making communications work
for everyone

Achieving decent broadband connectivity for everyone

Technical advice to UK Government on broadband universal service

Statement

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About this document

The UK Government intends to introduce a broadband universal service obligation (USO) that would give everyone a right to a decent broadband connection on reasonable request.[1] This is in recognition of the increasing importance of broadband to people's everyday lives.

In March, the Department for Culture, Media and Sport wrote to Ofcom requesting technical advice and recommendations on the design of the broadband USO.[2] We published a call for inputs in April, seeking views from consumers and industry on the broadband USO design.[3] We received 115 responses from a wide variety of stakeholders, which we have taken into account when developing our advice to Government. We published a report summarising these responses in August.[4]

This document sets out our advice to Government on how to achieve a decent broadband connection for all. We have set out a range of options for Government to decide which best meets its objectives.

[1] Government press release, November 2015 https://www.gov.uk/government/news/government-plans-to-make-sure-no-one-is-left-behind-on-broadband-access
[2] Letter from DCMS to Ofcom, March 2016 https://www.ofcom.org.uk/__data/assets/pdf_file/0027/53676/dcms_letter.pdf
[3] Ofcom, Designing the broadband universal service obligation: Call for Inputs, April 2016 https://www.ofcom.org.uk/__data/assets/pdf_file/0025/58336/broadband-uso.pdf
[4] Ofcom, Designing the broadband universal service obligation: Summary of responses, August 2016 https://www.ofcom.org.uk/__data/assets/pdf_file/0025/68335/summary_of_responses.pdf

Contents

Section 1

Executive Summary

1.1. The UK Government intends to introduce a broadband universal service obligation (USO) to give people "the right to request an affordable broadband connection, at a minimum speed, from a designated provider, up to a reasonable cost threshold". The Government's aim is to prevent social and digital exclusion and ensure people can generate new business and access local and public services.[5]

1.2. The Department for Culture, Media and Sport (DCMS) asked Ofcom to provide technical analysis and recommendations on 10 areas to support the design of a broadband USO. This report responds to that request, providing technical advice on each area in support of the questions posed by Government on the policy design of a USO that would secure universal availability of decent, affordable broadband for all consumers and smaller businesses. In preparing our advice, we have considered both:

- the aim of any policy – securing decent, affordable broadband for all, considering the costs of any intervention; and
- the mechanisms by which it can be delivered, with a focus on a USO.

1.3. Designing any policy to deliver universal, decent broadband is complex: many policy design features are inter-related. For example, the cost of any intervention depends on the definition of what 'decent broadband' might mean for consumers and therefore how to specify a USO. Given such inter-linkages, we have provided our technical advice through available options and scenarios.

1.4. Government has already set out some views on potential policy design. Its ambition is "for the minimum speed for a USO to be 10Mbps" which Government "will look to raise over time"[6], and it has set out a preference for an industry funding mechanism.[7] Where Government has indicated preferences, we have focused on these. Since Government has not yet made a decision on the final technical specification of a universal service obligation, we have included a range of options for the technical specification.

1.5. Ultimately, most choices relating to any policy to deliver universal, affordable, decent broadband services are for Government.[8]

Defining decent broadband

1.6. In its request for advice, Government asked for the level at which a broadband USO should be set. We have sought to answer that question by considering what

[5] DCMS, A New Broadband Universal Service Obligation: Consultation, March 2016, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/510148/Broadband_Universal_Service_Obligation.pdf
[6] Ibid.
[7] Letter from DCMS to Ofcom, March 2016 https://www.ofcom.org.uk/__data/assets/pdf_file/0027/53676/dcms_letter.pdf
[8] Under the current legal framework, some decisions are reserved for the regulator (for example, establishing an industry fund, designating the USP(s) and imposing the obligation). The legal framework is set out in Annex 1.

constitutes a 'decent broadband connection that allows full and effective social and economic participation'.

1.7. Past analysis by Ofcom[9] shows that, today, a download speed of 10Mbit/s would enable consumers' full participation in a digital society. As well as download speed, a range of other factors can affect the user experience for broadband:

- As people and businesses increasingly send data such as photos and videos, upload speeds become more important;
- Network congestion, caused when multiple people use the same network at the same time, can reduce the speeds experienced by users at busy times.

1.8. In responses to our Call for Inputs (CFI) in April, stakeholders had differing views on what the technical specification should be. Some argued for a basic USO: in effect, a 'safety net' for people and businesses. Others argued for an advanced, highly-specified intervention that would offer higher speeds. The question of what constitutes decent broadband will change with time as the needs of people and small businesses evolve. In addition, the requirements of SMEs are greater than those of individual consumers.

1.9. Given these points and the fast pace of change in consumer and business needs from broadband, we have provided advice on a range of technical specifications:

- Scenario 1: a **standard broadband** service, characterised only by a 10Mbit/s download speed;
- Scenario 2: a **more highly specified standard broadband** service, adding upload speed (1Mbit/s), latency (medium response time), maximum sharing between customers (a 'contention ratio' of 50:1), and a defined data cap based on current usage profiles (100GB per month); and
- Scenario 3: a **superfast broadband** service, with download speeds of 30Mbit/s, upload of 6Mbit/s, fast response times, a 'committed information rate' of 10Mbit/s (i.e. guaranteed 10Mbit/s at all times) and an unlimited usage cap.

1.10. The technical specification of network services is not the sole determinant of people's broadband experience, other factors can affect the consumer experience. Some of these factors are beyond network providers' control, for example the quality of in-home wiring. Alongside any network level intervention, it is important to make people and businesses aware of such factors and consider how to support them in resolving them. Ofcom's mobile app[10], which allows consumers to check the performance of their home broadband (as well as their mobile reception), is one example of such support. If the app finds a problem with either, it will explain possible causes and provide practical troubleshooting advice.[11]

[9] Ofcom Infrastructure report 2013 https://www.ofcom.org.uk/__data/assets/pdf_file/0027/58644/iru_2013.pdf

[10] https://www.ofcom.org.uk/phones-telecoms-and-internet/advice-for-consumers/advice/ofcom-checker

[11] The app also shows voice, 3G or 4G coverage from all major network operators, both indoors and outdoors, at any location in the UK – allowing people to compare which network offers the best service in places such as the home or office. Broadband availability and speed information is available using address-level data.

Any intervention needs to consider the future

1.11. There remains significant uncertainty about how consumer and business needs will rise. In 2010, Government defined a 2Mbit/s universal service commitment. By 2013, Ofcom's Connected Nations data suggested speeds of 8 to 10Mbit/s might be more appropriate given actual consumer usage. Last year evidence started to emerge that households with connections above 40Mbit/s consume significantly more data.[12]

1.12. In designing any intervention, Government may want to consider the extent it should be designed to take into account further future growth in broadband usage. Doing so could help to ensure that consumers and business that rely on the USO are not left behind those benefitting from upgraded services in commercial areas. Such an approach could support both better value for money by intervening once, and ensure that there is not a continual state of review, advice and reinvestment as requirements grow over time. Our range of technical specifications, including 10Mbit/s and more highly specified services, is intended to help inform this policy decision.

1.13. Although there is a clear benefit to a more highly-specified intervention, which could anticipate growing expectations and needs from broadband services in the future, there are also some risks:

- a higher specification would increase the direct costs of the intervention today;
- a higher specification could displace private sector investment, diminishing incentives to invest in future networks if the competitive advantage of such upgrades is undermined by any universal service; and
- there are inherent difficulties in choosing the best long-term technology, which may mean it is more efficient to invest in current technologies.

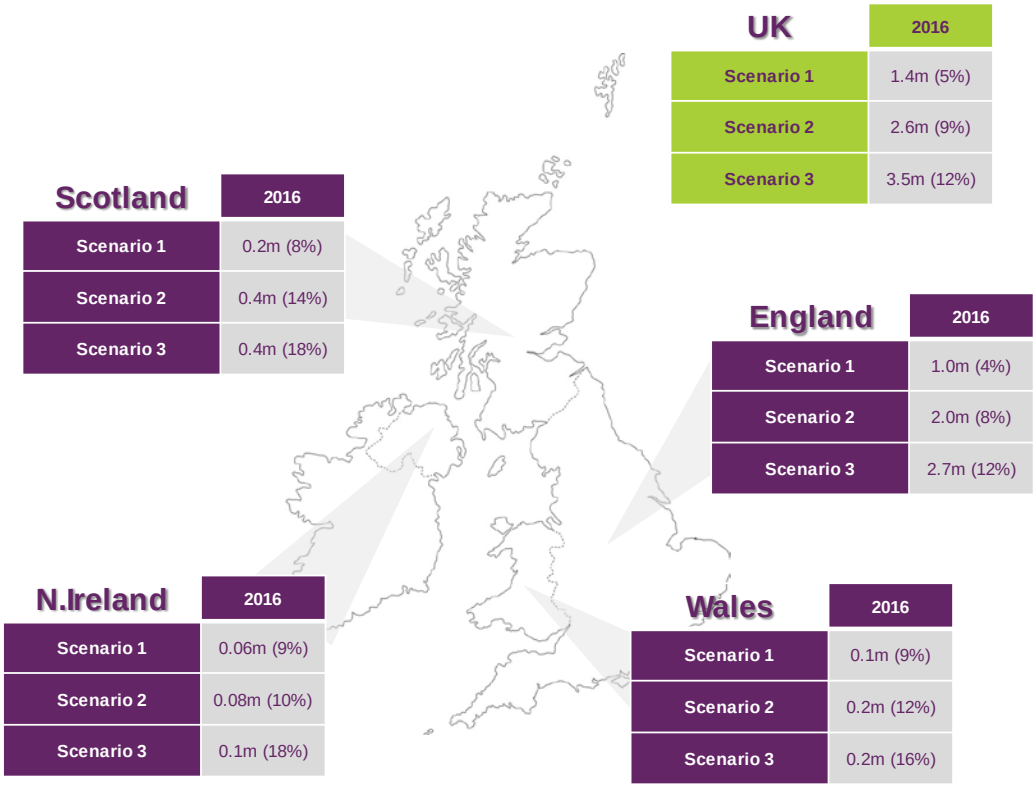
1.14. Whatever approach is adopted, the level of service provided may need to increase over time to ensure it continues to meet the needs of consumers and businesses who rely on it. We report to Government annually on the availability, take-up and use of broadband in our Connected Nations reports, which will allow us to monitor whether the broadband universal service is effectively meeting the needs of consumers and businesses. If there is evidence of any concern, Government has the power to commission Ofcom to undertake a formal review of the USO.

