Future of Connectivity in Local Authorities

dg:cities

The work undertaken over the last year as part of the LGA funded Digital Connectivity project, has focused on better understanding the connectivity requirements the Royal Borough of Greenwich (and other similar local authorities) will face in the coming 5 to 10 years, as well as exploring its options to meet those requirements. One delivery route, the provision of a dark fibre network by the local authority in social housing blocks and its subsequent commercialisation, was analysed in depth following a pilot deployment in the borough.

Executive Summary

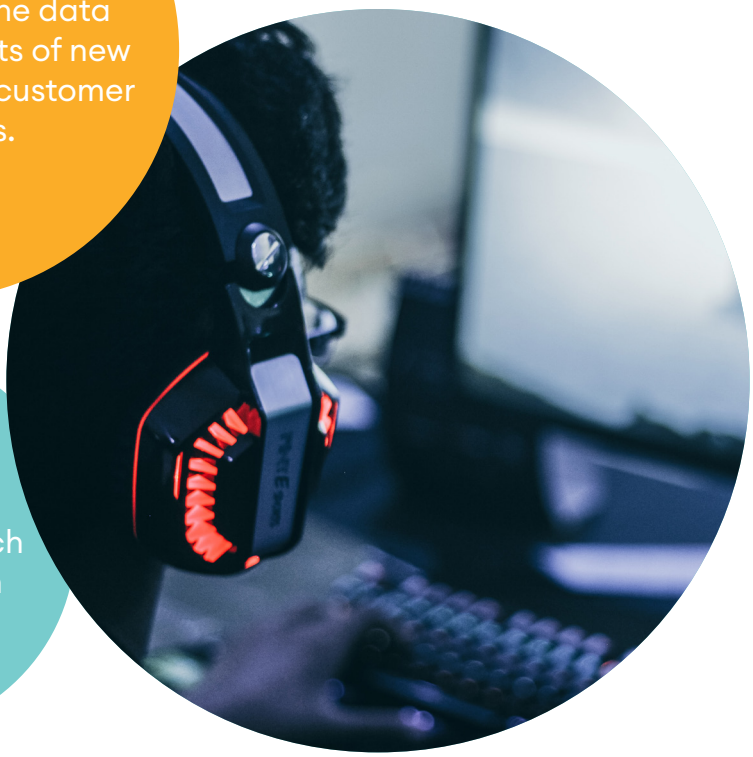
Based on current data and existing trends, it was a rather unsurprising conclusion that the demand for bandwidth is expected to continue growing. This is closely linked to increased video content consumption across all online users and higher quality videos and TV programmes moving over to broadband distribution. Online games are another service that has an increasing network demand, with a third of UK adults playing games online. In the future, increasing usage of AR/VR technologies supporting immersive real time applications will further increase the reliance on fast and low latency networks. The pandemic has helped to speed up working-from-home trends and it is expected that many workers will not return to the office full time. This, alongside online resources for education across all age groups and the increasing use of internet connected devices in healthcare, and online Council services, put further requirements on having fast and stable internet connections at homes.

"A third of UK adults are playing games online"

The chapter: **USE OF THE INTERNET** explores trends in the way internet use is changing in household, educational, healthcare and council sectors.

Whilst faster internet connections are necessary for many of the above-mentioned applications, it is estimated by the middle of this decade less than 10% of online users will have connections with 300Mb/s speeds or above. At the same time, users with connections speeds of below 30Mb/s will also fall to only 3%. A factor of 10 increase in home internet speeds, is only expected by about 2040.

ANALYSIS OF BANDWIDTH NEEDS outlines the data usage requirements of new technologies and customer behaviours.



ANNEX 2: RESIDENT RESEARCH describes research undertaken with residents in Greenwich.

"As Openreach retires the PSTN network used for voice calls, it will be important to support vulnerable people in the transition."

The latest full fibre networks rolled out today provide high speeds and low latency to customers, with various upgrade paths available for further development. Commercial networks will keep rolling out FTTH as the council is expected to support them with providing wayleaves to operators. Cherry picking is however, a concern both between different areas, and between different dwelling types within areas, with providers focusing on high density areas and Multiple Dwelling Units to maximise the number of potential customers and return on investment. A borough can also use its own funding to invest in delivering a network to directly promote fibre availability in areas that are not addressed by private sector players.

In the wireless domain, the key technology development is 5G, offering faster and lower latency connections on the go. 5G has the potential to provide connectivity that is in-par with fixed broadband, enabling various emerging applications to customers. Concurrently lower bandwidth systems like LoRaWAN are rolled out in several locations across the country, with use cases including a variety of Internet of Things (IoT) devices that require only low power and low volume data transmissions. Local authorities including Greenwich will need to consider whether benefits from such networks over traditional mobile networks for IoT installations

Another impact of the rollout of faster broadband services and modern wireless networks is the migration away from older network. As Openreach retires the PSTN network that is used for voice-calls and some other applications, it will be important to support vulnerable populations in the transition away from legacy systems.

ANALYSIS OF NETWORK OPTIONS outlines available network technologies, how they're changing and what new solutions might become available over time.

One option a council has to speed up the rollout of Fibre to the Home (FTTH) services, which has been looked at in some depth, is to install dark fibre infrastructure as it undertakes renovation works on its housing stock. On the face of it, the low marginal cost of installing fibre during a refurbishment reduces the cost that internet service providers face as they build a fibre network in multiple dwelling units. A council could install all cabling needed for FTTH, terminate the cables in a cabinet reducing costs and minimising disruption. When internet service providers reach the building, they only need to connect their network to the cabling within the cabinet, immediately having access to all users within the building. The council also has the opportunity to install multiple fibre cables to each housing unit at once, thus enabling a competition amongst multiple providers.

Greenwich has carried out installations as described above in two estates. Within the Flamsteed estate, a 2-core fibre cable was installed to all properties whilst at the Ernest Dence estate a 4-fibre solution was installed, with 4 separate distribution cabinets. The installation was carried out by a subcontractor, SCCI, on behalf of the Council, alongside a major retrofit programme. This resulted in a neat deployment, with all cabling running in clearly defined and labelled ducts to all homes. This is in contrast to ISPs installing their own cabling that usually happens in a 1-by-1 fashion.

“Internet service providers only need to connect their network to the cabling in the cabinet, immediately having access to all users in the building.”

SUMMARY OF WORK UNDERTAKEN ON THE ESTATES outlines the details of the model as well as the works that were carried out in Greenwich.

The key question of this model is its attractiveness to ISPs, the ability for the council to recoup its costs and the mechanism to do so. During the project various options analysed and discussions held with providers about ‘lighting the fibres’ and thus providing broadband services through the newly installed cabling.

Discussion about further challenges in detail are described in ISSUES IN PRINCIPLE.

The results are somewhat inconclusive, as operators identified a number of challenges with the model. This is in part because it is a non-standard' approach and doesn't sit easily in their current models of working. As their current approach is to rely on building, and managing the entirety of their networks, the interface with another service or maintenance provider on a small deployment was a barrier. An option that had some traction was to take ownership of the council-built fibre network and manage it as their own asset. Whilst this could be a viable solution in some instances, for example in the case of Greenwich, at Flamsteed, where a 2-core fibre is designed to be used by a single ISP, this would be less beneficial in, for example, at Ernest Dence, where up to four ISP could provide services, and would not achieve the intended benefit of attracting multiple providers, To achieve the hoped for benefits that a For the 4-fibre solution, could offer a Council would need to take a more active role in managing (and maintain the fibre). It might for example offer a period of exclusivity (ex. for a year) attract the first ISP to move in, but issues with relation to who provides ongoing maintenance of the network and meet service level agreements is an issue. Moreover, unless attractive to providers, they can seek their own wayleave to install fibre within the block and effectively over build in the installed network.

A full analysis of the various deployment options are detailed in OPTIONS FOR LIGHTING THE FIBRE

In Greenwich, a viable solution is to pass these fibre assets to a special purpose vehicle to market manage and maintain the fibre. This option allows the council to establish a standard approach for similar deployments, create a strong business case alongside the JV partner and coordinate any future installations to take place as the council continues to refurbish properties.

A complete set of recommendations are highlighted in the report's CONCLUSIONS AND RECOMMENDATIONS


BERATUNG FÜR GESCHÄFTSKUNDEN

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Introduction

This report builds on Greenwich's Digital Connectivity Strategy[1] which in 2019 set out the need for increased connectivity in the borough in the light of increasing demand for bandwidth by residents who consume more online video and other services, the ability of the council to deploy modern connected devices to support delivery of its services and the risk that delays to full fibre deployment may have a detrimental impact on economic regeneration in the borough.

Key actions arising from the strategy include the forthcoming deployment of a full fibre network in Woolwich with a commercial partner in a joint venture.

The council has also piloted deploying fibre into social housing residences when refurbishing estates, piloting this on the Flamsteed and Ernest Dence estates in Greenwich. The refurbishment has also given the council the opportunity to pilot IoT applications to promote energy efficiency and environmental monitoring.

This has been complemented with other activities to address digital inclusion, including the Digital Champions programme to support local community groups to provide training and digital devices to residents currently not online.

This report provides an overview of current trends, especially in the light of the Covid-19 pandemic, ongoing network deployments and new technology development and considers the wider connectivity needs of the borough. It provides context to some of the work we have carried out

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1 https://committees.royalgreenwich.gov.uk/Document.ashx?czJKcaeAi5tUFL1DTL2UE4zNRBcoShgo=mr9FVbRkE3Lx6wHBiv5CN6ejMWMCzUo267uSsHighSwznq7P7oyxBQ%3d%3d&rUzwRPf%2bZ3zd4E7Ikn8Lyw%3d%3d=pwRE6AGJFLDNlh225F5QMaQWCtPHwdhUfCZ%2fLUQzgA2uL5jNRG4jdQ%3d%3d&mCTIbCubSFfXsDGW9IXnlg%3d%3d=hFflUdN3100%3d&kCx1AnS9%2fpWZQ40DXFvdEw%3d%3d=hFflUdN3100%3d&uJovDxwdjMPoYv%2bAJvYtyA%3d%3d=ctNJFf55vVA%3d&FgPlIEJYlotS%2bYGoBi5olA%3d%3d=NHdURQburHA%3d&d9Qjj0ag1Pd993jsyOJqFvmyB7X0CSQK=ctNJFf55vVA%3d&WGewmoAfeNR9xqBux0r1Q8Za60lavYmz=ctNJFf55vVA%3d&WGewmoAfeNQ16B2MHuCpMRKZMwaG1PaO=ctNJFf55vVA%3d

looking at options for using dark fibre to improve connectivity on social housing estates.

The focus of this report is on considering the likely connectivity needs of the borough over the coming decade. By 'connectivity' we mean the networks which are used by residents, businesses and the public sector to communicate, access services and applications, consume and create content. We note, however, that networks are only a tool and that outcomes depend not solely on their availability and how they are used, but on a wider range of factors, including how data that passed through these networks is collected, analysed and shared.

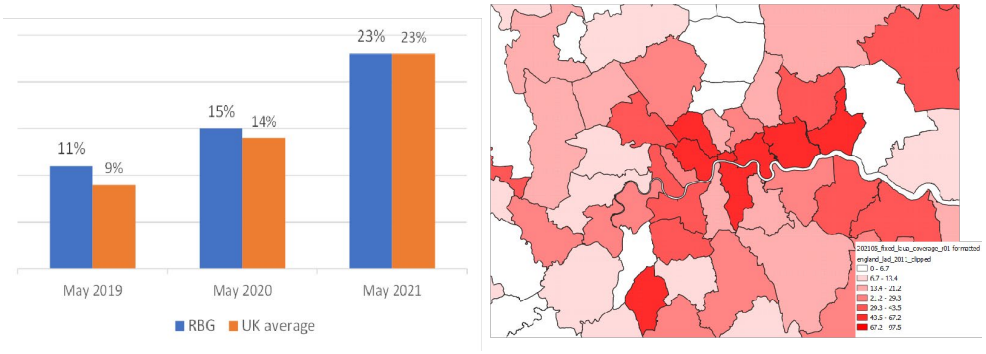
This report is complemented with a further report which looks specifically at options around the installation of dark fibre on social housing estates and an annex which contains additional detail on our programme of consumer research.

Overview of current availability of networks in Greenwich

THE BOROUGH'S EARLY LEAD IN FULL FIBRE HAS FALLEN BACK OVER TIME

Despite full fibre coverage in the borough doubling since May 2019 to 23% of all premises in May 2021 and increasing to 24% by September 2021, the early lead that the borough had over the national average has been eroded and availability of full fibre is lower than in several surrounding boroughs including Bexley, Newham and Tower Hamlets.

Figure 1: Availability of full fibre broadband, May 2021

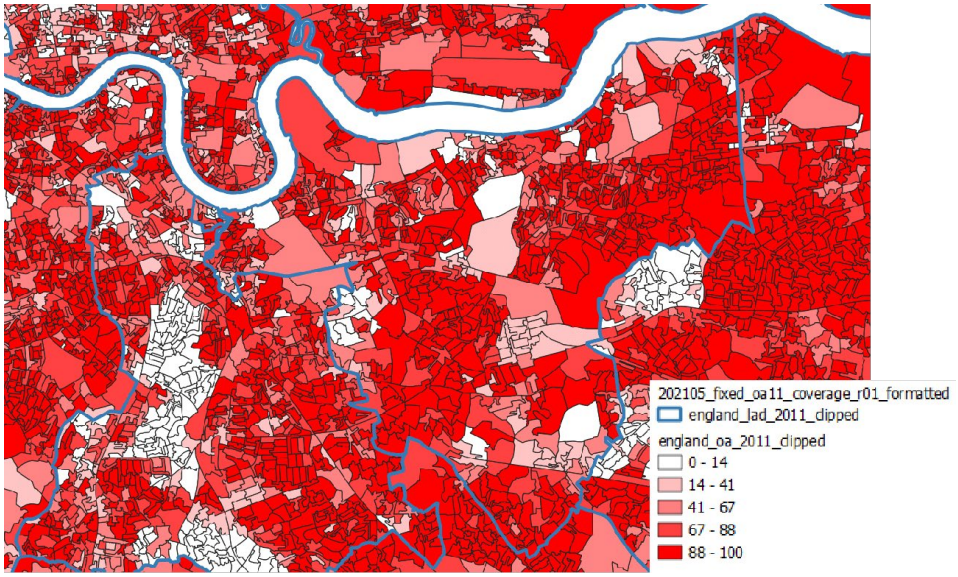


Source: Ofcom / DG Cities analysis Data licensed from Ofcom: https://www.ofcom.org.uk/research-and-data/multi-sector-research/infrastructure-research/connected-nations-2017/data-downloads/terms-of-use

Analysis of availability of fixed broadband with download speeds of 1Gb/s[2] or more within Greenwich itself[3] demonstrates despite a relatively high coverage figure in May 2021 of 77% properties (vs 39% of the UK as a whole, 65% in Lewisham and 79% in Bexley) there remain differences in availability towards the centre and south of the borough. This is likely to reflect coverage of Virgin Media's network which provides the bulk of gigabit capable broadband in the borough. Other operators providing gigabit capable broadband services to selected premises in the borough include Community Fibre[4] and Hyperoptic, which are rolling out full fibre networks to parts of the borough.

[2] Generally Virgin Media's DOCSIS 3.1 gigabit cable broadband service.
[3] Full fibre coverage data at the output area level is no longer published by Ofcom
[4] https://communityfibre.co.uk/press/community-fibre-announces-300000-homes-passed

Figure 2: Availability of gigabit broadband by Output Area May 2021



Source: Ofcom / DG Cities analysis Data licensed from Ofcom: https://www.ofcom.org.uk/research-and-data/multi-sector-research/infrastructure-research/connected-nations-2017/data-downloads/terms-of-use

Openreach plans to deploy its full fibre FTTP network to 25 million homes and businesses around the UK by December 2026. It plans to deploy FTTP to Thamesmead, Eltham, Kidbrooke, Woolwich exchanges in the borough in the 22/23-23/24 period.[5] Virgin Media has also stated publicly that it intends roll out a full fibre across its entire UK footprint by 2028.[6] Virgin Media is trialling this rollout first in Stoke-on-Trent, Salisbury and Wakefield.[7]

Openreach will retire the PSTN network used for voice calls and other non-broadband products by December 2025. This means that voice calls and other services such as some alarm signalling systems and telecare monitoring services will need to be delivered over a broadband connection (which may in part continue to be delivered over copper). Openreach has designated Thamesmead Exchange within Tranche 4 of its copper switch-off programme given it is one of the early exchanges where FTTP is being rolled out. From April 2022, operators will no longer

[5] https://www.openreach.com/content/dam/openreach/openreach-dam-files/images/transparency/Openreach_Full_Fibre_Build_Programme_24_June_2021_V1.pdf

[6] https://www.libertyglobal.com/virgin-media-o2-announces-2028-full-fibre-upgrade-plan/

[7] https://www.ispreview.co.uk/index.php/2021/11/virgin-media-o2-uk-update-on-wholesale-and-fttp-upgrade-plan.html

be able to order new copper products for premises served by the exchange which have access to FTTP.[8]

Mobile voice and data services provided by each of the UK's four mobile network operators (MNOs) are available in across the borough, but coverage varies by location and operator.

Figure 3: 4G data indoor coverage by operator

Source: Ofcom. Maps relate to 4G Data Indoor coverage

For example, residents in parts of Plumstead report difficulty in obtaining a signal allowing them to make and receive calls and SMS from within their homes. One way to mitigate this is to use a 4G handset with WI-FI calling capability meaning calls can be made on 4G networks (which in some areas may have better indoor coverage than 2G and 3G networks due to the spectrum used) or via the resident's Wi-Fi and home broadband connection. Many mobile operators (including all of the largest ones) offer 4G/Wi-Fi calling.

[8] https://www.btwholesale.com/assets/documents/products-and-services/hosted-communications/all-ip/btw-product-stop-sells-update-aug21.pdf

Use of the Internet

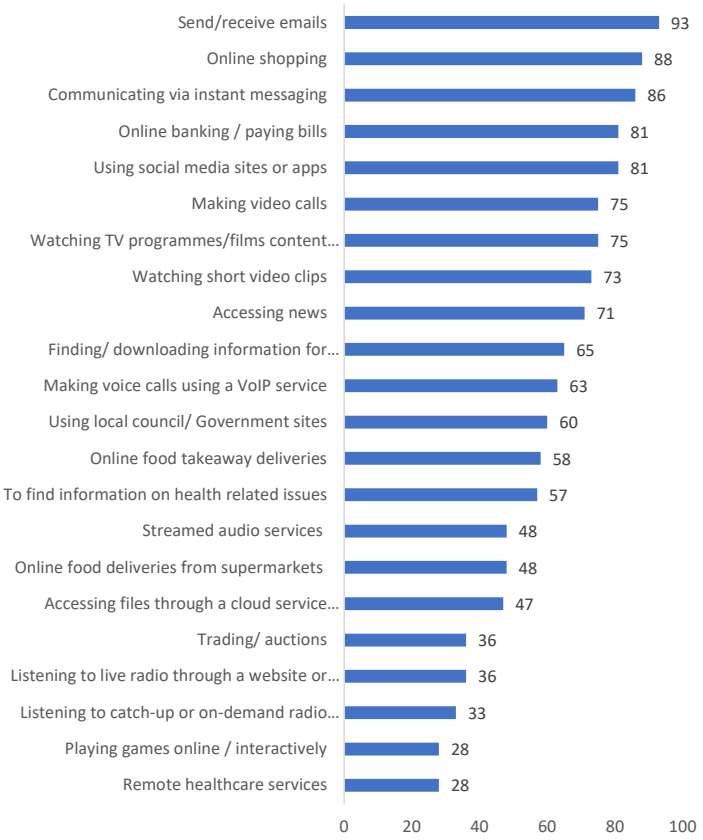
INTERNET USE HAS BEEN IMPACTED BY THE PANDEMIC

At the time of writing, the UK is still in the midst of the Covid pandemic and the changes this has brought to the way people live their lives, businesses operate and public bodies deliver services to their citizens.

Communicating via email and using instant messaging are among the most common uses of the internet by online adults in London, being used by around nine out of ten internet users respectively in 2021. Three quarters of internet users in London watch TV programmes or film content online. Looking at use of the internet to access public services six in ten online adults in London use local or national government websites and many use the internet to access healthcare services online. Generally, use of the internet is in line with that of the UK as a whole, though adults in London were more likely to use the internet for online food delivery takeaway than elsewhere in the country.

While take-up of e-commerce increased noticeably following the introduction of social distancing in March 2020, the pandemic has also impacted on the way people use the internet for communications and content consumption, with 56% internet users in London saying that they were making video calls more often, and 43% saying they were watching TV programmes or films more often.

Figure 4: Use of the internet in 2021 in London



Source: Ofcom (2021) Technology Tracker QE5A. Please think about any reason you may have for going online, at home or anywhere else, perhaps using a computer, mobile phone, tablet or smart watch, using broadband, through Wi-Fi or a mobile phone signal. Which, if any, of these do you do online? (MULTI CODE). Base: London adults who use the internet at home or elsewhere (excluding those completing a paper questionnaire)

Longer term implications from the pandemic are more difficult to draw at the present time. There is some evidence to suggest that some of the behavioural and attitudinal changes brought about by the pandemic may remain at least in part over the coming years. For example, working from home (whether full time or in a hybrid-manner) is likely to become prevalent over the next decade rather than would have otherwise been expected at the start of 2020, though many will still work in the offices at least part of the time.[9] Likewise, there is also some early evidence to suggest that some of the change in shopping behaviours away from

[9] https://www.mckinsey.com/industries/public-and-social-sector/our-insights/trends-that-will-define-2021-and-beyond-six-months-on

brick and mortar stores will be permanent, even as shops have opened up and restrictions have been relaxed.[10]

In its review of the long-term societal impact of the pandemic,[11] the British Academy suggests that the following areas will have a long-term societal impact:

- Increasing importance of local communities
- Low levels of trust in government (especially at the national level)
- Deeper inequalities – both geographic and structural
- Health inequalities and worsening health outcomes
- Greater awareness of the importance of mental health
- Pressure on revenue streams across the economy driven by changes in unemployment, consumer behaviour and other macroeconomic factors
- Higher unemployment and changes to labour markets
- A renewed awareness of education and skills, which has in part highlighted issues around digital inequality

The challenges identified by the British Academy are relevant considering the connectivity needs of the borough, its businesses and residents. They also echo some of the challenges identified by the Royal Borough in the 2019 strategy. While availability of networks and devices may play a part in helping to mitigate these challenges, the challenges also demonstrate the need to consider issues around digital inclusion, the quality of online public services being offered, and the digital skills required in the future. Furthermore, as public bodies such as the council increasingly seek to deliver public services online, and deploy connected devices and sensors into the public realm and social housing, people's attitudes towards privacy and data protection will continue to be salient.

Residential applications

Use of online video has grown over time

As noted in the brough's Digital Connectivity strategy, a key driver of demand for bandwidth is the growth in online video consumption and a shift away from broadcast TV towards video on demand services, in particular subscription video-on-demand (SVoD) services such as Netflix.

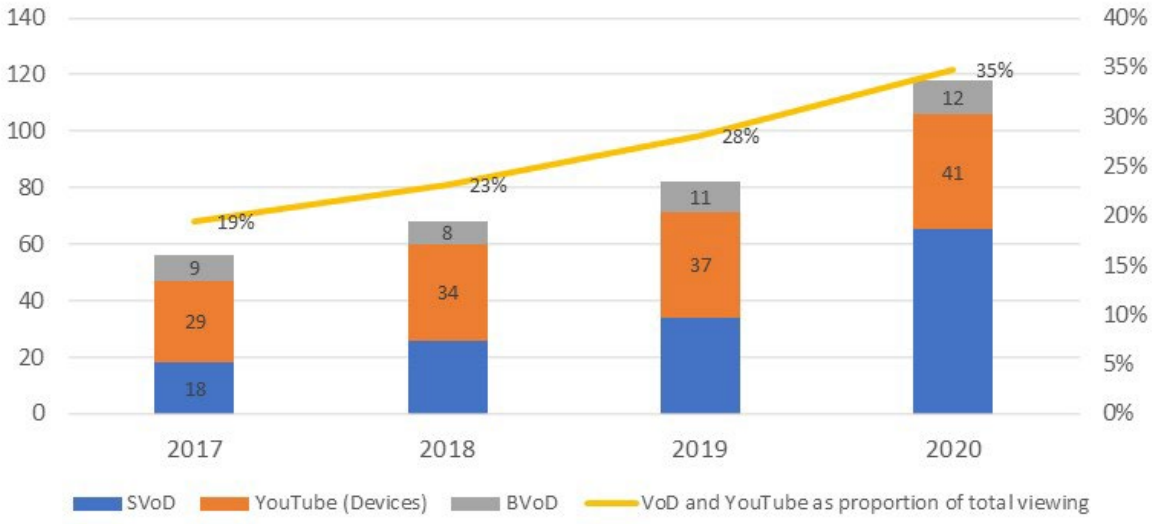
[10] ONS data for August 2021 suggests that online channels accounted for 27.7% retail sales in August 2021 compared to 19.7% in February 2020

[11] British Academy (2021) The COVID Decade Understanding the long-term societal impact of COVID-19 https://www.thebritishacademy.ac.uk/documents/3238/COVID-decade-understanding-long-term-societal-impacts-COVID-19.pdf

Figure 5: Average daily video consumption (minutes)

Source: Ofcom estimates of total video viewing, Modelled from BARB, Comscore and Touchpoints data; DGC analysis. UK population age 4+
Note: Subscription video on demand (SVoD) services include services such as Netflix and Amazon Prime video. Broadcaster Video on Demand (BVoD) includes services such as iPlayer, All4

Research by Ampere suggests that this trend is likely to continue. By 2021



almost half (48%) of online adults considered online video services to be their main way of watching TV and film. Furthermore, 42% of current SVoD could imagine not watching any broadcast TV in five years' time.[12] Reflecting these changes in behaviour, traditional pay-TV platforms such as Sky are shifting away from the use of broadcast networks. The SkyQ hybrid service uses a broadband rather than a satellite connection for the delivery of 4K video content, and Sky's Glass TV, launched in October 2021 offers all Sky services via a broadband connection, the first time that Sky has made all its services available in this way.[13]

It is not solely the amount of online video being consumed, but the resolution that is also likely to increase over time. The price of 8K TVs has

[12] Ampere Analysis Consumer research, age: online 18-64, Q1 2021, cited in Ofcom (2021) Media Nations UK Report https://www.ofcom.org.uk/__data/assets/pdf_file/0023/222890/media-nations-report-2021.pdf

[13] Sky's NOW service, launched in 2012 relies on a broadband connection but offers consumers a subset of the content available via Sky's Sky-branded pay-TV service.

fallen over time (and may reach £1000 by the end of 2021)[14] while 29% of those watching TV on a set at home used a 4K set as the main TV.[15]

The trends in online video therefore suggest demand for bandwidth is likely to increase. McKinsey estimates that global online video data will grow by a factor of 22 between 2018 and 2030 driven by increased take-up of online video in emerging markets and increased adoption of HD and UHD video more generally.[16]

Despite these trends, not everyone it is likely that some consumers in the UK will continue to consume broadcast TV via the DTT platform into the 2030s given its wide availability and being free at the point of use.[17]

Online games

Another key use of home broadband connections is for playing games online. Around a third of adults play videogames online or against other people, with two thirds of those ages 16-24 doing this. In addition to enabling people to play against each other, broadband connections are used for the distribution of games content and software, and increasingly for the streaming of game services. Between 2021 and 2023 NewZoo's base case is that streaming revenues will grow from $1.4bn globally to $5.1bn.[18]

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[14] Deloitte UK TMT Predictions 2021 https://www2.deloitte.com/uk/en/pages/technology-media-and-telecommunications/articles/tmt-predictions.html

[15] Ofcom Technology Tracker 2021 QH53

[16] McKinsey. (2020) Connected World Report. https://www.mckinsey.com/~/media/mckinsey/industries/technology%20media%20and%20telecommunications/telecommunications/our%20insights/connected%20world%20an%20evolution%20in%20connectivity%20beyond%20the%205g%20revolution/mgi_connected-world_discussion-paper_february-2020.pdf

[17] The Government does not see the role played by digital terrestrial television (DTT) in providing universal, free to access UK content being displaced by another technology by 2034. Government will legislate to extend the licences of the national commercial DTT multiplexes to 2034, with an option to review licences not earlier than 2030. https://www.gov.uk/government/consultations/consultation-on-the-renewal-of-digital-terrestrial-television-dtt-multiplex-licences-expiring-in-2022-and-2026/outcome/consultation-on-the-renewal-of-digital-terrestrial-television-dtt-multiplex-licences-full-government-response

[18] https://newzoo.com/insights/articles/cloud-gaming-market-first-billion-dollar-year-23-7-million-paying-users-will-generate-revenues-of-1-4-billion-in-2021/

Shifts in the way that the internet is being used suggest that connected devices that are not computers may become relatively more important – including cars

The take-up of internet connected devices that are not computers, smartphones or tablets has increased over time. By 2021, 50% UK adults had a smart speaker at home, while 17% had a smart home security system (such as a video doorbell or security camera) and 14% had smart lighting.[19]

Mediatique forecasts that by 2035, nine in ten homes will have a smartphone and a smart TV.[20] One area which may see rapid growth between 2020 and 2030 is the household take-up of connected cars, which reaches 72% in Mediatique's base case by 2035. Car manufacturers (OEMs) are offering increasingly advanced connected infotainment systems which often rely on embedded 4G connectivity to provide navigation, entertainment and management of car features. Over the next decade we believe this trend will continue with features such as hybrid radios (which integrate DAB and IP radio reception), and roadside-vehicle and vehicle to vehicle communication (which may allow for greater levels of autonomy) becoming standard on an increasing number of models. The low latency of 5G networks and their ability to be used on the move means that over the next decade, 5G networks may be key for vehicle-to vehicle and vehicle to roadside communication applications which may support both electrification and increasing autonomy.

