so regulators will need to understand the underlying economics of the markets and the business models, so they can identify when judgement can be exercised.

- **Less reliance on competition** – there's no longer a firm belief that competition is always enough to drive the right consumer and societal outcomes in all markets, driven by a growing political pressure to create the most conducive environment for innovation and the need to ensure consumer fairness and support for those in vulnerable circumstances.

- **Greater focus required on data privacy** - emerging technologies enable large digital platforms to collect vast quantities of data about users, which users are often not aware is being collected. Regulators needs to place users/consumers at the heart of any interventions related to data so that they can meaningfully engage with how their data is used.

2.13. Technology has a role to play in the dynamics of each of these themes as they evolve. However, what is pertinent from a regulatory perspective is not 'what' these technologies are, but rather 'how' market players use such technologies to shape the industry. This will create opportunities for new services which improve experiences for people and for efficiencies which maximise value for consumers. However, it also brings potential for greater consumer harm, especially for those who are digitally unskilled.

2.14. Considering the above, regulation will need to adapt to address these themes, and to unlock those opportunities whilst mitigating the risk of consumer harm, as well as remaining flexible to support the next disruption in the market. The remainder of this section describes three ways in which the focus of Ofcom's regulation needs to change.

Outcomes-focussed Regulation

2.15. Regulation should continue in the direction towards consumer outcomes and principles-based regulation. We've seen evidence of a continued shift in this direction during the Covid-19 crisis, with Ofcom taking a pragmatic approach to applying regulation in response to CPs' response to the crisis, giving CPs the flexibility to react in the way that best supports the needs of their customers. In BT's case this meant different offerings for BT, EE and Plusnet customers, as their needs and behaviours are different.

2.16. New technology can have a positive effect on consumer outcomes (e.g. Amazon shopping experience) and in such cases the impact on the consumer comes from the use-case, rather than the technology itself (for example a 1Gbps broadband service delivers similar benefits for consumers if it is delivered over fixed or wireless technology). Ofcom should apply a technology-neutral approach, focussing on the services and products which deliver the right outcomes for consumers, rather than the preferred method of technology to generate these outcomes.

2.17. In such cases, an outcomes-focussed regulatory framework ensures that innovation is not constrained. For example, there are prescriptive regulatory requirements which only apply to fixed broadband products (e.g. the Broadband Speeds Code of Practice). [✂ confidential].

2.18. When regulation is appropriate and proportionate, it can help deliver benefits from new technologies. For example, where a technology is facing a barrier to adoption due to a lack of consumer trust, regulators can use their toolkits (see 2.21) to understand consumer concerns and the benefits that might be realised by the technology use cases. These concerns can then be addressed by proportionate, outcome-focussed, technology-neutral regulation, whilst not constraining the innovation and the benefits delivered. An example of this in action is Open Banking, where banks are still liable for customers' accounts through FCA regulation, thus increasing consumer trust in the sharing of data in order to generate a better consumer experience. In such a case, prescriptive 'rule setting' and enforcement approaches might not

be the best tools for regulating new technologies. But rather, transparency can be a regulatory tool.

2.19. However, with new technologies and innovation will come emerging consumer issues. Differences in digital participation still exist. Studies from the ONS show that 8.4% of UK adults[3], equal to 4.5m people[4] have never been online. For many, this is driven by a lack of will or interest, rather than access to connectivity; in a 2019 ONS study 34% of households (Great Britain) said a lack of skills was the reason for not accessing the Internet (second highest reason after don't need the internet)[5]. Such a divide could be exacerbated by new services enabled by new technologies. A use case such as personalised pricing which is enabled by AI as a technology could have real advantages for an engaged customer, giving them tailored prices based on their individual needs.

2.20. But, concurrently, regulation needs to mitigate the risk that new technologies become discriminatory or exclusionary for a less engaged or a vulnerable customer. This subject is already being looked at by the CMA[6] and Ofcom[7]. Both acknowledge that technology allows firms to personalise prices in a more sophisticated way, based on a customer's individual characteristics using data and machine learning, and that there are regulatory implications from this:

- The use of data is being explored across many sectors so collaboration will be required to define the right legal and regulatory framework and avoid duplication at the edge of the market.
- There are benefits for the customers such as the potential for lower prices generally where labour costs can be reduced as a result of AI, or where a customer has been identified as vulnerable, increased customer satisfaction leading to less churn, greater consumer choice as a result of more information.
- But there are also risks, such as higher prices for some vulnerable customers, confusion caused by a greater number of prices, leading to a lack of trust. The CMA has also explored the potential for collusive outcomes leading to consumers paying higher prices (although unlikely where personalised pricing is used extensively)[8].
- Implications for the market include potential for weakened competition if churn is lowered as a result of personalised pricing.

2.21. An outcomes focus to regulation gives market players the flexibility to innovate for those customers who are engaged and want services that utilise new technologies to improve their quality of life, whilst mitigating the risks identified and protecting those consumers who require support to be educated in such new technologies in order to reap the benefits.

