SPC Network

Report for Vodafone UK

Consumer Benefits from 5G Mobile: A Process not an Event

December 2021

SPC Network
Chapel House
Booton
Norwich NR10 4PE
United Kingdom
www.spcnetwork.uk

About SPC Network

SPC Network was founded in 2003 and has worked for over 50 clients worldwide. We undertake Strategic Policy Development in platform and networked industries, by combining the knowledge of our consultants with specific and valuable skills to ensure rigorous analysis and exceptional advice. Our core consultancy team and network of partners have substantial experience in industry and consulting meaning that we understand the practical issues and challenges facing the market. Through advanced academic training, we have developed the key skills and rigorous approach needed to support our clients in the policy debate.

www.spcnetwork.uk

TABLE OF CONTENTS

1 EXECUTIVE SUMMARY

1.1 Introduction

1. 5G mobile communications, built on the three "pillars" of enhanced mobile broadband (eMBB), ultra-reliable low latency communications (URLLC) and massive machine type communications (MMTC), will deliver qualitatively different services to consumers than those delivered by 4G.

2. The incremental value of 4G was calculated as delivering £20 billion of consumer surplus over ten years[1] and as adding 0.7%, £14 billion, to GDP per annum[2]. The value of 5G is likely to be greater, it not only delivers higher broadband speeds but also dynamic benefits based on the other pillars. The annual benefit of just the business applications of 5G to the UK economy has been estimated at £15 billion[3], but as yet the additional economic value of consumer applications has not been calculated.

3. This report shows that the additional economic value of consumer benefits will be substantial: offering consumers private benefits, ranging from time saved to an improved quality of life, to societal benefits, such as greater social inclusion and reduced carbon emissions. We identify in this report that 5G is a process not an event, these benefits will emerge over time as 5G protocols develop and are adopted by network operators, app developers and consumers.

1.2 A Framework for Assessing Consumer Benefits

4. This report takes a structured approach to identifying the benefits of 5G for consumers specifically and finds that these benefits exist on two dimensions: static vs. dynamic and immediate vs. medium term vs. long term.

5. Static benefits deliver the same functionality as 4G but at a lower cost to the operators that is likely to be passed on to consumers via lower prices. Dynamic benefits are the ability for consumers to use mobile communications in qualitatively different ways to how they are

[1] Ofcom (2013) Press Release *Ofcom announces winners of the 4G mobile action* 20th February 2013
[2] Deloitte (2018) The impacts of mobile broadband and 5G: A literature review for DCMS.
[3] WPI Economics (2020) Levelling Up: How 5G can boost productivity across the UK.

used today. Static benefits are largely delivered over eMBB, whilst dynamic benefits require eMBB, URLLC and MMTC in various combinations.

6. The second dimension is the delivery of benefits over time. Whilst developments of mobile communications are referred to by "generations", each generation consists of a number of Releases of protocols by 3GPP[4] that support developing applications. What we know as 5G began with Release 15 in 2018, but has developed with Release 16 and Release 17, scheduled for 2022. These Releases need to be built into networks and user devices and finally adopted by app developers and consumers to support applications.

7. We have adopted Ericsson's language for naming the stages of application development as "business ready" "showcase level" and "R&D level".

1.3 Consumer Use Cases

8. We have identified many consumer use-cases of 5G, based on the two dimensions described, just a few of which have been described in this report. This selection of use cases is summarised in Table 1 and is likely to deliver the benefits to consumers set out in Table 2.

Table 1: Consumer Use Cases

	Business Ready	Showcase Level	R&D Level
Dynamic	Best Seat Experience.	Virtual Reality Social Media In-car entertainment.	The Metaverse. Haptic Internet. 5G hearing aids. See-through car.
Static	Faster downloads. Time saving of around 85%. Fixed Wireless Access	5G Broadcasting, due Release 17.	None identified. (Static benefits unlikely to be at R&D stage.)

9. In addition to direct benefits to consumers, 5G is likely to generate positive externalities, supporting social inclusion and the net zero target. The dynamic benefits shown in the table nearly all promote social inclusion by allowing users to take part in activities that might otherwise be closed to them. For example, Best Seat Experience can make an elderly or

[4] 3rd Generation Partnership Project

physically limited person feel as if they are attending an event alongside family members. 5G earphones allow wearers a better aural experience, bringing them into social activities from which they could otherwise be excluded.

Table 2: Consumer Benefits per Use Case

		Private benefits					Social benefits	
		Time saving	Enhanced Experience	Improved quality of life	Remove duplicate product	Physical safety	Social inclusion	Net Zero
Consumer Use Cases	Faster download or films etc.	✓	✓					✓
	5G FWA		✓		✓		✓	
	5G Multicast		✓		✓		✓	
	Best Seat Experience		✓	✓			✓	
	VR Social Media		✓				✓	
	In car entertainment/ workspace	✓	✓					✓
	Metaverse		✓					
	Haptic Internet	✓	✓	✓			✓	
	See through car					✓		
	5G Hearing aids			✓			✓	

10. These benefits of 5G will improve the lives of consumers, including vulnerable consumers, and society more generally in ways that are hard to quantify. In theory quantification would be possible based on measurements such as: the value of time saved from faster download times; the reduced cost of road traffic accidents by the improved safety of the "see through car"; and quality of life improvements from 5G hearing aids. We expect that the sum of all financial benefits would be very large.

1.4 Implications for Ofcom's Mobile Strategy Review

11. In the terms of reference for the mobile strategy review, Ofcom identifies that competition between vertically integrated mobile network operators and a range of resellers encourages

investment and innovation that delivers consumer benefits[5]. Taken together with the findings of this report, there are three implications for the mobile strategy review:

- It is critical that government and Ofcom recognise the substantial personal and societal benefits of 5G for consumers, even though some may still be speculative and not easy to quantify at this early in the technology's development. 5G applications using the URLLC and MMTC pillars are likely to be transformational, but it is uncertain which application types will be successful. This makes the 5G business case more risky for investors. Government and Ofcom support for a pro-investment 5G deployment regime that would enable it to be rolled out in full across the entirety of the UK would ensure that personal and societal benefits can be delivered to all consumers.
- Ofcom should be aware that the 5G ecosystem and financial models are not yet developed. It is not yet clear how 5G will be monetised, or by whom, and Ofcom should take account of this uncertainty in its decision making and allow the market to establish such financial models.
- Full 5G roll-out is a process not an event and this should be reflected in the regulatory framework. Much in the way they have for fibre, Government and Ofcom need to put in place a long term regulatory and pro investment framework to promote investment confidence.

[5] Ofcom (2021) *Mobile Strategy: Terms of Reference* 11 May 2021. Para 1.7

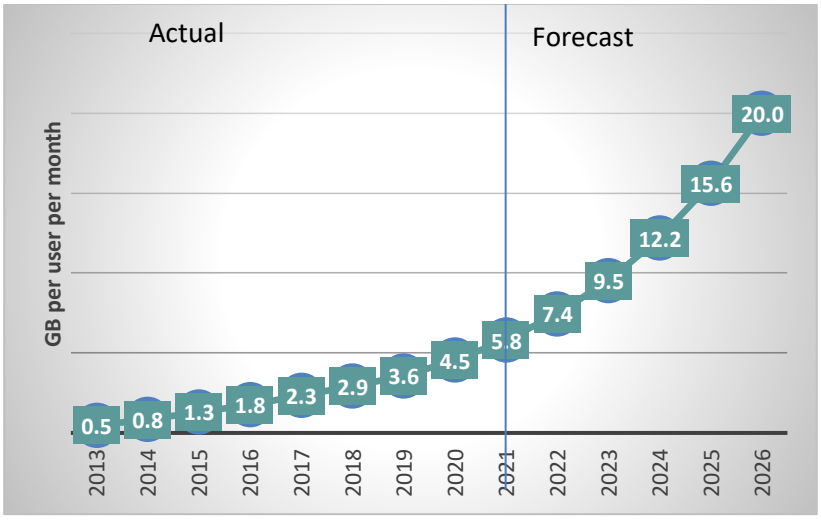
2 INTRODUCTION

12. This report has been prepared for Vodafone as a contribution to Ofcom's strategic review of markets that deliver mobile services (mobile strategy review)[6] and focusses on the use cases and benefits of 5G for residential consumers.

13. Ofcom refers to "a growing demand for high-quality mobile connectivity", which is likely to "be further driven by the development of innovative new services […] particularly if they become mass market applications that are used on-the-go"[7].

14. This growing demand can already be seen in an increase in monthly mobile data usage per user identified by Ofcom, which grew tenfold between 2103 and 2020. Ericsson predicts that in western Europe there will be a 28% compound annual growth rate in data usage between 2020 and 2026[8]. If this growth rate were to apply to the UK, then by 2026 the average user's data consumption would increase from 4.5 GB per month in 2020 to 20GB per month in 2026 as shown in Figure 1.

Figure 1: Monthly Mobile Data Usage per User: Actual and Forecast



Source: Ofcom Communications Market Report 2021, SPC Network

[6] Ofcom (2021) Mobile Strategy: Terms of Reference 11 May 2021

[7] Ibid Para. 1.11

[8] https://www.ericsson.com/en/mobility-report/dataforecasts/mobile-traffic-forecast?gclid=Cj0KCQjwqp-LBhDQARIsAO0a6aLF4x83bLXqYvFrcxG_k-xaJDQIi085HpaP2gFVmMyzt3x0FJ_EuAcaAl9zEALw_wcB&gclsrc=aw.ds Accessed 14th October 2021

15. It should, however, be noted that the significant growth in mobile data has not been accompanied by growth in market revenue. Enders Analysis has found that mobile service revenues in the UK have declined by around 5% over the period June 2009 to June 2020, caused by both competitive intensity and "regulatory hits"[9]. Ofcom's data show an even sharper fall of 32% between 2012 and 2020[10].