EDUCATION

Increasing personalisation of education is likely to drive demand for bandwidth in schools

The use of video conferencing to deliver lessons in real time increased significantly during the pandemic. More broadly, longer term trends in education suggest that use of real-time communications could become even more central in the way education is experienced by students. For example, Microsoft points to a shift towards "Deep learning", a more learner-centred approach to learning, where technology moves from "transmission and consumption" towards being "a connector and

[19] Ofcom Technology Tracker 2021
[20] Mediatique (2021) Ownership and use of audio-enabled devices in 2035 A report for the devices working group (BBC/DRUK) June 2021

amplifier".[21] Pointing to shifts in the labour market, Microsoft suggests that education will need to focus on developing creativity, problem-solving skills as well as develop socio-emotional skills. Digital tools which support real time collaboration and socio-emotional development may include mixed reality (i.e. AR and VR) to allow pupils immersive interactive experiences.[22]

Another area of growth in schools is the use of analytics to track and monitor pupil performance using cloud-based platforms such as Microsoft Azure,[23] an application using bandwidth in a relatively symmetric way.

Better quality bandwidth in schools may promote better educational and economic outcomes

Analysis by the Economist Intelligence Unit suggests that across countries, a 10% increase in school connectivity can increase the effective years of schooling for children by 0.6%, and GDP per capita by 1.1%.[24] Even in the US, where 99% of schools have a form of fibre connection to the internet, there remain significant differences in effective bandwidth per pupil, and EIU estimates that improving the quality of bandwidth across states could increase national GDP between 0.4% and 5.5%.

Schools in the UK currently use a mixture of connectivity. While FTTC is used by small schools, both download and in particular upload bandwidths can act as a constraint and that even by 2019 medium and larger schools had been advised[25] to use either full fibre broadband[26] or dedicated full fibre leased lines.[27]

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[21] Fullan, M., Quinn, J., Drummy, M., Gardner, M. (2020), "Education Reimagined; The Future of Learning". A collaborative position paper between New Pedagogies for Deep Learning and Microsoft Education. http://aka.ms/HybridLearningPaper

[22] Microsoft (2018) The class of 2030 and life-ready learning: The technology imperative https://education.minecraft.net/wp-content/uploads/13679_EDU_Thought_Leadership_Summary_revisions_5.10.18.pdf

[23] Microsoft (2018)

[24] EIU (2021) Connecting Learners: Narrowing the Educational Divide https://connectinglearners.economist.com/data/EIU_Ericsson_Connecting.pdf

[25] (2019) Selecting Broadband Connectivity for your school

[26] I.e. FTTH broadband. As with residential broadband capacity is shared with other users (a contended connection) meaning that user experience may vary

[27] These are also full fibre connections but with dedicated capacity between the end user and the core network, generally using the Ethernet protocol.

Healthcare

High quality connectivity is important across the healthcare sector

McKinsey distinguishes between broad categories of digital health including telehealth and care navigation e.g. patients researching conditions.[28] Use of networks in telehealth varies between synchronous applications i.e. those that require a two-way live audio-visual interaction (such as a remote video consultation) and asynchronous applications such as the passing of scans and documentation between medical professionals. Telehealth also includes remote monitoring of conditions by the use of connected devices used by people at home to measure vital signs. One particular telehealth situation which may generate significant amounts of data requiring real time analysis is the 'Hospital at Home', where patients who would otherwise be in hospital receive intensive monitoring at home, potentially including diagnostic services such as ultrasound or endoscopy.[29]

Better connectivity supports the adoption of IoT in healthcare, potentially generating over a trillion dollars of economic value annually worldwide by 2023

McKinsey estimates in 2020, IoT in healthcare generated $280bn in economic value globally.[30] Increasing IoT could generate between $550bn and $1760bn in 2030, with up to $1200bn of this coming from IoT used to monitor and treat illnesses.

De-centralisation of treatment away from hospitals into the community may increase bandwidth requirements for healthcare settings outside of hospitals

A trend towards treatment in smaller centres in the community and the move towards integrated care system approaches is likely to increase data flows between local centres and hospitals and between healthcare and social services. Activities such as remote endoscopies carried out in community-based diagnostics centres require real time data transfer while other applications may not require real-time connectivity. For

[28] McKinsey (2020) Virtual Health https://www.mckinsey.com/industries/healthcare-systems-and-services/our-insights/virtual-health-a-look-at-the-next-frontier-of-care-delivery

[29] https://www.hospitalathome.org.uk/what-is-hospital-at-home

[30] McKinsey (2021) The Internet of Things: Catching up to an accelerating opportunity https://www.mckinsey.com/business-functions/mckinsey-digital/our-insights/iot-value-set-to-accelerate-through-2030-where-and-how-to-capture-it

example, management of long-term conditions may result in large volumes of data being collected, but in many cases GPs may not have the need or capability to analyse and respond to this data in real time.

Connected ambulances allow for monitoring of patients on their way to hospital

Connecting ambulances to 5G networks offers the potential to increase the scope of real-time monitoring of patients by hospital doctors while the patient is being transferred to hospital. The increased capability of 5G networks allows a single connection to potentially replace dozens of separate 3G and 4G SIMs across individual pieces of equipment carried in ambulances.

Council services

Delivery of council services online

Greenwich's Digital Strategy sets out an expectation that residents choose to communicate with the council and access council services that are online by default.[31] Behind this, the council is upgrading its own connectivity, and is moving services to the cloud. While this may give greater flexibility as to how services are created, how they scale and potentially where and how they may be consumed, as with other large organisations, it may require the council to shift from wide area networking, WAN, products (i.e. high speed connections between its offices and server locations) to a greater focus on internet access.

Over the coming decade, cloud-based desktop applications will be likely to continue to be relevant for the council and other organisations, including businesses and workers based in the borough and may replace locally hosted services, given their potential cost and security advantages. This summer, Microsoft expanded its end-user cloud product portfolio by its Windows 365 cloud-based PC service which allows users to access a remote Windows desktop from a web browser. Services such as these potentially enables organisations to migrate even 'power users'[32] away from more expensive laptop and desktop computers towards cheaper devices (as the bulk of processing is done in

[31] https://www.royalgreenwich.gov.uk/info/200222/policies_and_plans/2259/digital_strategy_2020_to_2024/4

[32] For example, those running relatively demanding applications involving large complex datasets or calculations or creative applications such as image or video editing

the cloud) or even move towards use of employee-owned devices, although this would be subject to organisational security policies.

While video conferencing is a now well-established business application, some suppliers are looking for ways to facilitate more collaborative and immersive working. For example, Microsoft's Mesh collaborative working environment which includes 3D avatars and mixed reality will be integrated into its Teams tool form 2022. Meta (formerly Facebook) has been advocating the concept of the "metaverse", interconnected online 3D virtual environments in which people socialise, work, learn and relax. As part of this strategy, Meta is developing more immersive tools for workplace communications, scheduled to launch in 2022. Despite also starting work on metaverse tools, Zoom's CEO indicated in an October 2021 interview that he believed it will be several years before metaverse videoconferencing will be common.[33]

IoT and smart city applications

Some local authorities including Edinburgh and Sunderland are investing in large-scale integrated platforms to manage and integrate IoT deployments across their council areas. For example, Edinburgh is deploying CGI's SensorInsights360 platform[34] which will support sensors being deployed for estate management, waste management and lighting. Other cities including Paris and Barcelona have developed their own IoT platforms, some of which are open source.

Exact applications and services that will vary between locations, reflect differences in role. For example, public transportation and a significant proportion of roads within Greenwich fall under the jurisdiction of TfL rather than the council and this has implications for the scope of any deployment by Greenwich.[35] Likewise, the proportion of housing stock that is owned and managed by the local authority will vary across the borough.

There are a number of IoT initiatives ongoing in Greenwich and some that are being considered. In each use case, the IoT device by definition is connected to the internet through some means. Some, like most high-definition cameras that are used for anything from security, traffic

[33] Yahoo Finance interview with Zoom CEO Eric Yuan 25 October 2021 https://uk.finance.yahoo.com/video/zoom-ceo-metaverse-210052729.html

[34] https://www.smartcitiesworld.net/news/edinburgh-awards-five-year-contract-to-support-smart-city-transformation-7070

[35] However, residents in the Borough are likely to benefit from these London-wide initiatives such as TfL and Siemens' Real Time Optimiser (RTO) and FUSION algorithm for traffic management and control which is due to be rolled out across London having launched in pilot in South West London.

monitoring or fly-tipping monitoring, require fixed connections today to manage the data upload volumes. This makes their deployment costly and more limited in terms of where they can be deployed, as a cable needs to be installed and connected to each device.

Other devices use wireless connectivity, either by taking advantage of a local Wi-Fi network where a transmitter then collects and sends data from multiple devices to the cloud using a SIM card, or by the devices having a SIM card directly. This option has data charges that depend on the amount of data that is being transmitted.

The amount of data that is transmitted and the speed at which this needs to occur depend on the use case. For certain deployments, it is not time critical to send data and only small amounts get transmitted; e.g. sensors that monitor health of equipment. Others like cameras or vehicle to roadside equipment require much faster and data intense connections.

McKinsey estimates that the use of IoT in urban applications generated $290bn economic value globally in 2020, with centralised and adaptive traffic controlling the largest single source accounting for $50bn of this. By 2030, McKinsey believes traffic control applications could generate between $100-390bn globally through reductions in CO2 and by reducing the time people spend stuck in traffic.

The potential benefits to the deployment of IoT applications for local authorities go beyond more effective and responsive services to residents and may help to generate operational savings for local authorities. Analysis by Intelligens Consulting suggests that installation of humidity, temperature and CO2 detectors into social housing may pay back within two years given savings made as a result of earlier identification of rot and damp in houses and the council officer time saved by having to carry out manual inspections of homes.

Figure 6: Summary of local authority IoT applications relevant to Greenwich

	In-home	On-estate	Wider public realm
Environmental monitoring	Air quality monitoring	Air quality monitoring	Air quality monitoring Ambient noise monitoring “Smart bins” – identify when bins fall
Utilities and services	In-home energy monitoring and control of heating	Monitoring and control of communal boilers	Smart lighting
Security and public safety	Home security and monitoring	Access control to blocks Smart CCTV	Smart CCTV Foot-fall monitoring Gunshot monitoring

	Connected smoke alarm	Lift monitoring	
Transportation		Smart parking – sensors to manage car parking space	Dynamic traffic control Smart parking – sensors to manage car parking spaces Dynamic street management e.g., real time allocation of delivery and loading bays
Social care	Telecare alarms Monitoring of use of devices, lights, door openings		
Mobility		EV charge points	Optimal routing of council vehicles e.g., refuse collection EV charge points

Options to reduce barriers to take-up

The majority of adults in the UK use the internet but there remain significant numbers of digitally excluded people

In 2021, 93% UK adults reported having internet access at home via a fixed or mobile broadband connection, with household penetration in London at 96%.[36] However this total masks significant differences in internet use by age and socio-demographic group. Among the 5% UK adults reporting that they did not have access to the internet at home, 69% said they would be unlikely to get it within the next 12 months.[37] Among those without plans to get home internet access within the next 12 months, in 2021, the most commonly cited reason was a lack of need or interest (46%) followed by concerns about broadband set up costs (27%) and a feeling that others could go online for them (23%).[38]

The expense of going online is clearly a barrier for significant numbers of people. Ofcom[39] estimates that around 2 million households experienced affordability issues concerning internet access in the previous month–

[36] Ofcom Technology Tracker 2021, QE2
[37] Ofcom Technology Tracker 2021, QE24
[38] Ofcom technology Tracker 2021, QE25A
[39] Ofcom (2021) Affordability of Communications Services: Summary of Findings, July 2021 https://www.ofcom.org.uk/__data/assets/pdf_file/0015/222324/affordability-of-communications-services-summary.pdf

and of these 100 thousand households do not have home internet access at least in part due to cost. Overall Ofcom estimates that 3.3 million households are at highest risk of experiencing affordability issues with their fixed broadband.[40]

Consumer education and labelling may help to boost take-up of full fibre networks

To date, a significant number of fixed broadband speed upgrades have been as provider-led upgrades rather than customers actively seeking to migrate to (and pay for) higher speed packages.[41] This is consistent with our research which found that many residents struggled to recall their broadband package and headline speeds, but would more often be able to recall whether they had "superfast" or "fibre".

Currently "fibre" broadband is used to describe both full fibre or" fibre to the home FTTH / fibre to the premises (FTTP) as well as fixed broadband technologies that use copper pairs[42] or coaxial cable[43] to link the end user to the service provider's network. Analysis by WIK on behalf of City Fibre Currently "fibre" broadband is used to describe both full fibre or" fibre to the home FTTH / fibre to the premises (FTTP) as well as fixed broadband technologies that use copper pairs[44] or coaxial cable[45] to link the end user to the service provider's network. Analysis by WIK on behalf of City Fibre suggests that consumer confusion may be reduced and take-up of full fibre accelerated through an adoption of a labelling scheme and information programme.[46]

Analysis of bandwidth needs

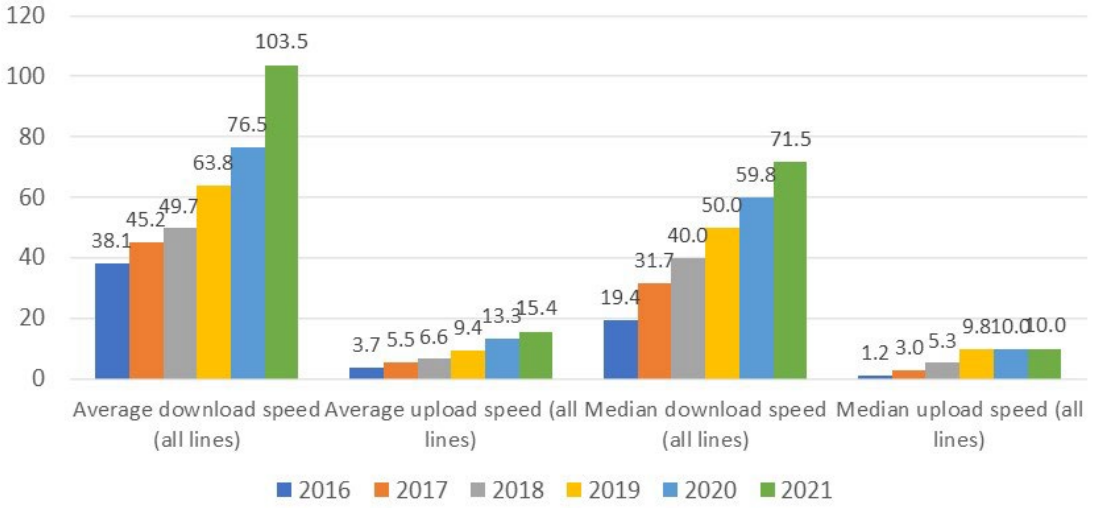
[40] This estimate is +/- 500k households and looks at issues with affordability based on proportion of household expenditure on fixed broadband service.
[41] Paragraph 2.13 Ofcom (2021) Fixed Wholesale Telecoms Market Review 2021-26: Volume 2 Market Analysis https://www.ofcom.org.uk/__data/assets/pdf_file/0023/216086/wftmr-statement-volume-2-market-analysis.pdf
[42] For example, in FTTC/VDSL deployments or G.Fast
[43] DOCSIS broadband on cable networks
[44] For example, in FTTC/VDSL deployments or G.Fast
[45] DOCSIS broadband on cable networks
[46] https://www.cityfibre.com/wp-content/uploads/2021/03/WIK-Consult-study-impact-of-labelling-on-full-fibre-adoption-March-2021.pdf

Average internet speeds in Greenwich have increased over time

Over the past 5 years, the average broadband download speed in Greenwich has more than doubled to reach 103.5 Mb/s by 2021 while the upload speed has more than tripled.

This growth in speeds reflects the increasing take-up of superfast and ultrafast broadband in the borough. By May 2021, 85% broadband connections in Greenwich had download speeds of 30 Mb/s or above, while 7% connections were ultrafast (i.e., 300 Mb/s or more), compared to 51% and 0.1% in 2017.

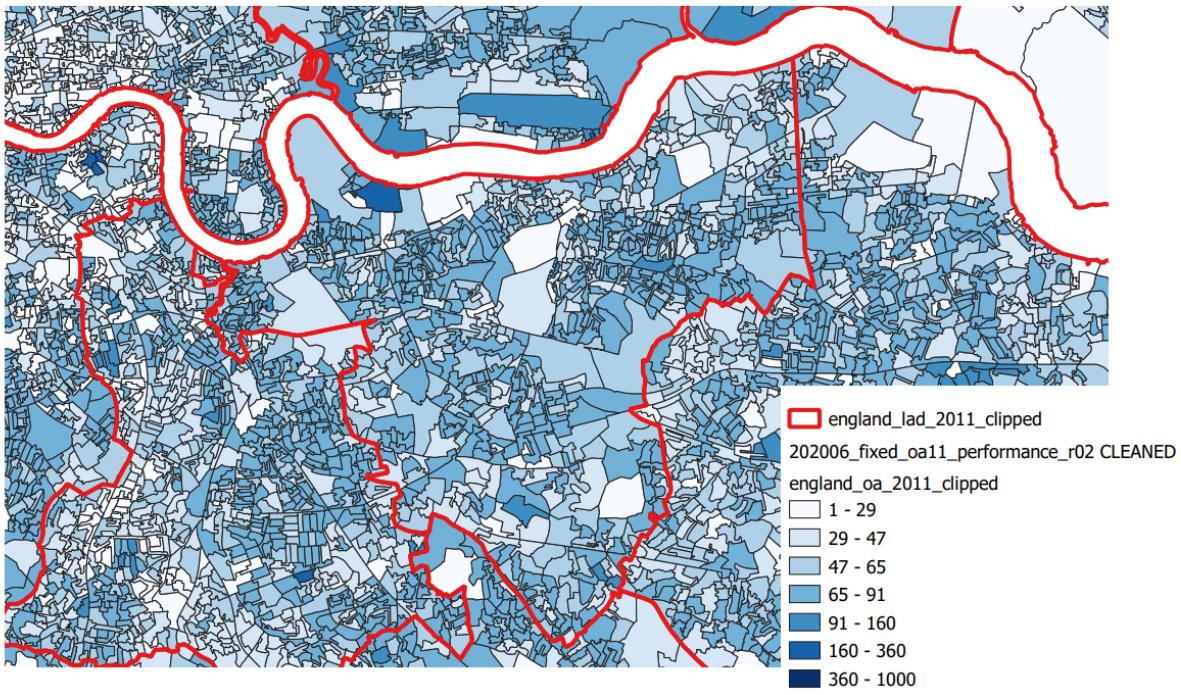
Figure 7: Download and upload speeds between 2016 and 2021



Source: Ofcom Connected Nations. Note: All premises

Download speeds vary across the borough. For example, there are pockets of relatively low median download speeds in parts of the south of the borough and in the Thamesmead area, while parts of the Greenwich Peninsular have median download speeds exceeding 100 Mb/s.

Figure 8: Median download speeds by output area June 2020



Source: Ofcom / DG Cities analysis Data licensed from Ofcom: https://www.ofcom.org.uk/research-and-data/multi-sector-research/infrastructureresearch/connected-nations-2017/data-downloads/terms-of-use

Average data use by fixed broadband connection in Greenwich has also increased over time

Data consumption via fixed broadband connection in Greenwich has increased over time and stood at 564GB by May 2021 across all connections. Those with superfast and ultrafast connections consume even more on average. Median data consumption per fixed broadband connection grew from 338GB in 2020 to 410GB in 2021.

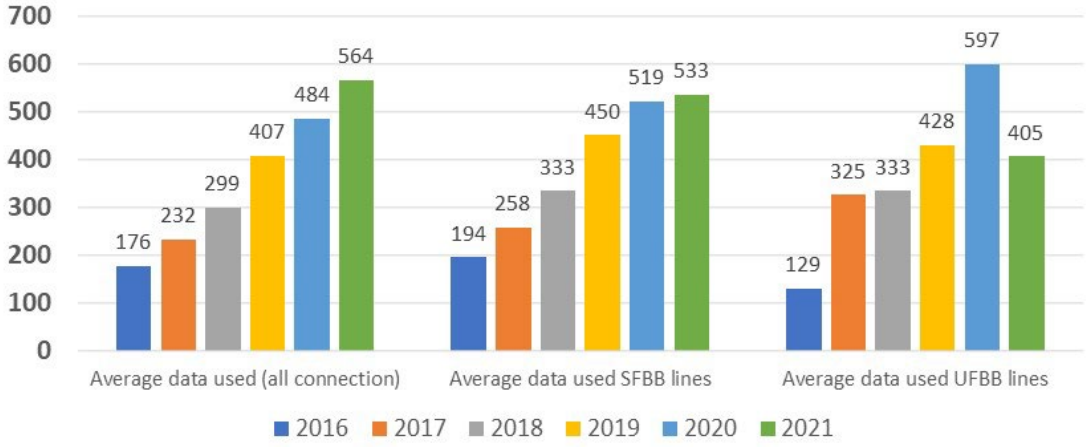
Figure 9: Average data (GB) per fixed broadband connection– Greenwich

Source: Ofcom Connected Nations Reports

Mobile data consumption in Greenwich has also continued to increase. Mobile data traffic in the Borough grew 33% between June 2020 and May 2021 – with data use in May 2021 being equivalent to approximately 10.3GB per capita.

Taken as a whole, the trends suggest that the amount of data being consumed will continue to increase over the next few years – but it is not clear that everyone will require full fibre within the next few years

WIK's household bandwidth demand forecasts suggest that between 8% and 40% UK households will demand speeds of 1GB/s and above by



2025 with the difference driven by assumptions made around the growth of bandwidth required for 4K video and other applications such as teleworking as well the take-up of 8K TV and VR. Under its low bandwidth use assumptions, 57% households would demand at least 300 Mb/s downstream and upstream driven by increased use of cloud computing services and increasing use of HD video, including in general web browsing. [47] For example, McKinsey estimates that between 2018 and 2030 the average amount of video data consumed per minute per user will rise by a factor of 6.5 to 95 MB/minute as they migrate from watching standard definition video to HD and UHD content.[48]

[47] WIK Consult (2018) The Benefits of Ultrafast Broadband Deployment. NB: WIK's forecasts do not account for developments in compression which would potentially reduce bandwidth requirements for video of a given quality.

[48] We note this is equivalent to average bit rate increasing from 2 Mb/s to 12.7 Mb/s. Source: McKinsey (2020) Connected World Report

Although the adoption of cloud-based desktop applications may increase demand for bandwidth, this needs to be put in context. For example, Microsoft's recommended bandwidth for its desktop service ranges from 1.5 Mb/s for light users doing data entry tasks to 15 Mb/s (for users using the service for CAD and graphic design or using a 4K display).[49] Upstream traffic is asymmetric to downstream traffic as the upstream traffic is user input to the browser rather than the downstream image of the desktop. Remote streaming of games does require significantly greater downstream bandwidth than desktop applications from a minimum of 5 Mb/s for Shadow to 35 Mb/s for Google Stadia's 4K streaming service. In March 2021, Steam enabled remote streaming at 8K resolution, which may require downstream bandwidth of 50 Mb/s or more to be usable. [50]

Cartesian[51] notes that asymmetry in peak time US broadband traffic has increased over time – from 4.5 times downstream:upstream in 2010 to 14.4 times by 2020, reflecting the growth of downsteam-heavy online activities (i.e. video consumption). To reset this long-term trend over the coming decade, there would need to be significant growth in online activities that are upload heavy.