The scale of the problem

1.15. Based on 2016 Connected Nations data, we have estimated the number of premises across the UK that are not able to get broadband of a given speed.

1.16. We have also estimated how many small to medium sized enterprises (SMEs) cannot receive a decent broadband service today. Among the 2.4m SMEs in the UK, around 200,000 (8%) cannot get a 10Mbit/s broadband service today. A broadband USO would deliver economic benefits by providing the connectivity businesses need to participate in and drive the digital economy.

[12] Ofcom, Connected Nations 2015, https://www.ofcom.org.uk/__data/assets/pdf_file/0028/69634/connected_nations2015.pdf



1.17. These numbers reflect only those premises that do not have access to a network capable of delivering the different technical specifications outlined above. They do not take account of customers who have access, but have chosen not to subscribe to a service. For example, Connected Nations 2016 data shows around 37% of premises currently take up a service with download speeds lower than 30Mbit/s but could upgrade to superfast, and over three quarters of premises that take up a service with a download speed lower than 10Mbit/s could get superfast broadband.[13]

1.18. Given implementation of any policy would not start immediately, and that further commercial and public sector deployment may occur, including further BDUK investment, we have also set out in this report the potential scale of the issue in 2017 and 2020. However, the level and location of future investments remains uncertain, especially for commercial investment. These future estimates should therefore be treated with caution.

Estimating the costs of delivering decent broadband

1.19. We commissioned Analysys Mason to undertake a detailed bottom-up modelling of the potential technologies and costs associated with implementing universal broadband based on upgrading and/or extending fixed networks today (based on the availability of fixed broadband services in 2016). The objective of this work is not to give a precise figure for each of the options examined. Instead, it represents a preliminary estimate of the order of magnitude of each option's cost, and what drives the costs, to inform policy development.

[13] Ofcom, Connected Nations 2016 https://www.ofcom.org.uk/research-and-data/infrastructure-research/connected-nations-2016

1.20. Based on current (2016) network availability, we estimate the total cost for delivering universal broadband would range from £1.1bn for a standard broadband service (delivered to 1.4 million premises) to £2.0bn for superfast broadband (to 3.5 million premises). This is based on a mixed technology approach to deliver the most efficient deployment, with the majority of connections delivered by fibre-to-the-cabinet technology, but also drawing on fibre-to-the-premises and fixed wireless technologies.

1.21. Mobile and wireless technology technically has the capability to deliver headline speeds consistent with a USO. However, providing a service equivalent to that of a fixed network requires a substantial amount of capacity per user. For example, our Connected Nations 2015 report indicates that a typical fixed broadband customer uses around 82GB per month whereas the typical mobile user consumes around 0.87GB per month, around 100 times less. Whilst wireless has been used to deliver broadband, mobile and wireless technology would not be able to deliver a USO on a national basis to all eligible premises without significant investment on additional capacity.

1.22. Costs may be expected to fall in the case of further future network deployment, either commercial or as a result of other public interventions by the UK Government, or devolved governments and administrations. For example, it is reasonable to assume implementation would start from the end of 2017. At that point, a smaller number of premises might require intervention to deliver decent broadband. In that case, total cost is estimated to be between £1.0bn to deliver a standard broadband service to 1.1 million premises and £1.7bn to deliver superfast broadband to 1.9 million premises.

1.23. We believe these estimates are appropriate to provide Government with a basis to make a decision on how best to deliver universal decent broadband. However, aggregate cost modelling network deployment faces a number of drawbacks, especially for the hardest-to-reach areas where local circumstances will significantly affect what can be built and how much it will cost. As a result, actual costs on individual connections can be higher or lower than the aggregate modelled numbers. This has been seen in commercial deployments across our sectors.[14] It is also important to note that future deployments from any source remain uncertain; cost estimates for future years are therefore necessarily more speculative.

1.24. Given these modelling uncertainties, policy choices that can reduce the risk of substantially higher than expected costs (e.g. setting a reasonable cost threshold) should be considered. Potential costs are set out in more detail in Section 8.

The potential effect on consumer bills

1.25. A central consideration in any USO mandated by Government will be the question of what costs would be borne by consumers. For the purposes of this advice, we have taken a cautious approach to estimating the potential effects on consumer bills, assuming an industry fund is implemented, as per Government's preference, and that the costs of industry's fund contributions are fully passed through to customers.

[14] Examples of this include commercial deployments where providers have materially changed plans as a result of deployment experience (for example, BT's original plans to deliver 25% of its superfast rollout through fibre-to-the-premises (FTTP) were adjusted as it learned more on costs and operational issues from actual deployments). Alternatively, providers have seen costs per connection for some technologies fall compared to their original business case, for example TalkTalk reported in November 2016 that build costs for its FTTP trial network in York (a joint venture with Sky and CityFibre) have come in "significantly under" the target cost per home passed of £500.

Given competition in retail broadband services and the need for any industry fund to be competitively neutral in its design, it is reasonable to expect that at least a proportion of an increase in providers' underlying costs would be reflected in consumer prices.

1.26. The actual amount paid by consumers will depend on a number of factors, including the period over which costs are recovered and which companies contribute. The options available are set out in more detail in Section 9 on funding mechanisms.

1.27. For example, assuming a seven-year cost recovery period and costs recovered from fixed broadband providers, on average consumers might see increases in household bills ranging from just under £11 per annum to deliver a standard broadband universal service to just under £20 per annum to deliver a superfast broadband universal service. Including mobile operators in any industry fund might reduce the average effect on household bills by just under 15%.

1.28. Whether and how to actually pass on any costs to customers would be a commercial decision for contributors. This analysis is therefore illustrative only. Communications providers offer a range of services across different sectors, and some may seek alternative ways to recover contribution costs, for example across a range of services they provide.

Affordability and social tariffs

1.29. Research suggests that the pricing of broadband today does not prevent most people from taking it up. However, there are issues of affordability for a small proportion of consumers. Given the policy aim of social, economic and digital inclusion, a social tariff for those consumers is likely to be appropriate. This may follow the existing social tariff intervention for those on low incomes. However, more work is required on how this is delivered to ensure effective targeting at those most in need.

Any universal broadband policy may require some limits on eligibility and cost

1.30. The cost-per-premises of delivering decent broadband to the very hardest-to-reach premises could be very high. Premises in the final 1% have an average cost that ranges from £2,780 per connection for standard broadband to £3,350 for superfast broadband. Those in the final 0.5% can cost between £4,460 and £5,100. The cost of serving the most expensive premises is estimated to be around £45,000 in all three of our scenarios. This could support the need to introduce a reasonable cost threshold (RCT) to limit the upper bound of the costs.

1.31. It may also be necessary to introduce mechanisms to ensure investment in commercial networks is not undermined. These can be delivered by policy choices on eligibility to minimise commercial distortions. Any USO will need clear eligibility criteria to determine who can access it in order to reduce the risk of 'overbuild' of competitive networks (such as community broadband schemes) and of distorting competition in broadband services in otherwise competitive areas. However, these criteria would need to be designed so consumers can easily understand if they are eligible or not. If consumers are not eligible, they should be given advice on how to switch or upgrade to a different fixed network provider delivering services that meet the USO technical specification.

1.32. Policies on universal availability often include such limitations. For example, the telephony USO does not require connections that cost more than £3,400 to be provided. Similarly, Digital Terrestrial Television (DTT) coverage is set at 98.5% of

UK homes. Water services also have a reasonable cost threshold applied, resulting in availability of less than 100%.[15] At the same time, it is clearly important any limitations do not undermine the overall policy goal.

1.33. For illustrative purposes we have estimated how such approaches might affect the number of premises benefiting from universal broadband today (2016), and the possible costs avoided. For example:

- a reasonable cost threshold of £5,000 per connection would leave between 30,000 and 38,000 premises left unserved in the standard broadband and superfast broadband scenarios respectively. This would reduce estimated costs by £280m for standard broadband to £320m for superfast broadband;

- alternatively, if, the policy was designed to cover 99.5% of UK premises, 140,000 premises would remain unserved, and potential costs would be reduced by £500m for standard broadband to £570m for superfast broadband.

1.34. If limitations are applied to the reach of a broadband universal service, consumers and businesses still need ways to get a workable broadband connection. For those in the very hardest-to-reach locations, this could take two forms:

- Consumers and businesses could meet additional costs above a reasonable cost threshold, receiving a service from the universal service provider. This is the same as today's telephony universal service obligation; or

- Consumers and businesses could be redirected towards an alternative lower specified product. For example, while satellite broadband may not be attractive as a general solution, it may provide the most effective backstop for the hardest-to-reach premises.