16. The change from 3G to 4G was primarily one of much improved mobile broadband and delivered consumer benefits through lower prices and increased consumer welfare. In 2013, Ofcom stated that it had "estimated the value of the benefits which 4G services will provide to UK consumers over the next 10 years (the 'consumer surplus') is likely to be at least £20bn" largely from the growth in data consumption driven by 4G[11].

17. The move from 4G to 5G is more qualitative: allowing new potential applications based on low latency and massive machine type communications as well as enhanced mobile broadband. Therefore, the value of the dynamic benefits of 5G are harder to definitively calculate today, especially given the uncertainty as to which of the applications that can be identified today will deliver improved utility to consumers and which will not. Commensurately, benefits that are harder to identify increase investment risk.

18. A literature review conducted for DCMS by Deloitte[12] on the impacts of 5G found "a clear agreement in the literature that mobile broadband is associated with significant positive impacts on national economies". The review quoted a 2014 study by Capital Economics for EE that found 4G technology adds 0.7% of the GDP to the economy each year, which would translate to a financial value of £14 billion p.a. based on the 2014 GDP figure or £140 billion over 10 years. The Deloitte report states later that "existing evidence, though limited, suggests that 5G could have macroeconomic impacts that are comparable to previous generations"[13].

[9] Enders Analysis (2020) Back in Play: Merger Prospects in UK Mobile Resurrected.
[10] Ofcom (2021) *Communications Market Report 2021*
[11] Ofcom (2013) Press Release *Ofcom announces winners of the 4G mobile action* 20th February 2013
[12] Deloitte (2018) The impacts of mobile broadband and 5G: A literature review of DCMS. Page 8.
[13] Ibid. Page 19.

19. A report for Vodafone in 2020[14] showed that 5G is, indeed, likely to have comparable economic impacts. It estimated that 5G would add approx. £15 billion p.a. to GDP for the next ten years, totalling £150 billion. However, this number is based only on business applications and does not include the economic benefits for consumers.

20. All forecasts have an inherent level of uncertainty, but there is no credible scenario that does not see continued growth in per capita consumption of data and with it growth in the value of the mobile market to the economy. The speed at which this value is delivered is likely to be dependent on the speed of 5G roll-out and the ubiquity and quality of coverage. Whilst policy makers will always rely on imperfect forecasts, the central thesis of this paper is that policy must allow for continued growth in data usage driven by both consumers and businesses.

21. Against this background of rapid growth in mobile data usage, Ofcom states that it wants to develop a strategy that supports the delivery of high-quality mobile connectivity and innovation to meet the future needs of people and businesses. Specifically, it wants to consider how these needs are likely to evolve and what new use cases might become possible in future. Ofcom states that this information will inform the high level outcomes it should be trying to achieve[15].

22. Much has already been written about potential consumer use cases and benefits of 5G, in particular by vendors such as Ericsson, Nokia and Huawei, all three of whom have a strong interest in selling 5G equipment to operators and consumers. These reports provide useful insights into the type of applications that 5G can support and the qualitative

> *"Delivering enhanced mobile broadband, ultra-reliable and low latency communication and massive machine-type communication, 5G applications represent tremendous" opportunities for consumers, homes, businesses and communities" (Huawei)*

> *"As the latest and most capable mobile network, 5G will underpin the growth of the digital economy in many countries, This explains a lot of the government -backed activities around the world that seek to influence or accelerate the pace of 5G deployment and commercialisation" (GSMA)*

[14] WPI Economics (2020) Levelling Up: How 5G can boost productivity across the UK.
[15] Ofcom, op. cit. Para 1.14

changes 5G will bring to consumers and businesses, and so form an important body of existing knowledge. However, the level of hype generated by some industry commentators may be counterproductive. Policy makers should, of course, retain some detachment from the hype, but also need to be careful not to overreact against the hype and become overly sceptical.

23. Vodafone has, therefore, asked SPC Network to review the consumer benefits of 5G communications in a structured and rigorous manner. Recognising the degree of uncertainty about the future consumer use cases of 5G, this report explores their benefits highlighting that 5G is a process not an event and that the qualitative changes under 5G introduce new capabilities that will take time to "play out" on both the supply and the demand sides. Our analytical framework and case studies provide a reasonable basis for thinking about potential future benefits.

24. The range of future applications, and the probability that other consumer use cases will emerge over time based on the three key pillars of 5G, suggests that basing a valuation of the future market on past evidence from 4G, or on business applications of 5G only, is likely to be an underestimate. 5G offers not only enhanced mobile broadband but also massive machine type communications and ultra-reliable low latency that, our report shows, will deliver benefits that cannot yet be valued.

25. We have also been asked to consider what direction the strategic mobile review should take to support mobile network operators' (MNOs) investment in consumer use cases.

26. This report is structured as follows:

    - Section 3 sets out a framework for assessing the consumer benefits of 5G;
    - Section 4 describes some of the likely use cases and benefits for consumers of 5G that fit into this framework and the private and social benefits they will deliver. At the end of each sub-section is a table summarising the benefits;
    - Section 5 considers the implications of this report's findings for the mobile strategy review.
    - Annex A provides a longer, but by no means exhaustive, list of consumer use cases by benefit type and sources of further information.

3 A FRAMEWORK FOR ASSESSING CONSUMER BENEFITS OF 5G

27. In this section of the report, we set out a framework for identifying and assessing consumer benefits from 5G. This framework has two dimensions: dynamic vs. static and, immediate vs. medium term vs long term, and so identifies six potential benefit types.

28. This systematic way of identifying 5G consumer use cases highlights that the benefits of 5G emerge and evolve over time and change from static benefits, that allow the same functionality as 4G but more efficiently, to dynamic benefits that allow consumers to do entirely new things.

3.1 Dynamic vs. Static

29. The first dimension of the framework is dynamic and static benefits, meaning the ability of 5G to do the same as 4G only more efficiently and its ability to deliver a completely new set of benefits for consumers.

30. An understanding of the key capabilities of 5G is necessary to understand how it delivers static and dynamic benefits. The enhancement of key capabilities of 5G compared with 4G are set out in columns 1 and 2 of Table 3. It should be noted that these are early design goals set by the International Telecoms Union (ITU), which may be different from what is achieved in practice. Nevertheless, we have adopted these capabilities for our analysis[16]. Columns 3, 4 and 5 show how each of these key capabilities is used by the three usage scenarios identified by the ITU:

    - Enhanced Mobile Broadband (eMBB). This supports applications that require larger data volumes and/or higher data speeds than current mobile broadband services.
    - Ultra-reliable, Low Latency Communications (URLLC), which has stringent requirements for throughput, latency and availability; and
    - Massive Machine Type Communications (MMTC), which is characterised by a very large number of connected devices typically transmitting a low volume of non-time sensitive data.

[16] ITU (2015) Recommendation ITU-R M.2083-0

Table 3: Enhancement of Key Capabilities from IMT Advanced to IMT-2020

Target Capability	1	2	3	4	5
	4G	5G	eMBB	URLLC	MMTC
Spectrum efficiency	1x	3x	✓		
Network energy efficiency	1x	100x	✓		
Peak Data rate (Gbit/s)	1	20	✓		
User experienced data rate (Mbit/s)	10	100	✓		
Area traffic capacity (Mbit/s per m^2)	0.1	10	✓		
Mobility (km/h)	350	500	✓	✓	
Latency (ms)	10	1		✓	
Connection density (Devices/km^2)	10^5	10^6			✓

Static Benefits

31. A static benefit is where 5G delivers the same services as 4G but can do so at lower cost per unit of output, for example Gigabyte transmitted. At a general level, the consumer benefit is a lower price for the same service (or a greater amount of data for the same price).

32. Static benefits are delivered by the capabilities that support eMBB as these benefits come from the user being able to do the same things as with 4G only faster and/or at lower cost. There are two specific capabilities of 5G that lead to lower costs: spectrum efficiency and network energy efficiency. In the longer term, opening up mm-wave spectrum could also be important.

Spectrum Efficiency

33. Spectrum efficiency is one of three factors that affect the capacity of a mobile network along with the amount of spectrum measured in Hertz (Hz) and the number of masts. Spectrum efficiency refers to the average data throughput per unit of spectrum resource and per cell, i.e. bits per second (b/s) per Hz.

34. 5G allows a higher level of channel throughput for the same amount of spectrum resource, due to greater reuse of the spectrum and improves spectrum efficiency by a target factor of

three. So even with the same amount of spectrum and the same number of masts, a 5G network has a higher capacity and so can transmit more data for the same cost in the radio access network.

35. For the consumer, greater efficiency means lower prices per unit of transmission, provided that networks pass on their costs savings to consumers.

Energy Efficiency

36. 5G is more energy efficient because it allows for a higher quantity of information bits to be transmitted or received per unit of energy consumption in the radio access network (RAN). Therefore a user can transmit more data per watt of energy used so a 5G network requires fewer watts per user for the same amount of data. 5G is targeted to be 100 times more energy efficient than 4G. Later in this report we refer to analysis undertaken by Columbia Climate School that shows how over 16 times as many movies can be downloaded over 5G than over 4G per kilowatt. However, it should be noted that more energy may be used in total as 5G users may transmit substantially more data each[17].

Dynamic Benefits

37. The dynamic benefits of 5G refer to its ability to deliver significant, qualitative changes in how consumers use mobile wireless communications and the benefits they obtain. Dynamic benefits arise when innovation allows the consumer to do things with 5G that they were unable to do with 4G and thus gain additional utility, even if they pay more in total. These benefits are also based on eMBB but may also require URLLC and MMTC.

3.2 Immediate vs. medium term vs. long term

38. The second dimension is temporal. At least some, and possibly, many of the benefits of 5G communications will not be immediate but delivered over the medium to long term. It cannot be expected, therefore, that all of the benefits of 5G will be delivered as soon as the mobile operators launch their 5G networks, or that they can even be known at this stage.