Given that video traffic is a key factor in consumer demand for bandwidth, improvement in video compression technologies could mitigate increases in bandwidth demand downwards over the coming decade. For example, Cartesian (2021) [52] notes that firms such as Twitch and Netflix have been able to reduce the required bitrate for videos of a given quality by 25% and 53% respectively through techniques such as use of adaptive bit rate and better compression and encoding.

Despite the on-going rollout of gigabit capable networks, as a whole, ISPs have told Ofcom that by March 2025 they expect only a small minority (9%) of their customers will have internet connections with speeds of 300Mb/s or more, though the proportion of people with a connection of less than 30Mb/s will fall to only 3%.[53] However, further ahead to 2040, bandwidth demands may increase more significantly.

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[49] https://docs.microsoft.com/en-gb/windows-server/remote/remote-desktop-services/network-guidance

[50] https://www.theverge.com/2021/3/22/22345504/steam-remote-play-8k-streaming-games

[51] Cartesian (2021) US-Broadband Household Bandwidth Demand Study https://www.cartesian.com/wp-content/uploads/2021/07/Cartesian_NCTA-US-Broadband-Household-Bandwidth-Demand-Study-July-2021.pdf

[52] Cartesian (2021)

[53] Figure 2.4 Ofcom (2021) Wholesale Fixed Telecoms Market Review 2021-26 Volume 2: Market analysis https://www.ofcom.org.uk/__data/assets/pdf_file/0023/216086/wftmr-statement-volume-2-market-analysis.pdf

Analyst Ben Wood forecasts that by 2040 household demand for bandwidth will grow by a factor of ten, suggesting a range of between 2Gb/s and 10 Gb/s will be required by then.[54]

While not all people will require gigabit connections within the next ten years, our research suggests that some residents would actively welcome faster and more reliable broadband connections. Even if they don't use applications that require 1Gb/s, a faster, more reliable fixed broadband connection may encourage greater take-up of online services. For example, in Sweden research found that people with FTTH used more local services online.[55]

Immersive real-time applications are among most demanding of applications for bandwidth

Increasingly immersive experiences require both greater speed (for wider field of vision) compared with traditional video and low latency – for real time interactivity (Ofcom 2020, WIK Consult 2018)[56],[57] Adoption of applications which use AR and VR (including in the home, school and healthcare settings) are especially likely to drive this given that high data rates and fluidity (driven by low latency) and necessary to make the experience life-like and help to reduce the risk of motion sickness.

Analysis by Mangiante et al.[58] suggests that VR requires between 25 Mb/s (for a 240p equivalent 30 FPS experience) at 40 ms streaming latency (i.e. a basic VR experience) up to 2.35Gb/s for a 4k equivalent VR experience. While an HD video stream can be delivered on a 10 Mb/s connection, the HD equivalent in VR can require 400Mb/s with a 20 ms streaming latency.

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[54] Vodafone (2021) Homes of the Future: Connectivity & Communities https://newscentre.vodafone.co.uk/app/uploads/2021/05/Homes-of-the-Future-Connectivity-Communities-FINAL.pdf

[55] WIK Consult (2018) The Socio-economic benefits of FTTH https://www.wik.org/fileadmin/Vortraege/2018/IH_FTTH_Conference_PLENARY.pdf

[56] Ofcom (2021) Technology Futures: Spotlight on the technologies shaping communications for the future https://www.ofcom.org.uk/__data/assets/pdf_file/0011/211115/report-emerging-technologies.pdf

[57] WIK Consult (2018) The Benefits of Ultrafast Broadband Deployment https://www.ofcom.org.uk/__data/assets/pdf_file/0016/111481/WIK-Consult-report-The-Benefits-of-Ultrafast-Broadband-Deployment.pdf

[58] Mangiante et al (2017) VR is on the Edge: How to Deliver 360° Videos in Mobile Networks https://dl.acm.org/doi/pdf/10.1145/3097895.3097901

However, the adoption of these technologies among the general population over the next decade is unclear, and their main applications may be outside of the home environment. Firstly, the requirement to wear a headset / glasses can be off-putting for some seeking a lean-back experience at home (one of the reasons behind the failure of 3D TV[59]). Secondly, some experiences such as those which involve physical movement when using VR and AR may require dedicated space that is unavailable in most homes. Finally, VR and AR do not necessarily require all content to be streamed from a remote server. If necessary, content can be downloaded and buffered rather than streamed in real time. It will always be quicker to stream content from local storage than from the cloud or servers located close to the edge.[60]

Bandwidth requirements for IoT applications vary – but are likely to increase with more advanced applications, especially those involving video

The number of IoT-enabled devices will grow over the coming decade. Cisco forecasts[61] that between 2018 and 2023, the number of machine-to- machine modules[62] in the UK will grow from 162 million from to reach a total of 401million. However, this growth in devices that use machine to machine communications will not necessarily translate into like for like growth in bandwidth use. By 2030, McKinsey estimates that despite accounting for 71% of connected devices (up from 38% in 2018), M2M devices will only account for 12% of total data traffic.[63]

This is because many IoT applications based on the monitoring of simple sensors such as temperature, humidity, air quality or providing telemetry (such a smart metering or identifying when a bin is full or car parking space is occupied) require minimal bandwidth (10 kb/s) and are tolerant

[59] https://www.wired.com/story/decade-in-review-3d-tv/

[60] For example SATA III can transfer data from a hard disk at speeds of up to 600 Gb/s

[61] Cisco (2020) Cisco Annual Internet Report Highlights Tool – UK https://www.cisco.com/c/en/us/solutions/executive-perspectives/annual-internet-report/air-highlights.html#

[62] Which provide devices with machine-to-machine communications

[63] Exhibit 6 McKinsey Global Institute (2020) Connected World: An evolution in connectivity beyond the 5G revolution https://www.mckinsey.com/~/media/mckinsey/industries/technology%20media%20and%20telecommunications/telecommunications/our%20insights/connected%20world%20an%20evolution%20in%20connectivity%20beyond%20the%205g%20revolution/mgi_connected-world_discussion-paper_february-2020.pdf

of significant latency (a second or more) given they do not require real time collection and analysis.

In contrast, some emerging IoT applications being deployed, especially in industry may require significantly greater bandwidth and lower latencies, reflecting their use of video and the requirement to send high resolution images to the cloud for real time analysis, for example, for image recognition.

In thinking about its connectivity needs, the borough may want to consider its approach to edge vs cloud computing. For example, in the event that the council rolled out smart CCTV cameras across public areas and its social housing stock, the location of image processing should be considered. An edge-based solution (where some processing is carried out locally such as the detection of movement or of identifying that there is a person in an image) would require the council to deploy more equipment to the location of the camera, but would mean that less data needs to be passed from the camera site to the council's systems. Alternatively, if analysis were to be done in real-time in the cloud, each site with CCTV would require sufficient upstream bandwidth to feed all video in real time.[64]

Analysis of networks options

The key network technologies for the next decade are starting to be deployed in the borough

In this section we consider fixed and mobile network technologies that are likely to play key roles in meeting the connectivity needs of the borough over the coming decades.

Fixed broadband services were first launched in the UK in 2000 and by 2021 93% of UK adults with internet access at home used a fixed broadband connection.[65] The combination of an always-on internet connections and significantly greater speeds compared to dial-up access has enabled real time applications such as cloud- based services and use of video. Since their launch, speeds and bandwidth have

[64] Bitrates from security cameras will vary according to the frame rate, the video resolution and how busy the image is (as less busy and slow-moving images can be compressed more efficiently). For example a 1080p video in a less busy area (such as a lightly used stairwell on an estate) at 6 frames per second may require 300kb/s while a 1080p video at 30 frames per second in a busy area (such as a high street) may require 10 Mb/s. https://www.ifsecglobal.com/video-surveillance/cctv-storage-cutting-frame-rates-not-best-way-ease-bandwidth-burden/

[65] Ofcom Technology Tracker 2021, QE9

continued to increase, with cable broadband networks being upgraded, and copper-based DSL broadband being supplemented with FTTC/ VDSL superfast broadband and full fibre broadband networks.

In addition, fixed-line business connectivity products (sometimes referred to as leased line) have continued to evolve. In contrast to consumer broadband products, these offer dedicated (uncontented) connectivity and can be used for a range of purposes by end users including connecting an organisation's network together and internet access. As with broadband, these products have evolved over time and take-up has shifted from copper to fibre, and towards Ethernet interfaces.[66]

The past few years have seen the widespread deployment of 4G and now 5G mobile networks, each generation offering improvements in data speeds and latency over the previous generation networks. Older 2G and 3G mobile networks[67] continue to support legacy mobile handsets (which may be predominantly used by those mainly using voice calls and SMS messaging) as well as for machine-to-machine communication in devices including alarm systems, some types of smart metres and telecare systems. However, these 2G and 3G networks are scheduled to be shut down by 2033 at the latest[68], requiring devices relying on these networks to be modified or replaced. In summer 2021 BT said it intended to phase out its 3G network in 2023 and then close its 2G network later this decade.[69] While older mobile networks are wound down, 5G technology is expected to continue to develop over the decade, increasing the bandwidth and spectrum and power efficiency of these networks and the devices that use them.

Wi-Fi networks, currently used by residents, businesses and the council for high-speed wireless internet access in generally fixed locations have also continued to evolve, with the latest Wi-Fi 6 standard offering greater speeds, the ability for networks to support a larger number of devices, greater power efficiency and improved router-to-router

[66] See paragraph 3.47-3.50 Ofcom (2019) *Promoting competition and investment in fibre networks: review of the physical infrastructure and business connectivity markets - Volume 2: market analysis, SMP findings, and remedies for the Business Connectivity Market Review (BCMR)* Ihttps://www.ofcom.org.uk/__data/assets/pdf_file/0025/154591/volume-2-bcmr-final-statement.pdf

[67] Which first launched in the UK in 1993 and 2003 respectively

[68] DCMS joint statement on the sunsetting of 2G and 3G networks and public ambition for Open RAN rollout as part of the Telecoms Supply Chain Diversification Strategy, 8 December 2021 https://www.gov.uk/government/news/a-joint-statement-on-the-sunsetting-of-2g-and-3g-networks-and-public-ambition-for-open-ran-rollout-as-part-of-the-telecoms-supply-chain-diversificatio

[69] https://www.reuters.com/article/idCAKBN2EK0ZP-OCATC?edition-redirect=ca

communications, aiding the deployment of mesh networks. These meshes to move between routers.

Taken as a whole, these developments in mobile and Wi-Fi networks are increasingly allowing them to be used for applications such as live streaming of HD video, and real-time time control of machinery that historically required either a fixed network connection or relied on wireless technologies with limited mobility (Wi-Fi). This does not necessarily mean that one type of network will necessarily displace the other.

Full-fibre broadband networks offer technical capabilities that other fixed broadband network types are unable to match

'Full fibre' can also describe the uncontended Ethernet fibre leased line products used by local authorities, education establishments. While the raw headline speeds of FTTH contended broadband products delivered via GPONs[70] can match these more expensive products, there remains significant differences between services in relation to average speeds, and service reliability. As with all contended access technologies, real life performance also depends on contention ratios, the split between upstream and downstream bandwidth and the amount of backhaul (currently often point-to-point fibre) used.

There are also currently significant gaps between real-world and actual performance of some of these networks, though these gaps may decrease in future as networks are upgraded. In the case of 5G, standards are still being finalised and current deployments may include a mixture of 5G radios with 4G components (limiting performance) and speeds achieved will also vary according to spectrum availability and the number of users on the network. Likewise, Virgin Media's current DOCSIS 3.1 deployment currently uses a mixture of DOCSIS 3.1 and the older DOCSIS 3.0 standard (for uploads) and bandwidth is also determined by the amount of spectrum reserved for DOCSIS as opposed to DVB-C television services. Although Virgin Media has indicated that it

[70] Gigabit passive optical network: a type of full fibre broadband access network which uses Ethernet for data transfer. The network itself is passive in that it does not use active electronics between the head end and the end user. Connections are shared between user as capacity is split among end users (using passive splitters), meaning that a fibre at single active port at the operators' head can serve multiple users. This means that each end user does not require their own dedicated fibre between the operator's head end and the end user premise, potentially allowing for cheaper and faster network build. This contrasts with a point-to-point network, where each end user has a dedicated fibre link to a port at the operator's headend.

will deploy full fibre as its next upgrade path, the DOCSIS 4.0 cable broadband standard will enable cable operators that continue to coaxial cable to deliver even higher bandwidths in future.

Figure 10: Summary of last-mile network technologies used for residential and SME broadband connectivity

Source: Ofcom UK Home Broadband Performance Report https://www.ofcom.org.uk/__data/assets/pdf_file/0020/224192/uk-home-broadband-performance-technical-report-march-2021-data.pdf , 4G.co.uk https://www.4g.co.uk/news/4g-injecting-new-lease-life-online-gaming-mobile-broadband/ Verizon https://www.verizon.com/about/our-company/5g/5g-latency, ISP Review https://www.ispreview.co.uk/index.php/2020/09/virgin-media-uk-trials-2-2gbps-broadband-to-homes-in-berkshire.html Open Signal https://www.opensignal.com/reports/2021/09/uk/mobile-network-experience-5g Note that product specifications may vary from theoretical maxima. For example Openreach's fastest FTTC product offers up to 80 Mb/s download and 20 Mb/s upload, while Virgin Media's

	Description	Technology	Fibre closest point to end user	Typical download speeds*	Typical upload speeds*	Latency
Fixed	DSL	ADSL2+	Exchange	Up to c. 24 Mb/s	Up to c. 1.4 Mb/s*	<25ms
Fixed	FTTC	FTTC/VDSL2	Street cabinet	Up to c. 90 Mb/s	Up to c. 40 Mb/s	<15ms
Fixed	Coax	DOCSIS 3.0	Street cabinet	600 Mb/s *(1Gb/s maximum)*	50 Mb/s *(up to 100Mb/s maximum)*	<20ms
Fixed	Coax	DOCSIS 3.1	Street cabinet	1140 Mb/s (up to 10 Gb/s in standard)	50 Mb/s (up to 10Gb/s in standard	<20ms
Fixed	FTTH	GPON	Into premises	2.488 Gb/s (maximum)	1.244 Gb/s (maximum)	<10ms
Fixed	FTTH	XGSPON	Into premises	1-3Gb/s (generally sold by CPs) 10 Gb/s (maximum in standard)	1-3 Gb/s (generally sold by CPs) 10 Gb/s (maximum in standard)	<10ms
Mobile	4G Cellular	LTE Advanced	Cell site	c. 40 Mb/s real world	c. 10 Mb/s real world	<50ms
Mobile	5G Cellular	5G	Cell site	10Gb/s+ c. 100-150 Mb/s 2021 real use	1GB/s+ c. 15 Mb/s 2021 real use	<30ms*

Gig 1 DOCSIS 3.1 product has an average download speed of 1130 Mb/s and 52 Mb/s upstream.

In addition to the broadband technologies set out above, is internet access that is provided by fibre Ethernet leased lines. These point-to-

point connections are used by larger organisations including larger businesses, local authorities and larger schools and colleges and in contrast to 'fibre broadband' products all bandwidth is symmetric and uncontended (i.e. unshared) with any other user and can offer lower latencies than broadband. Operators will generally install these fibre links on demand meaning that service may be possible in areas where full fibre broadband is unavailable, subject to site surveys and payment of installation fees. Repair times are also faster and take only a few hours compared to up to several days for residential and business broadband products. [71] However, these products are priced at a significant premium (i.e. several times higher) to fibre broadband of similar speed. [72]

Operators deploying early FTTH broadband networks using GPON have several upgrade paths to allow for higher speeds without replacing the fibre in their access networks. One option requires an operator to add a multiplexing unit after the active optical line terminals to combine the signals. [73] Another option is to use a technology such as Combo PON which allows 1Gb/s and 10 Gb/s GPONs to coexist on the same fibre by replacing line cards in the optical line terminal (OLT) without needing additional optical equipment in the access network. However, Combo PON generally requires operators use equipment from a single manufacturer across its network.

Operators deploying today have the option to directly install 10 Gb/s capable networks. For example, it is likely the network in Woolwich deployed by the borough's joint venture will be a 10 Gb/s capable XGS-PON (10 Gb/s symmetric PON). This would in theory allow residents and businesses to access services with headline speeds of up to 10 Gb/s in each direction. Over the next decade the capacity of PON networks will further increase with 25 Gb/s PON due to be field-trialled by Openreach and Nokia from December 2021.[74] In Belgium, operator Proximus has

[71] For example, BTnet offers a 100% availability guarantee with a repair time of 5 hours. https://business.bt.com/products/broadband-and-internet/bt-leased-line/

[72] For example as at 2 November a 100 Mb/s BTnet Ethernet fibre connection costs from £300/month compared to BT's FTTP Halo for Business 900 Mb/s downstream 104 Mb/s upstream product priced at £54.95/month https://business.bt.com/products/broadband-and-internet/bt-leased-line/ https://business.bt.com/products/broadband-and-internet/deals/

[73] A WDM1r unit which takes the optical feeds from a 10 Gb/s PON and a GPON and multiplexes these on to the single fibre. The frequencies of light used for 10 GB/s PONs and GPONs vary and so can all be carried on a single fibre. This additional equipment may affect the quality of the signals on the network and the maximum range from the OLT to the end customer.

[74] https://www.openreach.com/news/openreach-and-nokia-test-the-next-generation-of-full-fibre-broadband-technology/

already deployed this technology in Antwerp.[75] Speed increases beyond 25Gb/s are likely within the decade with Vodafone[76] currently prototyping 100 Gb/s PONs in their research labs. However, deployment of PONs with speeds greater than 25 Gb/s will likely require investment in additional digital signal processing equipment; the cost of this is expected to fall within the decade to make these deployments commercially viable.

The wireless networks being deployed in Greenwich reflect their different characteristics and use cases

Modern wireless technologies offer different combinations of bandwidth, latency, range, cost and complexity to deploy. While the bandwidth and latency of Wi-Fi, 4G and 5G networks allow them to potentially be used for the widest range of applications, from streaming video, providing general connectivity for consumer and business facing websites and apps as well as connectivity for IoT applications including remote sensors. There are trade-offs – for Wi-Fi this includes a limited range (though coverage can be expanded via mesh networks) and limited control over quality of service due to the use of unlicenced spectrum, while 4G and 5Gs devices using public networks are relatively power hungry and require users to pay a monthly subscription.

For IoT applications, low-power wide area network (LP-WAN) technologies LTE-M and NB-IoT are based around existing mobile networks and so require minimal additional infrastructure and can be plug and play for end users who have existing relationships with MNOs. Their advantages over traditional 4G and 5G services around power consumption and range come at the expense of bandwidth. LTE-M's lower latency and higher bandwidth allows it to be used for some real-time applications such as real-time medical monitoring, mobility applications, remote control and even voice, while NB-IoT offers slightly lower power consumption and lower on-going cost to the user, making it more suitable for metering and sensors which generate smaller amounts of data. Further versions of the 5G standards (3GPP release 17 and 18) are expected to be finalised within the next few years. These will include

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75 https://www.analysysmason.com/research/content/articles/proximus-25g-deployment-rdfi0-rdcs0/

76 https://www.telecomtv.com/content/access-evolution/whither-the-pon-next-stop-100gbit-s-on-a-single-wavelength-40761/ . Note that BT has also previously trialled a 100 Gb PON technology with Huawei.

features that will address IoT applications that tolerate lower throughput but greater energy efficiency than offered by existing 5G deployments.[77]

LoRA and Sigfox prioritise energy efficiency and cost at the expense of latency, bandwidth and mobility. This makes them especially useful for applications where small amounts of data are generated without needing to be sent and analysed in real time. These include air quality sensors or sensors to identify when bins are full or metering applications.

Figure 11: Overview of wireless network technologies

	Wi-Fi 6	4G	5G	LTE-M	NB-IoT	LoRA	SigFox
Networking type	LAN	WAN	WAN	Low Power WAN	Low Power WAN	Low Power WAN	Low Power WAN
Indicative range	50m	Several km	500m	Up to several tens km	Up to several tens km	Up to several tens km	Up to several tens km
Indicative bandwidth	Hundreds Mb/s	40 Mb/s	100Mb/s-1Gb/s	375 kb/s	60 kb/s	50 Kb/s	100bits/s
Infrastucture	Wi-Fi access points	4G cellular network	5G cellular network	Existing mobile networks	Existing mobile networks	Dedicated access points	Dedicated access points
Spectrum	Shared	Dedicated	Dedicated	Dedicated	Dedicated	Shared	Shared
Relative power consumption	Medium	High	High	Low	Low	Very Low	Very Low
Key applications	General internet access and content streaming Real-time two-way high bandwith IoT applications including video	General internet access and content streaming Real-time two-way high bandwith IoT applications including video Backhaul for low power narrowband networks Voice	General internet access and content streaming Real-time tw0-way high bandwith IoT applications especially those requiring low latencies including real time control Backhaul for narrowband networks Voice	Real-time sensor monitoring including from moving locations Remote control Voice	Data logging from sensors e.g. metering, environmental monitoring, parking meters, asset tracking, health monitoring	Non real-time data logging applications e.g. metering, environmental monitoring, asset tracking	Non real-time data logging applications e.g. metering, environmental monitoring, asset tracking

Source:
https://www.dhl.com/content/dam/dhl/global/core/documents/pdf/next-generation-wireless-in-logistics.pdf;
https://www.bluetooth.com/blog/wireless-connectivity-options-for-iot-applications-technology-comparison/ ;
https://www.electronicdesign.com/industrial-

[77] https://www.ericsson.com/en/reports-and-papers/ericsson-technology-review/articles/5g-evolution-toward-5g-advanced

automation/article/21806072/11-myths-about-lorawan; https://www.telenorconnexion.com/iot-insights/lte-m-vs-nb-iot-guide-differences

Note: A range of factors impact the actual performance (range and speed) of networks and performance. The actual range of wireless networks in urban areas such as Greenwich is likely to be lower than that in more rural areas.

Both public and private wireless networks are being deployed in the UK for IoT applications

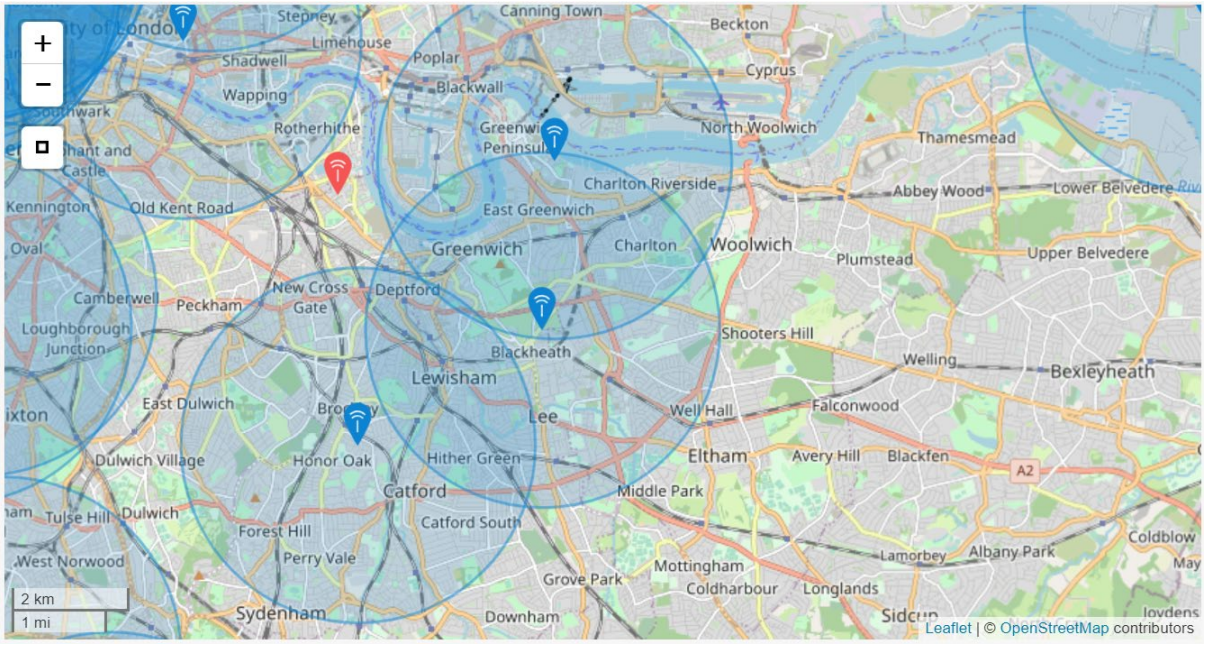
Public cellular based LP-WAN networks in the UK include Vodafone's NB-IoT network and O2's LTE-M network, both of which offer coverage across the UK[78].

The UK's public Sigfox network, run by WND covers 61 million people.[79] Among the large LoRAWAN[80] networks in the UK, things Network works with LoRAWAN to provide a network across the UK, while IoT Scotland is a LoRAWAN network for local authority applications covering 1.9 million people across 32 of 35 Scottish local authorities.[81] Connexin also operates a LoRAWAN network as part of its IoT network of networks serving its customers including local authorities and utility firms.[82] Another LoRAWAN network is operated by The Things Network, a decentralised network which allows individuals and organisations to install their own LoRAWAN gateways[83] to provide additional coverage and capacity for the network. At the time of writing, there were several gateways covering parts of the borough, including one gateway based on the Greenwich Peninsular. The capacity of the network is increased as individuals and organisations sign-up their gateways to the network. Helium[84] is another de-centralised IoT network, offering access to LoRAWAN hotspots in the US and Europe and in the US 5G services in

[78] https://www.gsma.com/iot/deployment-map/
[79] https://www.wndgroup.io/uk/
[80] LoRA is the radio technology used by the LoRAWAN wide-area networks. LoRA is also used as the radio element by non-LoRAWAN networks such as Amazon's Sidewalk and Symphony Link.
[81] https://iot-scotland.net/
[82] https://www.connexin.co.uk/network-of-networks/
[83] A LoRAWAN gateway is a device that acts as a bridge between LoRAWAN devices and internet-based network servers. Gateways can connect to the internet via cellular mobile networks (4G, 5G), Wi-Fi or fixed broadband connection. LoRAWAN gateways can cost from the low hundreds of Pounds and be built with off the shelf components such a Lora WAN Raspberry Pi and open source software.
[84] https://www.helium.com/

which hotspot owners mine the HNT cryptocurrency in return for providing network coverage. IoT device owners wanting access to the network purchase HNT which they 'burn' into Data Credits to pay for data packets carried over the network. In this way, owners of compatible hotspots are incentivised to add these to the network (and thus promote coverage) while owners of IoT devices can operate their devices at lower cost than via a cellular 4G or 5G network. Utility crypto credits are at their infancy but could become a technology to follow.