2.22. Moreover, the definition of a vulnerable customer is affected by the direction of the market and the technologies available. We have already seen through the Covid pandemic that customers are vulnerable depending on the unique situation (NHS staff, furloughed staff, students being home-schooled). An outcomes-focussed regulatory framework needs to be broad enough to support emerging vulnerabilities but narrow enough to ensure the support is afforded to those who really need it.

[3] BSG and Comres, Feb 2019. Digital Exclusion Research. Foreword.
[4] ONS, 16 May 2020, UK population estimates in 2019.
[5] ONS, August 2019. "reasons for households not having internet access 2019"
[6] CMA, Oct 2018. Pricing algorithms.
[7] Ofcom, Aug 2020. Personalised pricing for communications.
[8] CMA, Oct 2018. Pricing algorithms.

Anticipatory Regulation

2.23. Given the fast pace of the market environment and innovation into new technologies, an "anticipatory"[9] approach to regulation will be required that acknowledges and accounts for new challenges and future uncertainty. 'Anticipatory Regulation' principles provide regulators and government with a set of behaviours and tools to help identify, build and test solutions to emerging regulatory challenges, allowing regulators to have a *'positive' role to play in shaping how markets evolve, and in particular in which innovations are developed and deployed and how.*[10]

2.24. Regulators can use anticipatory principles outlined by Nesta to maximise the opportunities and mitigate the risks of rapid technology-driven market change. The principles of anticipatory regulation are set out in figure 2.3 below[11]:

Figure 2.3 – Principles of Anticipatory Regulation

2.25. Central to the principles of anticipatory regulation is that regulatory analysis needs to be forward-facing and embrace the challenge of making regulatory decisions in the face of greater uncertainty, less evidence and a greater number of risks[12]. This approach requires wider inclusion and engagement and a willingness to test and evolve regulation.

2.26. Regulation should make a toolkit available that acknowledges that there will be future challenges and create tools that are fit for purpose to deal with regulatory problems in the face of uncertainty, thus enabling innovation. Nesta suggests the use of *sandboxes: experimental testbeds; use of open data; interaction between regulators and innovators; and, in some cases, active engagement of the public*[13]. In addition, by coupling such a toolkit with an understanding the economics of the markets and emerging business models, regulators will be able to put themselves in a position where judgement can be exercised on future developments.

2.27. We are starting to see a shift towards such practices such as the digital sandbox introduced by the FCA and the City of London corporation[14], but this approach is still in pilot phase. In

[9] NESTA. Anticipatory Regulation.
[10] NESTA, March 2019. Renewing regulation 'Anticipatory regulation' in an age of disruption. p13.
[11] NESTA, March 2019. Renewing regulation 'Anticipatory regulation' in an age of disruption. p5
[12] NESTA, November 2017. A working model for anticipatory regulation. p8
[13] NESTA. Anticipatory Regulation.
[14] FCA, July 2020. Digital Sandbox.

addition, the ICO has just re-launched its sandbox[15] designed to support organisations using personal data to develop innovative products and services. The sandbox aims to enable innovators to work with ICO specialists to identify how personal data is used in their project. This helps them comply with data protection whilst giving reassurance from enforcement action and increasing public trust. Participants have been selected, and detailed plans are now being drawn up.

2.28. However, we are yet to see whether such tools allow regulators to assess the impact of new products and services *before* deciding on the appropriate regulatory treatment, whilst concurrently allowing innovators to 'play' in a more flexible environment in order to demonstrate proof of concept. In addition, adoption of the principles could be more systematic, including in fast-moving areas like digital markets where regulatory decisions must be made in the face of greater uncertainty, less evidence and a greater number of risks. Regulators could build capabilities in this area through best practice publications and collaboration with other sectoral regulators.

Regulation which reflects changing market dynamics

2.29. As outlined in section 1, digital markets are playing an increasingly central role in the global economy. A future regulatory framework needs to balance competition at a national level to promote innovation, with the flexibility to enable industry players to collaborate and compete with global competitors. Innovation can also be promoted by enabling investment in emerging areas of the market through the removal of existing regulatory constraints.

2.30. Consumer preferences are moving towards tailored, bundled services[16] with connectivity at their heart without regard for the technology over which such services are delivered. Digital players from adjacent markets could take this a step further by partnering with traditional telcos to offer connectivity as an add-on to value delivering products such as cloud computing. Harms can arise where a firm is able to leverage market power from a primary market into an adjacent market, foreclosing rivals through unfair commercial practices. Markets tipping in favour of one or few players can lead to consumer harm along multiple dimensions in digital markets, including higher prices, lower quality, compromise to data privacy, reduced innovation or online harms.

2.31. Such market dynamics mean it is essential that the regulatory framework considers current and future market dynamics, to avoid consumer harm and promote competition. Regulators should recognise where competition is taking place on a global scale and across the value chain and what UK businesses might need to do as a result in order to acquire the scale to be able to compete in a global market. The Digital Markets Taskforce is now rightly looking at how it should create an ex-ante regime for firms with 'strategic market status'. If well-designed and -implemented, this will help ensure UK firms can compete fairly and so invest further in R&D and innovation adoption here in the UK.