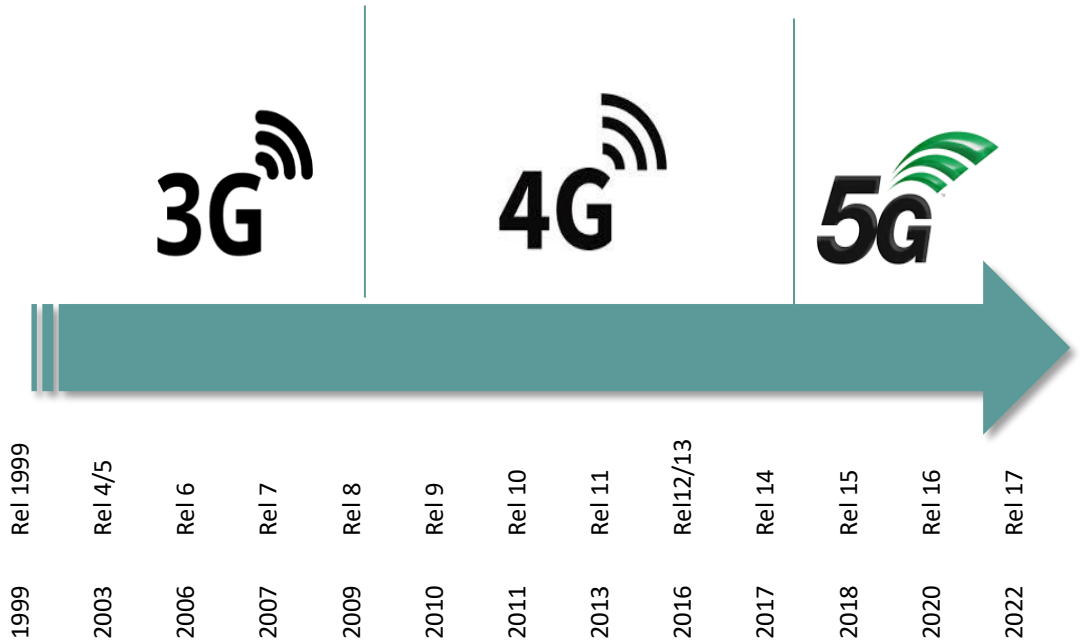
[17] The position may be more complex if use of 5G to download data displaces some other activity such that the net effect may be negative even with higher mobile energy usage.

Indeed, what will be demonstrated in the framework and the analysis in this report is that delivery of the benefits of 5G for consumers is a process not an event.

39. Whilst the conversation about mobile communications tends to be centred on new "generations", in reality there are many interim upgrades to the capabilities of mobile communications between generations and mobile communications standards continue to evolve.

40. The standard setting body, 3GPP[18], publishes several "Releases" of protocols that specify the standard capabilities of mobile communications. There are several releases within each generation, as shown in Figure 2. Before 3G, there were two variations of 2G data standards, EDGE and GPRS, and 3G had HSPA and HSPA+ as advanced variants. 4G had both LTE and LTE Advanced, which was the first gigabit mobile technology[19].

Figure 2: 3GPP Release Dates



[18] 3rd Generation Partnership Project - https://www.3gpp.org/

[19] Respectively: Enhanced Data GSM Evolution (EDGE), General Packet Radio Service (GPRS), High Speed Packet Access (HSPA) and Long Term Evolution (LTE)

41. The process timetable is driven by:

    - The timing of standards releases;
    - The lag between standards being finalised and the hardware, especially access devices, being deployed in the market; and
    - The lag between a service being available and consumer demand maturing.

42. Each Release increases the capabilities of the services mobile can provide, resulting in greater features and benefits for consumers. Release 17, which is scheduled for 2022, is expected to contain as many as 38 new or improved features. Below we show a selection of those features and their relevance to consumers[20].

    - New Radio Multiple Input Multiple Output (NR MIMO) and Dynamic Spectrum Sharing improve overall capacity.
    - NR (New Radio) over non-terrestrial networks and NR coverage enhancement have the potential to improve coverage.
    - Power saving will improve battery life and/or lower costs of networks by reducing electricity consumption.
    - Extended Reality is an extension of Virtual Reality and so will provide enhanced experiences for consumers.
    - 5G Multicast is an efficient means of broadcasting content to multiple mobile devices.
    - Multi SIM can make it easier for consumers to switch suppliers or have multiple subscriptions to improve coverage.
    - 5G wireless and wireline convergence will make it easier to MNOs to provide fixed wireless access.

43. Even within a Release there are three stages before the Abstract Syntax Notation and final release:

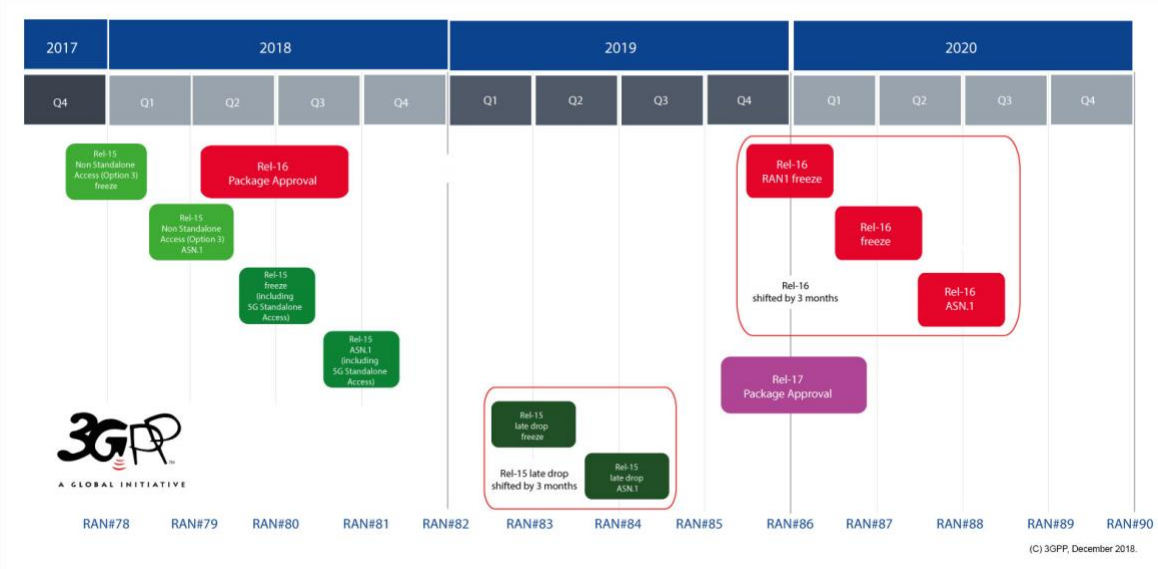
    - Stage 1: a service description from a service-user's point of view
    - Stage 2: architecture to support the service requirements

[20] A complete list of features in Release 17 can be found at https://www.3gpp.org/release-17

- Stage 3: Concrete implementation of the functionality and protocols
- Abstract Syntax Notation (ASN): interface description language for defining data structures.

44. It may take as much as three years to move from Stage 1 to the ASN for a Release, as indicated in Figure 3 which shows the timetable for Release 15, the first full set of 5G standards.

Figure 3: 3GPP Release 15 Timetable



Source: 3GPP

45. Ericsson has developed a roadmap of 28 consumer use cases of 5G that are available or to be introduced over time. It labels the time periods for release "business ready", "showcase level" and "R&D level"[21]. Ericsson is not specific about the definitions of the time periods, but they clearly show how new applications will emerge over time and that what consumers use 5G for in a few years' time may be quite different to how it is used for today. We have adopted Ericsson's labels for the readiness of consumer use cases in this report.

3.3 A Typology of Consumer Benefits

46. The framework developed above shows that there are different types of benefit for consumers depending on how they mix static vs. dynamic benefits and whether they are

[21] Ericsson (2021) Five ways to better 5G

business ready, showcase level or R&D level. This allows us to identify six Benefit Types shown in Figure 4 below. However, there is a correlation between the two dimensions and so whilst the typology allows for static benefits that are at R&D level, we have not been able to identify any. It is most likely that applications at the R&D stage will deliver dynamic benefits. We will describe how different applications have different Benefit Types in Section 4 of this report.

Figure 4: 5G Consumer Benefits Matrix

3.4 Externalities

47. Many of the benefits of 5G accrue directly to consumers. However, there are also likely to be substantial positive externalities that deliver wider social benefits. These could range from helping to reduce the UK's carbon footprint to closing the digital divide by improving rural connectivity. These will be discussed after the specific consumer benefits in Section 4.

3.5 Conclusion

48. Whilst much of the discussion in the press gives the impression that the upgrade of the UK's mobile network to 5G is a revolution, implementing a massive and sudden change in mobile technology compared with 4G, the reality is somewhat different. 5G will result in significant changes in the capability of mobile communications, but as with previous generations, these changes will happen over time as different Releases are first made available and then built into networks and access devices before being accepted by consumers.

49. This means that consumer use cases and their benefits will emerge over time as the technology is implemented throughout the 5G ecosystem and, as importantly, application

developers and users learn how to make the best of these upgrades. Likewise, mobile network operators will need to continue to invest in their networks to accommodate each new 3GPP Release. Future developments of 5G may then be contingent on operators' ability to earn an acceptable return on each new release rather than 5G as a whole.

50. For policy makers this means that there should be less focus on the headline transition to 5G (and 6G in future) and the attendant hype. Instead there should be more focus on wireless innovation on the supply-side and relentless growth in mobile data usage on the demand side. Policy should allow network operators and entrepreneurs to develop consumer focussed applications based on the capabilities of 5G without prejudging what those applications will be.