Figure 12: The Things LoRAWAN London Community gateway locations in SE London



Source: https://www.thethingsnetwork.org/community/london/ 4 November 2021

With the exception of Sigfox[85] it is possible for end users to deploy their own wireless networks using the above technologies, swapping higher up-front capital expenditure for potential operational expenditure savings and greater control over the network's security, coverage, and service quality. Given this, at some point the borough or the joint venture could consider deploying its own wireless networks, given its access to street furniture and increasing density of fibre. At the simplest, consideration could be given to deploying LoRAWAN gateways or mesh-based Wi-Fi for low and high-bandwidth applications. Private 4G and 5G networks[86] can be more complex and costly to deploy but these may

[85] Sigfox designates a single network operator for each country.
[86] https://www.sierrawireless.com/iot-blog/what-are-private-lte-networks/

offer greater security and stability than Wi-Fi for mission or safety-critical applications.

Barriers and costs of private cellular networks may fall as a wider range of firms enter the market to compete with the established mobile operators. Enablers of this include the release of suitable spectrum by regulators, and the ability to increasingly virtualise network equipment in software in the cloud, as opposed to the use of dedicated networking hardware. Amazon has starting to offer cloud based private cellular networks via cloud platforms such as AWS.[87] In November 2021, tower company Cellnex was awarded a contract to deploy a private 5G network to the Basing View business area of Basingstoke as part of the local authority's programme to improve connectivity to the high-tech businesses in the area and support its local 5G Testbed.[88]

While a detailed cost-benefit analysis is outside the scope of this report the following are likely to be considerations in any move for the council to deploy its own wireless IoT networks:

- The number of sensors deployed by the borough: Higher-up front capital expenditure may mitigate large on-going connectivity costs from third party networks if large numbers of IoT devices are deployed
- The location of sensors deployed by the borough and coverage from 3rd party networks: we note for example that there is some uncertainty as to how quickly and how far 5G coverage will be deployed outside of the densest urban areas and areas with the highest footfall
- The availability of fibre across the borough which can use for backhaul. In this respect the network operated by the council's JV could act as an enabler for the borough's wider IoT ambitions

Fixed and wireless networks complement each other - we expect to see the trend towards network convergence and fibre closer to the end user to continue

Given their different but complementary characteristics, both fixed and mobile networks will play roles in meeting the connectivity needs of the borough. Using Cisco's per capita device estimates[89], between 2018 and 2023, the number of networked devices in the borough will grow from

[87] Amazon's AWS Private 5G service is currently being launched in the US https://aws.amazon.com/private5g/

[88] https://www.totaltele.com/511667/Cellnex-signs-on-to-build-5G-private-network-in-Basingstoke

[89] Cisco (2020) per capita estimates that per capita total networked devices per capita will grow from 6.2 to 10.5 between 2018 and 2030 in the UK, with 3.1 of these devices using a mobile data connection. We have applied the 2018 population of Greenwich (286 thousand at 2018) to this figure.

approximately 1.8 to 3.0 million of which 30% (0.9 million) will use a mobile connection, the remainder using a fixed or Wi-Fi connection.

Fundamentally, investment in passive infrastructure such as duct and dark fibre can support the deployment of multiple types of networks. The same duct used for fibres for a FTTH GPON broadband network to serve residential and small business consumers can also potentially be used for the high-capacity symmetric Ethernet services which provide connectivity for large organisations, schools, hospitals and backhaul for mobile and wireless network base stations.

Going forward, operators are also starting to consider 25 Gb/s PONs as an efficient way to provide backhaul for 5G sites (especially in city centres) and to serve enterprise customers requiring bandwidths of 10 Gb/s. In theory this would allow a single network to serve residential broadband, SME broadband, large corporate enterprise connectivity and backhaul markets.[90]

Increasing demand for wireless bandwidth is leading operators to densify their networks and bring fibre closer to the end user. However, operators and industry experts tell us that the economics of this, in particular small-scale cells, can be highly challenging given the number of sites needed to provide coverage, and the fixed cost associated with each site. Opportunities to reduce the cost of deployment of these (for example through using existing fibre networks for backhaul) or sharing of street furniture with other services such as Wi-Fi routers (to defray the cost of wayleaves) may help to mitigate some of these concerns. In these cases, an operator might approach the local authority to offer a public Wi-Fi service in return for discounts on or zero cost wayleaves allowing them to deploy both Wi-Fi and cellular coverage.

Conclusions and recommendations

Demand for bandwidth over next ten years is highly likely to increase – but the size of this growth is currently uncertain

Both current data and future trends suggest that demand for bandwidth will grow over the next 10 years. However, there are significant differences in bandwidth forecasts during this time. This reflects uncertainties around the take-up of emerging immersive audio-visual

[90] https://www.5gradar.com/features/fiber-5g-and-the-pursuit-of-a-unified-infrastructure

activities including AR and VR, and the extent to which compression algorithms will continue to improve over the coming decade.

Based on existing trends, where many broadband connections have been upgraded by the operator, rather than the end customer, it is possible that ISPs will offer faster packages as standard potentially to encourage take-up of full fibre services, allowing for faster switch-off of the copper network. However, some operators currently offering both superfast and ultrafast broadband are pricing the latter as a premium product.

Bandwidth constraints per se are unlikely to be a constraint on online activities for many residents for several years – but deployment of full fibre across the borough would address concerns about areas that currently lack some superfast services

For most residents, bandwidth is likely not acting as a current constraint on online activities. Services offering download speeds of at least a gigabit were available to 78% premises in the borough in September 2021, yet the most recent figures from Ofcom show that in May 2021 only 7% fixed broadband connections had download speeds of 300 Mb/s or more. This may suggest that despite being able to move to a faster broadband package, residents either do not see the need, or are potentially dissuaded by the cost of a faster service. Some of the residents we spoke to on the two estates noted that while faster services were available from Virgin Media, they were unwilling to pay what they saw as a significant premium for the fastest speeds.

The most commonly used consumer facing applications are generally asymmetric in nature. However, our residents research found that some residents were suffering from poor in-home connectivity for a range of reasons such as poor Wi-Fi coverage, or insufficient bandwidth for members of the same household to work from home during the day. In particular, our research found that a majority of residents we spoke to on Ernest Dence (where superfast FTTC broadband using Openreach's network is unavailable) were unsatisfied with their broadband speed. Therefore, even in the absence of widespread adoption of new highly-bandwidth applications such as those offering immersive experiences, early deployment of faster fixed broadband networks will lead to benefits for residents.

Care needs to be taken to ensure that the needs of all residents are met

The pandemic has starkly demonstrated the centrality of online services to people's lives and their ability to act as citizens. The impact of digital

exclusion on individuals is likely to increase given the trends we have identified above.

We therefore recommend that:

- The council continues to research digital exclusion in the Borough to develop its understanding of who is digitally excluded and why. The resident research carried out on the Flamsteed and Ernest Dence estates could potentially be extended borough-wide. Periodic surveys (for example once every couple of years) could be used to track levels and locations of digital exclusion to allow for more targeted intervention
- The council continues to work with local partners to identify digitally excluded people, and work with them to promote take-up of online applications of benefit and interest to them. One way of overcoming this may be by ensuring that initiatives focus on specific practical benefits of going online e.g. the ability to make a video call to keep in touch with friends and family rather than about the ability to 'go online'.

Securing the best outcomes will require engagement with the market...

Business and residential consumers that are actively engaged with the market are more empowered to obtain the communications services that best meet their needs. The benefits of competition between networks, and interventions such as the four-fibre solution (deployed on Ernest Dence) are only fully realised when engaged and empowered consumers feel able to switch between operators and select the most appropriate packages for them.

Competition between operators should also benefit consumers by leading to lower prices. While incumbent operators facing limited competition may have incentives to price their highest speed packages at a premium, new entry into to the market should lead to lower prices for residents.

Engagement and empowerment also extend to the use of residents' data, both personal data, but also data about their environment. Citizens may be more likely to be accepting and welcoming of IoT use cases if they can see and engage with data collected from sensors in their surroundings. Making non-personally identifiable data available to the public may spur innovative use cases by residents and local businesses.

...And strategies to address migration from older networks

While full fibre and modern wireless networks present new opportunities and the potential for better user and societal experiences, the phase out

of older networks also requires attention. For organisations such as the council and local businesses, ensuring continuity of service requires that devices that rely on legacy networks (for example telecare alarms) are upgraded or replaced ahead of network switch-off.

Network changes will also affect consumers who may need to modify or replace their existing personal devices. While responsibility for supporting retail consumers through the changes sits with the operators, the council may also have a role to play, especially among vulnerable groups in reminding residents about these changes and, if necessary, pointing them to further sources of information and support. This activity could potentially run alongside and complement the borough's digital inclusion programme.

Technologies being deployed now may be upgraded over time – subject to the business case

Network technologies being deployed in the borough including GPON FTTH networks do generally appear to have upgrade paths, keeping them relevant for the next decade and beyond. Whether or not operators choose to do this over the next decade will be dependent on the firm's business case – a function of both cost and revenue.

Revenue uplift may be challenging for mobile operators given the past five years have generally seen real-terms declines in price especially of post-pay and SIM only packages. Between 2015 and 2020, average monthly mobile data use grew by 388% while the monthly price for average monthly mobile use fell by 22% in real terms. [91] The price premium for 5G has also fallen in the past year. Given these trends, it may be difficult for MNOs to directly monetise 5G services from many consumers. In contrast, many applications that benefit from 5G's lower latency and higher data rates concern business to business or business-to-business-to consumer applications, such as around smart mobility, or healthcare applications. In contrast, prices for fixed line telecoms have been more stable or even rising in real terms over the past five years as operators have increased line rental charges and call charges.

On the cost side, Moore's Law suggests that the price of electronics falls over time, other costs associated with network deployment including site rental, civils and power do not generally behave in this way. While there have been regulatory and legal interventions to reduce the cost of network deployment, networks may require significant up-front investment.

[91] Ofcom (2021) Pricing Trends Report

The council as an enabler and shaper rather than a director

As a local authority, Greenwich's role in the direct selection of technology and deployment of commercial networks (and national public service networks[92]) is likely to be limited and the Electronic Communications Code (ECC) limits the ability of the council to direct operator investment by controlling access to the council's property or exercising planning or street works control.[93]

However, there are steps the council can take to help shape deployments:

- **Engagement with operators seeking wayleaves to access council property and a public standardised wayleaves process.** While the ECC potentially gives operators significant leverage in negotiations with the council, the code requires that operators first seek to negotiate a voluntary agreement with the landowner before going to court.[94] A voluntary wayleave agreement with the council (which may include social benefits) is likely to be quicker for the operator, provides an opportunity to demonstrate its corporate social responsibility credentials and avoids negative publicity associated with court action. Despite this, we note that there is a benefit to the council's processes being broadly in line with those of other local authorities; if Greenwich is seen as 'different' it may make some operators less willing to deploy in the borough, especially to social housing estates as operators (especially larger ones seeking to deploy on a large scale) aim for standardised processes where possible.
- **Direct investment in networks**: Entering into a joint venture with a commercial partner allows the council or its subsidiary (DG Cities) to directly promote the availability of fibre networks in parts of the

[92] Such as the Emergency Services Network (ESN) and its predecessor Airwave network

[93] As discussed further in our report on dark fibre in social housing estates the Electronic Communications Code gives authorised operators the ability to install and maintain electronic communications networks and infrastructure without a street works licence. In the event than an operator is unable to conclude an agreement with a landowner or occupier to allow them to allow them to install, maintain and operate an electronic communications network, an operator with code powers can also seek a court order to impose an agreement on the said landowner or occupier. Additionally, operators with code powers can claim compensation from local authorities in certain situations where the local authority has obstructed access to equipment. See: https://www.ofcom.org.uk/phones-telecoms-and-internet/information-for-industry/policy/electronic-comm-code

[94] And landowners with operators – Ofcom (2017) Electronic Communications Code: Code of Practice paragraph 1.25 https://www.ofcom.org.uk/__data/assets/pdf_file/0025/108790/ECC-Code-of-Practice.pdf

borough. This has the potential to bring direct benefits not just to residents (who may benefit from access to full fibre broadband services sooner than would otherwise have been the case), but also to businesses and public sector bodies.

- Engagement with operators to understand their deployment plans for the borough. Ongoing engagement with operators and aid operators by drawing attention to local factors which could support investment in networks.

Through its own procurement decisions, the council can also shape the technologies being deployed in the borough. As a London Borough rather than a unitary authority, its remit is shared with the GLA/Mayor and TfL meaning that its potential breadth of any IoT deployment is likely to be smaller than that of a city such as Edinburgh, Glasgow, Paris or Barcelona which have deployed smart city platforms. Despite this, the breadth of activities of the council means that significant numbers of IoT devices and sensors could be deployed across the borough over the next 10 years in its housing stock, on its in streets and in its public places.

To ensure that large scale deployments are future proof, council teams seeking to buy and deploy IoT should give consideration is given to potential compatibility with future networks as part of the procurement process.

DARK FIBRE ON ESTATES

Introduction

The focus of this report is on the work done by the Royal Borough of Greenwich (RBG) in 2020-21 to install dark fibre on two of its estates in Greenwich (Flamesteed and Ernest Dence) while these estates were undergoing refurbishment. The report sets out and analyses potential options as to how services to residents (and the council) could be provided over these fibre installations. It also considers potential alternatives and complements to full fibre networks on estates. Finally, the report considers recommendations for local authorities seeking to accelerate the availability of gigabit internet access in their housing stock.

- Context and key questions the work is addressing
- Summary of work undertaken on the estates
- Options for lighting the fibre
- Alternatives and complements to FTTH on estates
- Recommendations and conclusion

This report is complemented by a second report looking more broadly at the connectivity needs of the borough. Further detail on consumer research used in the two reports is set out in a consumer research annex.

Context

As people do more online, and public services are increasingly offered online, both for the benefit of citizens and service providers, a good broadband connection has never been more important. As the Borough's Connectivity strategy notes, full fibre broadband is likely to underpin the high-quality connectivity that residents will require over the next decade

and beyond. As these networks require a fibre connection into each home, they can be expensive and time-consuming for operators to deploy.

Ofcom's data shows that as at September 2021 full fibre broadband is available to 24% of all locations in the borough, in line with the national average, but below that of several surrounding boroughs.

In the light of this the Borough has been looking for ways to ensure that its residents will be able to access full fibre networks and services in a timely manner. One way of doing this is to attempt to make the deployment of full fibre networks easier and cheaper for operators. An area where the council can do this directly is to reduce barriers to deployment in multiple dwelling units (MDUs) i.e., blocks of flats on estates that it owns. As a landlord the council carries out periodic refurbishment of estates which may include the replacement of electrical wiring, heating systems and upgrades and replacement of integrated receiver systems (the systems used to distribute broadcast TV systems from common aerials and satellite dishes to individual flats). The refurbishment of estates potentially allows for fibre cabling to be installed to each flat at a lower cost and at less disruption to residents.

After briefly describing the work carried out on each estate the questions this report looks at are:

- Does installing dark fibre on estates make sense in principle?
    - o Does dark fibre on estates help accelerate / ensure the deployment of fibre to residents in social housing by reducing the cost and time for operators to deploy to the estates?
    - o Does it help the residents and council by not having three or four operators drilling holes and duplicating what each other are doing?
    - o Does it make economic sense for both the council and operators for the council to install fibre during retrofit works?
- What models are there for lighting the fibre and what are the impacts on the council and operators for each? What are the potential alternatives?
- To what extend do the models give a council more control over deployment that it can to derive wider benefits to its residents?
- How replicable is the approach for different local authorities given the different models?

Summary of work undertaken on the estates

Work was carried out by SCCI working as a sub-contractor to the Borough's contractor for the refurbishment of the estates as part of the Borough's programme of capital upgrades. Upon discussion with SCCI, they indicated that the price paid by the council was the standard quotation for the work carried out on Flamsteed for the basic installation. SCCI suggested that the price paid for the work on Ernest Dence by RBG included a significant discount as SCCI wished to use the work to showcase the four-fibre solution to the Borough, and that the actual cost of the work was up to four times higher.

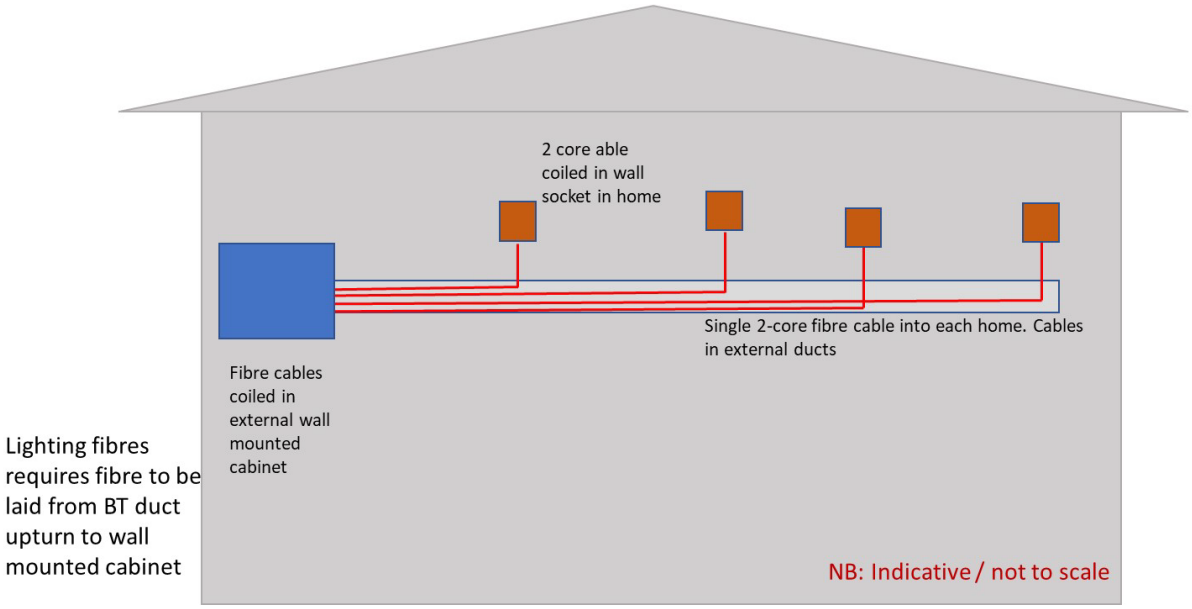
Flamsteed

Work was carried out on nine medium rise blocks (2-4 floors) on the estate; a total of 172 flats. The estate is currently served by both Openreach's network (including fibre to the cabinet) and Virgin Media's cable network. The work was carried out alongside the refurbishment of the IRS system and involved the provisioning of 2 core fibre cables into flats on the estate.

Summary of work carried out:

- Installation of tubing from BT up-turn point to low level fibre cabinet
- Aggregated multi-fibre cable run up side of block to a new FTTH cabinet located next to the TV-main head-end cabinet.
- Fibre loom run from the FTTH aggregation cabinet alongside the outside of the building with the IRS cable
- FTTH cable drop down side of building into flats
- Cables not terminated but coiled at both ends

Figure 13: Diagram of work carried out at Flamsteed



Ernest Dence

Work was carried out in Gifford, Aylmer and Jennings Houses, which comprise a total of 95 dwellings. Premises on the estate also include a community centre. The estate is currently served by both Openreach and Virgin Media's networks, although superfast broadband using Openreach's fibre to the cabinet services are not available on the estate.

The estate uses a communal heating system powered by three gas boilers. As part of RBG's programme of works, [REDACTED] has been installed to monitor the boiler system.

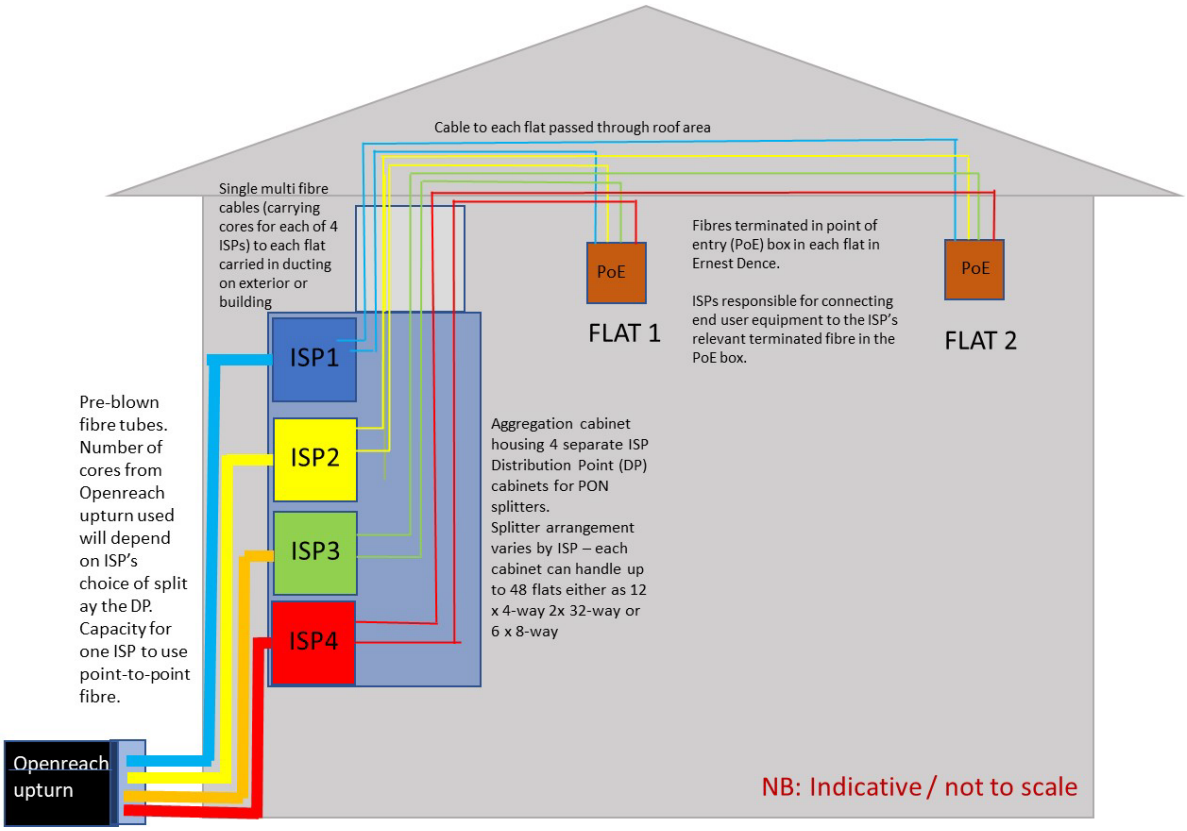
SCCI deployed its four-fibre solution to this estate. This included the following elements:

- Digging and installation of duct and fibre tubes from the Openreach upturn point (where Openreach's network enters the block) to an aggregation cabinet
- Externally mounted aggregation cabinet on each block containing 4 separate distribution cabinets (one for each ISP)
- Pre-installed steel trunking and fibre cabling from ISP distribution cabinet into the roof void of each block and down into the flats
- Each set of 4 fibre cables terminated in a point of entry box in lounge of each flat (NB: in other deployments using the 4-fibre solution the PoE box has been in other locations such as outside the front door of the relevant flat). In-flat termination was carried out on Ernest Dence.

This avoids the need for any additional drilling by the ISP when a resident first subscribes to the service.

In contrast to the installation at Flamsteed, the four-fibre installation allows for four separate networks operators to service each flat (and potentially other locations on the estate) using its own dedicated cabling. This allows up to four separate operators to serve the estate without each needing to install their own fibre, potentially making deployment easier and cheaper, while promoting competition between networks. A diagram of this is set out below:

Figure 14: Four fibre installation at Earnest Dence



SCCI has deployed the 4-fibre solution in other locations. In contrast to the Ernest Dence deployment (where the freeholder owns the installation) SCCI's standard practice for the set-up is to fund the installation of the fibre itself. Network operators then buy the fibres from SCCI.

As in the single fibre model, the ISP retains responsibility for the provision of the active optical termination unit (OTU) to the end user. The OTU forms the boundary between the GPON network and the president's own network using Wi-Fi or cat 5/6 Ethernet to connect to devices.

Issues in principle

THE TYPE OF REFURBISHMENT BEING UNDERTAKEN IMPACTS THE ATTRACTIVENESS OF THE MODEL TO OPERATOR AND THE COUNCIL

In theory, there are advantages to installing ducting and fibre into the blocks while other work is being carried out including cost and disruption to residents, especially if fibre is being run in the interior rather than the exterior of buildings. The downside to this is the need to co-ordinate installation of dark fibre with the Borough's maintenance and repair schedules. We understand this is generally fixed 2-3 years in advance but may change as a result of reprioritisation exercises.

However, the benefits of the approach for both the council and operators are likely to vary given the type of refurbishment work being carried out. Councils undertake a range of refurbishments and upgrades for their housing including:

- Updating of pointing
- Upgrades to electrical systems
- Upgrades to boilers and heating systems
- Upgrades to integrated reception systems (IRS)
- Work involving the installation of external wall insulation (EWI)

Refurbishments which include EWI work require special consideration and care with the phasing of work if any of the fibre is required to be installed externally. Drilling holes for ducting and cabling for fibre should be carried out before EWI is installed, as drilling holes in the insulation panels once they have been installed may adversely affect their performance and have implications for guarantees that the council may hold. Therefore, once EWI has been installed on an estate, there is a significant benefit to the council and residents in ensuring that operators do not drill through the panels when deploying their networks.

There are other systems that are designed to reduce the impact of fibre deployments in MDUs. For example, operators in some locations have installed in-block fibre in the cornice of corridors or on the outside of buildings using a system such as OFS Optics Invisilight system . This is designed to reduce the space required by, and the visual impact of a traditional installation through the use of thin cabling. This also potentially allows for much smaller holes to be drilled through walls. However, in the event that multiple operators seek to deploy to the

block, the lack of free cornices and small channels may add to the complexity of the installation. Finally, while the thin specialist cables (0.9mm in-building and 3.8mm external) minimise their visual impact and size of hole it may make them more fragile, especially if multiple installations are in close proximity.

Residents on the two estates told us that while they could see the benefits of the estate refurbishment programmes, the on-going work, in particular noise could be very disruptive for them.

Costs for operators

The cost for each operator to deploy their network to the homes on the estates will vary depending on the reach of their existing network and the technologies they deploy, density of buildings and site-specific factors. While average capital costs of building FTTH in the UK are around £300-400 per home passed plus additional costs per connection, these may vary considerably. For example, by reusing its existing cable network ducts, Virgin Media believes that it will be able to deploy its FTTH network for under £100 per home served, although final installation at the customers' premise may add an additional £100. The question therefore, is whether or not dark fibre significantly lowers the cost of connection compared to the operator's traditional approach. This is dependent on both the underlying installation cost of the dark fibre itself as well as the commercial terms on which it is made available to the operators.