2.32. As part of this look to the future, regulators should assess the impact that existing regulation has on the competitive dynamics of this wider ecosystem. Net neutrality regulation for instance, prevents telecommunications providers from charging those who benefit most from their network investments, i.e. the large digital platforms. This has contributed to the challenging investment climate faced by traditional telecoms players with no obvious consumer benefit. Similarly, if large global technology firms enter the market as connectivity providers in future, exerting competitive constraints on Openreach, Ofcom should lighten or remove ex ante SMP regulation on BT.

2.33. In addition, a more global view of the competitive landscape should drive a focus on regulation which stimulates long-term supply chain diversification, to avoid industry becoming reliant on one or two players (as is currently the case with Huawei). A different kind of regulatory intervention is required in order to stimulate such competition. New approaches

[15] ICO, Aug 2020. Children's privacy and data sharing in focus as regulatory sandbox re-opens.
[16] Ofcom, Jan 2020. Pricing trends for communications services in the UK. (p21) *"Eighty per cent of UK households buy two or more communications services from the same provider as part of a bundle"*.

such as Open RAN (see case study in section 3) offer the potential for supply chain diversification over the long term. But we are investigating the feasibility of using new technologies and vendors whilst concurrently arranging the removal of Huawei from the UK network. This approach is cost and resource heavy. We want to accelerate the progress of initiatives which explore emerging technologies, but the regulatory framework needs to support innovation by enabling investment in future technologies.

2.34. Regulators and Government can support CPs with this challenge by incentivising operator diversification R&D and enabling scale development in the UK through greater funding support. This could be by supporting trial programmes such as the Telecoms Infra Project[17] to accelerate development of new technologies, or by adapting existing resource intensive regulatory requirements in order to free up investment into R&D.

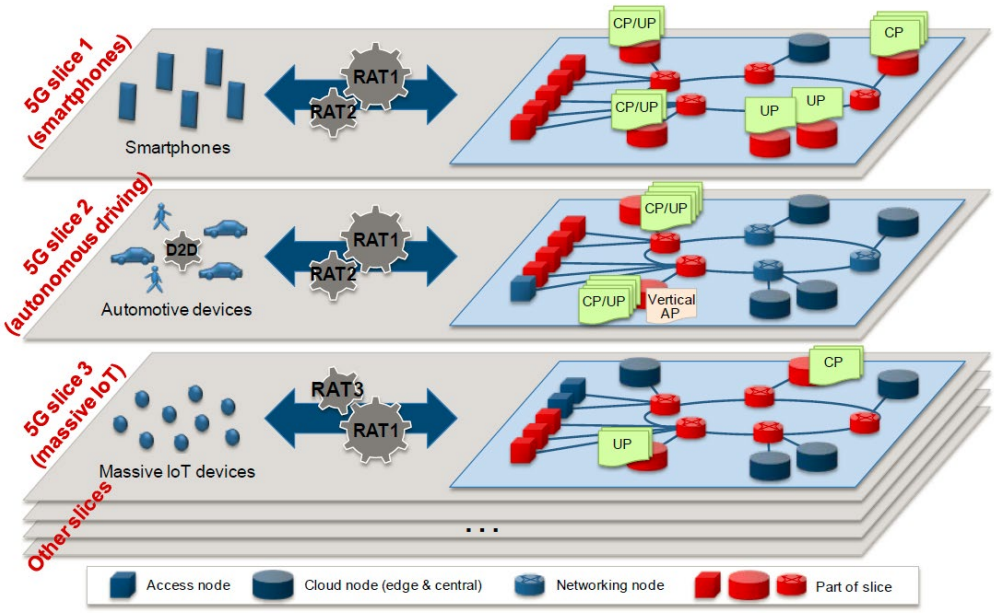
[17] https://telecominfraproject.com/

3. Case Studies

Network Slicing

3.1. Network Slicing is the segmentation of a single physical network into virtual ones, in order to provide a required level of performance (such as latency). Traditional network architectures are partitioned into virtual elements that can be linked. This allows virtual networks to be created on top of a common shared physical infrastructure which can then be customised to meet specific needs of applications, services, devices or operators. Each network slice comprises an independent set of logical network functions that support the requirements of the particular use case. Figure 3.1 illustrates the concept[18].

Figure 3.1 – Network functions to support the use case



3.2. Network Slicing is in its infancy, but we expect it to mature in the coming years to help operators address new service opportunities, thereby improving experience for people and businesses. Benefits include:

- **Flexibility** - simultaneous support can be provided for potential conflicting multiple service requirements such as high data throughput alongside low latency. Optimisation of each slice for the specific functionality required enables the delivery of these valued services to people and businesses, thereby improving the customer experience.
- **Agility** – new services can be deployed rapidly without disruption to existing services, again improving the experience for people and businesses.
- **Extensibility** – Different SLAs (e.g. security, reliability, latency etc.) may require isolation between different slices. Slicing can be done on a per service-type or even for individual customers, providing a bespoke service for people and businesses.
- **Delivery of new services** - operators will be able to gradually support new services as they deploy an increasing number of "network slicing enabling features" across their different network domains. Figure 3.2 illustrates some 5G use cases for network slicing.

[18] NGMN Alliance, Feb 2015. 5G White Paper. p47.