4 CONSUMER USE CASES

51. In this Section of the report, we consider examples of use case that fall into the six types of benefit outlined above. These are not predictions of which will be successful applications and which will not. As with many other predictions of the future, we may find that short term effects are exaggerated and long term effects underestimated. Further, alongside the case studies presented below, there will be new cases that only emerge in the future and which are unknown today. Therefore, our purpose here is to give a structured analysis of what might be consumer benefits over time as a means of assisting Ofcom in developing appropriate regulatory policy. A fuller, though still not exhaustive, list of consumer applications along with sources of further information can be found in Annex A.

4.1 Type 1 Benefit: Static, Business Ready

52. A Type 1 benefit delivers the same functionality as 4G, but does so at a lower cost per unit of output (e.g. Megabits transmitted) and is already available in the market where 5G has been rolled out by network operators.

Faster Downloads

53. An obvious example of a Type 1 benefit is video downloading to a mobile device given that there is a target for 5G to deliver ten times the user experienced data rate as 4G[22]. Letstalk.com has calculated that using 4G, video content would be downloaded at a speed of around 10 – 20 Mbps, whereas 5G should deliver download speeds of 100 – 200 Mbps. Figure 5 below shows comparative download times for various types of content on 4G and 5G networks and the time saved on 5G compared with 4G.

54. These times were calculated by the website letstalk.com using average download speeds reported by lifewire.com and applied to various media. Times are presented in hours:minutes:seconds. For example, according to this data, it tales around 49 minutes to download an average movie on a 4G network and just seven minutes and twenty seconds on a 5G network, saving 41½ minutes.

[22] See above

Figure 5: Comparative Average Download Times

Content Downloaded / Network	Movie	Album	10,000 emails	1,500 photos	iOS Games
4G	 00:48:52	 00:01:10	 00:06:40	 01:00:00	 00:01:57
5G	 00:07:20	 00:00:10	 00:01:00	 00:09:00	 00:00:17
Time saved	00:41:32	00:01:00	00:05:40	00:51:00	00:01:40

Adapted from letstalk.com/cellphones/guides/5g-vs-4g/

55. In February 2021, Netflix launched a new service, Downloads for You, which automatically downloads content to Android mobile devices based on the user's viewing history and wish list. Initially this service takes advantage of WiFi connection, but can also be done via mobile Internet[23]. Thus whilst much content currently downloaded to a mobile device may be short clips rather than full movies, this may way change in future. At the time of writing, Downloads For You was still not available on iOS.

56. A customer using 5G to download a movie or other content is not gaining any dynamic benefit as they can do the same using 4G. However, the increased speed means that they are getting a static benefit as they do the same thing, just faster. This qualifies as a business ready application as it can be done under the first release of 5G.

57. Amongst other static benefits from 5G that are business ready, Ericsson has found that 20% of 5G users in the US, Taiwan, Switzerland, Finland and South Korea have reduced their WiFi usage at home and in other locations by substituting residential WiFi with 5G[24]. This

[23] https://about.netflix.com/en/news/downloads-for-you-takes-on-the-go-to-the-next-level
[24] Ericsson (2021) Five ways to a better 5G

substitution was particularly prevalent where mobile operators offered unlimited data plans. It appears that unlimited 5G data meant consumers had no need to have both fixed and mobile broadband. In this case, the user can replace separate fixed and 4G mobile wireless with a 5G connection used at home and on the go. Again, the user does nothing different with 5G than they do with WiFi, hence a static benefit.

58. Ericsson has also established that 90% of mobile service providers that have launched 5G have also launched a 5G Fixed Wireless Access (FWA) service, which they define as a "*connection that provides primary broadband access through wireless wide area mobile network enabled customer premises equipment (CPE). This includes various form factors of CPEs, such as indoor (desktop and window) and outdoor (rooftop and wall mounted). It does not include portable battery-based Wi-Fi routers or dongles*"[25]. This definition would include products such as Vodafone's Gigacube which provides fixed broadband access over the 5G network[26].

59. The use of 5G FWA as a potential alternative to fixed broadband may be particularly relevant in rural areas and those with a large number of multi-dwelling units, where there might be problems with in-building wiring and/or fibre access. In these areas 5G FWA can fill in gaps where there is poor or no/pending fixed broadband coverage and can provide some competition to BT where there is coverage.

60. These are included as Type One benefits as FWA delivers much the same benefits to consumers as wired access, but can be done at a lower cost.

Summary of Type 1 Benefits

	Private benefits				
	Time saving	Enhanced Experience	Improved quality of life	Remove duplicate product	Physical safety
Faster download or films etc.	✓	✓			
5G FWA		✓		✓	

[25] https://www.ericsson.com/en/mobility-report/dataforecasts/fwa-outlook Accessed 15th October 2021

[26] https://www.vodafone.co.uk/gigacube/?icmp=uk~1_consumer~topnav~2_why_vodafone~2_5g~5_5g_broadband&linkpos=topnav~1~2~2~5

4.2 Type Two Benefit: Static, Showcase Level

61. A Type 2 benefit provides the same functionality as previous generations of mobile communications but is not yet ready for commercial launch.

62. An example of a Type 2 benefit is 5G Broadcasting, which is the ability to listen to live radio and watch standard TV broadcasts over a 5G mobile connection rather than cable, satellite or broadcast over current generation broadband. 5G Broadcasting takes advantage of the enhanced download speeds of 5G, up to 1 Gbps along with mobility. A key advantage over other forms of broadcast is that 5G allows content to be beamed to fixed or mobile devices without the need for a WiFi connection. The 5G Multicasting functionality of Release 17, due in 2022, makes this service possible. It is included as a static benefit as much audio and video content is on-demand rather than at time of broadcast.

63. For the consumer this means greater flexibility and choice of the platform on which TV or radio is consumed but over a single connection. Further, 5G's combination of high speed downloads and high capacity support higher quality streaming than 4G, while the densification of networks through micro infrastructure such as small cells will ensure mobile users can actually watch TV at the intended quality[27].

64. As part of the UK government's 5G Rural First programme, the BBC worked with the Orkney Islands Council to improve broadband and radio coverage on the remote island of Stronsay. It was chosen because it currently suffers from limited fixed broadband, little or no mobile coverage and poor digital radio coverage. As part of the trial, the BBC broadcast 13 digital radio stations live over 5G and offered mobile internet access to participants.

65. The BBC states that initial feedback from audience research has been "extremely positive, with participants particularly valuing the consistency of the connection, the additional range of digital radio services and the greater reliability and ease of use ('less wiggling of aerials'!)"[28].

[27] https://www.5gradar.com/features/10-ways-5g-will-revolutionize-broadcasting Accessed 29th September 2021.
[28] https://www.bbc.co.uk/rd/blog/2019-03-5g-rural-first-network-orkney Accessed 19th October 2021

Summary of Type 2 Benefits

	Private benefits				
	Time saving	Enhanced Experience	Improved quality of life	Remove duplicate product	Physical safety
5G Multicast		✓		✓	

4.3 Type Three Benefit: Static, R&D Level

66. A Type 3 benefit provides the same functionality as previous generations of mobile communications but is still in the research and development phase. No benefits of this Type have been identified during our research, which is perhaps not surprising given that R&D tends to concentrate on new applications rather than the development of current ones. Static benefits tend to be short term and so already out of the R&D Level.

4.4 Type Four Benefit: Dynamic, Business Ready

67. A Type 4 benefit is both dynamic and business ready. By dynamic we mean that it is innovative and provides the user with an experience they could not obtain on 4G. It is possible that consumers would pay more for these types of services than they would for a 4G equivalent, but they would be willing to do so as they deliver greater utility.

Best Seat Experience

68. A good example of a type four benefit is a "best seat event experience" at a sports or music event. The technology needed to provide this can be delivered by 4G, but there is a qualitatively improved experience using 5G. A best seat experience can deliver an enhanced consumer experience when compared with broadcast TV and provide a richer experience for attendees at the event.

69. In October 2020, EE announced an "immersive sports viewing service" called Match Day Experience using Augmented Reality on its 5G network. The service includes six key features:

    - **Watch Together**, which allows viewers to hold on-line chats with others during a match using a split-screen interface.

- **360**, which allows viewers to select from a range of camera angles and a "pinch and zoom" facility allows viewers to zoom in on specific areas of interest.
- **Match Day Live** allows customers to access team line-ups, formation and in-game stats from wherever they are watching the action.
- **Stadium Experience** allows customers to use Augmented Reality to visit various stadiums behind the scenes, including dressing room, dug-outs, trophy rooms and tunnel areas.
- **Dolby Atmos** multi-dimensional sound.
- **Manager Mode** which provides facilities such as player speeds and paths of shots to give the viewer the feeling of being the manager.[29]

70. An example of the benefits of best seat event experience is provided by EE at the FA cup final in 2019 between Manchester City and Watford. A short video can be viewed here https://vimeo.com/340870583. Fans of the two teams who could not attend the event were able to enjoy a richer experience than they would on linear broadcast TV, although the result suggests that the Manchester City fans may have enjoyed it rather more! Amongst other things, they could be "near" to friends and family at the match, zoom in on particular sections of the pitch and even virtually walk through the tunnel with the players on to the pitch as seen in Figure 6.

71. The service is provided using 360^{O} cameras located at strategic points around the venue. These could be in public areas, so that the viewer gains the same experience as if s/he were there, or could be in exclusive areas normally closed to the public. The viewer can use either a smart phone or, in more advanced cases, an AR/VR headset to watch the event and any accompanying content. Both examples are shown in the video.

72. Enhanced mobile broadband and ultra-reliable low latency are important for best seat event experience to work. Any delay between what is seen live and what is seen on the pitch or stage could be unacceptable, especially for event attendees who would not want to experience a delay between seeing the action on the pitch and on their device.