Funding a broadband universal service

1.35. There are a number of ways a broadband universal service obligation could be funded: through an industry fund; through public funding; or a combination of the two. Government has expressed a preference for an industry fund, and we have set out how that would work if we were responsible for implementing it under the current European framework. Much of the advice we set out in this report on the design of the intervention could apply to a range of funding mechanisms.

1.36. Ofcom would be responsible for setting up any universal service fund, and we would consult on the specific design. The key elements of any fund design would include:

- **What is the net cost?** How far are there wider benefits (such as revenues from new customers, incremental revenues from existing ones, increase in brand value) for a universal provider that offset the costs incurred in delivering a universal service?

[15] Water companies are entitled to recover the "reasonable costs" of making a water or sewerage connection - this varies by provider. For example, the 2015-16 maximum reasonable cost contributions that Scottish Water will provide for domestic dwellings is £1,555.31 for water and £1,805.35 for sewerage (http://www.scottishwater.co.uk/you-and-your-home/your-charges/2015-2016-charges/information-about-your-charges-201516/rcc-for-dwellings-201516). The water company will also only usually connect to the boundary of the road where the main is and the customer will then have to pay for the cost of connecting their property to this, including if it goes across a third party's land.

- **Over what period can the universal service provider recover costs?** This has a direct bearing on the annual cost to consumers and industry, and to the cash flows of the universal service provider. Options include recovering costs over the economic life of assets[16], over a defined (potentially shorter) period, or year by year. Regulatory charge controls face a similar question, and Ofcom typically allow cost recovery over the economic life of an asset.

- **Which industry participants contribute?** Contributors could be all communications providers, or could be more limited. In deciding who contributes, the key considerations would be how to design the fund to be recoverable from as many people and businesses as possible, and limiting the risk of competitive distortions between providers who are and are not contributors.

- **How to judge the level of contributions?** Contributions could be based on revenues, customers or profits. Typically, share of revenues are used in examples of other universal service funds.

It is likely there would be only a small number of providers capable of effectively providing a USO

1.37. Our CFI sought views from industry on whether providers would be willing or interested in being designated as universal service provider (USP). However, few scale providers expressed an interest in being designated as a USP. No mobile or fixed wireless providers have come forward for designation as a USP to date. As such, there is unlikely to be competition to deliver a broadband USO across the whole of the UK.

1.38. The most efficient outcome for any broadband universal service may be to make use of, and build upon, existing scale communications networks. This would imply BT may be best placed to be a designated USP for the UK, and KCOM for Hull. This is because existing UK network structures mean that the majority of eligible premises will be connected to BT's copper network or will live in areas where BT's network is present, except in Hull, where KCOM has an extensive presence. We may also not consider it proportionate to impose the obligation on smaller providers unless they have volunteered.

1.39. Whichever companies are designated as a USP, in the absence of a competitive process, it will be important to secure value for money. This will require rigorous scrutiny of the costs and benefits of providing the USO. The calculation of net cost in the universal service fund is crucial in this, only taking into account efficiently incurred costs.

[16] Annualised costs (plus a reasonable return) would be recovered by the time the invested assets reached the end of their useful life. The lifetime of the assets deployed will depend on the 'blend' of the different types of infrastructure used.

Section 2

Introduction

Background

2.1 As people and businesses increasingly use online services in their day-to-day lives – for communication, information, entertainment, shopping, public services and more – it becomes increasingly important for them to be able to access a decent internet connection. Although the majority can do so, there are many that still cannot, and availability tends to be worst in rural areas, in the nations and for small and medium sized enterprises (SMEs).

2.2 In November 2015, the Government set out its intention to introduce a broadband universal service obligation (USO) to ensure that "households and businesses can get the broadband speeds needed to do business online, access key services or stream live TV".[17] It set out an ambition to give everyone a right to a broadband connection with a download speed of 10Mbit/s on reasonable request.

2.3 The Department for Culture, Media and Sport (DCMS) subsequently published a consultation on the Government's proposed approach to introducing a new broadband USO.[18] DCMS asked Ofcom to provide technical analysis and recommendations to support the design of the USO.[19] This report addresses this request.

2.4 DCMS has asked Ofcom to provide advice on the following:

- **The level at which a USO should be set**: This should include an appropriate download speed, including analysis in the first instance of the Government's stated ambition that the universal right should be set at 10Mbit/s. It should also consider the appropriateness and level of other parameters, such as upload speed, latency and capacity, and include analysis of what is required for consumers and small business users to fully participate in the digital society;

- **Footprint and potential demand for the USO**: This should include, to the extent that it is possible, an assessment of the number and location of premises that would be in scope of a broadband USO, including in rural areas, and how this will evolve over time. It should include an estimate of what percentage of premises might take up a USO and what factors may affect this demand, particularly in the hardest-to-reach rural areas;

- **Aggregation of demand and efficiency**: Options for the most efficient design and delivery of a broadband USO, to ensure that the maximum number of people who want to get connected do get connected - particularly in sparsely populated rural communities;

[17] Government press release, November 2015 https://www.gov.uk/government/news/government-plans-to-make-sure-no-one-is-left-behind-on-broadband-access
[18] DCMS, A New Broadband Universal Service Obligation: Consultation, March 2016 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/510148/Broadband_Universal_Service_Obligation.pdf
[19] Letter from DCMS to Ofcom, March 2016 https://www.ofcom.org.uk/__data/assets/pdf_file/0027/53676/dcms_letter.pdf

- **Reasonable requests and cost thresholds**: Possible factors for determining whether a request for connection is reasonable, including an appropriate cost threshold;

- **Affordability and pricing**: Advice on pricing of connections provided under a broadband USO. In particular, how different options such as uniform pricing and other pricing rules might be applied in practice, and how the USO can be affordable; this should include consideration of a social tariff to ensure it is affordable to all;

- **Costs and technologies**: A detailed preliminary estimate of costs arising from implementation of the USO based on different types of network architectures and technologies. This should include an assessment of the likely timescales over which these costs will arise, and the potential technologies that could support a USO;

- **Providers and designation**: Options for the mechanism for designation which is competitive and delivers value for money. This should include consideration of possible different types of providers, for examples, regional providers, and smaller providers using innovative technologies;

- **Minimising market distortion**: Views on the extent of any market distortion arising from the implementation of a broadband USO, and advice as to which aspects of the design of the USO could impact upon and minimise distortion. This includes limiting the potential for overbuild of existing networks, and minimising risks to retail competition;

- **Funding**: The mechanism for industry funding the USO, including through an industry cost-sharing mechanism, the most appropriate mechanism and who should contribute to it. This should reflect the Government's preference for an industry-funded scheme, and include an assessment of the costs which industry potentially might be asked to bear. It should also consider the impacts on consumer pricing, including consumers who request a connection under the USO, as well as the wider group of consumers using broadband services; and

- **Review**: How often, and on what basis, a broadband USO could be reviewed in order to ensure that it continues to meet the needs of homes and businesses.

The basis for our technical advice to Government

2.5 In April 2016 we published a Call for Inputs[20] (CFI) seeking views from consumers and industry to inform our analysis. In August 2016 we published a summary[21] of the responses[22] received.

2.6 Having taken into account these responses, alongside those expressed by stakeholders in extensive discussions, we set in this report the main issues relevant

[20] Ofcom, Designing the broadband universal service obligation, April 2016 https://www.ofcom.org.uk/__data/assets/pdf_file/0025/58336/broadband-uso.pdf
[21] Ofcom, Summary of Responses to the CFI, August 2016 https://www.ofcom.org.uk/__data/assets/pdf_file/0025/68335/summary_of_responses.pdf
[22] The responses can be viewed at: https://www.ofcom.org.uk/consultations-and-statements/category-1/broadband-uso-cfi

to and options for any policy to deliver decent broadband that is universally available and affordable.

2.7 In setting out our advice, we have focused on how the policy of universal decent broadband might be achieved. One tool that can be used to achieve this objective is a broadband USO[23], but there are other tools at Government's disposal, such as Government-led programs to extend broadband coverage (funded by Government or industry, through a levy).

2.8 Approaching the Government's request for advice in this way will provide the Government with the best available advice on how it might secure its overarching policy objectives.

Given the uncertainties we set out a range of scenarios and options

2.9 In this report we provide the Government with facts and options on which policy judgements can be made. This is necessary as any final universal service policy decision is based on a number of inter-related choices.

2.10 It will be for the Government to decide which options best fit its policy objectives, and how far a USO is the best tool to deliver them. If that is the case, the detailed specification of the USO will then be set in secondary legislation, after which implementation will pass to Ofcom.

2.11 We set out in detail the potential costs of broadband universal service based on different numbers of premises which may be eligible. We also consider different technology options and specifications for any universal service itself. If a broadband universal service has a higher technical specification – e.g. higher download or upload speeds – the cost of delivering it will be higher since more premises will be likely to request it. There is a link and trade-off between coverage, capability and cost.

[23] Annex 1 describes the current legislative framework for a USO.

Section 3

What is decent broadband?