Figure 3.2 – 5G use cases for network slicing

3.3. As network slicing technology matures, providers will need to be able to ensure that from a technical point of view they can deliver the features and customisation required by the customer without impacting performance and service levels on other "slices". Slices will need to be sufficiently isolated to ensure demand and/or service upgrades on one slice don't affect another. In addition, in future, traffic patterns may become unpredictable as the number of slices and services grows. Providers will need to have some certainty that the infrastructure will exist to provide value adding services, before they invest in the technology at scale.

3.4. In order to support technology such as network slicing, regulators should assess the impact that existing regulation has on the competitive dynamics of this wider ecosystem. In particular for network slicing, a review of the BEREC net neutrality guidelines and the definition of "*specialised services*" and "*detriment to the general quality of the IAS*"[19] is required to ensure we can deploy the capabilities and enable additional services for consumers and businesses. Without some control over the way traffic is prioritised on different slices of the network, some of the benefit for consumers will not materialise.

[✂ confidential]

3.5. [✂]

3.6. [✂]

3.7. [✂]

3.8. [✂]

Figure 3.3: [✂]

3.9. [✂][20]

3.10. [✂]

[19] BEREC, June 2016. BEREC Guidelines on the Implementation by National Regulators of European Net Neutrality Rules. Article 3(5).
[20] [✂]

3.11. [✂][21] [22] [23] [24] [25]

3.12. [✂]

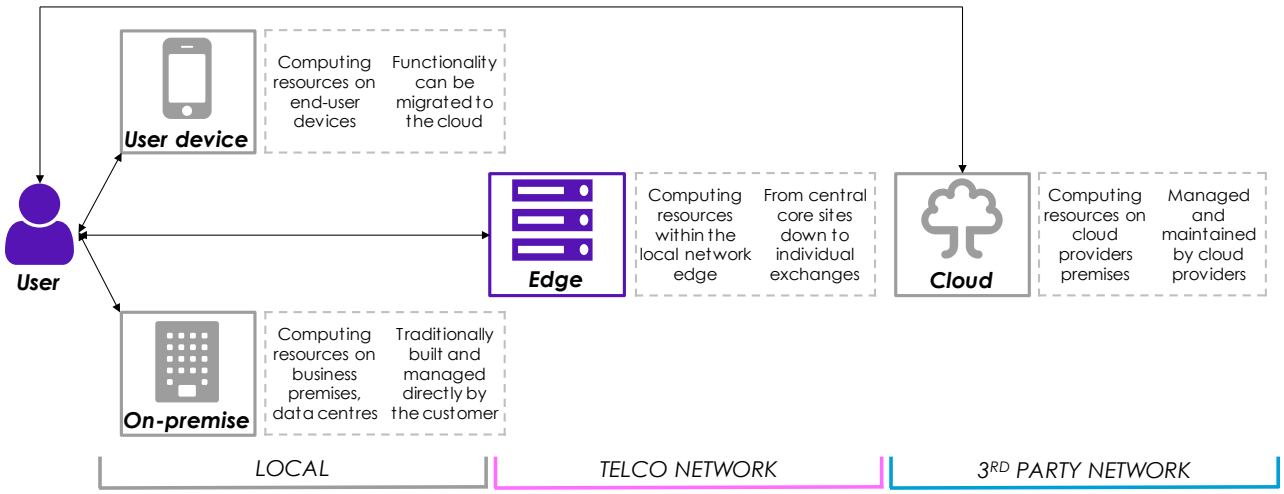
Network Edge

3.13. Edge computing is a fast-growing digital market, where edge platforms provide applications closer to the end user. The demand for edge computing is expected to grow rapidly, in part because of the vast amount of traffic that is expected to be generated by Internet of Things (IoT) devices and other applications such as self-driving cars and robotics. These devices and applications are increasingly placed at the edge of local area networks, which avoids the need to carry all information across the whole network to cloud-based applications. For example, data from sensors in factories can be analysed by critical industrial systems at the edge where low latency is essential.

3.14. Edge computing deployed within a local area network will be specific to that customer and most likely a particular application. Edge computing can also be deployed within the communications networks to provide a capability for multiple customers and applications i.e. network edge.

3.15. Figure 3.3 shows how computing capabilities can be hosted at different locations, and how network edge compares to other forms of hosting

Figure 3.4: Computing Capabilities at Different Locations



3.16. Hosting computing capabilities at the network edge has several advantages over the alternatives:

- Latency: Applications hosted at the network edge improve the performance of latency sensitive applications, such as in gaming or in machine sensors, improving the experience for people.
- Predictability: The latency of applications hosted at the network edge have greater predictability than cloud-based applications accessed over the Internet.
- Bandwidth: Delivering services closer to the end customer has the potential to reduce network contention and increases available bandwidth, thereby increasing performance of the network and reducing the cost of delivering the service, and ultimately maximising value for the customer.

[21] [✂]
[22] [✂]
[23] [✂]
[24] [✂]
[25] [✂]

- Security: Processing sensitive data at the network edge means it is exposed to fewer external threats via the internet, enhancing security and resilience.