[29] EE Press Release, October 2020. Available at https://newsroom.ee.co.uk/ee-unveils-uks-most-immersive-sports-viewing-service---available-as-part-of-the--exclusive-ee-5g-full-works-plan-for-iphone/

Figure 6: Best Seat Experience

Source: EE

73. Matt Stagg, director of mobile strategy at BT Sport is reported in Raconteur as saying: "5G will provide the vast amount of bandwidth fans need to consume and share whatever content they like. 5G gives you much more capacity per hertz of spectrum, making it more cost effective for operators to provide capacity in a challenging place like a stadium".[30]

Summary of Type 4 Benefits

	Private benefits				
	Time saving	Enhanced Experience	Improved quality of life	Remove duplicate product	Physical safety
Best Seat Experience		✓	✓		

[30] https://www.raconteur.net/technology/5g/5g-technology-sports/ Accessed 28 September 2021

4.5 Type Five Benefit: Dynamic, Showcase Level

Virtual Reality Social Media

74. Facebook's Horizon is a virtual reality (VR) social media application currently in Beta test. This is the first case study reported here for which low latency is essential as well as high levels of bandwidth.

75. Social Media is widely used by consumers and the coronavirus pandemic has increased usage as people were unable to meet in real life. According to Cybercrew, there are some 48m social media users in the UK and using social media for an average of 110 minutes per day[31]. Ofcom's Online Nation report 2021 illustrates the extent of social media usage across all age groups, including the over 65s. For example:

    - 39% of all time spent on-line is on a social media sites owned by Facebook or Google;
    - 75% of on-line adults use WhatsApp at least once per month and 58% use Facebook Messenger;
    - 91% of social media users over 65 use Facebook. Younger users (16 – 24) are more likely to use Instagram, Snapchat or TikTok.

76. Current social media applications allow users to keep and build relationships with networks of people through shared interests, but in a two-dimensional manner. Users post text, pictures of video content about what they care about or have been doing recently, but the current generation of social media does not allow for virtual shared experience.

77. VR social media changes that by taking a step further and gets users closer to actually being together in a virtual space where they can share their interests and activities.

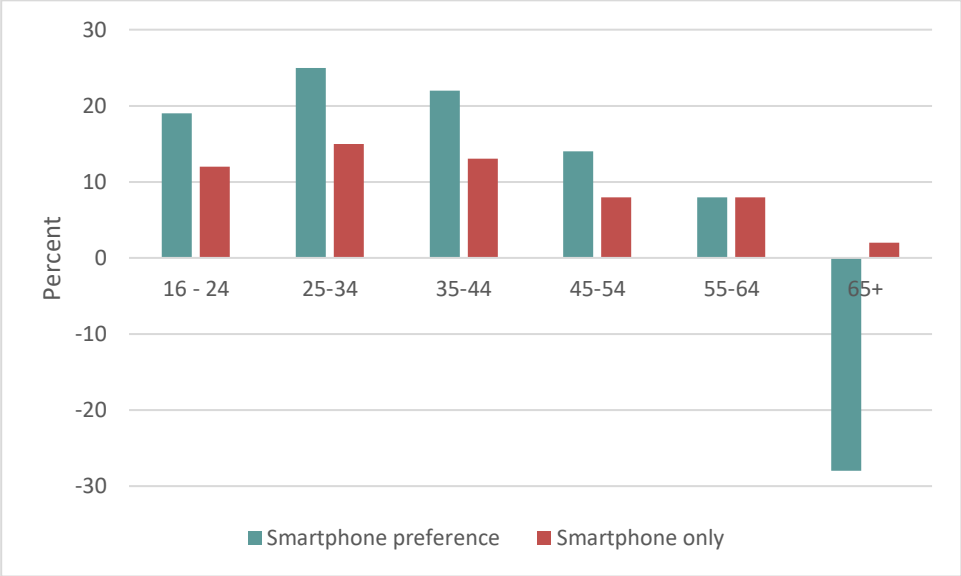
78. Facebook defines virtual, social presence as "authentic and lifelike collaboration between people and colleagues in a virtual setting"[32]. Users can manipulate real and virtual objects using their hands and sense of touch. Facebook claims that their avatars can use the subtlety of human expression to convey complex emotions and audio from voices and other sources to sound like they do in the real world.

[31] https://cybercrew.uk/blog/social-media-statistics-uk/ Accessed 29th September 2021
[32] https://tech.fb.com/the-future-of-work-and-the-next-computing-platform/ Accessed 29th September 2021

79. Social media is widely used on mobile devices. In the UK, Cybercrew reports that 39m people use social media on their mobile devices[33], which almost certainly includes usage at home on WiFi as well as outside in locations such as commuter trains. The increasing use of mobile devices is only likely to grow with VR, not least through an increase in wearables, such as connected glasses.

80. Ofcom's Online Nation report[34] shows that younger age groups have a clear preference for connecting to broadband via a smartphone rather than a computer. Figure 7 shows the difference in the proportion of each age group who use smartphones rather than computers to access the Internet[35] and the proportion who report only using a smartphone. It can be implied from this chart that younger generations are more likely to be users of 5G, rather than fixed broadband, and that their preference may well continue as they become older.

Figure 7: Smartphone Preference by Age Group



Data Source: Ofcom *Online Nation 2021 Fig. 1.14*

81. Enhanced Mobile Broadband along with URLLC are the main features of 5G that will support virtual social media. eMBB offers the peak data rates that consumers will need to interact

[33] https://cybercrew.uk/blog/social-media-statistics-uk/ Accessed 29th September 2021
[34] Ofcom (2021) *Online Nation*
[35] This number is calculated by subtracting the proportion of each age group who use a computer to go on-line from the number using a smartphone as shown in Figure 1.14 of Online Nation 2021.

with the applications and low latency is required to prevent any delay in interactions between users in the virtual space.

82. The consumer benefits of VR social media extend beyond simply the improved experience for the core users of social media, who tend to be in the younger age groups. Older age groups have found social media vital during the coronavirus pandemic as perhaps the only means they had of keeping in touch with friends and family.

83. A study undertaken by Dr Gemma Wilson et al, explored the use of technology by older people during Covid-19. Their qualitative study of 20 older users (65+) highlighted the importance of technology and social media for social relationships, specifically visual communication tools during the pandemic.

84. One "almost housebound" participant said that without social media he would no longer get to socialise with people outside of his own home. He describes the informality of social media as a space in which he can simply greet others and be greeted himself. He told the researchers: "social isolation is one of the big problems and to know that there is someone that you can just greet and say something to when you get up in the morning is helpful"[36].

85. Taking social media to the next level of VR is only likely to improve the benefits that such vulnerable people get from social media. Whilst these users may be more likely to access social media over fixed broadband, social media companies are only likely to develop the next generation of services if they can be accessed over mobile, given the proportion of users who prefer mobile access. This will require 5G access and so the benefits for fixed broadband users are indirectly dependent on 5G.

In-Car Entertainment

86. In-car video entertainment today is currently based on physical units, such as CDs and DVDs and screens for rear-seat passengers. 5G mobile will allow visual content to be sent to the in-car system and so offer a broader choice of entertainment for passengers, once 5G is widely available along road networks. In the short term such entertainment is most likely to be used

36 https://www.ucl.ac.uk/psychiatry/sites/psychiatry/files/blog_how_can_technology_impact_social_connection_for_older_adults_during_covid.pdf Accessed 29th September 2021

by children in rear seats, but in the longer term there may be demand from adult passengers, especially if autonomous cars become widely used.

87. An example of a provider of 5G in-car entertainment is the German start-up company Holoride (www.holoride.com). This company is producing VR video content that in some cases is adapted to the motion of the car. Video content can be either games or TV programmes.

88. Holoride says that its 5G in-car experiences have three key components:

    - Motion synchronisation: the content reacts to the driving route and style.
    - Traffic awareness: Traffic around the vehicle, such as traffic jams during rush hour, are taken into consideration during the experience development process and affect the way the user experiences the entertainment.
    - Location awareness. The roads and world around the vehicle define the environment that the passenger experiences in VR. Holoride software generates content based on map data and incorporates actual surroundings into the entertainment.

89. The in-car experience does not have to be pure entertainment (such as VR game) but could also be education, productivity or mindfulness. Thus, the user could be learning, working or relaxing as well as playing games.

90. Vodafone refers to a mobility concept known as the Quarter Car, in which each passenger has their own in-car experience and so can enjoy a private journey. The passenger could be gaming, working, learning or relaxing. This concept could encourage more lift sharing in which the passengers can each be in their own world.

91. 5G in-car entertainment may well require all three key capabilities of IMT2020: eMBB, URLLC and MMTC. Low latency is likely to be particularly important for the three key components listed above.

92. The most significant consumer benefit is likely to be better use of time that might otherwise be wasted as a passive passenger. The Quarter Car concept, and the potential it creates for

increased lift sharing, would also bring with it the benefit of fewer cars on the road and an accompanying reduction in fuel usage and pollution.

Summary of Type 5 Benefits

	Private benefits				
	Time saving	Enhanced Experience	Improved quality of life	Remove duplicate product	Physical safety
VR Social Media		✓			
In car entertainment/ workspace	✓	✓			

4.6 Type Six Benefit: Dynamic, R&D Level

93. Type 6 benefits deliver brand new services to consumers but are still in the research and development phase. There are many examples of these use cases that may or may not be successful in the market place once they move to the Business Ready phase, if indeed they do.

The Metaverse

94. The Metaverse is perhaps the highest profile consumer use case in the Type 6 category. The word refers to the convergence of physical, augmented and virtual reality in a shared on-line space[37]. If successful, it will take the concept of VR Social Media discussed above and translate it to a 3D world accessible through a variety of devices allowing people to interact with the Internet in a more natural way.