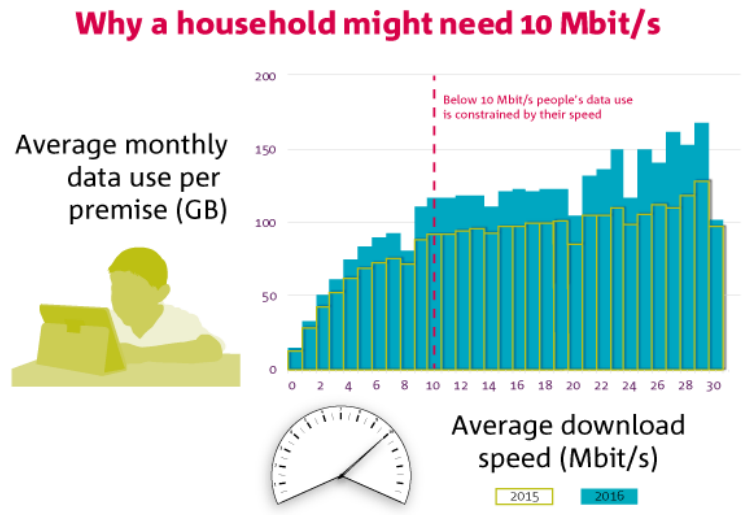
A 10Mbit/s download speed may be sufficient now but may need to evolve over time

3.1 The Government has an ambition of making broadband available with a minimum download speed of 10Mbit/s. This is considered to be the speed which enables full participation in a digital society.[24] Analysis has shown that:

- The average amount of data used by a household appears to be constrained by the speed of its broadband connection for connections below 10Mbit/s[25]; and
- Below 10Mbit/s, access speed can be the dominant factor in the perceived quality of a broadband connection.[26]

3.2 Our evidence shows that a speed of 10Mbit/s is sufficient now to allow multiple users to simultaneously use the internet, including web browsing, video streaming, video calling and gaming.

Figure 3.1: Relationship between download speed and data usage



Source: Ofcom, Connected Nations 2015 [27]

3.3 In our 2015 Connected Nations report, we published data showing the relationship between the volume of data downloaded each month and the download speed available. We found that usage of broadband tends to vary with the download speed

[24] DCMS, A New Broadband Universal Service Obligation: Consultation, March 2016 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/510148/Broadband_Universal_Service_Obligation.pdf

[25] Ofcom, Connected Nations 2015- https://webarchive.nationalarchives.gov.uk/ukgwa/20160702162836/http://stakeholders.ofcom.org.uk/015.pdf

[26] Report on the Measurement of Internet Quality of Experience, November 2015 - https://webarchive.nationalarchives.gov.uk/ukgwa/20160702162836/http://stakeholders.ofcom.org.uk/

[27] Ofcom, Connected Nations 2015, https://www.ofcom.org.uk/__data/assets/pdf_file/0028/69634/connected_nations2015.pdf

that is available. Households that had a download speed of below 10Mbit/s available to them downloaded less than households that had higher speeds available. Usage seems to be restricted on connections with a download speed below 10Mbit/s.

3.4 Our report also indicated that half of premises received broadband at speeds in excess of 10Mbit/s.[28] We can expect that, over time, data demands and usage from individuals and businesses will continue to rise. This is because:

- Individual internet services will require more bandwidth to work properly or quickly. For example, web pages and social media sites will contain more pictures and video content, so using the same service for the same amount of time will require higher network capacity.

- The use of online services is also likely to continue to grow: residential customers may increase the amount of video content (e.g. television and films) consumed; businesses are likely to increasingly rely on cloud computing and storage; and increasing adoption of 'smart' devices in the home and workplace may introduce more capacity demands on broadband connections.

- Capacity requirements of the content itself is also likely to increase as pictures and videos will be of higher quality and definition.

3.5 Although innovation in compression and transmission techniques, particularly for video content, can help mitigate this increase, it is unlikely to completely compensate for it.[29] Taken together, we expect capacity demands on broadband networks to continue to rise.[30]

3.6 However, it does not follow that increased data usage leads to a similar rise in the required broadband capacity provided to a premises. The amount of capacity will depend on both the demands of individual services and the number of simultaneous online users in a premises.

3.7 As a result of these factors, it is not possible to predict exactly how bandwidth requirements may evolve over time, but it is very likely an initial 10Mbit/s rate would need to be reviewed in the future.

3.8 As well as download speed, a range of other factors can affect the user experience for broadband. Most notably, as people and businesses increasingly send data such as photos and videos, upload speeds become more important. As such, a more demand technical specification, with quality standards extending beyond download speeds, could become more important for consumers in future.

The needs of businesses and consumers may be different

3.9 The definition of 'decent' broadband may vary depending on the needs of the end users. In particular, SME users could benefit from a technical specification with

[28] Ofcom, Connected Nations 2015, https://www.ofcom.org.uk/__data/assets/pdf_file/0028/69634/connected_nations2015.pdf
[29] A report by Communication Chambers for the Broadband Stakeholders Group estimates that the rate of improvement in compression vary, although tend to be around 10% [per annum]: http://www.broadbanduk.org/wp-content/uploads/2013/11/BSG-Domestic-demand-for-bandwidth.pdf
[30] For example, Cisco estimate that IP traffic will grow at a compound annual growth rate (CAGR) of 22% from 2015 to 2020. http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/complete-white-paper-c11-481360.html

quality standards extending beyond download speeds. Compared to residential broadband users, SMEs are more likely to need services with higher upstream bandwidth requirements, such as video conferencing or sharing documents for collaboration (although some of the most popular business applications, such as email, web access and online ordering tend to be less reliant on upload speeds).

3.10 Currently, less than 30% of SMEs report using these more bandwidth-intensive activities, such as online data backup, cloud services, VoIP and video conferencing. Moreover, smaller SMEs are even less likely to use these services compared to businesses with at least 10 employees.[31]

3.11 However, the needs of SMEs may evolve in future. A study looking into the expected bandwidth demands for SMEs in the UK over the next 10 years concluded that, while "the median downstream demand for small business premises rises from 5 Mbps in 2015 to 8.1 Mbps in 2025"[32], the median upstream demand would rise from 1.3 Mbit/s today to 2.7 Mbps. The report noted that these demands were highly variable, depending on the specific nature of the business and employee count.

3.12 To achieve the Government's intention, a downstream connection of 10Mbit/s is expected to support simultaneous web access and email for a small number of users, along with limited use of video calling. An upstream connection of at least 1Mbit/s will give an SME sufficient bandwidth to carry out video conferencing or upload files in reasonable timescales, although only for a small number of employees. It may not be enough for larger numbers of users to do so simultaneously. For example, Skype recommends a minimum download and upload speed of 400 kbps to support a single high quality video call.[33] This capacity requirement will increase as the number of simultaneous calls take place at a premises.

3.13 Bandwidth requirements will increase as the number of employees increase, as a larger number of users may need to access internet services simultaneously. As a result, this kind of broadband connection may not be suitable for larger businesses. However, SMEs may not have the option to buy a leased line connection, as this is generally a more expensive option than relying on a residential or mass-market broadband connection.

Why some premises still cannot get 10Mbit/s

3.14 The primary reason why a premises cannot receive broadband with predicted speed of at least 10Mbit/s is that they are served by a long copper line.[34] As a result of the telephony USO, there is fixed line coverage to almost all premises, but copper lines longer than around 2.8km are unlikely to be able to deliver broadband speeds in excess of 10Mbit/s.[35] The speed of cable broadband services, which are not provided over copper lines, are not reliant on the length of the line. Broadband packages on

[31] Figure 166, Jigsaw research on the 'SME experience of communications services', October 2014. https://webarchive.nationalarchives.gov.uk/ukgwa/20160702162836/http://stakeholders.ofcom.org.uk/

[32] http://www.broadbanduk.org/wp-content/uploads/2013/01/Small-Business-Connectivity

[33] How much bandwidth does Skype need? https://support.skype.com/en/faq/FA1417/how-much

[34] Other factors include the material of the telephone line (e.g. aluminium), its thickness (or gauge) and its general quality (including the quality of joints and interconnects).

[35] http://www.increasebroadbandspeed.co.uk/2012/graph-ADSL-speed-versus-distance

cable have a minimum 50Mbit/s download speeds, which exceed the download speeds in the scenarios that are examined in this report.[36]

3.15 Premises that cannot get 10Mbit/s broadband are in areas that are currently served on long lines through ADSL or VDSL and there are no alternative networks available. ADSL is the technology used for standard broadband services from an exchange. VDSL is the most commonly used technology used for broadband services from a cabinet.

3.16 It is important to note that there is a difference between what we define as download speed (sync speed) and the actual speed end users experience. The sync speed is the maximum speed that is achievable between the Internet Service Provider's (ISP's) access network and the consumer premises. In reality, the actual speed that is provided to an end user is typically lower than the sync speed and this will vary depending on the amount of contention in the network at that point in time, and other factors such as quality of in-home wiring, which cannot be easily controlled for. Hence, we define our scenarios (described later in this section) based on technical specifications that can be measured and monitored.

Technical specification scenarios

3.17 Respondents to our CFI had differing views on what the technical specification should be:

- Some argued for a basic, 'safety net' USO (under the framework set out by the Universal Service Directive (USD)) giving access to core digital services, with an emphasis on avoiding market distortions such as the deterrence of commercial investment or overbuild of commercial and community networks. This view was primarily put forward by industry stakeholders.

- Others argued for an advanced, highly-specified intervention. This vision was put forward primarily by public sector, local government and consumer stakeholders, along with the majority of individual respondents. It favoured a highly-specified technical performance, uniform pricing and universal availability (100% of premises) with less regard given to cost or the risk of market distortion.