3.17. In order to deliver a network edge service, a provider must integrate a range of different capabilities across the edge value chain. Large Digital firms are well positioned to extend their cloud computing capabilities to provide a scalable, closely coupled platform across the value chain, as demonstrated by figure 3.5 below which shows the role of digital platforms in the network edge value chain:

Figure 3.5: Digital Platforms in the Network Edge Value Chain

Capabilities	Description	Players in market
Applications	End user software that serves a customer need	Ambient.ai, Microsoft, G Suite, X.CLOUD
Platform	Scale-able 'Sandbox' capability for application developers	Anthos, Windows Azure, amazon web services, Elastic Beanstalk, MobiledgeX
Middleware (Operating System, Virtualisation)	Compatible operating system that integrates with multiple platforms	CANONICAL, Windows Server, Linux
Hardware (Server, Storage, Networking)	White-label hardware with multi-platform capability	DELL, cisco, hp, intel
Real Estate (Connectivity, Cooling, Power, Space)	Infrastructure and access to network edge	BT, vodafone, 3, O2

3.18. Such positioning in the value chain can drive several features of the market:

- a multi-sided market - the platform can monetise on either side of the market (although currently principally by selling to applications rather than to end users)
- network effects leading to tipping - applications are likely to seek access to a large (potentially global) market, and new market entrants in particular benefit from using a single platform to provide network edge services due to lower costs, less complexity and unified security. As the platform attracts more applications as it grows bigger and reaches global scale. Over time, the strength of network effects could lead to further concentration in the market and tipping towards one or few players.
- Leveraging adjacent markets – as network edge platforms have close links with cloud computing, applications interested in network edge often purchase cloud computing services simultaneously, unlocking benefits such as low latency and access to data in a centralised location.

3.19. The leading position of AWS, Google and Microsoft both in network edge and cloud computing shows how competitive advantages in cloud can be leveraged into network edge in a manner that rivals not active in cloud computing cannot replicate as they cannot replicate the scale, APIs and access to relevant data that large tech firms active in cloud computing have.

3.20. Should such features materialise, future partnership relationships would be affected, generated by an imbalance of power. Large global players would be able to consolidate their position across the entire ecosystem and leverage into other markets to expand the ecosystem even further, in a way that limits rival firms' ability to compete on fair terms. As a result, smaller firms would find themselves tied into unfavourable contract terms, impeding future growth (and therefore competition) and risking consumer harm as costs are passed through to the end user.

Low Earth Orbit Satellites

3.21. Low earth orbit (LEO) broadband satellites orbit 500 to 2000 kilometres from earth and can deliver high speed satellite internet through a network of multiple satellites. Some proposals ultimately aim to provide an alternative network in space through the satellites communicating with each other (similar to the narrowband Iridium system). SpaceX, OneWeb and Telesat are launching LEO constellations aiming for commercial offers as early as 2020, while Amazon has shared its plans to launch thousands of LEO satellites (Project Kuiper) to provide broadband services around the world over the coming years. Although timing and pricing of these services remain uncertain, they may pose a medium-term risk to fibre investment in some rural/remote areas.

3.22. The technology is emerging – broadband LEOs (not to be confused with narrowband LEO systems such as Iridium, Globalstar and Orbcomm) are new and not yet proven at scale, so we're unsure how these services will evolve in the near-term. But they offer the prospect of commercial broadband with terrestrial-like latency and similar speeds to cable, high-speed copper and 4G fixed-wireless, ranging from 100Mbps to gigabits per second. In addition, they could offer a lower cost alternative for delivering high speed connectivity to hard to reach, rural areas.

3.23. In order to make an LEO offering viable at scale, investment from Governments and Regulators may be required, and we have seen appetite for this already in the Governments acquisition of OneWeb[26]. Within the timeframe of fibre investment (i.e. over several decades) these technologies could offer a high-quality alternative, initially to dispersed rural fibre customers but given the scale of investment to the mass market in the longer term, and this is a risk borne by fibre investors and traditional players in the telecoms sector.

3.24. Regulation today needs to take into account the possibility of future emerging technologies, focussing on the outcomes for consumers, rather than the technology that delivers those outcomes, whilst promoting investment in new and existing technologies. This would enable choice for customers whilst providing certainty for investors in the long-term regulatory environment. Ofcom's current policy intent is to promote investment in full fibre and 5G networks and does not consider LEOs as a potential medium to long-term alternative to these networks. In forming today's regulation, Ofcom should reflect the uncertainty LEOs pose to investors in full fibre and 5G networks, without which such investors may not be willing to commit sufficient capital to meet Ofcom's policy goals. In practical terms, this includes stating the risks posed by LEOs upfront as part of the 'fair bet' framework in Ofcom's Wholesale Fixed Telecoms Market Review. This will give investors the confidence that they will have the opportunity to earn sufficient upside return in compensation for the downside risks (including those posed by LEOs) associated with investing in full fibre networks today.

3.25. In addition to commercial broadband it has been suggested that OneWeb may also form the basis for a UK Global Navigation Satellite System (GNSS). We do not believe the current platform or satellite constellation plans are capable of supporting GNSS. If the UK GNSS is to be based on OneWeb then technical requirements and the impact on its broadband capability should be established quickly.