95. Meta, formerly known as Facebook, is one of the main companies developing the Metaverse, announcing the recruitment of 10,000 new staff in Europe to work on its development. However, it is far from alone, with companies, such as Epic Games and Roblox also investing in the metaverse to create other immersive experiences. This means that interoperability will

[37] The Verge (2021) *Mark in the Metaverse* https://www.theverge.com/22588022/mark-zuckerberg-facebook-ceo-metaverse-interview

be crucial so that users can move between metaverse domains as easily as they move between websites[38]

96. Epic Games, the maker of Fortnite, has embedded live performances by global artists such as Ariana Grande in games giving consumers access to concerts and performers access to millions of viewers. The Ariana Grande concert involved an avatar of the artist but other performers have appeared in real life, for example the hip hop artist Travis Scott who performed to a global audience of twelve million[39].

97. The metaverse, however, is not all about games and music. Facebook is experimenting with more realistic virtual meeting, social media and chat facilities. The early stage of the metaverse means that there are likely to be many applications that have not yet been discovered.

98. 5G mobile technology is likely to play an important role in the development of the metaverse as many users will want access on the go, whether via a handset or some other mobile access device. The various capabilities of 5G discussed throughout this report will be essential for the metaverse to deliver its potential. Verizon says that "growing access to 5G can support the ongoing development of the Metaverse by providing the speed and power that make it possible for digital worlds to function. Mobile hardware companies are developing 5G-ready devices capable of running software beyond that which we have now — devices that can support the Metaverse"[40].

99. It is likely that all three pillars of 5G – enhanced mobile broadband, ultra-reliable and low latency communications and massive machine type communications – will be needed and used to deliver the full experience of the metaverse.

100. Consumers will benefit from a richer and more natural internet experience allowing them to do all the things they do today in an enhanced virtual world as well as take part in mass-events, such as concerts, and private events, such a virtual test drive of a new car.

[38] https://www.ibc.org/understanding-the-metaverse-opportunities-challenges-and-gen-z/7863.article
[39] BBC (2021) Apparently it's the next Big Thing. What is the Metaverse? *https://www.bbc.co.uk/news/technology-58749529*
[40] https://www.verizon.com/about/news/5g-makes-metaverse-real

However, we suspect that most of what the metaverse can deliver to consumers has not been thought of yet.

Haptic Internet

101. Haptic refers to all touch and related capabilities and is commonly used in relation to the science of touch in real and virtual environments. The haptic internet delivers physically tactile experiences remotely. Ericsson states: "(w)ith the 5G tactile internet, control of real or virtual objects can take place at the real-time speeds, enabling an ecosystem whereby human skills can be delivered without boundaries"[41]

102. Vodafone uses rugby to demonstrate the haptic internet. In the demonstration video,[42] a tackle cylinder containing various sensors that pick up the force, location and direction of the tackle is located in Coventry Ricoh Stadium. Various players then tackle the cylinder and the data picked up by the sensors are transmitted over Vodafone's 5G network to a teslasuit worn by Wasps centre back Juan de Jongh, who is in London, so that he feels the tackle and responds (see Figure 8).

103. This video shows how the haptic internet works. However, for the consumer, perhaps the greatest foreseen benefit of haptic technology will be the ability to touch and feel products they are buying via e-commerce. Today internet consumers can see the product, and may even able to see it in situ, but haptic technology would go further and allow them to feel the product, just as they would in a real-world shop. For example, when buying furniture, the consumer will be able to get to know what the item feels like before they buy, allowing the consumer to make a more informed choice.

104. Interhaptics shows the example of a consumer purchasing a sofabed and experiencing the feel of the material and how the sofa converts to a bed. They say:

> *"Moreover, there is the possibility to add haptic feedback for e-commerce scenarios, improving the immersion and user experience of the customer. Thanks to these features,*

[41] https://www.ericsson.com/en/blog/2019/4/5g-tactile-internet Accessed 29th September 2021
[42] The short video can be seen here https://youtu.be/E7Z47ymJdsM

customers can try the ergonomics and use of the products with realistic behaviour and movements."[43]

Figure 8: Haptic Rugby Tackle Demonstration

Source: Vodafone

105. Beyond applications for e-commerce, haptics could allow people with visual impairments to feel their environment and read braille on websites or obtain an understanding of what is presented to them via touch. Haptic technology is already used in non-connected products, such as smart canes, but with 5G these can be connected to the Internet to provide an even richer environment for the visually impaired.

106. O2 has worked with NTT Data and AEG to develop haptic wireless technology that can guide a visually impaired person from the entrance to their seat in the O2 Arena in London. This uses a small, hand-held device called a Buru Navi that houses vibrating weights that shift and point a user to a targeted location, making them feel as if their hand is being guided, just as it could be by a fully sighted person[44].

107. Another benefit of haptic technology, once it is further developed, will be the ability to have closer forms of communications than just voice and sight. People will be able to shake

[43] https://www.interhaptics.com/blog/2020/06/12/haptic-feedback-for-ecommerce-with-interhaptics/ Accessed 30th September 2021
[44] https://businessblog.o2.co.uk/2019/06/26/making-mobility-and-accessibility-easier-through-technology/

hands and even hug across thousands of miles. In other demonstration application shown by Vodafone, the comedian Jon Richardson is in Las Vegas and his wife is in London. He is able to close his eyes and identify each finger she touches using the haptic robotic hand where she is located[45]. One could also imagine how a visually impaired person would be able to feel the contours of the face of the person they are communicating with as is done in the real world.

108. There are very likely to be other consumer benefits of haptic technology over 5G that have not yet been identified or even dreamt of by technologists and entrepreneurs, as is the nature of products that are still in their R&D phase. However, the ability to engage human senses other than sight and hearing, and so enrich their experience, will without doubt lead to new consumer use cases and benefits.

109. Haptic technology relies on the URLLC capability of 5G that allows a sense of touch to be transmitted around the world in real time. The experience of Juan de Jongh in the video clip above would not have been realistic had the delay in transmission between the tackle cylinder and the teslasuit been delayed due to latency in the network.

See-through Car

110. The automotive industry is moving towards cars based on assisted driving, where there is a serious question about how sensor data is processed in real time by local Artificial Intelligence (AI) and what decisions are passed to the driver. However, this is some way in the future. In the meantime, the see-through, or transparent, car allows drivers of other cars to see hazards, such as on-coming traffic, that would normally be blocked from sight. In one version, the see-through car uses external cameras to allow the driver to see through the sides and rear to get a better view than afforded by mirrors or reversing cameras.

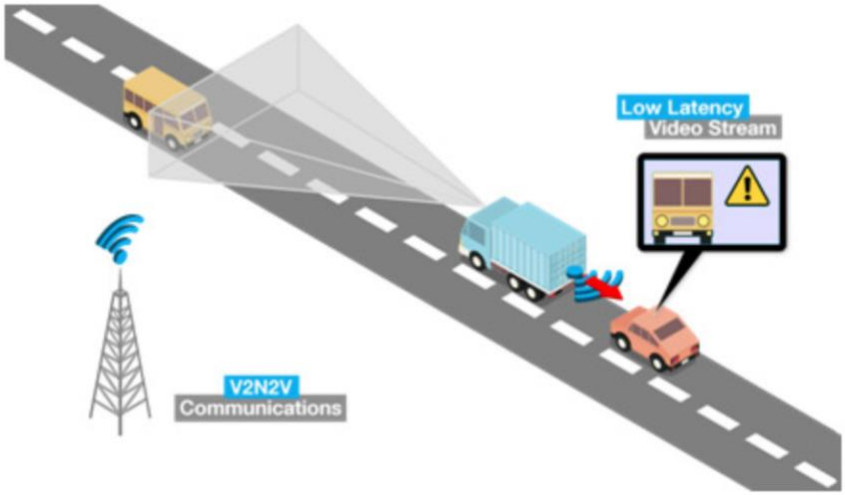
111. Another application allows the driver in the car behind to see through the car in front and so determine if it is safe to overtake or whether there is some hazard ahead that will make such a manoeuvre dangerous. This capability has been developed by Orange and Ericsson.

[45] https://newscentre.vodafone.co.uk/features/touchy-feely-robots-to-remote-controlled-dogs-5g-help-make-it-happen/

112. In the application the "vehicle to everything" (V2X) capability of 5G is required. To do this, a vehicle equipped with a high-definition camera connected to the mobile router can transmit the video stream when automatically requested by the mobile router of a vehicle behind, as shown in Figure 9. The video stream is then transmitted via the vehicle slice using local breakout, ensuring low latency.

113. The main limitation of the use case in this form is the fact that it uses a great deal of bandwidth. However, the advantage is that it provides a visual depiction of the vehicle slice performance at low latency while maintaining speed, compared to the mobile broadband slice, which is the first to be affected by any deterioration of radio and network performance.