3.18 Given the wide range of responses, alongside our analysis of a USO with a download speed of 10Mbit/s, we also consider the implications of options with higher specifications. This approach is important given the evolving nature of broadband services over time. For example:

- Bandwidth demands (and supply, in commercial areas) may grow rapidly in the next few years. Between 2011-2015, we saw average speeds grow from 7.6Mbit/s to 28.9 Mbit/s.[37]

- The definition of decent broadband from a universal service perspective may similarly evolve – in 2010 the universal service commitment was 2Mbit/s. Today, the debate has moved on to at least 10Mbit/s.

[36] http://www.virginmedia.com/shop/broadband/speeds.html

[37] All connections including 'up to' 2/Mbit/s and less. SamKnows measurement data for all panel members with a connection in November 2015. Panel base: 1639. https://www.ofcom.org.uk/__data/assets/pdf_file/0017/71540/fixed-bb-speeds-nov15-report.pdf

- Service characteristics for broadband may change over time, as upload speeds and factors such as latency (or the responsiveness of connections) become more important as consumers upload data (e.g. to social media) or use real-time services such as gaming.

3.19 In addition, various stakeholders and respondents to our CFI have called for a future-proofed intervention which looks beyond a 10Mbit/s download specification.

3.20 Given these points and the need to consider how a USO might work in the future, we have included estimates of what providing superfast broadband for all might mean in our advice. However, there are risks that could arise from higher specification universal services:

- a more highly specified USO increases the risk of negatively affecting commercial incentives to invest;
- it would come with a higher cost of intervention, which may result in greater costs on consumer bills; and
- some stakeholders would argue whether higher specifications, including superfast broadband, would today fit with the policy intent of the USD in terms of functional internet access.

3.21 We have developed three scenarios for the technical specification of a broadband intervention, set out in Figure 3.2.

Figure 3.2: The three scenarios for technical specification

	Scenario 1	Scenario 2	Scenario 3
	Standard broadband (10Mbit/s download speed)	More highly specified standard broadband (10Mbit/s download + 1Mbit/s upload)	Superfast broadband (30Mbit/s download + 6Mbit/s upload)
Download speed[38]	10Mbit/s	10Mbit/s	30Mbit/s
Upload speed	None defined	1Mbit/s	6Mbit/s
Latency[39]	None defined	Medium response time	Fast response time
Contention ratio/ Committed Information Rate[40]	None defined	50:1	CIR: 10Mbit/s
Data usage cap (monthly)[41]	None defined	100GB	Unlimited

[38] The sync speed is the maximum speed that is achievable between the Internet Service Provider's (ISP's) access network and the consumer premises. In reality, the actual speed that is provided to an end user is typically lower than the sync speed. This varies depending on the amount of contention in the network at that point in time, and to other factors such as quality of in-home wiring.
[39] Latency is the round trip delay in the transmission of data. In particular, this can affect the performance of live applications, such as live video streaming, gaming and video calling/conferencing.
[40] Contention is the degree to which bandwidth is shared between different end users at the same network node.
[41] Providers use data caps to manage the amount of data consumers use. Consumers tend to be charged more if they exceed their data caps.

3.22 **Scenario 1: standard broadband.** This is the most basic scenario, only setting a minimum requirement of 10Mbit/s for download speed.

3.23 **Scenario 2: more highly specified standard broadband.** This scenario builds on Scenario 1 and introduces a minimum upload speed specification, as well as setting requirements for latency, contention and a data usage cap. Most consumer internet usage today relies largely on downloading content from the internet, for example web-browsing, email and standard video streaming. However, some other common applications, such as video conferencing and sharing large images and video files (which may be particularly useful for SMEs) can require a decent upload speed. For example, sharing or remotely storing ten 5MB digital photographs at 1Mbit/s would take a little over six minutes. The introduction of a specified contention ratio helps to mitigate against speed reduction at busy times.

3.24 **Scenario 3: superfast broadband.** Under this scenario, as well as increasing the minimum sync speed requirement to 30Mbit/s, we also explore the impact of increasing the minimum upload speed to 6Mbit/s which is the median upload speed of superfast broadband lines today. Finally, we also increase the requirements on latency, contention and data caps to test the costs of providing a broadband service with a very high quality of experience. Increasing to superfast download speeds, coupled with a specification of a CIR should provide high confidence that the end user's experience will exceed 10Mbit/s at all times.

3.25 The technical specification is not the sole determinant of the people's broadband experience. As noted above, the actual speeds experienced by consumers tend to be lower than the sync speed of a line. For example, a sync speed of 10Mbit/s under Scenarios 1 and 2 does not mean that users would experience download speeds of 10Mbit/s at all times of the day; the download speed received by the consumer during peak hours would likely be lower than 10Mbit/s. Regardless of the network technical specification selected, other factors can affect the consumer experience. Some factors are outside the control of the USP(s), while more technical factors (such as zero contention) would require a more highly-specified technical specification than we consider in this report.

3.26 The factors beyond the control of the network provider include, for example, the quality of the wiring in the consumer's home. Alongside any network level intervention, it is important to support people and businesses who may be affected by such factors. Ofcom's mobile app[42], which allows consumers to check the performance of their home broadband (as well as their mobile reception), is one example of such support. If the app finds a problem with either, it will explain possible causes and provide practical troubleshooting advice.[43]

We have included superfast services, although reasonable arguments might be made both for and against a superfast USO under the USD

3.27 Under the USD, connections provided under a broadband USO should be capable of supporting "data communications at data rates that are sufficient to permit functional internet access, taking into account prevailing technologies used by the majority of

[42] https://www.ofcom.org.uk/phones-telecoms-and-internet/advice-for-consumers/advice/ofcom-checker

[43] The app also shows voice, 3G or 4G coverage from all major network operators, both indoors and outdoors, at any location in the UK – allowing people to compare which network offers the best service in places such as the home or office. Broadband availability and speed information is available using address-level data.

users and technological feasibility." Specific data rates are not set out in the USD to allow flexibility for Member States to define functional internet access according to their national circumstances. However, the USD makes clear that the services covered by the USD should be those that "become available to a substantial majority of the population."

3.28 The European Commission provided further non-binding guidance in its last review of universal service in 2011.[44] This suggested Member States could be asked to consider setting a data rate for the broadband USO that is used at national level by at least half of all households, and by at least 80% of all households with a broadband connection. Superfast connections are likely to be higher than the rates that fall within this guidance.

3.29 While the guidance provided by the Commission is not binding and higher data rates may be used, they would need to be justified to ensure that such measures were compliant with the provisions of the USD and were no more burdensome than necessary to achieve the policy goal. Different stakeholders have argued both for and against a superfast USO under the USD.

3.30 We believe it is important to include a superfast scenario, including a comparison of how eligibility and cost might be affected. We have included this scenario for a number of reasons:

- the level of performance consumers need from their broadband will evolve over time. In this context, many CFI respondents called for a more 'future-proof' universal service, that would not require frequent reviews and upgrades down the path. This was both for timeliness (i.e. time to review and implement updates) and efficiency (i.e. efficiencies from having one more significant intervention) reasons;

- some CFI respondents argued the purpose of any broadband universal service intervention should be 'equality' i.e. delivering a service to more remote or difficult to reach areas that was equivalent to that received available to the rest of the UK;

- some policy makers (for example, Scottish Government and the Department for the Economy in Northern Ireland) have already made commitments to increased provision of superfast broadband; and

- by delivering much higher speeds, a superfast specification would provide the greatest confidence that consumers using a broadband universal service could receive at least 10Mbit/s at all times.

3.31 We also note that the legal mechanism of a USO is only one of the tools Government has at its disposal to deliver decent broadband to all, including more highly specified services.

[44] Universal service in e-communications: report on the outcome of the public consultation and the third periodic review of the scope in accordance with Article 15 of Directive 2002/22/EC, available at http://ec.europa.eu/information_society/newsroom/cf/dae/document.cfm?doc_id=3747

These three scenarios form the basis of our advice to Government

3.32 In Section 4 we provide detail about how many premises cannot currently receive each of these technical specifications. In Section 5 we describe how eligibility may be determined for universal broadband.

3.33 In turn, these estimates inform our analysis in regards to the costs associated with providing a network that meets the specified requirements. These scenarios represent a broad range of options, each will result in differing levels of consumer experience and footprint of potentially eligible premises and will also expand the scale of deployment as the specification increases. We therefore recognise that there is a trade-off to be made between the specification and overall cost of delivery. It should also be noted that, as the specification of any broadband universal service increases, the scale of possible market distortions grows.