The four-fibre structured wiring installation does require more infrastructure (i.e. fibre tubing and larger cabinets) than a single operator's deployment. It also requires greater amounts of fibre to be spliced, given that each home requires four connections. As a result, cost estimates for the four-fibre solution are approximately around £375 per home served. Based on our discussions with operator we understand that this is broadly in line with the cost of a standard operator-led deployment and that the structured wiring by itself is unlikely to fundamentally change the overall economics of deployment for operators, assuming the cost of the dark fibre installation is passed to the operator.

It was suggested to us that in situations where estates are undergoing significant refits beyond those being carried out on Flamsteed and Ernest Dence (for example significant work to fundamentally modify structures) or in new-build situations, the cost of deploying a structured

wiring solution for an operator may be higher as the other works taking place may require the operator to undertake a greater number of site visits to take place over a longer period of time.

THE MODEL USED TO LIGHT THE FIBRE

As we discuss in the following section, the degree to which the council is able to exercise control over the fibre deployment, the wider benefit the council may be able to achieve through the deployment and the likely level of interest in using the fibre by operators will reflect the model by which the fibre is lit.

Willingness of operators to use fibre

It is our understanding that from a technical perspective the fibre installations on the estate meet the requirements of Openreach concerning the type of fibre cables installed. Furthermore, the four-fibre solution does potentially make it easier and quicker for certain types of operators to provide services to networks.

From our discussions with SCCI, some operators have used the SCCI full fibre solution in locations outside of Greenwich and that they are currently interested in using the system to deploy to Ernest Dence (albeit SCCI's model involves the transfer of fibre to the network operator). However, we also believe that some operators may wish to continue to deploy their own networks on an end-to-end basis, in particular if these operators regard themselves as infrastructure, rather than telecoms service providers.

Consistency of processes and assets in the access network across the operator's portfolio may be an important factor in any decision to use a pre-installed multi fibre solution, especially for operators deploying at scale. While the use of existing fibres may reduce upfront capex to bring their service to an estate, it may also add operating expenditure as maintenance and other processes may differ from their other locations. Even in cases where the fibres themselves are sold to operators themselves, operators may be concerned that another party (likely the council or its contractor) will continue to be responsible for maintenance of common assets such as outer cabinets and shared outer duct.

Operators using Openreach's physical infrastructure access (PIA) may be even more sceptical of a model where the council retains ownership of the fibre and rents it to the operators, as this could conflict with their rationale for using PIA rather than renting dark fibre (if available) or using an active wholesale product. An operator using PIA and deploying their

own fibre retains full ownership and control over the fibre (if not the ducts and poles) and therefore renting fibre in the final segment could be unappealing to these operators.

Despite these challenges, operators do share in-building fibre networks both in the UK (as in other four fibre deployments), but also abroad. The French regulator, ARCEP imposed 'symmetric' regulation on operators requiring that the first operator to deploy fibre to a multiple dwelling unit (MDU) makes the in-building fibre available to other operators in order to promote competition and reduce the cost of deployment given that in-building fibre in a multiple dwelling unit can account for c.60% of the cost per line.

Pricing of the dark fibre.

In cases where the council commissions and pays for the installation in the first instance there is a potential tension between maximising the council's financial return (or minimising cost of deployment) against the benefits from a more rapid take-up by operators or greater social benefit from operator subsidised connectivity provided to community groups or community centres.

In any case a price would need to be determined and agreed between the council and operators. While Openreach publishes rental prices of dark fibre (by the metre) we note that these are predominantly for main links and that the product is regulated. Furthermore, it is likely the council would retain some responsibility for the maintenance of common assets used by all operators, and the cost of this would need to be factored into pricing.

If looking to base pricing on cost (or cost-plus), it is necessary to consider the treatment of fixed costs and how these are apportioned across operators. At the time of installation of the multi fibre solution there is no guarantee that four operators will use the system, or that all homes on the estate will take a FTTH service).

Other commercial terms

Initial discussions with operators suggest that the first operator to deploy on a multi -fibre system may seek a period of exclusivity to off-set the risk

of being first into the market where demand for FTTH services may be uncertain. However, we also note that the first fibre operator to reach an estate also has a first mover advantage. In the absence of an operator deploying to an estate with a four-fibre system without a period of exclusivity, a trade-off would need to be made between the length of exclusivity (and the impact on residents' choice of broadband operator) against the potential speed of network roll-out to the estate and the size of any social benefit concessions that the operator may provide as part of its agreement.

When granting wayleaves or selling or renting dark fibre, the council may have an opportunity to seek concessions on behalf of its residents. As noted in the table above these might include:

- Discounted / complementary connection and/or subscription to community centres on the estates or in the borough
- Support for digital inclusion programmes
- Discounted / complimentary Wi-Fi for residents
- Discounted / complementary IoT connectivity for the borough e.g., for CCTV cameras
- Commitments to social tariffs

For example, under Hounslow's 2021 borough-wide wayleave agreement with Hyperoptic, it will offer 20 free connections to community centres in addition to providing funding for digital inclusion projects.

The interaction of the dark fibre installation with the Electronic Communications Code (ECC): can the council compel operators to use a multi-fibre solution if it is available?

As operators continue to build out their networks, the potential for operators to target the same areas and buildings will increase risking multiple rounds of installation, multiple breaks in walls (necessitating fire stopping) and consequent disruption to residents.

Although only as at September 2021 under 1% premises in the UK as a whole were covered by two alternative fibre networks , this figure was high as 23.1% in Southwark. While the numbers in Greenwich are much lower at 1100 premises (0.9% of premises), as operators are continuing to seek wayleaves to deploy their network to the council's housing stock, this figure is likely to grow over the next few years.

A question arises as to whether it is possible for the council to require operators seeking to deploy FTTH to blocks where there is capacity on an installed multiple fibre solution to use it. The Electronic

Communications Code (ECC) gives operators with code powers certain rights to place equipment and infrastructure for the provision of electronic communications networks on land and buildings owned by third parties. In cases where a landowner or occupier and the operator with code powers are unable to agree an operator can apply to the court under Paragraph 20 of the code to seek the imposition of an agreement. The tests set out in Paragraph 21 of the Code allow a court to impose an agreement do not appear to require that the operator consider alternative sites before seeking an order from the court. However, when making an order the Court "must include the terms the court thinks appropriate for ensuring that the least possible loss and damage is caused by the exercise of the code right". This suggests that in the event that an operator sought an order under Paragraph 20, the council would have the opportunity to argue that any such conditions should require the use of an established multi-fibre system on the basis it would minimise disruption to residents, the impact on the look of the building and impact on the structure (e.g. around fire stopping etc). In the final event it would be up to the Court to decide on the conditions and on the fees paid by the operator to the council for wayleaves.

At the present time we understand that the courts have not yet ruled on the issue of landlords refusing access to additional operators on the basis of existing network availability nor on any conditions which require operators to use a pre-installed structured fibre solution.

Options for lighting the fibre

In the table below we set out some ways in which the dark fibre on the estates could be lit. We present four ways in which the dark fibre could be used to support the council's objectives:

1) Use of the dark fibre to provide a contended FTTH broadband service to residents' apartments

2) Use of dark fibre to provide a contended FTTH broadband service to residents' apartments and also provide a subsidised contented FTTH broadband connection / service to a community centre on the estate for use by the centre and its service providers

3) As 2 but the council also wishes to deploy a free Wi-Fi service to residents on the estate

4) As 3 but the dark fibres are also used to support the council's IoT applications on the estate

As set out in the table below there are multiple potential models by which these outcomes may be achieved, each with strength and weaknesses.

These models differ depending on whether a single fibre or multiple fibre e.g. four fibre approach is used.

A key advantage of the four-fibre solution is that by potentially reducing the cost and increasing speed of deployment, it may enable a greater number of operators to economically serve any given estate. Even in the event that the largest operators (i.e. Openreach and Virgin Media), did not use pre-installed fibre, the four-fibre solution may promote the entry of smaller operators into the market.

SUMMARY OF OPTIONS FOR LIGHTING FIBRE

		Scope of deployment			
	Description	1: Resident FTTH broadband	2: Resident FTTH broadband & community centre	3: Resident FTTH broadband & community centre & estate Wi-Fi	4: Resident FTTH broadband & community centre & estate Wi-Fi & IoT
Single fibre (2 core)	Give over / sell to Openreach	Y Cost: [REDACTED] (dependent on whether sold at cost or given to Openreach) Time: Likely dependent on Openreach roll-out plan.	Unlikely – Openreach unlikely to subsidise service to community centre as part of its standard build	N	N
Single fibre (2 core)	Council builds then auctions to highest bidder	Y	Challenging if auction purely financial criteria	Challenging if auction purely financial criteria	N
Single fibre (2 core)	Council builds then passed ownership to operator based on beauty parade	y	Y – can build this into selection criteria	Y – can build this into selection criteria	N
Single fibre (2 core)	Council nominates single fibre solution at same time as other works	Y – but may be limited choice of retail ISPs for residents Cost: £0 (paid for by operator)	Y – may be able to extract concession from operator to pay for connection for	N	N

		Time: Likely faster to deploy than Openreach	community centre connection		
Single fibre (2 core)	The council's joint-venture delivers services over single fibre installed at same time as other work	Y – NB: may be limited choice of retail ISPs for residents as smaller wholesale operators may have relatively small number of retail ISPs Cost: [REDACTED] Revenue uplift for JV	Y – can direct investment and installation (though may need retail operator)	Y – if have spare fibre installed in communal areas	Potentially some IoT applications- if have spare fibre installed in communal areas could use this for some IoT applications
Single fibre (2 core)	Fibres rented to full fibre operator VXFiber who uses fibres to deploy its Active Open Access platform. VXFiber's platform allows multiple operators to provide services to end customers on a simultaneous basis. NB: VXFiber or another party would need to deploy its own point-to-point fibre network to the estate. Point to point fibre may require additional ducting within estates given additional number of fibres used.	Y - Option for residents to access multiple service providers on top of VX's service platform. In UK deployments to date have included range of service providers including SMEs targeting local customers Only those operators on VXFiber's platform are able to access the network	Y- Council could potentially select different service provider to those providing connectivity to residents	Y - Council could potentially select different service provider to those providing connectivity to residents.	Y - could potentially service IoT applications via specific service provider on network. Relatively low barriers to entry for service provider on VXFiber system vs more traditional wholesale models. Could this mean the council could manage this IoT service element itself?

4 fibre (2 core)	Third party e.g., SCCI pays for and builds 4 fibre solution that it sells to other operators	Y Cost: £0 Time: c. 4 months (site install) plus network installation build (assume PIA). NB: commercials may mean that 1st network to take fibre is offered period of exclusivity (e.g., 6 months) before other operators can connect to the system	? - may be able to extract certain concessions [REDACTED]	N – no guarantee - though council could try and influence through wayleave agreement [REDACTED]	N
4 fibre (2 core)	Council / JV pays for and installs 4 fibre solution renting fibres back to operators One fibre is reserved for JV and its customers	Y – Allows JV to serve customers Cost: [REDACTED] upfront plus ongoing opex for general maintenance of system Revenue: On going from rental of fibres to operators (maximum 3-4) – but take-up is not guaranteed. Some network operators may reject fibre rental model and may be unwilling to use existing infrastructure Time: c. 4 months to install as part of estate renewal programme.	Y – can ensure that community centre is connected as part of agreement (or by JV)	Y – council can direct overbuild to provide additional duct and fibre to communal areas to connect Wi-Fi access points. Potential to use JV for service	Y - Potential to reserve one of the 4 fibres for future council applications into residences (i.e., allowing 3 networks plus council fibre). But council would need to find partner to light and manage its reserved fibre unless JV took on responsibility

		To promote take-up 1st ISP to use fibres could negotiate exclusivity period e.g., 6 months. Alternatively potential to flex rental payments so that first operator pays discounted rental for fibre vs operators that sign-up later? Renting fibres may be unattractive to some operators			
4 fibre (2 core)	Council / JV pays for and installs a 4-fibre solution and then sells back fibres to operators	Y Cost: [REDACTED] up front Revenue: [REDACTED] from sales Council / JV could still retain ownership of 1 of 4 fibres and sell remainder to three independent networks Council or JV may need to continue to perform basic maintenance of shared infrastructure including ducting and outer cabinets even when fibres sold due to assets being used in common	Y	Y	Y
Wayleaves only	Do nothing	Cost: £0 Time: Dependent on operators.	Y – if operators choose to deploy network	Potential to link wayleave to social value activity	N – in event that council wanted to install IoT it could rely on wireless

		No guarantee that networks will deploy to blocks. However smaller operators seeking wayleaves and estates may also likely to be overbuilt by Openreach build (and potentially Virgin Media). Risks unsightly uncoordinated fibre deployments on estate – risk of sequential installations damaging existing installations			

Further details and aspects of different approaches are set out in Annex A.

Source: DG Cities

In the cases above where the council itself commissions and pays for dark fibre, it (or its representatives) will need to negotiate commercial terms with the operators and bear some financial risk in the event that not all fibres are lit.

Deployment of a single fibre cable limits the potential to use the dark fibre network for the council's applications

We note significant challenges if the council were to reserve one core out of a two-core single fibre cable as deployed on Flamsteed. While there are potential benefits to the council having reserved and dedicated capacity for its own applications and services, we consider that such an arrangement is likely to be technically complex to implement and may be rejected by operators for the following reasons:

- Unwillingness of operators to share fibre cables given issues around control and repairs
- Additional complexity in splicing and treatment at the OTU
- Reduction in resilience of main internet connection (as the second core is no longer a back-up).

However, as an alternative, as part of works on the estate, additional dark fibre could be installed during estate renovations into key communal areas and other locations such as plant rooms in order to provide fixed network connectivity for IoT devices. While many simple sensors require only limited bandwidth and do not need to operate in real time, other IoT devices such as smart cameras may require greater bandwidth and lower latencies. However, this installation could be independent of the network used for FTTH provision to residents and use a different technology such as point-to-point Ethernet rather than GPON. In contrast to GPON, the bandwidth (and fibre) on point-to-point fibre Ethernet networks is symmetric, not shared with other users and allows for guaranteed bandwidths, faster fault detection and repair and greater security.

Installing this additional fibre on estates would potentially allow the council to consolidate IoT devices on a single fixed network at a future date and would potentially allow for the network to be used as on-estate backhaul for Wi-Fi, small scale cells for 4G and 5G mobile or LoRAWAN-gateways.

Reservation of a fibre in multi-fibre installations for online council services delivered in residences is more practical

In cases where the council (or JV) rather than a third party commissions and installs a multi-fibre solution, there is an option to reserve a fibre for

council use. This would mean that each home on an estate could potentially have a dedicated fibre channel for civic applications, at an opportunity cost of a reduction in the number of network operators being able to use the system.

But do we expect multiple alternative operators to overbuild each other? Reserving a fibre for possible future council use, would still allow Openreach, an alternative third-party FTTH operator such as Community Fibre and the joint venture all to service the estates without laying new fibre in the blocks. This is in addition to Virgin Media whose network currently also services these estates. Reservation of a fibre at the time of installation gives the council an option value but does not preclude the use of the fibre by a commercial ISP at some point in the future.

It is also important to note that reservation of dedicated fibre is not necessary in many cases. As noted in the report looking at the connectivity needs of the Borough, many uses of the internet with citizen value such as accessing information about public services or conducting transactions with public bodies can be seen as part of normal online activity. More immersive applications e.g., use of video conferencing for education or to access healthcare is similar to use of video sharing platforms or services such as Zoom used for personal or business communications. Given this, to address barriers around the take-up of these types of public online service caused by affordability or lack of awareness, social tariffs on the commercial ISPs serving the block and training might better support these objectives.

Alternatively, in the event that the council wished to ensure that all residents could access civic services it could consider deploying a free Wi-Fi service for residents or a targeted intervention to provide subsidised 5G fixed wireless access (FWA) to vulnerable or excluded residents.[95] To conserve bandwidth for civic purposes on a free Wi-Fi network the council could impose controls on access and IP addresses visited (for example blocking services such as Netflix and online gaming). Dark fibre on the estates could be used to provide backhaul (i.e. the connection back to the internet) for such a Wi-Fi network. Again, it is important to note that this may be independent from the FTTH networks installed for residents. For example, as noted above, symmetric and uncontended fibre leased line Ethernet products with business grade service level agreements (SLAs) and repair times could be used to provide the backhaul for the Wi-Fi network.

[95] Fixed wireless access provides wireless broadband between the operator's base station and a fixed location at the end user's premises

Current IoT devices deployed by the council on the estates use a range of networks

Current IoT deployments by RBG use multiple networks, reflecting the use of multiple solutions providers and the use of fully managed services where connectivity is bundled with the service platform. [REDACTED]. Providers of managed solutions may in some cases prefer end-to-end control (to ensure quality of service and fault finding etc) and consistency and so may want to manage connectivity elements.

Alternative approaches to IoT offer greater integration. For example:

- Data integration – use of APIs to allow data from different end-to-end managed platforms to be brought together for storage and analysis.
- Platform integration – single platform is used to manage devices and networks and allow deeper integration of services. This does not require single communications network to be used – can mix FTTH with cellular, Wi-Fi and LoRAWAN which are independent of each other (and potentially using different CPs). In contrast some authorities including Edinburgh and Glasgow have deployed platforms to integrate and manage 'smart city' applications. Greenwich does not currently have an IoT platform.
    - Network integration: This can relate to:
    - A common core network e.g., a core fibre used to support multiple access networks (Wi-Fi, LoRAWAN, FTTH connection)
    - A single comms network used to provide connectivity for devices e.g., all of the council's IoT devices plugged into a wired fibre connection on the estate

In-home council IoT applications

As noted above, in-home IoT devices could be connected wirelessly to a council-controlled LoRAWAN or Wi-Fi access point located on the estate. Many applications such as environmental or alarm monitoring have relatively low bandwidth demands and can even be served by 2G GSM networks or LoRAWAN networks. Use of wireless connections within residences may reduce the risk of these devices being unplugged or interfered with, especially if they are low power devices with internal batteries that can be sealed.

IoT applications that require very low latencies and/or large amounts of bandwidth include real time control of safety critical systems, and applications that use video. However, these may potentially raise a wider set of privacy concerns if deployed en-masse by the council across its housing stock given the amount of data collected on residents and the potential intrusion into their lives. We note that with existing IoT trials using with the HomeLink system, some residents have expressed concern

about the feeling of being monitored by the council and some residents have tried to disconnect alarms etc. However, in some situations IoT applications managed by the council that collect and analyse significant amounts of data in real time may generate significant social value, for example in use of video analytics to monitor elderly residents with dementia.[96]

Another application with social value as noted in the report on the connectivity needs of the borough, intensive monitoring of patients at home who would otherwise be in hospital ('Hospital at Home') is being used by the NHS to reduce cost and improve clinical outcomes. In such cases where significant amounts of data need to be generated and analysed in real time, a reserved dedicated fibre connection may offer performance advantages even over 5G networks and would not impact the resident's existing broadband connection or contract.

Options for lighting council reserved fibre

In situations where fibre is reserved by the council for its own applications, the council will need Options for lighting council reserved fibre may differ from those for lighting fibre designed for resident broadband, reflecting differences in the type of connectivity being procured and the network connectivity. For connectivity underpinning critical applications, the council may seek higher SLAs around reliability and repair times than is available from broadband ISPs.

1. Bundled IoT connectivity: This would rely on using connectivity bundled with the IoT service rather than IoT connectivity provided by the council / JV
2. Use of a retail Ethernet uncontended leased line product to connect the estate to the internet and the RBG network – this would be a managed service contract similar to those used for schools, businesses etc Given it is an active Ethernet product the customer premises equipment will differ from that used for GPON broadband networks as may the in-building wiring. It is possible that the supplier may also provide FTTH broadband services to the estate (as they can use PIA to bring multiple fibres to the estate)
3. Use of JV to manage and light fibre. This might be done in a couple of ways:

a. A third-party ISP uses the JV's network to provide the service to the council

[96] In addition to video analytics, systems may also apply algorithms to data collected from sensors monitoring use of electrical appliances or on doors to identify behaviours that are out of the ordinary and which may warrant further investigation by a carer https://www.theguardian.com/us-news/2021/jun/03/elder-care-artificial-intelligence-software

b. The JV provides the retail service to the end user i.e., the Council directly. [The potential for this has been discussed at the meetings with the bidder]

Summary of potential options for local authority IoT connectivity

	Bundled IoT connectivity	**'Retail' leased line ethernet from existing supplier e.g., O2 or JV**	**JV manages and lights FTTH broadband fibre -**	**Council contracts with FTTH broadband operator**
In-home reserved fibre channel on FTTH broadband in 4 fibre solution	N/A	Effectively duplicates the GPON - FTTH deployment. Would likely need additional fibre wiring – potentially including additional set of wiring for the ethernet connection into each apartment separate to that of the FTTH broadband	Yes – can fit into existing 4 fibre wiring set-up	Yes – can fit into existing 4 fibre wiring. Would likely seek bespoke contract with ISP for the service
Narrow band IoT applications in communal areas e.g., temperature, humidity, light, air quality	May rely on embedded SIMs and other wireless options such as LoRAWAN Homelink and so may bypass fibre to estate and on the estate itself	Yes Could use wireless to connect from estate Ethernet switch in comms room to sensors to reduce on-estate wiring. If wired on-estate network required, fibre Ethernet As an alternative could use on estate cat 6 copper cables to connect router to sensors (which may also allow for power to be supplied) – maximum length c.100 metres	Yes – though may need to add in additional wiring / capacity in boxes to connect not just each flat but also each communal point on estate that council wished to have access to fibre. Standard 4 fibre wiring might need extension	Yes – though may need to add in additional wiring / capacity in boxes to connect not just each flat but also each communal point on estate that council wished to have access to fibre
Broadband IoT in communal areas e.g., connected video cameras		Yes- point to point Ethernet leased line product offers higher quality guaranteed bandwidth than FTTH broadband	Yes – but connection would be contented broadband grade product which may be less suitable for applications	Yes – but connection would be contented broadband grade product which may be less suitable for applications

		Use of fibre ethernet cable possible for on estate wiring. Alternatively, could use cat 6 copper cables to connect router to sensors (which may also allow for power to be supplied) (up to 10 Gb/s) up to 100 metres	requiring sustained guaranteed speeds and low latency. Might need to add in additional wiring / capacity in boxes to connect not just each flat but also each communal point on estate that council wished to have access to fibre	requiring sustained guaranteed speeds and low latency. Might need to add in additional wiring / capacity in boxes to connect not just each flat but also each communal point on estate that council wished to have access to fibre

Alternatives and complements to on-estate fibre

Fixed wireless access (FWA) using 5G networks may provide an alternative to fibre for some residents living in areas with coverage

Three in particular has positioned its £30/month up to 5G fixed wireless access service as an affordable alternative to fibre broadband. However 5G coverage is not uniform across the Borough – for example Three's FWA service is currently unavailable in locations on the two estates.

Operators are continuing to build out coverage of their 5G networks, though the approaches taken by the MNOs differ. Some operators including EE and O2 appear relatively enthusiastic about small cells (potentially using antennas mounted on council-owned assets such as lampposts) to provide infill for their 5G deployments. In contrast Three's deployment is currently focused around the use of more traditional macrocell sites (generally on rooftops) and roadside sites and Three intends to upgrade 91% of its sites in the borough for 5G.

Given this, the borough's engagement with MNOs and with small cell operators such as Ontix could be used to encourage 5G FWA coverage in areas with social housing. However, we note that propagation characteristics of the frequencies used to provide 5G FWA (in particular the millimetre wave frequencies (24-47GHz) which may offer bandwidths of several Gb/s) mean that signals cannot be received deep inside buildings – and may be blocked by surrounding buildings more than those used for mobile 4G and 5G coverage (generally between 700 MHz up to 3.5GHz). As with other wireless technologies, bandwidth and quality

of service cannot be guaranteed – dependent on local environmental factors and number of users (as spectrum is a shared resource).

Mesh Wi-Fi network

An emerging technology, mesh Wi-Fi networks may address some of the weaknesses of a stand-alone FWA system, in particular issues around in-building coverage and in some situations might act as an alternative to FTTH for some residents with relatively low bandwidth demand. In a mesh Wi-Fi network, a 5G FWA router (which could be located outdoors to provide direct line of sight for millimetre wave frequencies), or a fibre connection provides the system's connection to the internet. This router connects with Wi-Fi-access points located around the site or within the building. These access points are also interconnected with each other, to form a mesh.

Our research on the estates suggests that prior to installation of any mesh Wi-Fi network, surveys might be required to understand likely in-home reception. Many respondents we spoke to on the Flamsteed estate said that they had problems with in-home Wi-Fi reception, being unable to use their broadband connection in certain rooms. In addition to Wi-Fi equipment itself, other factors behind the performance of Wi-Fi signals including physical obstructions, the presence of other Wi-Fi networks and interference from other sources. The construction of the apartment blocks will therefore likely impact performance and might result in difficulties in reception, if, for or example in-home walls are especially thick, or contain metal.

Investment in duct on estates

An alternative to the deployment of dark fibre on estates may be to build out fibre ducts to each flat and key communal and service areas when estates are undergoing refurbishment.

Under this model operators would be able to deploy their own fibre into the council's ducts and this might co-exist with the four-fibre model. This option may be appealing to operators using PIA to deploy their own fibre and gives them end-to-end control. It may also give operators greater flexibility in the network architectures they deploy, both in the short term (to provide connectivity for IoT or wireless network access points) and in the longer term, if there is a shift away from GPONs to another technology for full fibre broadband. For the council, installation of ducts prior to EWI work could reduce the risk of operators seeking to drill through the insulation.

There are some downsides to pre-installation of duct. While physical ducting may last for several decades and require minimal maintenance if installed to the manufacturer's specifications, a duct-based model is not a hands-off model for the council. Firstly, as with models where the council owns the dark fibre, the council will likely need to play an on-going role in assigning and renting out of ducts. Furthermore, monitoring will be required in cases where multiple operators are seeking to deploy in the same duct to ensure that new installations do not have adverse effects on existing operators and their fibres.

Recommendations and conclusions

Lighting fibre: Single fibre installation

Passing fibre to Openreach is one potential approach for single fibre installations (Flamsteed) and offers several advantages:

- Openreach is likely to offer the widest choice of retail ISPs for end users – including large national brands which include players offering social tariffs. It therefore makes sense to pass this to an open access operator with the widest range of customers
- Residents moving to FTTH may be able to remain with their existing ISPs and bundles (and so aid take-up as users may be able to migrate to FTTH without coming to end of their contract with their existing ISP)

Even in the event that Openreach was unwilling to pay for the fibre, [REDACTED] could potentially be seen as a payment by the council to avoid disruption to residents. However, the decision to sign-over council property to Openreach would need to be taken by the Borough.

