

THE USE OF VIRTUAL AND AUGMENTED REALITY IN THE WORKPLACE

Implications for the roll-out
of next generation broadband
infrastructure

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In 2018, Frontier Economics produced a report for the National Infrastructure Commission (NIC) on the benefits of different types of broadband infrastructure up to 2050. Whilst setting out different scenarios, the report emphasised the uncertainty involved with making such long-term forecasts in a rapidly evolving sector. Indeed, since the publication of the report, the COVID-19 pandemic has resulted in widespread changes in how people work, shop, interact and spend their leisure time. One of the most marked shifts has been towards much greater remote working – a trend that is likely to persist, at least partly. This helps explain why companies, including Big Tech, are exploring how virtual and augmented reality can help to maximise the effectiveness of remote working.

This article explores the implications of the swelling of the ranks of remote workers and whether the technologies they might adopt will require higher bandwidths. In particular, we discuss how our estimates of the potential benefits of VHCN set out in our report for the NIC may be affected. Our chief conclusion is that the considerable increase in remote working does indeed strengthen the case for the widespread roll-out of VHCN as quickly as possible.

WFH

The surge in remote working since we produced our report was very difficult to foresee as it has been largely driven by COVID-19. There is a wide range of statistics on the impact of the pandemic on remote working, but they all show a considerable increase in working from home. Data from the ONS¹ suggests that in 2019 (on average during the year), just 26.7% of the workforce had done any

¹ <https://blog.ons.gov.uk/2021/05/17/working-from-home-comparing-the-data/>

EXEC SUMMARY

Telecom operators and policymakers have to make tough decisions about the optimal mix of broadband infrastructure in the future and how rapidly to roll it out. The broadband technologies with the highest capabilities also tend to be the costliest - the widespread deployment of full fibre broadband would provide the best performance, but it is also the most expensive option. Most policymakers have now come to the conclusion that the expected benefits of very high capacity networks (VHCN), i.e. full fibre plus 5G, justify the significant investments required. For example, the European Commission (EC) has included the roll-out and take-up of VHCN as an explicit objective within its telecoms regulatory framework.

work from home². In contrast, by April 2020, following the outbreak of COVID-19, the proportion of people in employment who had done some work at home had jumped to 46.6%³. The practice is especially commonplace in the information and communication sector⁴, which may have particularly high bandwidth requirements for remote working.

Working from home, to some degree at least, looks to be here to stay. Workers and firms have come to appreciate the attendant benefits of not having no commute, more flexibility to look after dependents, less need for expensive office space, helping the environment, etc. It seems likely that many businesses will move towards a hybrid model, with people working remotely part of the time and spending the rest of the week at the office. According to the ONS, 85% of those currently working from home favoured such a set-up⁵.

A NEW REALITY

In the grand scheme of things, Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (MR) are still at an early stage of development. VR is a technology that uses headset-mounted displays to create an immersive audio-visual experience. The aim is to simulate the user's presence in a virtual environment using images and sounds. In contrast to the fully immersive virtual experience that VR offers, AR blends real life and digital life by overlaying virtual sensory elements in the user's physical environment. Pokémon Go is a well-known example of AR. MR combines elements of both VR and AR, where real-world and holographic images are blended - in real time - to produce a seamless user experience. Notable examples are Microsoft's HoloLens and Lenovo's Mirage headsets.

POTENTIAL USE CASES FOR VIRTUAL AND AUGMENTED REALITY

VR has a wide range of potential applications:

- **Gaming.** Enthusiasts are already using VR headsets to enhance their experience of video games. To date, it is the gaming sector that has largely powered sales of VR headsets.
- **Education.** Teachers can use VR to bring a fresh approach to education. For example, VR could enable students to explore foreign countries and historical sites.
- **Healthcare.** VR can be used to train new healthcare professionals and/or to carry out remote surgery.
- **Entertainment.** Firms have already started to provide some of their content, such as concerts and sporting events, as “immersive experiences” to give the audience the feeling that they are actually present.

² This was based on the ONS Annual Population Survey (APS).

³ This was based on the ONS Labour Market Survey (LMS).

⁴ Ibid

⁵

<https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/articles/businessandindividualattitudestowardsfutureofhomeworkinguk/apriltomay2021>

- **Remote working.** VR can enable remote workers to work more closely with their colleagues, e.g. by having an avatar, hearing people speaking from different locations when in a meeting, being able to share content, having a whiteboard, etc.