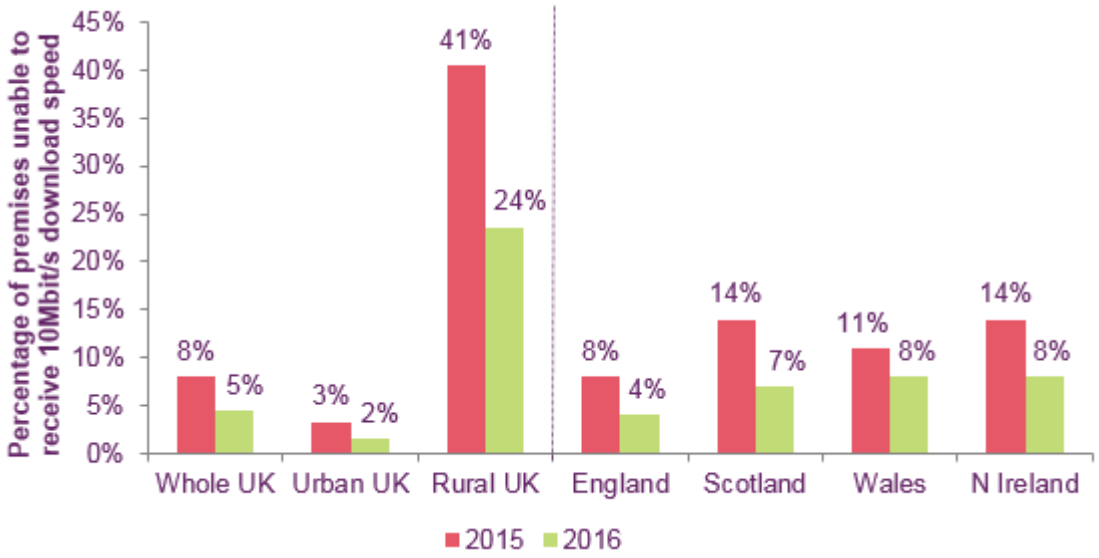
Section 4

What is the potential scale of the problem?

More premises are now able to receive 10Mbit/s broadband

4.1 Over recent years, the number of premises that cannot receive at least 10Mbit/s download speeds (from either their current supplier or an alternative fixed network) has fallen significantly, from 15% in 2014 to 5% in 2016. While small in percentage terms, this still means 1.4 million premises currently cannot receive a download speed of 10Mbit/s, with 70% of them in rural areas. Largely because there are proportionately more rural premises in Wales, Scotland and Northern Ireland, a greater percentage of premises in these nations cannot receive 10Mbit/s, as illustrated in Figure 4.1.

Figure 4.1: Percentage of premises unable to receive 10Mbit/s download speed



Source: Ofcom, Connected Nations reports [45]

4.2 Data from our Connected Nations report also shows that around 8% (200,000) small to medium sized businesses are not currently able to get a broadband service with a download speed of 10Mbit/s.[46] An economic benefit of universal broadband is to close this gap.

4.3 The improving picture shown above has come about predominantly because of commercial and publicly-funded roll-out programmes to deliver superfast broadband,

[45] Please note that Ofcom's rural and urban definitions have changed slightly since Connected Nations 2015 was published, and as a result, 2015 coverage figures have been re-calculated to allow for comparison. See Connected Nations 2016 report for description of methodologies used to calculate data.

[46] Ofcom, Connected Nations 2016, https://www.ofcom.org.uk/research-and-data/infrastructure-research/connected-nations-2016

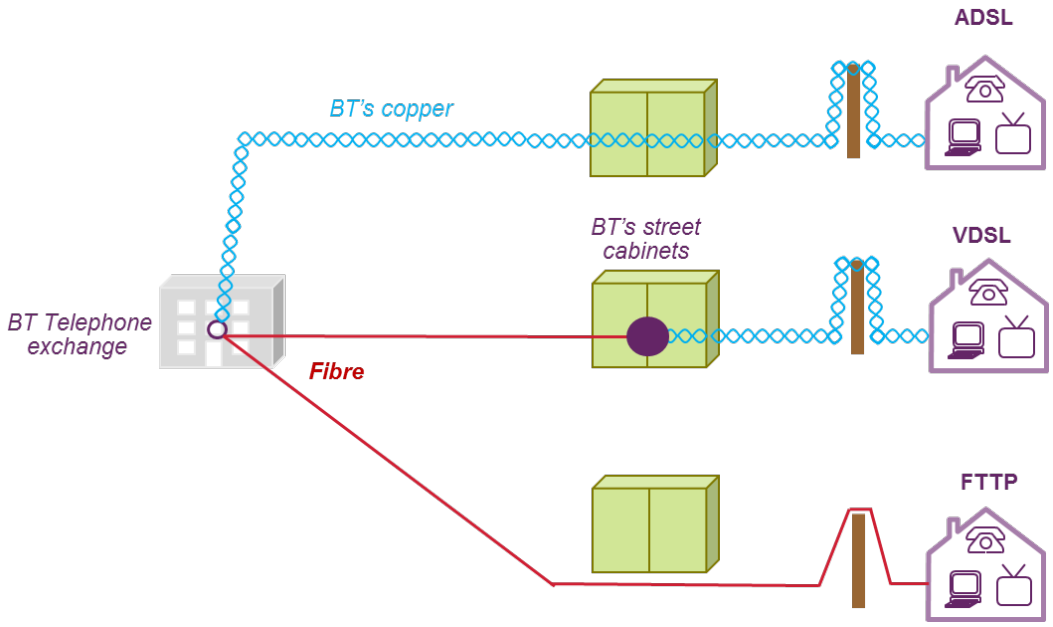
which is now available to around 90% of UK premises. We discuss these roll-out programmes in more detail below.

4.4 It is not yet clear, however, the extent to which new roll-out of superfast broadband will provide the remaining sub-10Mbit/s premises with faster broadband. Some will be covered by further commercial and publicly-funded roll-out but some, particularly the most geographically isolated, will not. These are the premises that any further intervention will need to address.

4.5 Nearly all premises in the UK have a fixed line connection, with almost all of them served by a copper or fibre connection over the Openreach or KCOM networks, or a cable (HFC[47]) connection from the Virgin Media network. Approximately 80% of active residential lines are served on the Openreach network and nearly all have download sync speeds which are determined by the length of the copper line connecting the premises to the network.[48]

4.6 The speed of a broadband service on these lines decreases as the length of the copper line increases (although it is important to note that line length is not the only factor that can impact broadband speeds). This means that premises that are further away from exchanges or cabinets are more likely to be unable to receive at least 10Mbit/s. Since 2010, Openreach has been upgrading these lines to fibre to the cabinet (FTTC), reducing the distance of the copper connection to be able to offer superfast broadband. Figure 4.2 shows the basic network architectures of standard broadband, FTTC (also known as VDSL) and FTTP connections.

Figure 4.2: Schematics of ADSL, VDSL (FTTC) and FTTP connections



4.7 Existing network availability may be used to determine whether a premises is able to request a decent broadband connection that meets the requirements set out in the technical specification. For example, a premises may request a connection with a

[47] Hybrid Fibre Coaxial

[48] Ofcom, Communications Market Report 2016, Figure 4.13, August 2016 https://webarchive.nationalarchives.gov.uk/ukgwa/20160702162836/http://stakeholders.ofcom.org.uk/
The vast majority of fibre connections are FTTC connections, which are still reliant on the copper connection from the cabinet to the end user.

technical specification outlined under Scenario 1 if it did not receive a predicted speed of at least 10Mbit/s. As discussed in Section 3, this could be because:

- It is too far from a cabinet that has been upgraded to FTTC;
- It has not been upgraded to FTTC and is too far from the exchange to get a good quality ADSL connection. Within this group, some premises may receive a network upgrade as a result of BDUK investment; or
- There is not an option to upgrade to FTTC as there is no cabinet (these are known as an 'Exchange Only Line') and the premises is too far from the exchange to get a good quality ADSL connection.

4.8 Figure 4.3 shows our estimates for the number of premises that do not currently meet the technical specification defined in each scenario and do not have alternative existing networks available which could provide a connection capable of delivering each respective specification. Our analysis starts from a conservative assumption of how many premises do not currently receive connections capable of meeting the defined technical specification, and assesses the availability of services based on current fixed broadband coverage, as this was the most detailed set of coverage information available to us. The figures below are discussed in further detail in our cost modelling assessment in Section 8.

Figure 4.3: Estimate of the number of premises that cannot receive the technical specification outlined under each scenario in 2016

Million premises (*as % of total premises in Nation*)	Scenario 1: 10Mbit/s download speed	Scenario 2: 10Mbit/s download + 1Mbit/s upload	Scenario 3: 30Mbit/s download + 6Mbit/s upload
England	1.0m (*4%*)	1.9m (*8%*)	2.6m (*12%*)
Scotland	0.2m (*8%*)	0.4m (*14%*)	0.4m (*17%*)
Wales	0.1m (*9%*)	0.2m (*12%*)	0.2m (*16%*)
NI	0.06m (*9%*)	0.08m (*10%*)	0.1m (*17%*)
Total UK	**1.4m (*5%*)**	**2.6m (*9%*)**	**3.5m (*12%*)**

Source: Ofcom analysis based on Connected Nations 2016 Report data

4.9 Scotland, Northern Ireland and Wales have the largest proportion of premises that currently cannot receive broadband meeting the various technical specification scenarios since they tend to have a higher proportion of rural premises that are connected to longer lines and therefore experience slower broadband speeds.

4.10 Different nations have different geographies and different existing network infrastructure. As discussed earlier, there are a number of reasons why a premises might not receive a predicted speed of 10Mbit/s. Some network challenges are more prevalent in certain nations than others, resulting in different patterns in the potential number of eligible premises at the nation level. For example, Northern Ireland has experienced a large roll-out of FTTC technology over the past five years. This means that those premises that may be eligible for a decent broadband connection (under any scenario), are more likely to be a result of being located far from an upgraded cabinet, and less likely to be affected by a cabinet that has not been upgraded at all. Therefore, the technology choices that a chosen provider may employ in a nation will vary considerably, with particular approaches being able to deliver certain technical specifications more easily and in a more cost-effective manner.