We note however that this approach is not without risk and does not guarantee outcomes in terms of timings. A smaller operator could potentially light the fibre more quickly than Openreach based on current deployment plans, and in our view given its scale Openreach would likely overbuild in areas with a single FTTH network operator.

While Openreach potentially offers the widest range of choice of retail ISPs, the current FTTP GEA product portfolio allows retail ISPs using active products to offer only asymmetric services to a maximum 1Gb/s download and 200 Mb/s upload. This contrasts with the symmetric broadband products offered by firms such as Community Fibre and 4th

Utility which offer symmetric 1 Gb/s contended services. Certain full fibre operators have decided discounted tariffs targeted at vulnerable consumers, though the eligibility of these and product offered may differ from those offered by BT and KCOM, the UK's two designated Universal Service providers which are required to offer social tariffs.

In the light of this we suggest that consideration could also be given to selling the fibre to an altnet, potentially via an auction (if the council wished to maximise its financial return) or via a beauty parade in which operators (which could include Openreach) would be invited to submit tenders to the council addressing selection criteria with the council reviewing and selecting the winning tender on a qualitative basis.

Further work would be needed to design an auction or beauty parade, but the criteria in the beauty parade could include the degree to which consumers will have a choice of operator, the willingness of the operator to provide additional social benefits, such as connections to community centres and/or on-estate Wi-Fi consideration of time to market and the range and price level of retail services offered to residents. Given it is likely Openreach will overbuild with its FTTH network, and the current availability of gigabit broadband via Virgin Media on the estates, concerns about monopoly power of a single fibre operator will likely be time limited in the event that the operator of a non-open network were to take over the fibre.

In any case, the network operator using the installed fibre on Flamsteed will need to carry out additional work to link from the Openreach duct upturn to the cabinet, and terminate and splice these into the dark fibre. The operator will also need to carry out in-apartment work to terminate the connection and install a socket plate to allow the fibre to be connected to the subscriber OTU.

Lighting fibre: Multiple fibre installation

For some operators, the four-fibre solution is likely to lead to faster and lower cost deployment of fibre to their customers. However, an assumption in the four-fibre solution deployed on Ernest Dence is the use of Openreach PIA and a GPON architecture for three of the four operators. While many full fibre broadband networks being deployed follow this model, alternative type of network deployment can be used to provide gigabit broadband. For example, we understand that in some places Gigaclear and VXFiber use point-to-point fibre. The four-fibre deployment on Ernest Dence allows for one of the four operators to use this architecture as an alternative to GPON, though an operator would also need to seek permission to install additional powered cabinets to house its active equipment.

Virgin Media's existing reach means that in most places it uses its own ducts. An operator using an alternative architecture could connect into the structured fibre wiring on the estate – however this could require the laying of additional duct and fibre and cabinets around the site.

The four-fibre rather than single fibre approach is more future proof and avoids many of the problems associated with un-coordinated deployment of fibre on estates by multiple operators seen in certain other boroughs.

Residential fibre as a catalyst to broader fibre deployments on estates

By reducing barriers to deployment of residential FTTH broadband on the estates, the dark fibre installation may also reduce the complexity. This is because operators connecting their (generally GPON) networks to the estates using PIA are likely to bring additional spare fibre to the estate. The presence of existing spare fibre to the estates reduces the cost and time needed for the deployment of point-to-point Ethernet fibre to estates used for the Council's IoT applications including smart CCTV cameras (and potentially for on-estate Wi-Fi).

In the light of the above we conclude:

- The quickest deployment of any fibre and least cost approach would likely be the SCCI model given that SCCI has previously deployed this in other locations. The model avoids the council taking on responsibility for allocating fibre and maintaining the system and does not need to fund the work up front. However, the council gives up some control over the infrastructure.

- The opportunity for the council to deploy dark fibre is likely to be time limited (i.e., within next 3-4 years) given current the deployment plans of Operators. Existing operators serving the estates (Openreach and Virgin Media) are, in our view likely to overbuild with their FTTH networks within the next 5 years.

- Without clear steer in relation to the four-fibre solution, within 6-12 months operators may continue to approach borough with request for wayleaves and install independently. Not granting borough wide wayleaves during this time helps to control and reduce this but ability of council to control network deployments is impacted by the Electronic Communications Code (ECC) which is generally tilted in favour of operators.

- We also note operators will want a standardised set of processes and products – and this might also suggest that the borough adopts a standard approach to social benefits offered in return for wayleaves

- Passing the assets to the council's joint venture entity solves many practical problems for the borough as the joint venture will be better equipped to market and manage the fibre. Therefore, we recommend work could involve developing the business case with the successful JV bidder. In absence of the JV, the council would need to carefully consider the challenges of going into the telecoms business by playing an active role in renting fibres or ducts to operators.

- One way to promote the longevity of interventions on the estates may be to install spare duct across the estate including into each apartment as well as across communal areas and plant rooms. This would potentially allow for new network infrastructure to be deployed in case operators wanted to replace GPON networks at some point in the future and would also give greater flexibility in the deployment of IoT and wireless network access points on the estates. Landlords renting duct rather than fibres to operators may be more acceptable to operators and avoids the council taking on responsibility for maintaining fibre. However, use of the duct would require ongoing oversight from the council.

- The equipment required by different types of fibre networks varies. Given this, when planning on-estate fibre deployment, consideration should also be given as to reserving locations where operators can install active equipment. This is especially relevant for operators seeking to deploy broadband via point-to-point Ethernet such as Gigaclear and VXFiber as well as installations that use point-to-point Ethernet for the council's on-estate IoT applications

- Another matter to consider is concerns that of current procurement of on-estate solutions that involve IoT. We note that some on-estate IoT equipment such as CCTV cameras may have a service life of a decade or more and may only be replaced or upgraded infrequently. When procuring IoT solutions, we recommend that the council considers the potential for the solution to use fibre in future even if initially it uses an alternative network such as 4G. This would not require the council to always adopt fibre-compatible solutions (whether using fibre directly or Wi-Fi) when deploying IoT solutions but would mean that the council gives due consideration to future-proofing its deployments in this area.

ANNEX 1- FIBRE INSTALL

Further detail on potential models for fibre install

SINGLE OPERATOR FIBRE INSTALLATION

Pass fibre to Openreach

Openreach offers scale and potential to offer wide range of consumer ISPs (up to 300) offering bundles via active wholesale product. Smaller wholesale operators less likely to have relationships with a wide range of retail ISPs

However, passing to Openreach may have disadvantages:

- Parts of RBG are on Openreach network and list to build – but other operators may be willing and able to deploy more quickly than Openreach to Flamsteed.
- Other operators may be able and willing to deploy more quickly – and may not preclude eventual overbuild from Openreach
- Openreach GEA product specifications and price relatively unattractive compared to products offered by some of the alternative non-BT/Virgin Media networks (altnets)

Sell / give to Openreach

Advantages

- Low risk partner (reputationally)
- Residents likely to have access to largest number of retail ISPs (up to 300) offering a wider range of packages and bundles other whole operators compared to other wholesale operators

Disadvantages

- Even if interested in asset Openreach may not wish to pay for it (so council may have to write off investment)
- Other operators might light fibre sooner than Openreach (and this would unlikely preclude overbuild by Openreach)
- No guarantee that presence of assets will accelerate Openreach FTTH build to estate – deployment too small scale for major scale operator such as Openreach to modify its plans (unless council requires this as part of transfer agreement – which may make it less likely for Openreach to agree in first place…)

- Openreach's product portfolio may be limited / more expensive than altnets seeking to build market share. For example Openreach does not currently offer symmetric 1Gb/s broadband product.

Pass to altnet offering wholesale services e.g., Gigaclear, Cityfibre

Advantages

- Potentially superior wholesale products than those offered by Openreach
- Potential for council to extract social concessions e.g., community centre connections as part of deal - (though agreements could be complex as service would be provided by retail ISP
- Does not preclude overbuild by Openreach

Disadvantages

- Relatively limited number of retail ISPs on platform vs Openreach
- Limited / no council control over which retail ISPs are available

Pass to retail ISP e.g., Community Fibre

Advantages

- May lead shortest lead time to flight fibre – 1st mover able to potentially capture 100% demand for fibre
- Opportunity for direct council influence on retail ISP e.g., concessions around community centres, social tariffs in advance of awarding concession / passing asset
- May not preclude overbuild from Openreach in longer term

Disadvantages

- Council effectively choosing winner / monopolist service provider (though likely time limited due to overbuild)
- Limited choice of packages for residents (majority of whom may take existing bundles) – though given shift away from PSTN and cable/satellite TV this may be less important in future

Questions

- How is retail ISP selected? Public tender with beauty parade to get most value for residents?

Pass fibre to JV

Advantages

- Keeps all RBG network assets within single entity
- Potential to use estate trial / pilot deployment more broadly
- May strengthen customer appeal of JV (if access network connected to it)
- Avoids need for council to develop commercial offering in-house

Disadvantages

- Likely limited / no overlap with phase 1 of build limited (though could be used to steer build in Phase 1 or 2)
- Slow deployment (given delays to establishing JV and getting network built)
- Perception of conflict of interest for council with other ISPs?

Council run-retail ISP

Advantages

- Council retains full control over asset
- Direct control over services – including ability to set social tariffs

Disadvantages

- Council sets up small scale ISP business – economics of this likely to be challenging – and commercial risk and operational risk for council
- Difficult economics – small sub-scale ISP likely to have higher costs
- Risks perception of conflict of interest with third-party ISPs seeking to invest in borough
- Limited resident choice

Ernest Dence 4 fibre solution

Different set of considerations arise in the four-fibre model given presence of one operator does not foreclose another.

Key questions / decisions to consider up front irrespective of approach to ownership

- Is there ex ante reservation of capacity?
    - Reserve 1 of four fibres for council applications? R
    - Reserve 1 fibre for Openreach?

- Method for determining who has capacity (whether rented or sold)
    - First come first serve?
    - Auction?
    - Beauty contest? What criteria?
- Interaction with RBG's approach to wayleaves
    - Code powers – might operators simply use Code Powers to gain access to blocks if they didn't like deal offered with 4 fibre approach?
    - Openreach publicly indicating that might also seek to upgrade existing equipment in some situations - this may not require consents or new wayleaves if replaces existing infrastructure (though will be dependent on site-specific situation)

Ownership and monetisation models for 4 fibre model

SCCI model – SCCI pays for, installs and sells infrastructure to other operators

Advantages

- No up-front resource required from council
- SCCI incentivised to get fibre lit quickly
- Does not rule out social benefits

Disadvantages

- Minimal council control – difficult to ensure council's wider social objectives achieved [REDACTED]
- Less control over social benefits than if RBG maintains control

Council as owner – RBG pays for, installs and rents infrastructure to single operator who is responsible for managing the system

Advantages

- Allows council to pass responsibility for maintenance and operation of system to third party
- Potential veto control - could even be JV
- On-going relationship with operator may allow RBG to require social tariffs as part of the agreement
- On-going revenue stream

Disadvantages

- Low acceptance of approach by operators as they are forced into
- Liability for repairs – may be outside RBG core area of expertise and may be off-putting to operators

Council as owner – RBG pays for, installs and rents infrastructure to operator(s)

Advantages

- Maximum council control over selection of operator - could even be JV
- On-going relationship with operator may allow RBG to require social tariffs as part of the agreement
- On-going revenue stream
- Can reserve fibre for council applications

Disadvantages

- Commercial risk – no guarantee that all fibres will be taken
- Low acceptance of approach by operators – risks operators seeking to use Code Powers to deploy own fibre
- Need for approach to select operators in event fibre is oversubscribed
- Liability for repairs – may be outside RBG core area of expertise – CPs may be wary of this
- Need for council to develop in-house commercial capability for pricing etc

Council as commissioner – RBG pays for, installs and sells infrastructure to operators

Advantages

- Council control to whom infrastructure is first sold (declines after that)
- Large up front cashflow to RBG vs rental
- More likely to be accepted than rental arrangement as operator retains control
- Council can potentially hold back a fibre for its own applications

Disadvantages

- Limited control over asset once sold
- On-going maintenance needed of common assets

ANNEX 2 – RESIDENT RESEARCH INTRODUCTION

This document is an annex to the two DG Cities reports looking at Dark Fibre on social housing estates and the broader connectivity needs of the Borough. Where appropriate these two reports draw from the research and trends identified in this annex.

This annex focusses on consumer use of and attitudes towards connectivity in the UK and in particular on the Flamsteed and Ernest Dence estates in Greenwich where the borough has installed dark fibre to homes while the estates have been undergoing refurbishment. This work by the borough supports its overall Digital Connectivity Strategy.

This document is set out into several sections:

- Some high-level contextual consumer behaviour trends
- Our findings from our programme of research we carried out with residents on the two estates
- Methodological annex including lessons learnt

Digital connectivity trends: UK insights

In this section we set out some high-level trends relating to people's use of connectivity in the UK to provide context to our research with residents. Where relevant, we discuss these trends in more detail in our two reports.

KEY TRENDS IN PUBLIC DIGITAL CONNECTIVITY

INTERNET USE

Present day trends in internet take-up

Connecting to the internet regularly is something over nine in ten UK adults[97] do: 92.1% of adults in the UK (97.4% in Greenwich & Bexley) had used the internet in the last three months, up from 83.3% in 2019.

However, use of the internet varies by age group: almost all adults aged 16 to 44 years in the UK has used the internet within the past three months (99.5%), compared with 54.0% of adults aged 75 years and over.[98]

While there has been little change in internet use for adults aged 16 to 44 years in recent years, the proportion of those aged 75 years and over who had used the internet within the last three months nearly doubled since 2013, from 29.1%, to 54.0% in 2020.[99] Rates also differ across the country: London continued to be the UK region with the highest recent internet use (94.9%) in 2020, while Northern Ireland remained the lowest at 88.0%.[100]

Looking more specifically at access to the internet at home, in 2021 data from Ofcom shows that 94% people had access to the internet at home, and 91% had a fixed and/or mobile broadband internet connection at home, with the 65 and over demographic group less likely to have either than younger age groups.[101]

Digital exclusion: who experiences barriers to internet use?

[97] Defined as persons aged 16 and over by ONS

[98] ONS (2020) Labour Force Survey. Accessed on: https://www.ons.gov.uk/businessindustryandtrade/itandinternetindustry/bulletins/internetusers/2020

[99] ONS (2020) Labour Force Survey. Accessed on: https://www.ons.gov.uk/businessindustryandtrade/itandinternetindustry/bulletins/internetusers/2020

[100] ONS (2020) Labour Force Survey. Accessed on: https://www.ons.gov.uk/businessindustryandtrade/itandinternetindustry/bulletins/internetusers/2020

[101] Ofcom (2021) Communications Market Report 2021 Interactive Data https://www.ofcom.org.uk/research-and-data/multi-sector-research/cmr/cmr-2021/interactive-data

Digital exclusion is a real challenge for key demographics in the UK. Looking at data from the ONS showing trends over time, around 6.3% of adults in the UK had never used the internet in 2020, down from 7.5% in the previous year and 14.0% in 2013. This reflects increasing take-up of the internet by older demographics.

For example, in 2013 65.5% people aged 65 and over had never used the internet, compared to 38.8% in 2020. The number of disabled adults who were recent Internet users in 2020 reached almost 11 million, 81% of disabled adults; up from just over 10 million (78% of disabled adults) in 2019.[102]

Time spent online

The amount of time people in the UK spend online has increased over time, with adults spending on average 217 minutes each day online in September 2020, an increase of 40 minutes since September 2017 and an additional nine minutes above average online time in 2019. The majority of time spent online is on smartphones, accounting on average for 69% time online in September 2020, compared to 59% in September 2019.[103]

Impact of COVID-19 on consumer digital habits and digital wellbeing

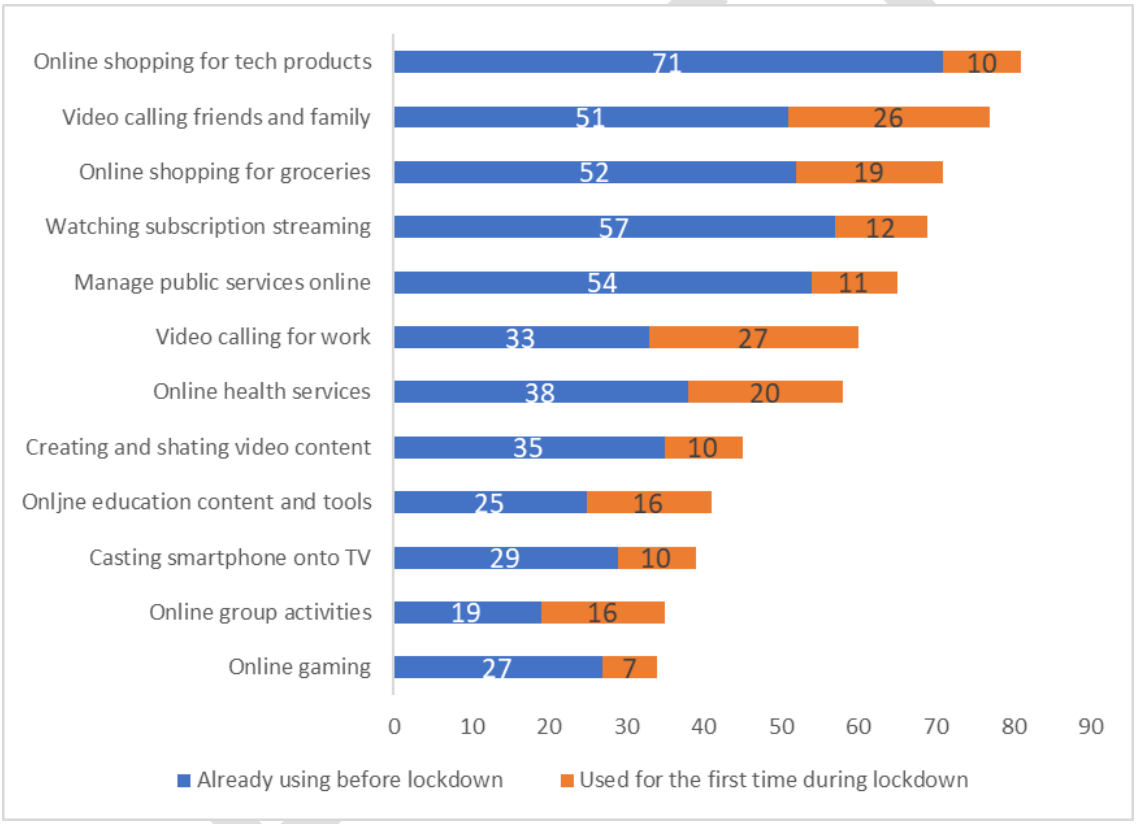
The Covid-19 pandemic and lockdowns have impacted people's use of the internet. An EY survey of 2,500 respondents found that households adopted a range of services for the first time during national lockdowns. Video calling led new adoption with a 27-percentage point (pp) rise in adoption, while online health services (up 20pp) and education (up 16pp) have also grown. Forty-three percent of respondents said their internet connectivity needs as well as their TV and streaming needs have increased.[104]

[102] ONS (2020) Labour Force Survey. Accessed on: https://www.ons.gov.uk/businessindustryandtrade/itandinternetindustry/bulletins/internetusers/2020

[103] comScore MMX Multi-Platform and Mobile Metrix, Age 18+, September 2020, UK. Note total time online excluded TV set and smart device online use. Accessed via Ofcom (2021) *Online Nation Interactive Report* https://www.ofcom.org.uk/research-and-data/internet-and-on-demand-research/online-nation/interactive

[104] EY. (2021). Decoding the digital home. Accessed on: https://www.ey.com/en_uk/news/2021/05/digital-home-services-boom-fuels-uk-consumer-anxiety-around-well-being-and-data-privacy-finds-ey-study

Figure 15: adoption of digital services by UK residents during COVID-19 (%)



Source: EY (2021) Decoding the digital home n=2500 UK consumers Available from https://assets.ey.com/content/dam/ey-sites/ey-com/en_uk/topics/tmt/ey-decoding-the-digital-home1.pdf

There are, however, potential negative impacts of increased digital service use during the pandemic: 41% of UK households in the EY research said they were more concerned about the impact of the internet on well-being than they were pre-pandemic while digital fatigue 46% to seek downtime from internet enabled devices.

Data from Ofcom's 2021 Technology Tracker also supports the notion that the pandemic has impacted existing online behaviours. For example, 64% of internet users had used the internet for online shopping more often since the start of social distancing in March 2020, while around a half of internet users were making video calls or communicating via instant messaging more often (51% and 49% respectively). [105]

Device ownership

Almost 9 in 10 adults (89%) in the UK had a smartphone in 2021,[106] with 73% adults having 4G and 7% having 5G handsets. Personal use of smartphones by grown 55 and over age group remains lower than grown that of younger demographics (96% of 18-24 vs 78% 55 and over). Ofcom's data also shows household ownership of laptop computers (76%) is higher than that of desktop PCs (47%) and tablets (65%). Laptop ownership is highest among the 45-54 age group with 89% household ownership.

The smart home and consumer IoT

Improving internet connectivity to neighbourhoods will also help to bring smart home functionality to households that would previously have been less likely to adopt it. A 2019 study by Smart Home Week found that almost 6 in 10 (57%) of UK homes are now equipped with some sort of smart device, and 45 percent of households are planning to make their homes even smarter in the future.[107]

Smart home devices form part of what is described as the 'Internet of Things' (IoT). This has become a prevalent system in which people,

[105] Ofcom (2021) Technology Tracker data tables QE5B, UK adults Base: Those who use the internet at home or elsewhere (excluding those completing a paper questionnaire) https://www.ofcom.org.uk/__data/assets/pdf_file/0015/219102/technology-tracker-2021-data-tables.pdf

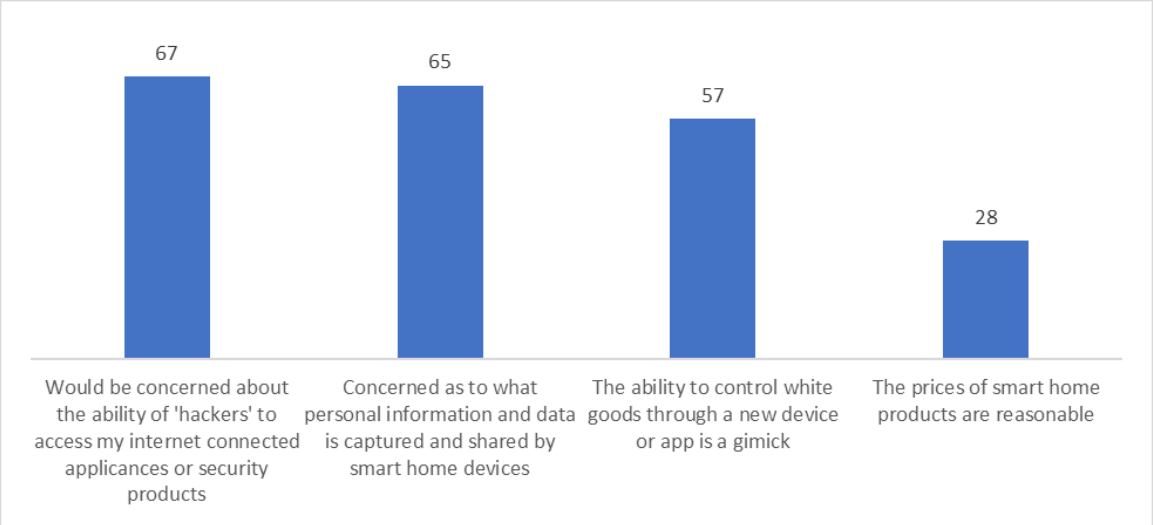
[106] Ofcom (2021) Communications Market Report 2021 Interactive Data https://www.ofcom.org.uk/research-and-data/multi-sector-research/cmr/cmr-2021/interactive-data

[107] Tech Radar research on smart home technology growth : https://www.techradar.com/uk/news/how-5g-wi-fi-6-and-ai-will-provide-a-smarter-home-experience

processes, data, and things connect to the Internet and each other. Globally, Cisco estimates that machine to machine connections will grow 2.4-fold, from 6.1 billion in 2018 to 14.7 billion by 2023. There will be 1.8 M2M connections for each member of the global population by 2023. Connected home applications, such as home automation, home security and video surveillance, connected white goods, and tracking applications, will represent 48 percent, or nearly half, of the total M2M connections by 2023.[108]

Consumer attitudes towards smart home devices are mixed. On the one hand, 50% UK adults lived in a household with smart speaker in 2021, and a third had smart home technologies such as a connected security system or smart thermostat or lighting.[109] On the other hand, research by EY suggests that two thirds of consumers are concerned about aspects of security of connected appliances or security products and 65% are concerned about the personal information that is being captured and shared by smart home devices.

Figure 16: UK household attitudes towards smart homes (%)



Source: EY (2021) Decoding the digital home n=2500 UK consumers Available from https://assets.ey.com/content/dam/ey-sites/ey-com/en_uk/topics/tmt/ey-decoding-the-digital-home1.pdf

[108] Cisco. (2020) Annual Internet Report: https://www.cisco.com/c/en/us/solutions/collateral/executive-perspectives/annual-internet-report/white-paper-c11-741490.html#Trends

[109] Ofcom (2021) Communications Market Report 2021 Interactive Data https://www.ofcom.org.uk/research-and-data/multi-sector-research/cmr/cmr-2021/interactive-data

Future trends for network use

The take-up and use of connected devices and online services will likely affect both the quantity and make-up of data being carried by networks. Average monthly data used per UK broadband connection has increased over time, rising in 2021 to 453 GB per connection, up from 429 GB in 2020 and 315 GB in 2019.[110] Drivers of this growth include increasing take-up of online video streaming services, and increasing homeworking as a result of the pandemic.