Open RAN

3.26. Open RAN consists of a group of technological approaches designed to make the radio access network (RAN) more cost effective and flexible, summarised as "Flexible, disaggregated RAN". Open RAN is an example of Network functions Virtualisation (NfV) and Software Defined Networks (SDN) (see below), and involves a shift away from traditional, proprietary radio hardware and network architectures towards new, virtualised platforms and a more open vendor ecosystem.

- Network Functions Virtualisation - network functions such as network security and routers are implemented as software that can run on standard IT hardware. Replacing specialised network appliances. The decoupling of the software from the hardware allows greater flexibility in the deployment & management of network functions.

[26] https://www.gov.uk/government/news/uk-government-to-acquire-cutting-edge-satellite-network

- Software Defined Networks - software-based network control functions are separated from the data forwarding functions such as routers and firewalls. The network functions may be dedicated hardware or virtualised i.e. NfV.

3.27. The three key components of Open RAN are:

- **Virtualised RAN** – RAN components implemented as software functions are more flexible as they can be updated, scaled up/down and moved more quickly
- **Disaggregated** – Allows for centralisation of many RAN functions (Cloud RAN). For better coordination between RRUs, and more efficient processing. Uses the O-RAN architecture for Central Unit/Distributed Unit/RAN Radio Unit disaggregation
- **Open interfaces** – To allow for the RAN components to come from different vendors. The open interfaces should be 3GPP and O-RAN compliant

3.28. The use of Open RAN has several advantages over the traditional network architectures:

- **Diversification of the Supply Chain** – the traditional radio access network relies on dedicated hardware which is compatible across the network to deliver functionality; the market is dominated by Ericsson, Huawei and Nokia, and proprietary extensions and features mean that telcos must buy from a single vendor in a geographic region (to ensure handover works correctly, for example). This over time has led to consolidation in the equipment supply chain and is something that the industry is currently dedicating time and effort to address in the removal of Huawei equipment. Open RAN on the other hand is software based, moving towards virtualised platforms and a more open vendor ecosystem. This shift allows smaller suppliers to enter the market, creating resilience, as reliance on one vendor is reduced, and competition.
- **Cost reduction and efficiencies** – a software-based approach provides more effective control and programming of capacity, latency, spectrum usage and service quality, resulting in a more efficient network and reducing the cost of delivery of services. Greater diversity in the supply chain should also reducing cost thereby maximising value for customers.
- **Enabling new services** – Open RAN introduces greater flexibility into the network by allowing, for example, access to lower layer data and control functions. These can enable the delivery of 5G core-enabled technologies and new services such as network slicing and private networks, which are highly valued by people and can improve overall user experience.
- **Connectivity in hard to reach areas** – Open RAN technology has the potential to be a more cost-effective way of enabling 4G connectivity in areas which have been hard to reach previously. This could help to plug the gaps in current 4G networks, improving the experience for people.

3.29. The ongoing industry response to consolidation in the equipment supply chain (particularly for radio access networks) has been a drive for the development for open architectures which incorporate telecommunication standards. New approaches, such as Open RAN, offer the potential for this over the longer term with the right support from Government and Regulators. However, in the short-term, Open RAN is very unlikely to be a solution to consolidation in the network, due to lack suppliers, so we will continue to rely predominantly on scale global vendors.

3.30. For the longer term, Government and Regulator support will be necessary to accelerate progress and enable scale deployment in the UK as soon as possible within the next decade. In particular, greater funding support for a Future Network Initiative (FNI), potentially through the DCMS 5G Testbeds and Trials programme, could offer an operator-class research platform for universities and companies to trial new approaches to network deployment and operation, to collaborate to build and prove end-to-end solutions, and to test hardware and software in a scaled environment. An FNI could be the focal point of R&D initiatives to support the telecoms supply chain, while complementing the proposed National Telecoms Capability (which will focus on the testing of security of new equipment for the UK market). A regulatory framework in turn will need to be set up to support such testing and collaboration.

3.31. It's worth noting that funding capacity within the industry is constrained, with available capital dedicated to existing infrastructure commitments and resource intensive programmes (such as the removal of Huawei). Regulators should also consider how they can incentivise investment in diversification of R&D through the redirection of resource and costs from existing regulatory requirements. [✂ confidential]

Drones

3.32. Drones, or unmanned aerial vehicles (UAV) are aircrafts without a human pilot on board. Drones can be operated by human remote control, autonomously by onboard computers, or piloted by a robot. At present Drones are most commonly used in visual line of sight (VLOS) but looking forward we expect to see uses beyond VLOS (BVLOS) such as autonomous delivery flights. Looking even further into the future, Drones and autonomous vehicles could become ubiquitous as companies such as Uber[27] develop air taxis.