Ongoing roll-out programmes will reduce the number of premises that cannot receive the technical specifications in the future

4.11 As noted above, a combination of publicly-funded and commercial programmes to roll-out superfast broadband has reduced the number of premises that currently cannot receive a connection capable of delivering at least 10Mbit/s. We expect that ongoing roll-out will continue to reduce the number of premises that cannot receive each of the three technical specifications outlined above in the future. For example:

- **BDUK estimates that it could extend superfast broadband coverage to 97% of premises by 2020.** BDUK, a publicly-funded programme, has a target of providing a connection of 24Mbit/s to 95% of premises by the end of 2017. The programme may be extended further, possibly to 97% of premises, as a result of lower than forecast costs and higher than expected take-up.[49]

- **Governments in the nations are also funding superfast broadband rollout.** The Scottish Government has pledged to provide superfast broadband to all areas by 2021.[50] In Wales, the Superfast Cymru programme expects to provide superfast broadband coverage to 690,000 premises by June 2017.[51] In Northern Ireland, the Superfast Rollout Programme is aiming to deliver superfast coverage to 39,000 additional premises by December 2017.[52]

- **Commercial deployments are ongoing.** KCOM aims to provide superfast coverage to all premises in its network by the end of 2020[53], while Virgin Media is extending its network to an additional 4 million homes[54]. BT is trialling a new technology, Long Reach VDSL (VDSL)[55] to increase the speeds of VDSL services. In addition, a number of smaller providers are delivering superfast or ultrafast broadband in areas with little existing coverage.

[49] Currently, an extra £258m is available for additional infrastructure deployment as a result of the so-called gainshare mechanism. This is likely to increase further as take-up of superfast broadband increases, therefore increasing the amount of funding available to expand superfast broadband deployment. If this money is used to invest in additional network infrastructure, it could make a significant contribution to upgrading premises that are in the final 5%. Slide 23, BT Results presentation, May 2016 https://www.btplc.com/Sharesandperformance/Quarterlyresults/2015-2016/Q4/Downloads/Slides/CapitalMarketsDay-Part1.pdf

[50] Scottish Government, A Plan for Scotland 2016-17, 2016 http://www.gov.scot/Resource/0050/00505210.pdf

[51] In addition to the expected 663,000 premises covered by commercial roll-out, SFBB coverage in Wales should reach 96%. http://gov.wales/docs/det/publications/160923-superfast-cymru-project-timeline-and-targets-en.pdf
For those premises that are unable to receive superfast broadband as a part of the Superfast Cymru scheme, the Welsh Government runs the Access Broadband Cymru scheme which part funds the installation costs for a new broadband connection. The new connection must at least double the consumer's existing broadband speed.
http://gov.wales/topics/science-and-technology/digital/infrastructure/superfast-broadband/step-four-superfast-not-available/?lang=en

[52] Department for the Economy Northern Ireland https://www.economy-ni.gov.uk/sites/default/files/publications/deti/Telecoms-General-Fact-Sheet.pdf

[53] KCOM response to Broadband USO Call for Inputs https://webarchive.nationalarchives.gov.uk/ukgwa/20160702162836/http://stakeholders.ofcom.org.uk/ [54] Virgin Media Project Lightning announcement, April 2016 http://www.virginmedia.com/corporate/media-centre/press-releases/virgin-media-announces-largest-uk-fibre-broadband-rollout.html

[55] http://www.ispreview.co.uk/index.php/2016/09/bt-reveal-massive-uk-g-fast-pilot-lr-vdsl-broadband-trial-areas.html

4.12 To estimate the likely number of eligible premises in the future we have relied on overall projections, drawing on BDUK estimates for future superfast coverage.

4.13 Figure 4.4 sets out our estimates for the number of broadband premises that may be eligible for a decent broadband connection under each of the scenarios for two future points in time: end of 2017 and 2020s. The 2017 estimates are based on BDUK achieving their target to roll-out SFBB to 95% of premises. The 2020 estimates assume that BDUK will extend superfast coverage to 97% of premises. It also assumes that there will be further commercial coverage based on a wide deployment of LR-VDSL. In both cases, we also assume that additional premises will gain access to services with sync speed greater than 10Mbit/s as a result of the upgrades described. Projections split by nation, and by rurality within each of the nations, are provided in Annex 3.

4.14 There are a number of drivers behind the below projections, one of them being that ongoing publicly-funded superfast broadband interventions such as BDUK will continue to deploy in this time frame and will therefore bring faster speeds to many premises that currently do not receive 10Mbit/s (Scenario 1). Connections are most likely to be deployed to the most economically viable premises, so while there may be a significant reduction in eligible premises under Scenario 1 between 2016 and 2020, the most difficult-to-reach premises are the most expensive to serve, which results in smaller reductions in the projections as the technical specification increases.

4.15 A smaller number of eligible premises by early 2020s could lead some stakeholders to advocate waiting until then to intervene in the market. However, by then the definition of what decent broadband means (10Mbit/s) may have moved (depending on how consumer needs evolve) and the scale of the problem could be higher than the projections below.

Figure 4.4: Future projections of the number of eligible premises

Million premises *(as % total UK)*	Scenario 1: 10Mbit/s download speed	Scenario 2: 10Mbit/s download + 1Mbit/s upload	Scenario 3: 30Mbit/s download + 6Mbit/s upload
Today 2016	1.4m *(5%)*	2.6m *(9%)*	3.5m *(12%)*
End of 2017	~1.1m *(4%)*	~1.8m *(6%)*	~1.9m *(7%)*
Early 2020s	~0.3m *(1%)*	~0.6m *(2%)*	~1.1m *(4%)*

4.16 Having considered the definition of decent broadband and set out the scale of the problem, the rest of this document now goes on to consider design options for any broadband universal service obligation.

Section 5

Who should benefit from a broadband universal service intervention?

Understanding eligibility

5.1 Whatever the model of intervention and funding mechanism, it is important to consider whether an intervention should be truly universal, i.e. available to everyone independently of where they live and of how much it costs.

5.2 A critical element in designing any broadband universal service intervention is therefore to decide on the circumstances in which consumers and businesses are entitled to benefit from it. This is a crucial first step in designing policy: it has a direct bearing on the cost and on the potential for overbuild. We refer to this issue as the 'eligibility' of consumers and small businesses for a broadband universal service. We should make sure an intervention is proportionate, i.e. the benefits it delivers compensate for the costs. We should also aim to avoid or at least minimise the overbuild of existing networks, since this has the risk of pushing off the market smaller community based providers.

5.3 In the CFI responses, some parties (particularly public sector bodies and consumer groups) argued for an intervention which applies to everyone, placing significant weight on the goal of equity and fairness for 100% of UK people and businesses, regardless of location or circumstance. Other respondents (primarily from industry), argued for a more restricted intervention. They considered that if a USO was to be introduced, it should act as more of a 'safety net' to prevent social and digital exclusion by giving access to online services only where commercial or public sector deployments would otherwise not reach, given the economics of building suitable networks.

5.4 We have considered the following options for how eligibility might be approached:

- Define eligibility based on whether a premises already has access to a suitably capable connection (e.g. 10Mbit/s download speed or more, depending on which technical specification scenario is chosen) from any provider; or

- Give every premises in the UK the right to request a broadband USO (as technically defined) from the designated USP(s), regardless of whether other broadband networks are already available.

5.5 A second layer of eligibility, to ensure costs are capped and are proportionate is to set a 'reasonable cost threshold' (RCT). This section covers the two points above. RCT is covered in Section 8 (cost estimation). It is helpful to consider reasonable cost threshold in the context of the potential costs and distribution of costs of delivering a truly universal broadband service.

Defining eligibility based on existing network access

5.6 To control costs and reduce the risk of network overbuild, any intervention could be targeted only at those consumers and smaller businesses that do not already have a network available that is capable of delivering decent broadband. This would reduce

the overall scale and cost of any intervention, being limited to 5% of UK premises in Scenario 1 for instance, as opposed to an undefined number of UK premises, depending on who is the USP(s).

5.7 Such an approach would limit the risks of distortions to commercial investment incentives, as funds would not be available for a USP to 'overbuild' existing networks or to gain a marketing benefit from its status, for example as the 'only truly nationwide network'.

5.8 However, this approach may create a more complex consumer journey where consumers (or the USP(s)) will need to understand current availability and capability of existing broadband networks in a particular location before making a successful request for a broadband universal service funded connection. This risk can be mitigated in part through a clearly and simple design of the 'consumer journey' and making network reach information readily available either to consumers or to the USP(s).

A universal service for all

5.9 This approach would enable an easier consumer journey in that everyone in the UK would be eligible. A provider with responsibility for delivery of decent broadband would need to respond to any request and incur appropriate costs.

5.10 However, without any boundaries on those eligible to benefit from any intervention, the costs of provision will be at the top end of the scale since costs will be incurred regardless of the level of expected benefits for individual premises. Further, an intervention which applies to all may also have the effect of providing support for network roll out in areas which already benefit from decent broadband and thus give rise to market distortions. Whether under a roll out program or on-demand program, if the provider entrusted with securing the policy is simply filling gaps in its own network coverage, this may risk overbuilding networks which have already rolled out to those areas, or are planning to do so in the near future.