The potential applications of AR are very broad. Arguably more so than VR, as there is likely to be less demand for full immersion than for some useful augmentation of the user's physical setting while still being able to see their surroundings and communicate with others. In future, consumers could visualise new furniture by 'placing' it in their home, conduct a holographic call/videoconference or answer emails without the need for a screen or keyboard.

POSSIBLE USE OF VIRTUAL AND AUGMENTED REALITY IN THE WORKPLACE

The likely permanent shift towards greater remote working clearly creates a strong demand for any tools that can help to make it more effective and enjoyable. So far, there has been much greater use of video conferencing⁶, webinars and messaging services during the pandemic. However, companies are increasingly looking to take things a step further, by using VR and AR. Indeed, the Big Tech firms, among others, are investing significant sums in VR and AR technologies (see box below).

⁶ See for example <https://www.bbc.co.uk/news/business-56247489>

BIG TECH'S FOCUS ON VIRTUAL AND AUGMENTED REALITY

According to IDC, a market research firm, worldwide spending on AR and VR is expected to increase more than sixfold to \$72.8 billion in 2024 from about \$12 billion in 2020⁷. Indeed, Big Tech firms (notably Facebook, Microsoft, Google and Apple) are investing large amounts in AR and VR, with a range of potential use cases in mind. For example, Facebook recently announced a major push into AR and VR. This forms part of the firm's strategy to create a "metaverse" - a large communal cyberspace, underpinned by AR and VR, that enables avatars to move seamlessly from one activity to another⁸.

Facebook CEO Mark Zuckerberg has gone as far as saying that he views the "metaverse" as the successor to the mobile internet - instead of just viewing content, users will be present in it^{9,10}.

An important component of Facebook's AR, VR, and MR strategy is to create tools that increase the effectiveness of remote working. Recently, the firm launched a new app ("Horizon Workrooms"), which allows people to work together in a shared virtual office. The app can project a user's real-life computer into this virtual office, viewed through Facebook's Oculus VR headsets, allowing workers to sit with colleagues, chat and make use of virtual whiteboards¹¹.

Facebook is not alone in focusing on the use of VR, AR, and MR in the workplace. In May, Microsoft CEO Satya Nadella said the company was working to build an "enterprise metaverse"¹². Microsoft's MR glasses (HoloLens) could have a key role in this vision.

THE DIGITAL HIGHWAY REQUIRED TO UNDERPIN DEVELOPMENTS IN VIRTUAL AND AUGMENTED REALITY

THE NEED FOR SPEED

No matter how much firms invest in AR/VR hardware and software, the use of such technology will be held back if the underlying data-carrying broadband infrastructure is not up to scratch. In 2018, Frontier Economics was commissioned by the NIC to consider the potential benefits (in the period to 2050) from investments in different forms of broadband infrastructure that could be rolled out in the coming decade in the UK. We developed two scenarios:

⁷ <https://www.washingtonpost.com/technology/2021/08/19/facebook-vr-app-remote-workers/>

⁸ To date, the closest that anyone has come to creating a metaverse is probably Fortnite. As well as allowing users to play video games, Fortnite has a number of additional features, such as live concerts and exclusive access to new music albums (<https://www.matthewball.vc/all/themetaverse>).

⁹ <https://news.sky.com/story/facebook-and-apple-smart-glasses-will-soon-be-upon-us-but-are-they-just-another-fad-12396720>

¹⁰ <https://www.theverge.com/22588022/mark-zuckerberg-facebook-ceo-metaverse-interview>

¹¹ <https://www.ft.com/content/9b73b3e4-6d68-4530-9879-58480b72335e>

¹² <https://news.microsoft.com/wp-content/uploads/prod/2021/07/Microsoft-Inspire-2021-Satya-Nadella.pdf>

- 1 In the **moderate evolution** scenario, we forecast likely changes in demand based on the continuing development of existing uses and applications of broadband. Such an approach is necessarily limited, as it did not attempt to predict completely new use cases. There can be a tendency to underestimate the rate at which successful new technologies are taken up initially.
- 2 In the **ambitious innovation** scenario, we attempted to account for the inherent uncertainty in forecasting future technology-related use cases over a thirty-year horizon. This uncertainty reflects the fact that forecasts are inevitably based on previous (recent) trends, which can neglect new applications.

We considered the required bandwidth for a range of different use cases under the two scenarios, with one of the use cases being VR and AR¹³. Bandwidth requirements are potentially large for VR¹⁴ and AR¹⁵, as the following figure shows. The requirements are a function of the assumed resolution and type of VR/AR device used, the number of devices per household and improvements in video compression¹⁶.