3.33. The increasing use of Drones in the UK business sector and public services will play an important role in the UK economy. A study from PwC[28] indicates Drones can produce an uplift to the UK GDP of £42 bn over by 2030, employing 628,000 people. Examples include:

- Drones can make a crucial difference in monitoring the impact of global warming, controlling risks, manging costs and improving safety.
- Drones can be used in Health for the emergency delivery of blood samples and NHS has been trialling them for the COVID response. This would enable the delivery of new services which are valued by people and businesses.
- Utility companies are increasingly deploying them to survey remote infrastructure, reducing costs and risks for their staff, and increasing network access. They can also be deployed to increase network access in emergency situations as 'flying cell towers' [29].
- They can also be used in logistics such as in the retail sector, ports or 'private campuses' to optimize supply chains, asset management and provide security services, substantially improving efficiency and response time.

3.34. It is clear from the use cases that Drone technology cuts across multiple sectoral regulatory frameworks. Connectivity in particular will be a central theme as the technology develops: Drones are connected machines and will need connectivity not just for 'command and control' but also for their 'payloads' (live or recorded videos to be streamed back to the control units). Existing regulations in different sectors are considered a major barrier to the adoption and scalability of drone technologies. /Ofcom should maintain and accelerate a constructive dialogue with air space regulatory bodies (e.g. CAA) and other stakeholders (including data regulators such as the ICO) to define as soon as possible a clear, innovation-friendly framework for the UK allowing the private sector to unlock the benefits that drones can bring to society and the economy as a whole. In particular, Ofcom should implement directions from CEPT/ECC as soon as feasibly possible. Current findings[30] indicate the limited interference caused by drones and their potential coexistence with traditional devices on 4G network, effectively recognising and empowering the role and the benefits that cellular technology can bring to the Drones ecosystem.

3.35. What is more, regulators have a part to play in enabling the benefits from Drones to be realised in society. A proportionate, transparent regulatory framework could help people become comfortable that the technology is safe and secure, and so unlocking all of its benefits. We understand that the new Regulatory Horizons Council will be looking at drones as one of its early priorities.

Smart Cities

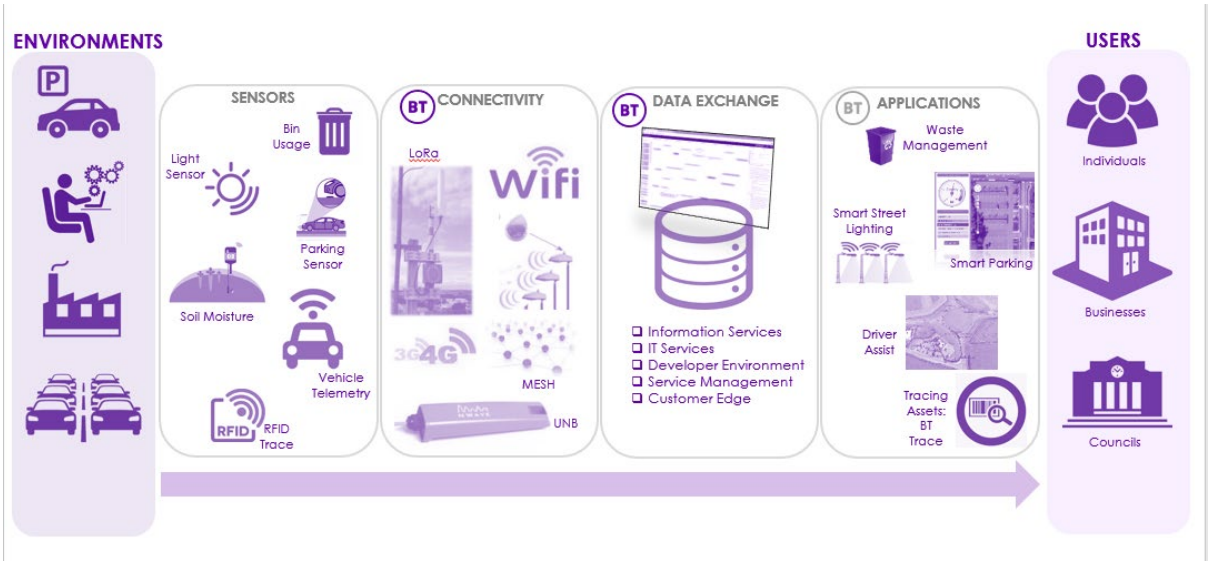
[27] https://www.uber.com/us/en/elevate/
[28] PWC, 2018. Skies without Limits.
[29] https://www.wired.com/brandlab/2018/11/bird-plane-flying-cell-tower/
[30] ECC, July 2020. Analysis of the usage of aerial UE for communication in current MFCN harmonised bands.

3.36. Smart cities are places where existing networks and services are made more efficient through the use of digital technologies for the benefit of residents and businesses in that area. In this sense, smart cities may be viewed not as a new technology, but the application of several new technologies to deliver new and more efficient services in a particular area. These technologies can help deliver better traffic management, improved water and waste services, more efficient lighting and energy use in buildings and safer infrastructure, among other benefits.