Figure 9: Transparent Car Use Case



Source: Towards 5G

5G Hearing Aids

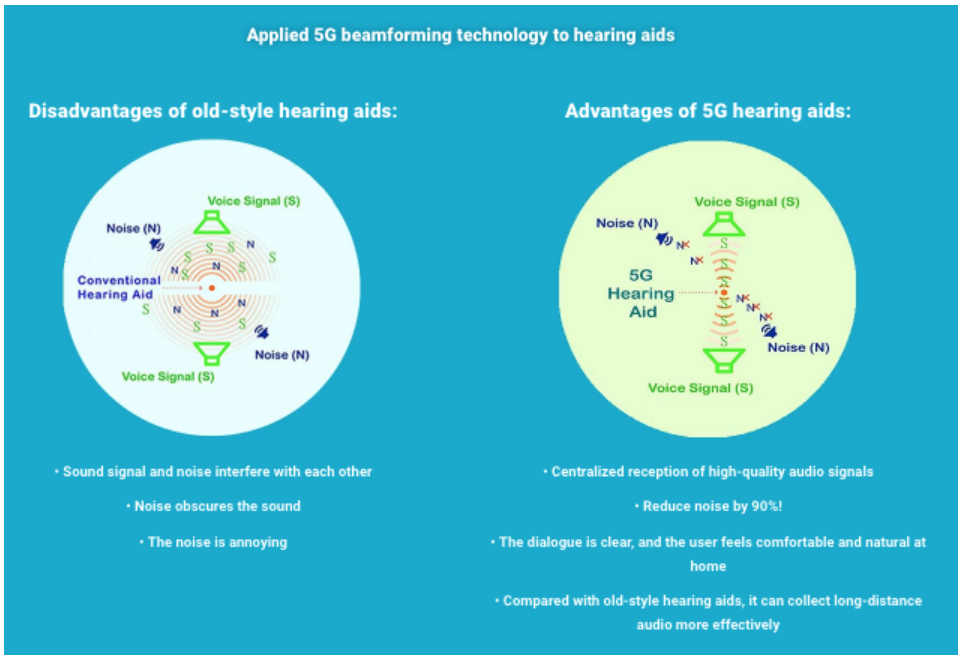
114. There are some eleven million people in the UK who suffer from hearing loss, including profound deafness. Deafness brings with it social, economic and mental health problems. Deaf people are twice as likely to have mental health problems as the general population

and less likely to be employed. UK government figures show that 65% of working age deaf people are in employment compared with 79% of the general population[46].

115. Hearing aids are an effective way of enabling people with hearing loss take a fuller role in society and preventing some of the negative the social, economic and health problems deafness can cause.

116. A Hong Kong company, Easyhear, has developed 5G enabled hearing aids that use the beamforming capabilities of 5G to cut out background noise. Compared with traditional radio transmission, Easyhear say that 5G beamforming facilitates more focussed coverage with less interference. This results in background noise being eliminated so that only the voice signal is heard, giving the user a superior experience. Figure 10 below shows how these hearing aids exclude background noise so that only the desired voice signal is heard.

Figure 10:Applied 5G Beamforming Technology to Hearing Aids



Source: Easyhear.com.hk

[46] https://www.gov.uk/government/publications/understanding-disabilities-and-impairments-user-profiles/saleem-profoundly-deaf-user

117. In the UK, the Engineering and Physical Sciences Research Council (EPSRC) is funding the Cognitively-Inspired, 5G-IoT Enabled Multi-Modal Hearing Aids (COG-MHEAR) under the Transformative Healthcare Technologies for 2050 research scheme.

118. COG-MHEAR hearing aids will help the wearer to use their cognitive human ability to cut out background noise and enable him or her to focus on listening to a single talker. The project will use data science related to machine learning and privacy algorithms along with the Internet of Things (IoT) and 5G wireless technology[47]. This is a longer term development than the 5G hearing aids already developed in by Easyhear, but should provide an even better experience.

Summary of Type 6 Benefits

	Private benefits				
	Time saving	Enhanced Experience	Improved quality of life	Remove duplicate product	Physical safety
Metaverse		✓			
Haptic Internet	✓	✓	✓		
See through car					✓
5G Hearing aids			✓		

4.7 Externalities

119. The benefits described above are those that are experienced directly by the individual user. However, at least some consumer oriented applications will generate positive externalities that benefit society as a whole. Although not the main focus of this report, a non-exhaustive list of examples of these wider benefits are discussed below.

[47] For more information, visit https://www.eng.ed.ac.uk/about/news/20200319/paving-way-next-generation-hearing-aids

Social Inclusion

120. Adequate broadband access is well known to be an important contributor to social inclusion, so households that cannot access adequate broadband are very likely to suffer from some form of exclusion.

121. Ofcom data show that 95% of households in the UK have at least 30Mbps fixed broadband but that only 57% have at least 100Mbps. Unsurprisingly, most of the households that have inadequate broadband are in the rural areas of northern England, Scotland, Wales and Northern Ireland. To the extent that 5G can provide a lower cost of deployment for superfast and ultrafast broadband speeds using FWA, 5G can increase the level of social inclusion beyond just being able to access the Internet.

122. The value of increased social inclusion is highlighted by the National Health Service which explains that "people who are digitally excluded are at risk of worse access to services and worse health outcomes"[48]. Improvement of health outcomes is a benefit not only to the consumer but also to society as a whole.

123. The examples above of haptic technology for the visually impaired and 5G hearing aids for people with hearing loss will also improve social inclusion as both visual impairment and hearing loss may mean people are excluded from some activities. Further, there is research that shows that sensory impairment can lead to mental health problems and increase the risk of dementia, with all the attendant personal and social exclusion that can cause.

124. One could also imagine a time when patients do not need to attend a doctor's surgery for a physical examination as haptic technology could allow the doctor to locate concerning lumps remotely, speeding up diagnostic time and, therefore, treatment. Earlier treatment would ensure patients are not excluded from society and so society benefits from more people being included.

[48] NHS Digital (2019) Digital Inclusion Guide for Health and Social Care p. 17

Net Zero

125. Progress towards a net zero carbon economy is a central plank of government policy and one that is enshrined in law. 5G technology has an important role to play in meeting this target that extends beyond the benefits derived by individual consumers.

126. Directly, 5G will require less electricity to undertake tasks than previous generations of mobile technology. As noted earlier in this report, 5G requires fewer watts per user to perform the same tasks as 4G. Research undertaken by Columbia Climate School has found that 1 Kilowatt hour (KwH) of electricity is required to download 300 high definition movies using 4G. However, 5G will allow 5,000 ultra-high definition movies to be downloaded using 1 KwH of electricity[49]. The same number of movies can therefore be downloaded with a 92% reduction in electricity usage and a commensurate reduction in harmful emissions from electricity generation.

127. There are also many indirect benefits from 5G technology that have positive effects on reducing greenhouse gas emissions. Columbia Climate School highlight how 5G can help improve traffic flow in cities so reducing traffic congestion and idling. They quote a project in Pittsburgh that reduced greenhouse gas emissions by 20%. They also say that 5G technology can be used to reduce food waste and water leakage[50].

4.8 Summary

128. The consumer use cases described above form only a small sub-set of the likely use-cases that will emerge over the short, medium and long term bringing static and dynamic benefits as well as positive externalities. Whether consumers are simply using their mobile network to download films faster, to enhance in-car entertainment or live in a metaverse, or perhaps a different set of activities not listed here, there are many and varied ways in which they will gain benefits from 5G. The complete set of expected private and social benefits are shown in Table 4.

[49] https://news.climate.columbia.edu/2020/08/13/coming-5g-revolution-will-affect-environment/
[50] ibid

Table 4: Private and Social Benefits Summary

		Private benefits					Social benefits	
		Time saving	Enhanced Experience	Improved quality of life	Remove duplicate product	Physical safety	Social inclusion	Net Zero
Consumer Use Cases	Faster download or films etc.	✓	✓					✓
	5G FWA		✓		✓		✓	
	5G Multicast		✓		✓		✓	
	Best Seat Experience		✓	✓			✓	
	VR Social Media		✓				✓	
	In car entertainment/ workspace	✓	✓					✓
	Metaverse		✓					
	Haptic Internet	✓	✓	✓			✓	
	See through car					✓		
	5G Hearing aids			✓			✓	

129. Common to all of these use cases will be the enhanced mobile broadband capability of 5G, which as noted earlier will provide user experienced data up to ten times faster than 4G and at a lower cost that the competitive mobile market is likely to pass on to consumers. The other usage scenarios of 5G, URLLC and MMTC, will almost certainly be used in some 5G consumer applications, for example URLLC will be needed for AR/VR social media.

130. There may be some uncertainty about which cases will need which capabilities, but that should not be seen as a weakness. Entrepreneurs and other investors will either find uses for these capabilities that benefit consumers or they will not. What is important is that policy does not prevent them from doing so.

5 FUTURE MOBILE STRATEGY

5.1 Summary and Discussion

131. This final Section draws on the consumer use-case examples discussed above to suggest how Ofcom's mobile strategy review could support innovation on the 5G networks as the standards develop.

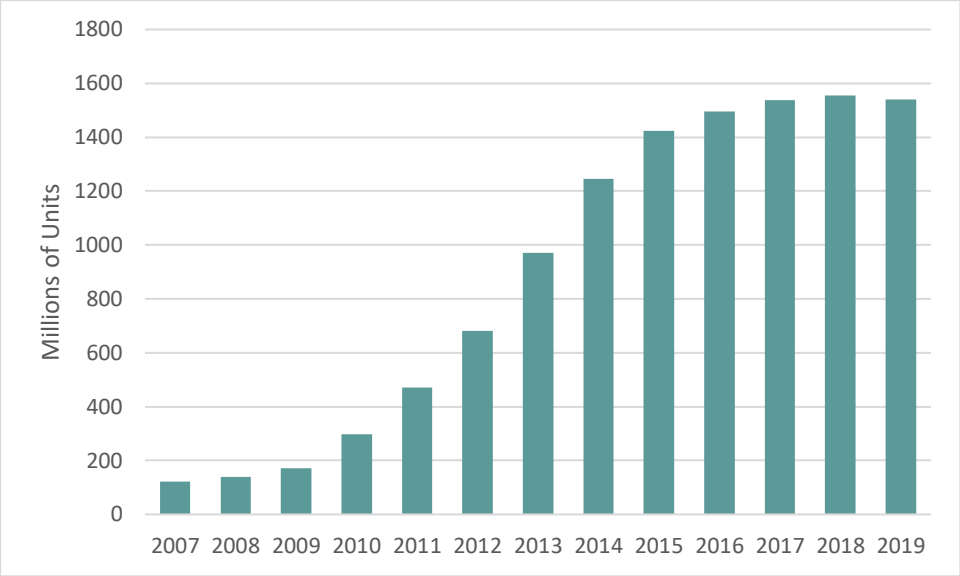
132. 5G technology will be important in delivering static and dynamic benefits to consumers. However, the most significant finding from the examples above is that 5G is not an event, delivering consumer benefits overnight, but a process that requires continued investment in networks, innovation in applications and growth in demand.