TABLE 1 BANDWIDTH REQUIREMENTS FOR AR/VR (MBPS)

| SCENARIO | 2020 | 2025 | 2030 | 2035 | 2040 | 2045 | 2050 |
|------------------------|------|------|------|------|------|-------|-------|
| 'Moderate evolution' | 38 | 34 | 79 | 114 | 142 | 162 | 146 |
| 'Ambitious innovation' | 75 | 174 | 253 | 314 | 361 | 1,011 | 1,528 |

Source: Frontier

Importantly, under the “moderate evolution” scenario, Fibre To The Premises (FTTP) i.e. full fibre, offered limited incremental benefits over other broadband technologies when considering the use of VR/AR (this was also true for most other use cases that we examined). Fibre To The Cabinet (FTTC), which is currently used by many households in the UK, would provide adequate bandwidth up until 2029. This is consistent with experience during the COVID-19 pandemic. Most existing applications¹⁷ (which included hardly any VR/AR for remote working) can be delivered via current broadband infrastructure. After all, nearly everyone was able to work remotely in the UK during the crisis, despite the lack of FTTP and 5G.

However, the optimal technology mix looks quite different under the assumptions of the “ambitious innovation” path, as only FTTP would allow users to tap the full potential of VR/AR under this scenario (up

¹³ We also considered the use cases for premium audiovisual displays, Small Office Home Office, smart home applications, user-generated content, next generation video communication, telehealth and telecare, online classrooms and support for 5G infrastructure.

¹⁴ It is necessary to deliver the visual display directly in the centre of the user’s field of vision, but also potentially across their entire field of vision. This is so that when a user turns their head or otherwise moves, the accompanying video display immediately changes.

¹⁵ We assumed that, all technical characteristics being equal, AR will require the same or less bandwidth than VR, since only part of the user’s field of view needs to be augmented, rather than all of it in the case of VR.

¹⁶ In our “ambitious innovation” scenario, we assumed that “advanced” VR/AR would take off more quickly than in our “moderate evolution” scenario. We also assumed some take-up of “ultra-advanced” VR/AR in the later years. By contrast, there is no ultra-advanced VR/AR at any point over the next 30 years in our “moderate evolution” scenario. Further, for our “ambitious innovation” scenario we assumed two AR/VR devices per household compared with one under our “moderate evolution” scenario.

¹⁷ E.g. video conference, browsing the internet, downloading files.

to 2045)¹⁸. The likely permanent shift towards remote working, entailing greater use of VR/AR, might now make the “moderate evolution” scenario less plausible. This is especially the case given that the increased deployment of VR/AR in the workplace could accelerate their adoption for other purposes. This is what happened with personal computers - once PCs were established in the workplace, demand from home users increased. All of this serves to demonstrate some of the inherent difficulties with making long-term forecasts, especially in a sector that is subject to significant uncertainty. If the “ambitious innovation” track is now more likely, due to the change in habits brought about by COVID-19, then there is a real need to roll out VHCN as soon as realistically possible.

WHAT ABOUT LATENCY AND RELIABILITY?

Our 2018 analysis focused on the bandwidth requirements of AR/VR. However, AR/VR will need more than just high speeds - ultra-low latency¹⁹ will also be critical. If latency is not low enough, users run the risk of getting ‘virtual reality sickness’ through disorientation as their sensory information (e.g. sight and sound) falls out of sync. Consequently, there must also be investment in the core network to support AR/VR - simply rolling out FTTP and 5G access networks may not suffice.

Reliability will also be important. We all are used to our image freezing occasionally during a video conference, but having to put up with a frozen hologram could be much worse. FTTP can be considerably more reliable than other broadband technologies, which is another reason why FTTP is likely to be needed to fully unlock the potential of VR/AR for remote working.

ENSURING THE NECESSARY INVESTMENTS TAKE PLACE

The shift towards remote working strengthens the potential benefits from having broadband infrastructure with high bandwidths, good reliability and ultra-low latency. The EC has already included widespread access to and take-up of VHCN as an explicit objective of its Electronics Communications Code (ECC)²⁰. However, the key challenge is to design policies that will incentivise the necessary investments. If remote working does remain popular in the long-term, policymakers will also want to redouble efforts to avoid a digital divide, something which will require the necessary broadband infrastructure to be both available and affordable.

¹⁸ 5G would allow users to benefit from the full potential of VR/AR under this scenario, up to 2041.

¹⁹ Latency is a measure of time delay. A lower latency corresponds to a shorter delay.

²⁰ See recital 23 of “DIRECTIVE (EU) 2018/1972 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 establishing the European Electronic Communications Code.”

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