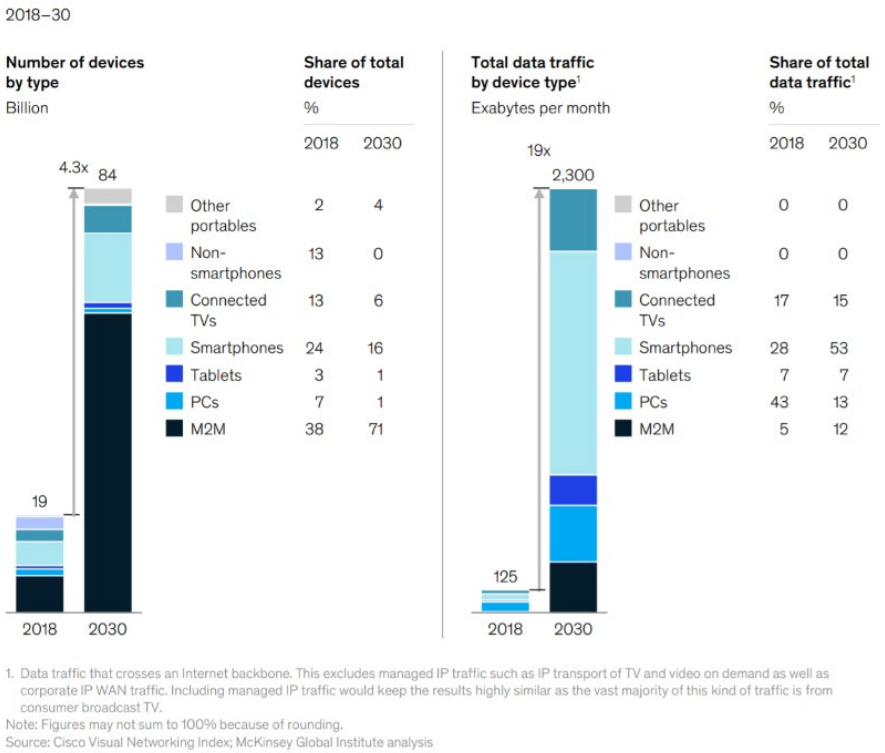
Looking forward, research by the EU commission highlights that across Western Europe internet usage, as a percentage of the regional population, will grow from 82% in 2018 to 87% by 2023. Globally, the average number of devices and connections per capita will grow from 2.4 in 2018 to 3.6 by 2023. In Western Europe and the UK this will almost double from 5.6 to 9.4 devices and connections per capita.[111]

By 2030 device usage trends are expected to rapidly increase as mobile devices become increasingly relied upon for online browsing, accessing video content, and using smart devices. Data from McKinsey highlights this shifting trend and the impact on data flows:

[110] Ofcom (2021) Connected Nations 2021: UK Report https://www.ofcom.org.uk/__data/assets/pdf_file/0035/229688/connected-nations-2021-uk.pdf

[111] EU Commission 2021 Foresight Report: https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_4534

Figure 17: Device and data usage forecast, 2018-2030[112]



Source: McKinsey Global Institute (2020) Connected World Report

Future bandwidth requirements are discussed in further detail in our report on the connectivity needs of Greenwich.

[112] McKinsey Global Institute (2020) Connected World Report. https://www.mckinsey.com/~/media/mckinsey/industries/technology%20media%20and%20telecommunications/telecommunications/our%20insights/connected%20world%20an%20evolution%20in%20connectivity%20beyond%20the%205g%20revolution/mgi_connected-world_discussion-paper_february-2020.pdf

Digital connectivity trends: Greenwich insights

We conducted research in Greenwich to explore digital connectivity trends on two key estates: Flamsteed and Ernest Dence. This research is designed to inform the development of the council's connectivity implementation and improvement retrofits on these two estates. More information about this work can be found in the Connectivity needs Greenwich report.

Methodology

The methodology consisted of a mixed-methods qualitative and quantitative approach including:

- A door-to-door survey was conducted on Flamsteed and Ernest Dence estates. A copy of the survey can be found at the end of the document.
- An online workshop with local volunteers and community leaders on Flamsteed (and Caletock, a neighbouring estate). A copy of the discussion guide can be found at the end of the document.
- Two telephone interviews were undertaken with a local community organisation manager and a local community leader and volunteer.

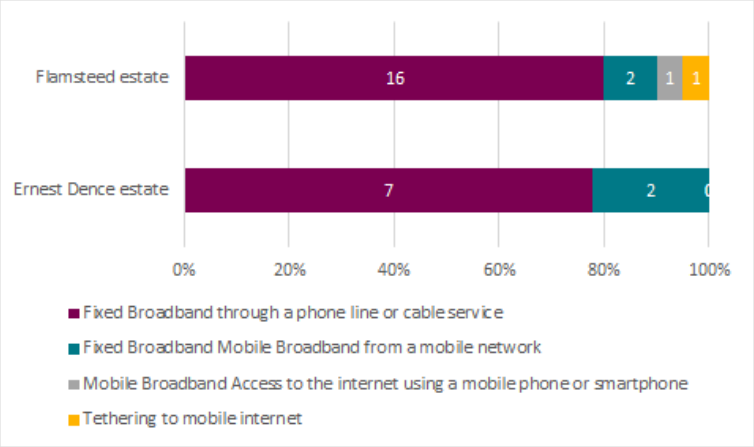
More detail about the methodology, including lessons learned, can be found in the appendix.

Findings

Connectivity at home

We asked residents to describe how they connected to the internet at home. Our data highlights a significant preference for fixed broadband connections through phone line or cable services.

Figure 18: Connection preference



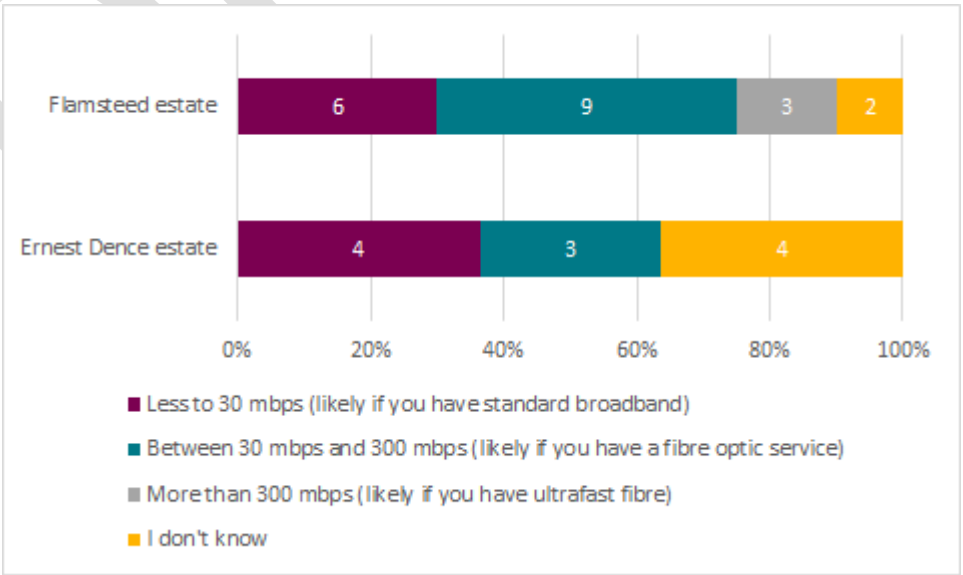
Connectivity differed across groups according to local community leaders and volunteers who we spoke to:

"The younger families are different: they have a package like PAYG, and they use bundles for their services but they don't have equipment at home for example for kids to do schoolwork. This was a big issue in the pandemic as kids couldn't get online to do their schoolwork and many were sharing devices." Flamsteed community volunteer.

Bandwidth speed, quality and requirements

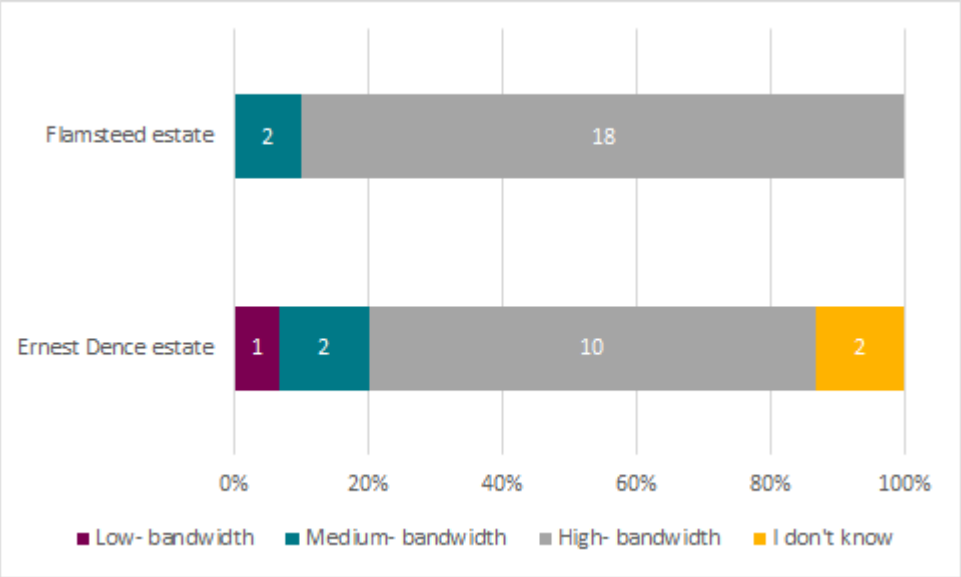
We asked residents about the type of service speed they are currently on with their provider. Some residents highlighted that their current provider doesn't deliver the speed they expected:

Figure 19: Internet speed at home



We asked residents the types of tasks they undertake online to explore their bandwidth requirements. Figure 20 illustrates responses against low, medium and high bandwidth activity. Resident were given examples of low (e.g. instant messaging), medium (e.g. listening to web radio, listening to music online) and high (e.g. streaming video, playing video games online) bandwidth activity:

Figure 20: Resident activities online



The data highlights that residents on both estates are high-bandwidth users, requiring high capacity internet connections to be able to do what they want online.

Our interviews with local community leaders and stakeholders highlighted that vulnerable members of the community are interested in using the internet for online shopping, speaking with friends which is increasingly important during COVID-19 lockdown, and making GP appointments

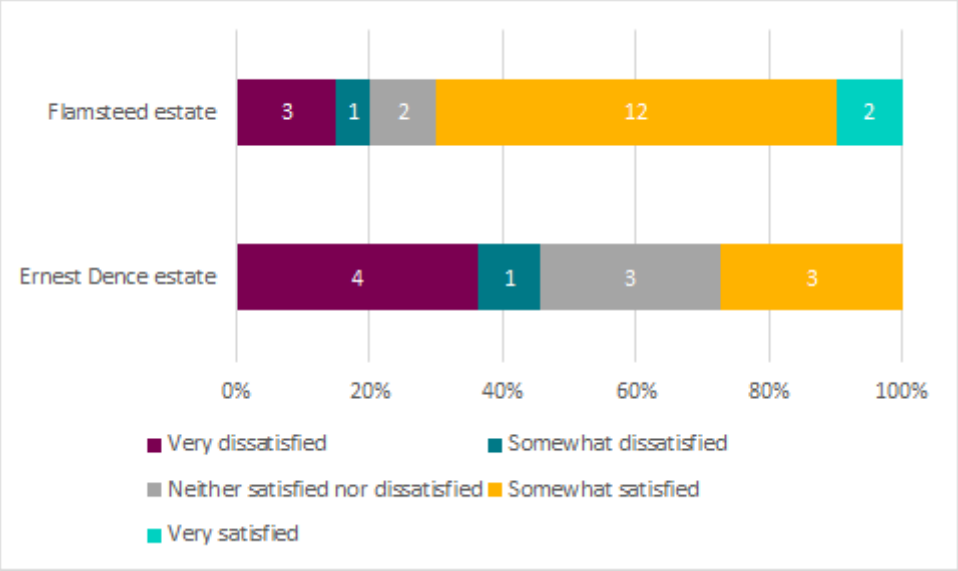
"Now that elders have been able to do it (go online) they are interested in learning to do more. They don't have anything like Netflix or other streaming services, they mainly use the internet for basic forms, doing online shopping, and using ZOOM to speak to friends and family."
Flamsteed community volunteer.

Satisfaction

Internet speed is an important factor for residents to consider when looking to understand how they can use the internet and what they can

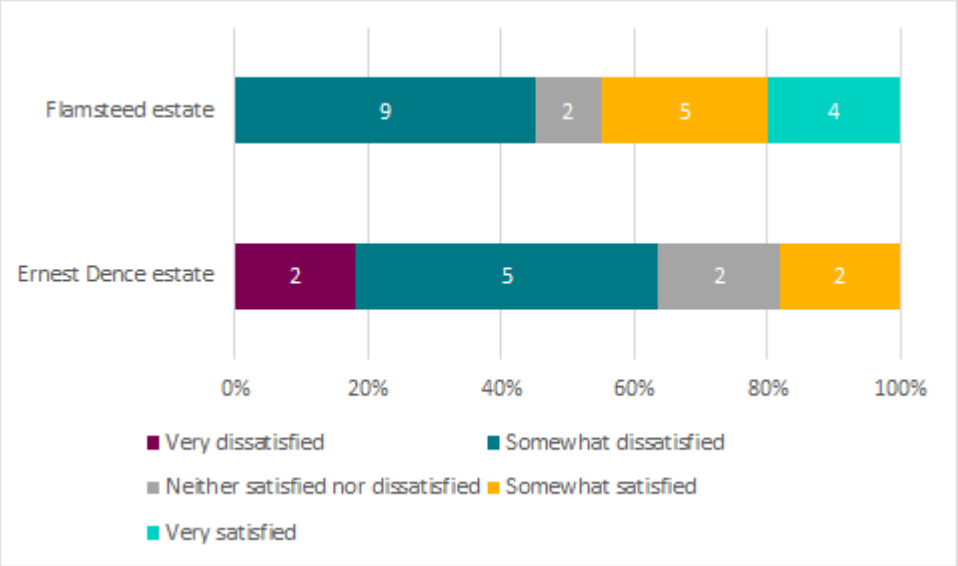
use it for. We asked residents whether they were satisfied with the speed that they current experienced at home:

Figure 21: Satisfaction with internet speed



Service reliability is also an important measure of quality for residents. We asked residents to describe the quality of their service, e.g. Whether signal strength differs across their home, and whether the service regularly fails. This differed across sites - several residents on flamsteed estate referenced a major service outage earlier in 2021 and issues with signal strength in their home.

Figure 22: Satisfaction with internet reliability



Residents at the Flamsteed & Caletock estate online workshop shared several important reflections about the quality of the service they currently experience:

- Speed and reliability of the service fluctuates according to daytime hours and demand. One resident spoke about service dropping out when her children and partner are using the internet for schoolwork at the same time. They have had to move to using mobile data alongside their broadband connection to be able to work from home.
- One respondent noted that their family member on the estate has two broadband connections for 4 adults who live and work in the flat on the estate but it does not meet their needs. Many on the estate have to tether to their phone for their children to do school work as the internet has seemed to be at capacity throughout the day during the pandemic.

Comments from respondents on both estates suggested that in-home Wi-Fi coverage was an issue, especially on the Flamsteed estate, where several respondents said that they struggled to access a usable Wi-Fi connection in their bedrooms. Some residents said that they believed Wi-Fi problems to be caused by the blocks had originally been constructed citing thick walls and the presence of metal in the walls; both of which may impede Wi-Fi signals.

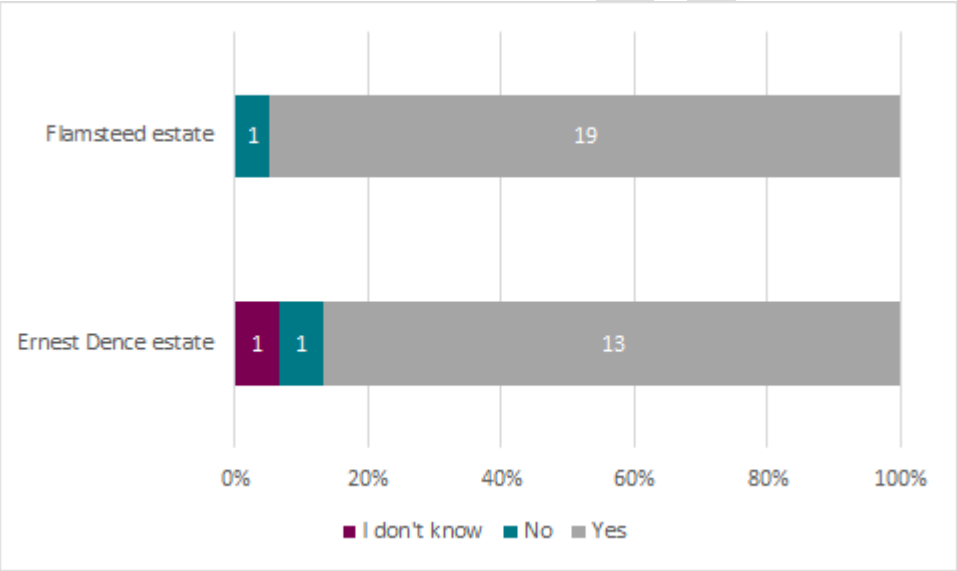
Among those mentioning their ISP by name during the interview, 11 of 21 respondents on Flamsteed said their ISP was Sky, with four respondents naming Virgin Media. In contrast, four of ten respondents on Ernest

Dence said they took Virgin Media broadband, twice as many who said they used Sky. This may reflect the lack of availability of superfast broadband via Openreach's FTTC network to properties on Ernest Dence estate, meaning that residents wanting a fixed superfast broadband must use Virgin's network.

Device usage

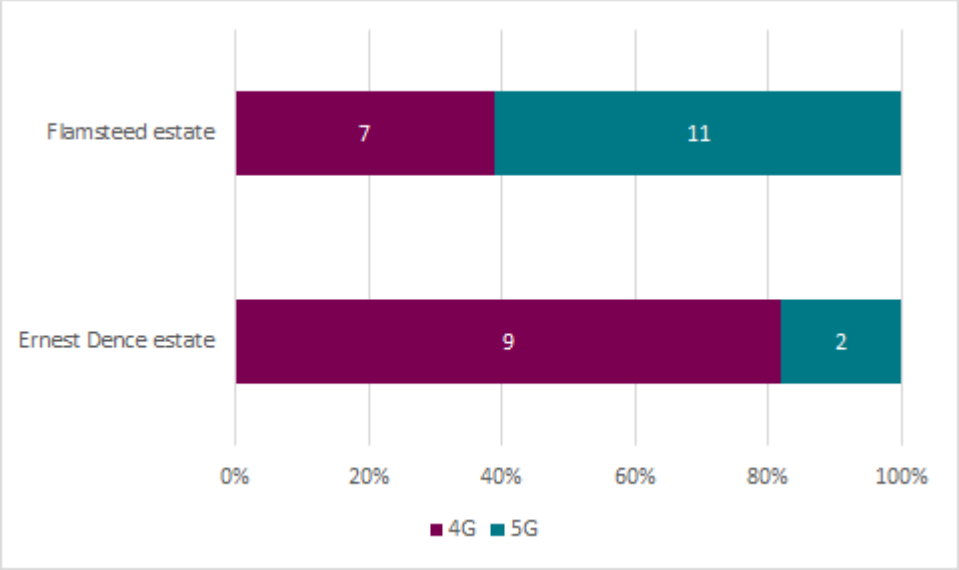
We asked residents about the devices they use at home to access the internet.

Figure 23: Do you or anyone in your household own a smartphone?



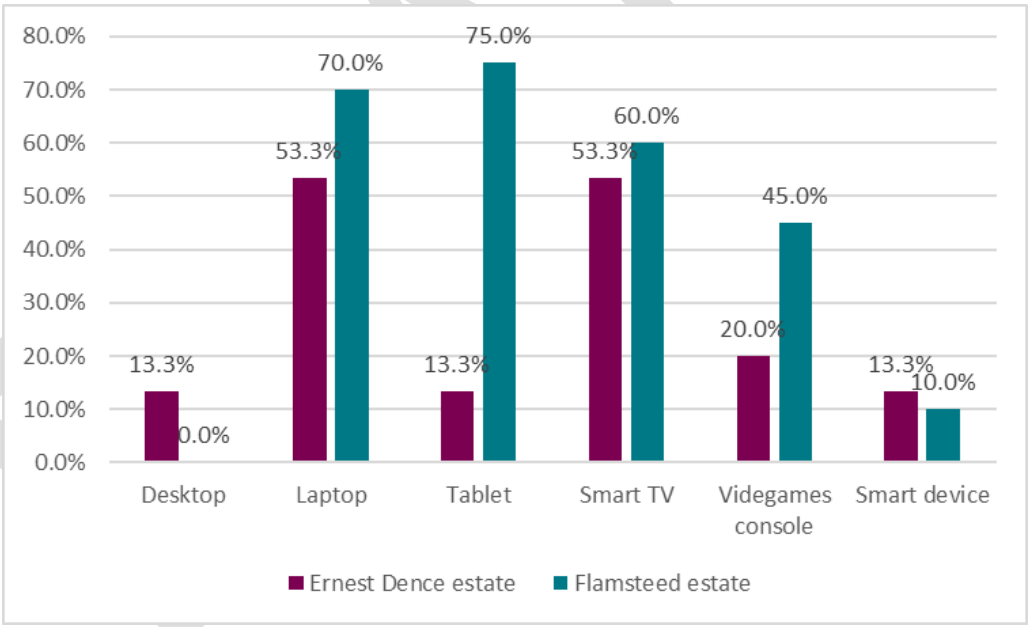
We also asked about the mobile connectivity type of smartphones used by residents:

Figure 24: 4G or 5G smartphone connectivity



We also asked about other devices that residents may use to access the internet. These are described below in figure 25:

Figure 25: Devices in use to access the internet



Barriers to using the internet

Our interview with local experts highlighted issues that groups on the Flamsteed estate face when trying to access the internet:

- A local community leader and volunteer highlighted the financial barriers that some of the most vulnerable members of the local community face when considering using the internet. They cited high data costs as a barrier to online participation.

- A local community volunteer noted that many older people have out of date devices, including old smartphones that no longer work effectively and do not make best use of super-fast connections (e.g. 5G network availability).

Views on estate-wide fibre

There was a positive response from residents when asked whether they would be interested in using fibre on their estate if it were made available. Some were interested in accessing faster and more reliable services, but others reflected that fibre access will not benefit those who do not have good quality equipment:

"Fast fibre would benefit many and would encourage others to engage with it, but some people don't have the equipment to use it anyway then it's not going to benefit them." Community Leader and Volunteer

The benefits of services would also need to be made clear to residents, particularly older residents who still use their landline and do not yet have a broadband or mobile data connection:

"Mainly elders use their landline, if they use any way of connecting that's the main thing they have and they feel happy using it." Community Leader and Volunteer

Cost of fibre was seen to be a major barrier for resident:

"Upgrading to fibre is good, but understanding of what fibre is and how it works are not as important as cost for these families. If you have the best connection, if they can't afford it they can't use it....if you look at the bigger picture then as costs go up it's good that the council wants to reduce costs by helping with their heating (e.g. smart meters) but in the end it's all about money. People need support in the short term to benefit from services like improved connections like fibre." Community Organisation Manager

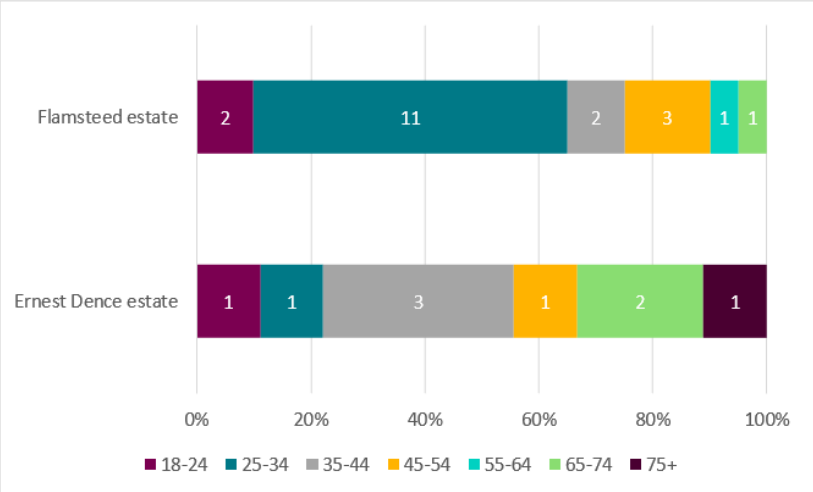
Interest in smart technology on the estate

Residents we spoke to in workshops showed moderate levels of interest towards smart technology being deployed on the Flamsteed estate for their benefit. Main reflections were:

- Some concern over increased surveillance and reduction in privacy through cameras and other connected devices which were termed “big brother”.
- Interest from one resident over the value of simple sensors to help the council to monitor the estate’s safety and environment, but questions if that would work if the quality of the internet connection was not adequate.

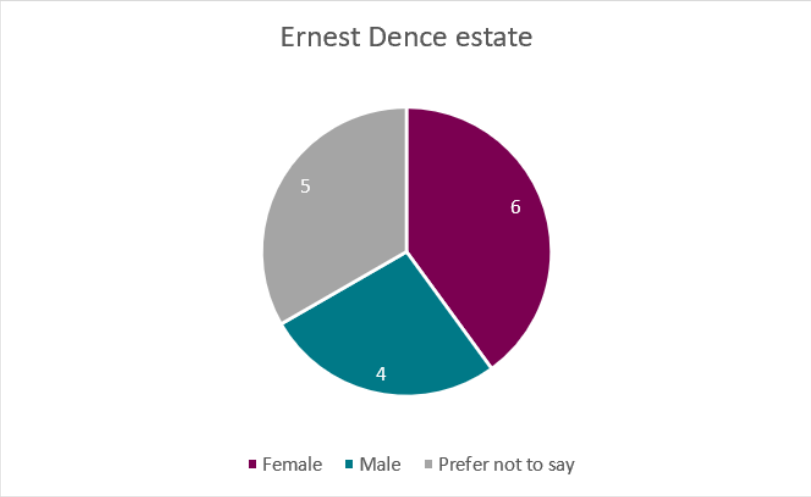
Sample demographics

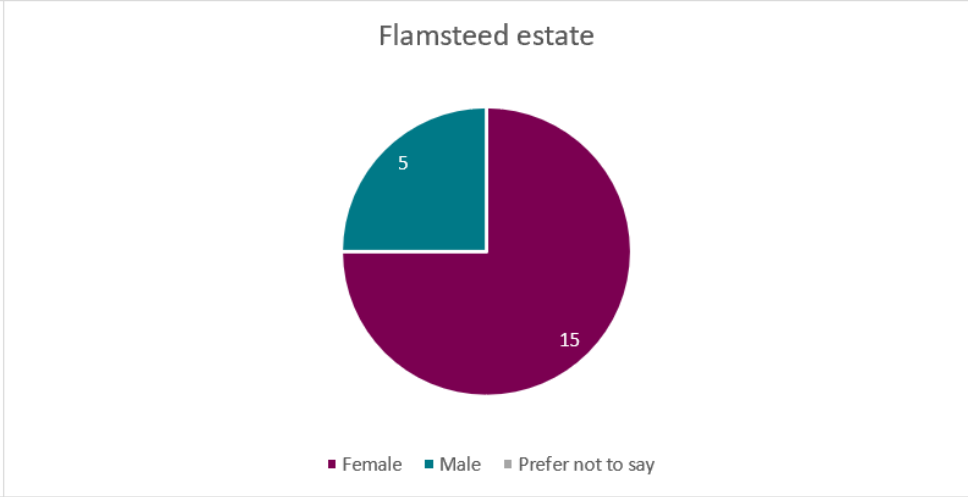
Figure 26: Sample demographics



Respondent ethnicity

	Ernest Dence estate	Flamsteed estate
African	2	2
Caribbean	0	4
Any other Black / African / Caribbean background	0	5
Bangladeshi	1	1
Any other Asian background	2	0
Any other Mixed / multiple ethnic background	1	1
White English/Welsh/Scottish/Northern Irish/British	2	5
White and Asian	1	0
Any other white background	2	1
Prefer not to say	4	1





Additional detail

Methodology

Research questions

A mixed methods approach was applied to the following research questions:

- What is the current digital connectivity/internet status of residents of the Flamsteed and Ernest Dence estates?
- To what extent are residents of the Flamsteed and Ernest Dence estates satisfied with their current internet provision (if any)?
- What are current digital connectivity/internet needs of residents on Flamsteed and Ernest Dence estates?
- What are the future digital connectivity/internet needs of residents of Flamsteed and Ernest Dence estates?