133. We anticipate that the early benefits of 5G will largely be static, allowing consumers to do more efficiently what they can already do on a 4G network. However, this report shows that with time and new 3GPP Releases those benefits will become dynamic: offering consumers entirely new services and substantially increased utility.

134. The launch of 4G, with its higher data rates compared with 3G, facilitated a huge growth in sales of smartphones. Until 2009, when the first 3GPP 4G Release came out, global smartphone sales were quite low, at just over 140 million per annum, despite the launch of the iPhone in 2007 which relied on WiFi for data connectivity. However, as Figure 11 shows, there was a rapid acceleration in smartphone sales after 2009 once networks were upgraded to 4G and the iPhone had mobile data functionality. By 2015 sales had increased tenfold to over 1.4 billion units per annum before growth flatten out and started to decline in 2019. Over the same period, the number of active apps available on the Apple's App Store rose from just 500 to 1.85 million. Google's PlayStore has 2.56 million apps[51]. The same complementarity we see between 4G, the sales of smartphones and the number of active apps can be expected to play out again with 5G and devices that may eventually replace smartphones.

[51] Source: Businessofapps.com

Figure 11: Global Smartphone Sales 2007 - 2019



Source: Statista.com

135. Mobile networks are the key enabler of the mobile ecosystem, mainly because of their ability to deliver large quantities of data to users on the move with appropriate levels of quality at affordable prices. However, innovation has been driven as much by devices and apps as by new network features. The increased capacity of 5G networks can be seen as a baseline of future benefits. Additional benefits will come from the URLLC and MMTC facilities of 5G.

136. We cannot predict how consumers will access services in future, but we can be reasonably certain that it will not be the same as today and access devices will take maximum advantage of the features of the 3GPP Releases that comprise 5G. Meta is expecting wearables, and especially smart glasses, to replace the smartphone as the most commonly used device for social networking and communications.

137. The benefits of 5G services currently at showcase and R&D level are only predictable in broad terms and may be dependent on regulatory, technical and other decisions made today. There is, therefore, likely to be a path dependency that could support or restrict future developments on 5G. For example, if a decision today results in companies incurring large sunk costs, it may not be possible for them to reverse that decision. This could mean

than firms will not invest now for fear of that investment becoming stranded or they may not invest in future if they have already incurred sunk costs that cannot be recovered.

5.2 Implications for the Mobile Strategy Review

138. In its Terms of Reference for the mobile strategy review, Ofcom refers to three current strategic priorities. The findings of this report has implications for the first of these priorities: supporting investment in strong, secure networks[52].

139. Ofcom also explains that its:

> *"… current approach to the mobile sector is primarily to support competition among vertically integrated providers, the MNOs, and a range of resellers. This competition encourages providers to invest, innovate and deliver the services that customers want, both now and in the future"[53].*

140. We agree with Ofcom that competition between network operators encourages investment, innovation and delivery of services customers want, now and in the future. The evidence presented in this report highlights the need for long term and continuous investment as the process of upgrading to 5G and beyond evolves.

141. In the Strategic Review of Digital Communications, Ofcom indicated that it had a role to play where firms are unable to make the necessary levels of investment to maintain current levels of competition in the long term, although it was not specific about what that role may be [54]. Again, we agree that Ofcom has an important role to play in creating an environment in which this investment incentivised.

142. In our view, the development of consumer benefits has the following three major implications for Ofcom's strategic priority of supporting investment.

[52] Ofcom op cit. footnote 6. Para 1.6.
[53] Ibid para 1.7
[54] Ofcom (2015) Strategic Review of Digital Communications: Discussion Document July 2015. Para 9.91

Consumer Benefits of 5G are Substantial but hard to Quantify

143. It is critical that Ofcom is cognisant of the substantial benefits of 5G for consumers, even though they may not be easy to quantify so early in the technology's development.

144. This report shows that consumer applications will have a variety of benefits, from improving consumers' quality of life by enhancing their experience of activities such as watching sports events, through to improved physical safety. They will also generate positive externalities for society as a whole.

145. The 5G business case is more challenging than it was for 4G, which was the first mobile standard to be developed specifically for data, using packet, rather than circuit, switching. The business case was therefore built primarily on an improved mobile broadband experience.

146. As the 5G standard develops, applications using the URLLC and MMTC pillars are likely to be transformational for users but more difficult to predict making the business case for 5G more risky. Ofcom should be aware of this and not take actions that increase risk for investors.

Financial Flows

147. Ofcom should be aware that the 5G ecosystem and financial models are not yet developed and should take that into account in its relevant decision making.

148. Whilst benefits to consumers are likely to be significant, it is not yet clear how money will flow through the 5G ecosystem and therefore which members of the 5G ecosystem will benefit, other than consumers. This could also make the 5G business case more challenging and investments more risky. It is important that all parts of the system have a fair opportunity to earn a reasonable return on revenues[55].

A Process not an Event

149. It is important that Ofcom recognises that 5G is a process not an event and its development should be allowed to play out over the investment cycle. Ofcom should not

[55] See, for example, Ofcom (2021) *Net Neutrality Review: Call for Evidence* 7 September 2021

make early decisions that could harm that process on the basis of expectations and hype rather than evidence. Much in the way they have for fibre, Government and Ofcom need to put in place a long term regulatory and pro investment framework to support investment confidence[56].

150. The use cases and consumer benefits of 5G will emerge overtime as new 3GPP Releases are agreed. The transition to 5G should not be seen as an event, but as a process during which networks, service providers and consumers will develop and use new services, many of which cannot be identified at this stage. The outcome of the strategy review should allow network operators and entrepreneurs to develop consumer based applications on the capabilities of 5G as they develop over time and should not prejudge what will be successful applications.

[56] In much the same way as Ofcom has indicated it will support fibre over the investment cycle. See speech by Melanie Dawes to FTTH Council Europe, 3rd December 2020, available at https://www.ofcom.org.uk/about-ofcom/latest/media/speeches/2020/full-fibre-must-be-a-fair-bet

Annex A: List of Potential Consumer Applications by Benefit Type

Benefit Type	Application	Information source
1	• Higher broadband access speeds • Improved rural connectivity • Lower network congestion • Fixed Wireless Access • Fixed-mobile convergence • Replace home WiFi • Instant cloud • Higher quality video calling • 5G enabled video capture • Home security	• https://www.forbes.com/uk/advisor/broadband/what-is-5g-broadband/ • https://dcms.shorthandstories.com/5g--rural-connected-communities/index.html • https://blog.viavisolutions.com/2020/01/29/will-5g-be-the-answer-to-the-current-network-congestion/ • https://www.ericsson.com/en/fixed-wireless-access?gclid=CjwKCAjw-sqKBhBjEiwAVaQ9a6PX-4ejiNKypKCtG-XrpCc3XS_UpONWqVuHcWtyb-WtSbsSLGjEUxoCOVkQAvD_BwE&gclsrc=aw.ds • https://www.broadband-forum.org/download/MR-427.pdf • https://www.vodafone.co.uk/gigacube/ • https://www.ericsson.com/en/edge-computing?gclid=CjwKCAjw-sqKBhBjEiwAVaQ9a91Mrykla2c7D3Hkph91pVfsUSWSTBVKf-V0H0B0aalTh4cFTQUJRRoCNhsQAvD_BwE&gclsrc=aw.ds •

Benefit Type	Application	Information source
2	• 5G TV to replace cable - is TV not a device similar to a laptop, hence a 1st order?	• https://5g.co.uk/guides/5g-tv/ •
3		
4	• Best seat event experience • Spatial HiFi music	• https://vimeo.com/340870583 https://imagination.com/insights/we-create-game-changing-5g-enabled-fan-experience-vodafone-business • https://www.hifinews.com/content/why-5g- a pr matters-hi-fi

Benefit Type	Application	Information source
5	• 360^{O} video live streaming • Social Virtual Reality • Smart venues • 5G in-car entertainment - again is it possible to think of this as a 1st order • Immersive learning • Home robots • Smart Mirror connectivity	• https://streamshark.io/enterprise/360-live-streaming/ • https://www.forbes.com/sites/cathyhackl/2020/08/30/social-vr-facebook-horizon--the-future-of-social-media-marketing/?sh=28593abc5b19 • https://ungerboeck.com/resources/smart-venue • https://www.holoride.com/experience • • https://newsroom.bt.com/uks-first-5g-immersive-classroom-brings-richer-learning-experience-to-pupils/ https://blogs.worldbank.org/digital-development/how-can-5g-make-difference-education • https://www.mouser.co.uk/applications/robotics-and-5g/ • https://www.youtube.com/watch?v=sdLyUZnGKGY • https://syneoshealthcommunications.com/blog/the-poseidon-smart-mirror-is-the-new-health-and-wellness-hub-at-home • • • • •

		•
Benefit Type	• Application	• Information source
6	• 3D hologram calling • Hearing aids • Augmented reality windows • See through cars • Personal environmental impact management • Smart resource repurposing • Mobility as a Service (MaaS) • Multi-modal hearing aids	• https://www.youtube.com/watch?v=Ilq2qtFHTf8 https://www.ericsson.com/en/news/2018/11/3d-holographic-calls-with-5g • • https://gtr.ukri.org/projects?ref=EP%2FT021063%2F1 • • https://spectrum.ieee.org/the-transparent-car#toggle-gdpr

		• https://www.telit.com/blog/how-5g-enables-advanced-metering-infrastructure-smarter-utilities/ • https://home.kpmg/uk/en/home/insights/2019/09/a-mobility-revolution-with-5g-at-its-heart.html • https://gtr.ukri.org/projects?ref=EP%2FT021063%2F1