3.37. Different layers of technology, communications, data exchange and applications are required to make a city 'smart'. As shown in Figure 3.6, these include:

- The sensors and instrumented systems: IoT-based sensors and control systems. These may be deployed local authorities, citizens or application service providers.
- Connectivity: a variety of technologies to connect sensors with data exchange services and applications
- Data exchange: A trusted and secure capability to allow transfer and sharing of data between applications and services.
- Applications and services: smart city services include smart parking, smart lighting, waste management and asset tracking

Figure 3.6 – Layers required to make a city 'smart'



3.38. All layers working together will enable the growth of smart cities. The global smart city market is predicted to grow to more than $2.5trn by 2025.[31]

3.39. Smart cities provide a host of benefits for residents and businesses. They can improve connectedness (both physical and digital) between residents, improve environmental quality, improve health outcomes, enhance safety and provide more jobs in a particular region. The scale of the benefits means there is an opportunity for government to facilitate and support investment and adoption of these new technologies.

3.40. For example, in Milton Keynes, MK:Smart was developed as collaborative initiative between businesses and government, partly funded by the Higher Education Funding Council for England, to develop innovative solutions to support innovative growth in Milton Keynes.[32] An important component of this project was to develop 'MK Data Hub', which collects huge amounts of data about energy usage, transport, social and economic factors, to better manage resources within the city. BT worked with local government in Milton Keynes, alongside other commercial partners, to deliver this Data Hub, and BT was awarded for its smart city data hub service management functions.[33]

[31] PwC. Creating the smart cities of the future.
[32] MK:Smart. About.
[33] MK:Smart related project wins coveted award at TM Forum Livev. 30 May 2017.

3.41. Regulators can also support the growth of smart cities, by removing certain barriers to use cases, and enabling greater fair competition that promotes investment in the technologies that enable smart cities. In particular, we believe Ofcom and other regulators can assist with:

- **Net Neutrality** – Covid has demonstrated that we sometimes need to prioritise the traffic on our network to keep essential services running. This will be pertinent with smart cities with emergency services alongside other use cases. In the long term, greater proliferation of slicing and private networks will also drive this need so that different applications can use the most efficient part of the network to reach the end user, without compromising the quality of other applications.
- **Cross-sectoral collaboration** – The number and variety of stakeholders operating within smart cities makes them a complex environment. Regulators will need to focus on communications plans to mobilise a complex set of stakeholders (e.g. local councils, schools) in order to enable the innovation to happen at pace and scale. Regulators can also assist with collaboration across sectors. For example, BT's InLinks in smart cities require collaboration between stakeholders in digital connectivity, transport and energy so they can users with information of air quality, traffic control and provide personal device connectivity.
- **Merging of infrastructure and digital markets** – the convergence of these two worlds raises issues around the use of personal data and privacy. This reiterates the importance of making the end user central to the design of any data remedies, such as interoperability, when the Digital Markets Taskforce considers applying data remedies in certain digital markets.
- **Regulate the right players** – Regulators need to look across the value chain and regulate the players with market power in digital markets, taking into account the economics of these markets including their two-sided nature and susceptibility to 'tipping points'. As the CMA has discussed in its digital advertising market study, digital players with 'strategic market status' can leverage market power into adjacent markets in a manner that impedes fair competition from rival networks. In the context of smart cities, where different services in different parts of the value chain may be procured by a single provider, there is additional risk of large digital firms leveraging market power to unfairly capture the entire value stack. Regulators should ensure fair pro-innovation competition from smaller players is not prevented.
- **Interoperability** – Smart cities require interoperability between devices and applications in order for end users to receive the benefits of greater interconnectedness within the city. Regulators have a large role to play in helping to develop these systems with open standards and set rules so that large digital firms with market power do not design standards that give preference to their own services.
- **Shift in the value chain at the network level** – smart cities may change the connectivity needs of consumers, potentially with greater use of dark fibre access services to give businesses more flexibility over the connectivity needs. Ofcom's regulatory framework needs to consider changes in usage of dark fibre over time when setting regulation of dark fibre in wholesale fixed markets.

4. Our approach and next steps

4.1. In response to Ofcom's Call for Inputs we have identified the technologies we are aware of that will have an impact on the areas that Ofcom regulates in future. We have included a long list of these technologies in excel format (see appendix 1).

4.2. For each technology identified, where possible, we have provided:

- A brief description of the technology
- a view of the potential impact of the technology on the sectors Ofcom regulates, the criteria listed in section 3.16 of the Call for Inputs document;
- the current state of development of the technology, including any demonstrations of feasibility;
- any unresolved issues or barriers which need to be addressed for the technology to achieve full potential;
- references to key publications and the leading groups working on the technology;

4.3. In some cases, the technology is very new or still in early stages of the development so we can't be sure of the impact of the technology on the industry. In such cases we've still included these technologies, so we can have further discussions with Ofcom if of interest.

Next Steps

4.4. We would be very happy to discuss any of the technologies we have provided in our appendix 1 in more detail, acknowledging that we have more information on some areas than others.

4.5. However, we're particularly keen to discuss Network Edge, Open RAN [✂ confidential], as we have identified these technologies as potentially having a significant impact on the market dynamics and therefore the regulatory framework.

5. Annex 1 – Long List of Emerging Technologies

5.1. Annex 1 is available separately.

6. Annex 2 – BT's Response to Digital Markets Taskforce call for information

6.1. Annex 2 is available separately.