Sampling methodology

To sample we attended the target estates and undertook a door-knocking process between 10:30 am and 3pm, in which odd or even door numbers residences were approached for interviews. All door responses were recorded on a spreadsheet to log those which were available and those which were not. Doors that were not approached on the advice of the estate management team were also logged in the record.

At both Flamsteed and Ernest Dence estates we knocked on at least 80% of viable doors. At Flamsteed 15 complete responses were recorded, and at Ernest Dence 20 were recorded.

Lessons learnt

There are several lessons we take away from this project:

More resources are required for recruiting to online methods

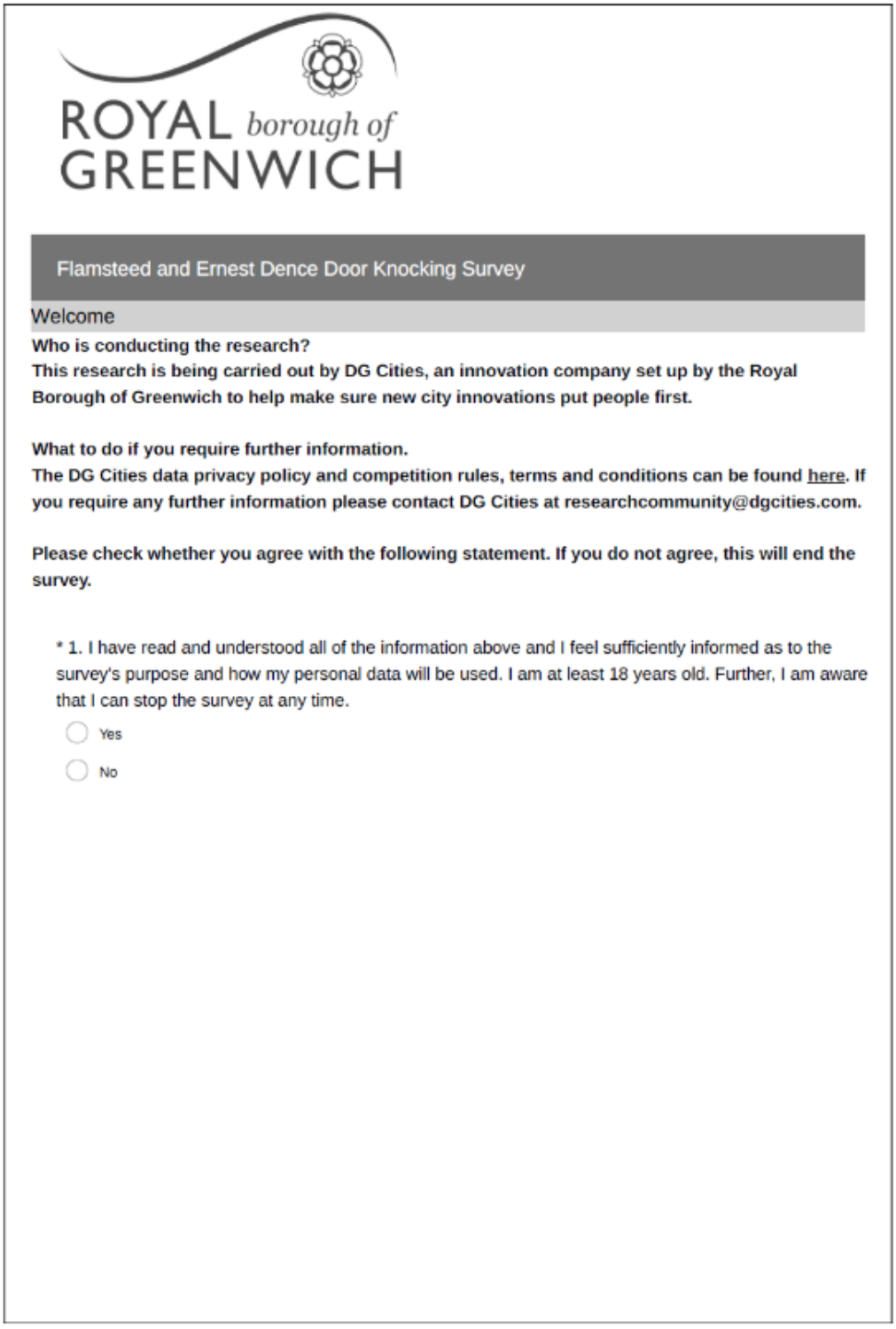
In contrast to the level of engagement with our daytime face to face surveys at the two estates, we were unable to run an evening online workshop for residents (as opposed to residents representing wider

community groups). After several attempts by the council's resident engagement team to advertise the online 1-hour workshops held during the early evening, there were insufficient registrations from users. We left messages and emails with interested residents but unfortunately were unable to speak to any individuals virtually. All interview data was collected in-situ.

Varying door-knocking times may have provided a more robust sample

Due to COVID and seasonal timings we had to limit our time on the estates to daytime door-knocking sessions. We approached the council to understand the best times to undertake the exercise and followed the advice provided to us regarding residences to omit from the study. In future studies we would look to revisit the sites at a different time of day to provide a more robust sample.

SURVEY INSTRUMENT



ROYAL borough of GREENWICH

Flamsteed and Ernest Dence Door Knocking Survey

Welcome

Who is conducting the research?
This research is being carried out by DG Cities, an innovation company set up by the Royal Borough of Greenwich to help make sure new city innovations put people first.

What to do if you require further information.
The DG Cities data privacy policy and competition rules, terms and conditions can be found here. If you require any further information please contact DG Cities at researchcommunity@dgcities.com.

Please check whether you agree with the following statement. If you do not agree, this will end the survey.

* 1. I have read and understood all of the information above and I feel sufficiently informed as to the survey's purpose and how my personal data will be used. I am at least 18 years old. Further, I am aware that I can stop the survey at any time.

- Yes
- No

ROYAL borough of GREENWICH

Flamsteed and Ernest Dence Door Knocking Survey

Section 1: Internet usage

The section includes questions about your use of the internet.

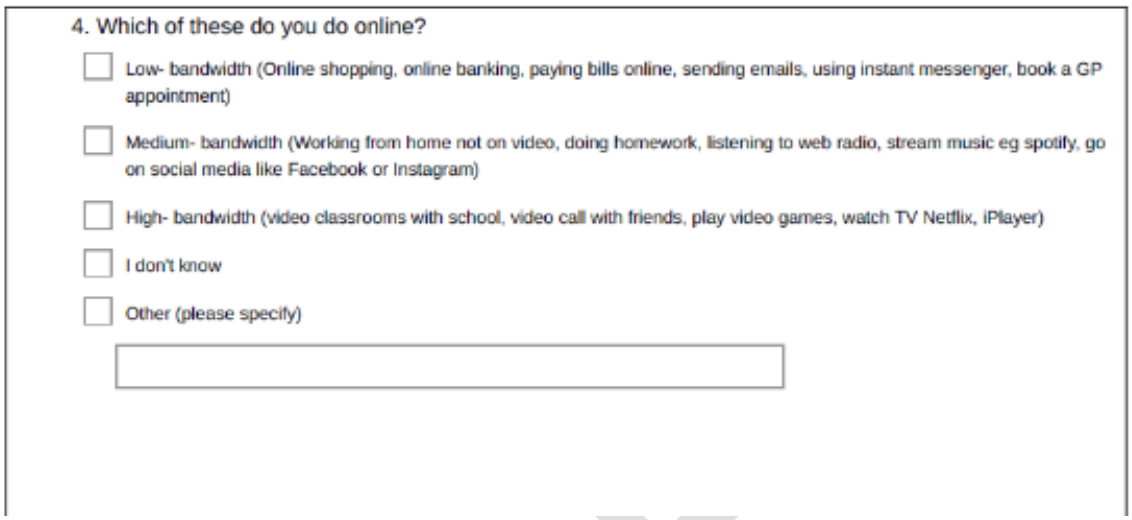
* 2. How many hours do you spend online in a typical week?

Please think about the time using social media and messaging, watching films, TV programmes and videos online, playing games online, on video calls, searching for information online and doing schoolwork. This could be using a mobile phone, laptop, tablet (like an iPad), computer, games console or Smart TV. Please think about weekdays and weekends, either at home or anywhere else.

- ○ Over 22 hours
- ○ 16 to 22 hours
- ○ 12 to 15 hours
- ○ 9 to 11 hours
- ○ 6 to 8 hours
- ○ 3 to 5 hours
- ○ Up to 2 hours
- ○ None
- ○ I dont know / unsure

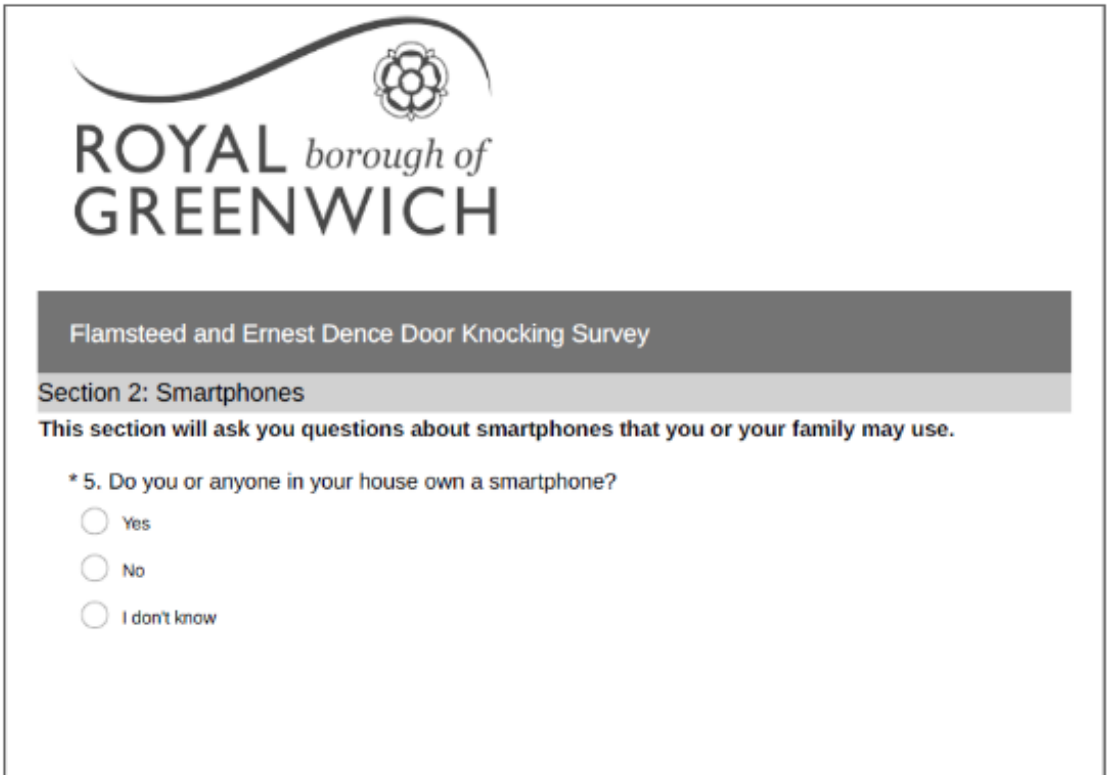
* 3. How often do you personally go on the internet, at home or elsewhere

- ○ Several times a day
- ○ About once a day
- ○ Several times a week
- ○ At least once a week
- ○ Less often
- ○ Never
- ○ I don't know



4. Which of these do you do online?

- [ ] Low- bandwidth (Online shopping, online banking, paying bills online, sending emails, using instant messenger, book a GP appointment)
- [ ] Medium- bandwidth (Working from home not on video, doing homework, listening to web radio, stream music eg spotify, go on social media like Facebook or Instagram)
- [ ] High- bandwidth (video classrooms with school, video call with friends, play video games, watch TV Netflix, iPlayer)
- [ ] I don't know
- [ ] Other (please specify)



ROYAL borough of GREENWICH

Flamsteed and Ernest Dence Door Knocking Survey

Section 2: Smartphones

This section will ask you questions about smartphones that you or your family may use.

* 5. Do you or anyone in your house own a smartphone?

- ( ) Yes
- ( ) No
- ( ) I don't know

Flamsteed and Ernest Dence Door Knocking Survey

Section 2: Smart phones

This section will ask you questions about smart phones that you or your family may use.

6. Do you have a 4G or 5G service? These are services that enable faster mobile internet access. 4G was launched in the UK in 2012 and 5G became available on some new mobile phones in 2019.

- [ ] Yes – 4G
- [ ] Yes – 5G
- [ ] No, neither
- [ ] I don't know

7. Which type of connection do you use MOST when using your smartphone at HOME?

- ( ) My home WiFi connection
- ( ) Communal WiFi connection (e.g. community centres, or estate WiFi)
- ( ) Mobile data connection (4G/5G)
- ( ) Tether to someone else's mobile data connection (4G/5G)
- ( ) Other (please specify)

  [ ]
- ( ) None of the above

8. Which type of connection do you use MOST when using your smartphone outside of your home?

- ( ) Communal WiFi connection (e.g. Estate WiFi or community centre WiFi)
- ( ) My own mobile data connection (4G/5G)
- ( ) Tether to someone else's mobile data connection (4G/5G)
- ( ) Other (please specify)

  [ ]
- ( ) None of the above

Flamsteed and Ernest Dence Door Knocking Survey

Section 3: Other digital devices

This section will ask you questions about other digital devices.

9. Do you own any of the following?

- [ ] Desktop (PC or Apple)
- [ ] Laptop (PC or Apple)
- [ ] Tablet computer - e.g. iPad
- [ ] Other (please specify)

None of the above

10. Does your household have any of the following devices that are able to connect to the internet?

- [ ] Video games console (e.g. Playstation or Xbox)
- [ ] Smart TV
- [ ] Any Smart Home device (e.g. Ring Doorbell, Amazon Alexa, Google Nest, Smart Refridgerator, Smart Lightbulbs)
- [ ] Other (please specify)

None of the above

ROYAL borough of GREENWICH

Flamsteed and Ernest Dence Door Knocking Survey

Section 4: Internet connectivity at home

This section will ask you questions about internet connectivity to your home.

* 11. Do you have access to the internet at home?

- ○ Yes
- ○ No
- ○ I don't know

Flamsteed and Ernest Dence Door Knocking Survey

Section 4: Internet connectivity at home

This section will ask you questions about internet connectivity to your home.

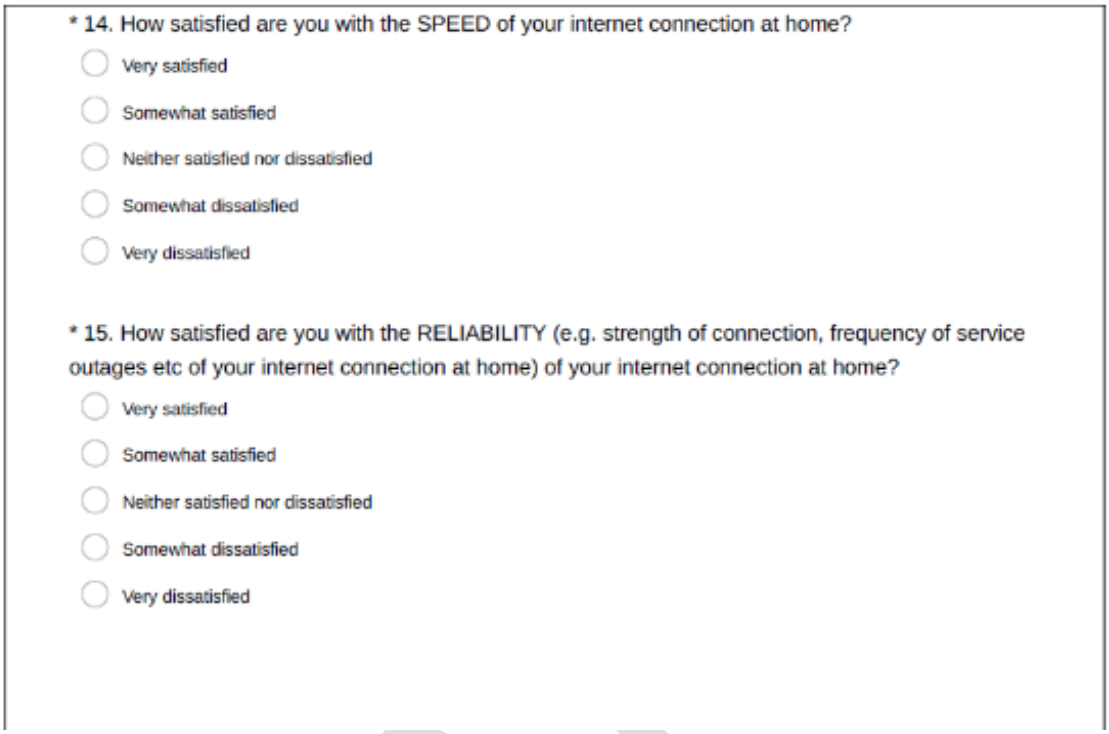
* 12. Which of these methods does your household use to connect to the internet at HOME?

- [ ] Fixed Broadband through a phone line or cable service – perhaps using a Wi-Fi router to go online, via any device
- [ ] Fixed Broadband Mobile Broadband from a mobile network – connecting via a USB stick or dongle or Mobile Wi-Fi router, or built in connectivity in a laptop or netbook or tablet computer with a SIM card
- [ ] Mobile Broadband Access to the internet using a mobile phone or smartphone – using your phone's 3G or 4G or 5G mobile network
- [ ] Mobile Internet Accessing the internet on a device such as a laptop or tablet using your mobile phone's internet connection – known as tethering
- [ ] Tethering another different device (write in other)
- [ ] I don't know
- [ ] Other (please specify)

- [ ] None of the above

* 13. What is the speed of your internet connection at home?

- ( ) Less to 30 mbps (likely if you have standard broadband)
- ( ) Between 30 mbps and 300 mbps (likely if you have a fibre optic service)
- ( ) More than 300 mbps (likely if you have ultrafast fibre)
- ( ) I don't know
- ( ) Other (please specify)

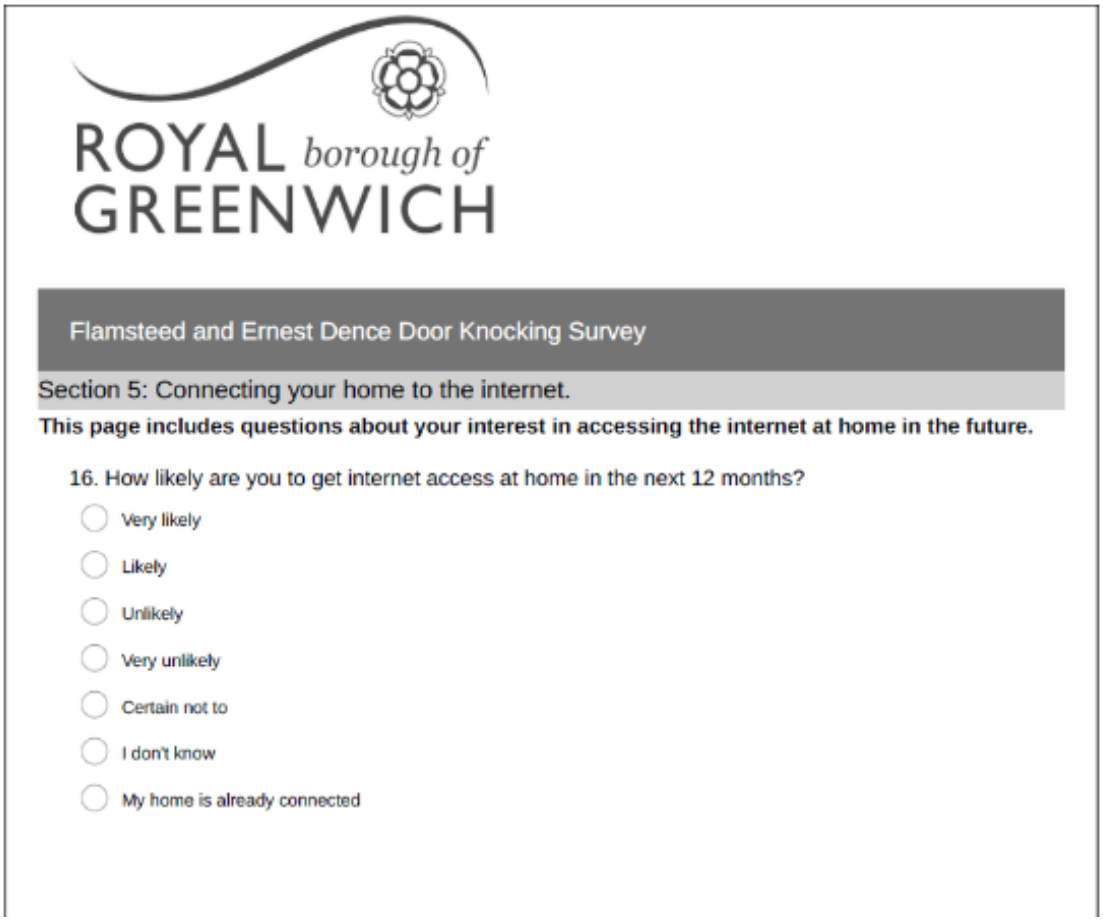


* 14. How satisfied are you with the SPEED of your internet connection at home?

- Very satisfied
- Somewhat satisfied
- Neither satisfied nor dissatisfied
- Somewhat dissatisfied
- Very dissatisfied

* 15. How satisfied are you with the RELIABILITY (e.g. strength of connection, frequency of service outages etc of your internet connection at home) of your internet connection at home?

- Very satisfied
- Somewhat satisfied
- Neither satisfied nor dissatisfied
- Somewhat dissatisfied
- Very dissatisfied



ROYAL borough of GREENWICH

Flamsteed and Ernest Dence Door Knocking Survey

Section 5: Connecting your home to the internet.

This page includes questions about your interest in accessing the internet at home in the future.

16. How likely are you to get internet access at home in the next 12 months?

- Very likely
- Likely
- Unlikely
- Very unlikely
- Certain not to
- I don't know
- My home is already connected

ROYAL borough of GREENWICH

Flamsteed and Ernest Dence Door Knocking Survey

Section 5: Connecting your home to the internet.

This page includes questions about accessing the internet at home in the future.

17. What's your reason for not being connected to the internet?

- ○ No need to go online/ not interested
- ○ Broadband set up costs are too high
- ○ Cost of a desktop, tablet or laptop computer to use the internet is too high
- ○ Cost of a mobile phone handset to use the internet is too high
- ○ Monthly cost of a fixed broadband service is too high
- ○ Monthly cost of a mobile phone service is too high
- ○ Getting online/ getting connected to the internet is too complicated
- ○ Using the internet is too complicated
- ○ Happy to use the internet at work/ elsewhere
- ○ Someone else can go online for me if necessary
- ○ Don't have broadband where I live
- ○ Broadband is too slow where I live
- ○ Concerned about security/ fraud/ privacy
- ○ Concerned about harmful/ offensive content
- ○ I have a disability (e.g. poor eyesight)
- ○ Other (please specify)

[ ]

- ○ None of the above

Flamsteed and Ernest Dence Door Knocking Survey

Section 6: Improving internet connectivity on your estate

This section will ask you questions about how to improve internet connectivity on your estate.

* 18. Which estate do you live in?

- ○ Flamsteed estate
- ○ Ernest Dence estate
- ○ Other (please specify)

  [ ]
- ○ None of the above

19. Are you:

- ○ A leaseholder (e.g. you have a mortgage, or own the property and have a lease with the council)
- ○ A social housing tenant (e.g. you or the council pays rent)
- ○ I don't know
- ○ Other (please specify)

  [ ]

20. Do you have any other opinions about internet connectivity on your estate? Please tell us below

[ ]

Flamsteed and Ernest Dence Door Knocking Survey

Section 7: About you

The next questions are questions about you. This information will help us make our research inclusive of people from different backgrounds.

21. What is your age?

- 18-24
- 25-34
- 35-44
- 45-54
- 55-64
- 65-74
- 75+
- Prefer not to say

22. What is your sex?

A question about gender identity is next

- Female
- Male
- Prefer not to say

23. Is the gender you identify with the same as your sex registered at birth?

- Yes
- No
- Prefer not to say

24. What is your ethnicity

- ○ White English/Welsh/Scottish/Northern Irish/British
- ○ White Irish
- ○ White Gypsy or Irish Traveller
- ○ Any other white background
- ○ White and Black Caribbean
- ○ White and Black African
- ○ White and Asian
- ○ Any other Mixed / multiple ethnic background
- ○ Indian
- ○ Pakistani
- ○ Bangladeshi
- ○ Chinese
- ○ Any other Asian background
- ○ African
- ○ Caribbean
- ○ Any other Black / African / Caribbean background
- ○ Arab
- ○ Prefer not to say

25. Do you have any long-term physical or mental impairments which limits your daily activities or the work you can do, including problems due to old age? [tick all that apply]

- ☐ I do not have any physical or mental impairments which limit my daily activities
- ☐ Mobility impairment
- ☐ Age related mobility difficulties
- ☐ Visual impairment (not including prescription glasses)
- ☐ Respiratory problems
- ☐ Hearing impairment
- ☐ Learning disability
- ☐ Mental health condition
- ☐ Serious long-term illness
- ☐ Don't know
- ☐ Prefer not to say