5.11 There may, however, be ways in which to limit the potential market distortion of broadband universal service through the design of the universal service offered to consumers. Such mitigations would aim to reduce the potential for substitution from commercial or community broadband schemes and therefore limit the impact of a universal service intervention on their adoption or affect their roll-out. Examples of such mitigations may include:

- Limiting any universal service so maximum performance is set at the technical specification (e.g. 10Mbit/s and no higher for Scenario 1). This might reduce demand for the service for consumers who have superfast broadband available to them but did not want to pay for it;

- Requiring the USP(s) to use commercial wholesale access to existing networks to fulfil requests in areas with commercial networks, and only build new network infrastructure if such wholesale access was not available. However, there would be no power to require wholesale deals, and problems could arise in situations where the USP(s) contested the terms of any wholesale offer;

- Precluding the USP(s) from making a net cost USO fund claim for new connections (or excluding such claims from the net cost claim) where there is pre-existing alternative infrastructure (note that this is not allowed under the USD), thereby reducing the USP(s)'s incentives to build such connections.

However, this reduces the benefits of a simpler consumer journey in that requests could be turned down in the same way as was described in the detail regarding the first eligibility approach. Alternatively, requests may not be turned down, but it would be for the USP(s) to provide these connections on a commercial basis.

5.12 However, any intervention with such mitigations is necessarily more complex, and may raise further issues. For example, the USP(s) may have to be restricted from offering any service beyond the USO service (i.e. any faster than the USO service) in the future to that premises. This could lead to a potential restriction in consumer choice, e.g. superfast broadband would not be available over the USP's network even if it was capable of delivering it.

Effect of eligibility for this advice

5.13 In order to provide advice on the potential scale and cost of any intervention, it is necessary to be clear as to the approach which has been taken in terms of which premises are or are not eligible to receive the benefit of the intervention. This report has been prepared on the basis that eligibility criteria would be applied to reduce the costs of intervention and to ensure that market distortions are reduced to a minimum. We have consequently assumed that the benefit of any intervention would only be available to consumers and smaller businesses who cannot access networks that already provide decent broadband.

The consumer journey is an important consideration

5.14 In order for all consumers to be able to access a decent broadband connection, it is important that the broadband USO is as simple as possible to request. Our consumer research demonstrated the potential for confusion if consumers were not able to readily understand the circumstances in which they could get a USO service. In particular, consumers should not have to undertake time-consuming and complicated measures in order to get the USO.

5.15 Consumers should therefore be able to readily understand the circumstances when they can and cannot get the USO. This means that it is important to have clear, objective criteria which define who is eligible to request a broadband USO.

5.16 In Figure 5.1 we set out an illustrative consumer journey for a broadband USO intervention.

5.17 Under this approach, everyone would be able to request the USO but a new (or upgraded) network connection would only be made available to consumers where:

- their current connection is not able to deliver an equal or better technical specification than the one defined for the broadband USO; and
- an alternative fixed broadband network, that provides an equal or better technical specification than the one defined for the broadband USO, is not available.

5.18 If consumers are not eligible, they should be given advice on how to switch or upgrade to a different fixed network provider delivering services that meet the USO technical specification.

5.19 Responsibility for determining whether a request could be met by an alternative network could lie with the USP(s), Ofcom, or a third party. In practical terms,

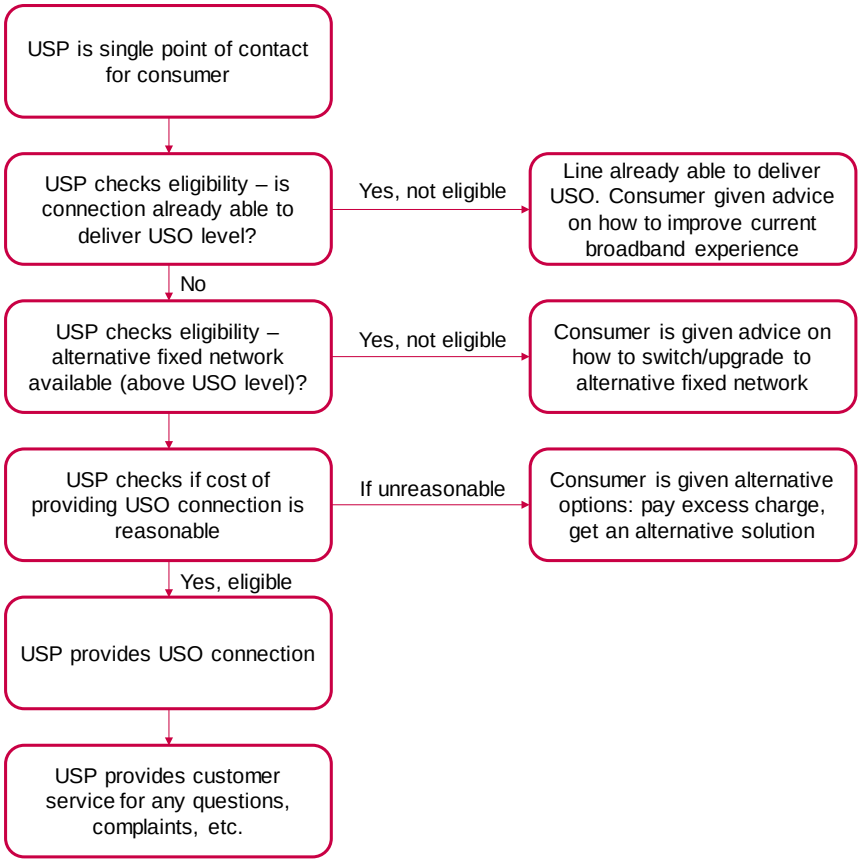
information on the availability of alternative networks could be gathered by maintaining an online database of premises that have requested a USO connection that is made accessible to other network providers. The USP(s) would need to have a clear incentive to explicitly take into account the availability of alternative networks, since it may otherwise simply use the USO scheme to overbuild other networks.

5.20 Prospective customers of the USO will also need to understand:

- How the broadband USO works, and in particular the type of connection provided;
- The benefits of a decent broadband connection in terms of improved speed and access to online services. For example, this could take the form of information on the type of services that can be accessed using a broadband USO connection;
- Information on any charges they would face when requesting a broadband USO connection (e.g. standard connection charge plus any applicable excess construction charge where the connection cost exceed the reasonable cost threshold);
- Information on how to request a broadband USO connection.

5.21 In practical terms, this information could be provided through a single telephone number and online portal. However, it will be important to ensure that other offline channels are used in order to reach all potential consumers.

Figure 5.1: Consumer journey



Section 6

How should universal, decent broadband be priced to ensure affordability?

6.1 In order for any intervention to be effective, it must ensure services consumers receive are affordable. If a USP is required to provide decent broadband to a consumer but sets its prices at a level which means the consumer will not take up the offer, the policy objective will have failed. This position is supported by the USD.[56]

6.2 A further concern may arise in relation to vulnerable and low income groups. While prices may be affordable in a general sense, there is a risk that certain groups may become socially excluded if their circumstances mean they are not able to afford services. The Communications Act makes provision for a social tariff for such consumers so they can participate fully in society. We consider the potential need for a social tariff for broadband services across the UK (i.e. not just for those consumers without decent broadband) separately from the overall issue of affordability.

6.3 We set out below options for ensuring the pricing of universal broadband is affordable. It should be noted, that the universal services covered by the USD do not currently include the broadband service (i.e. the ongoing service for which a monthly fee is typically payable) but only the broadband connection (i.e. the installation or upgrade of the connection).[57] The consideration of affordability for the broadband service therefore falls outside the scope of a USO today. However, affordable broadband connection and service charges should be a key element of any policy design.

Affordability and current market outcomes

6.4 There is no commonly-used definition of 'affordability', and it is not defined in the USD or implementing legislation. In our research, we generally consider affordability in the context of a good or service being affordable for a consumer if the consumer is able to purchase it without suffering undue hardship.

6.5 To inform this report we have reviewed current pricing of and spend on broadband, and researched the financial consequences for consumers of either buying or not buying communication services, including broadband.[58] We also commissioned a study analysing the profile of postcodes in 2015 where 50% or more of premises did not have a connection capable of a 10Mbit/s or above download speed. This was

[56] In order to constrain the pricing of universal services (including broadband) under the USD framework, the Communications Act 2003 permits the use of a common pricing structure and the fixing of tariffs. In this regard, for decent broadband pricing, it is relevant to consider the fixed telephony USO (as set out in the Electronic Communication (Universal Service) Order 2003) which reflects this in requiring prices for universal services to be affordable, and uniform throughout the United Kingdom, unless Ofcom determines that there is clear justification for not doing so.

[57] This can involve an initial upfront connection or activation fee for the set up/installation of broadband, which could include items such as routers. Separately, for a number of the most expensive premises to connect, consumers may have to pay an additional up-front non-uniform excess construction charge in order to have a connection. The affordability of this additional charge is not considered here.

[58] Kantar Media Affordability of Communications Services Omnibus: data pack, December 2016 https://www.ofcom.org.uk/__data/assets/pdf_file/0026/95138/Affordability-of-Communications-Services-Tracker-2016.pdf

done to provide illustrative insight as to whether consumers in those areas were any more likely to experience affordability issues compared with the UK as a whole.[59]

Current pricing

6.6 Figure 6.1 below shows a summary of Ofcom data on pricing and spend of telecoms services generally and specifically in relation to fixed broadband services. Where upfront charges apply to advertised dual play packages, they currently can range from £0-£25 for standard broadband packages and £0-£50 for superfast packages.[60]

Figure 6.1: Pricing and spend dashboard

Pricing and spend (based on 2015 data/prices)	
Average monthly household spend on all telecoms services (fixed & mobile)[61]	£82.17
Average monthly spend on residential fixed broadband (excluding line rental)[62]	£15.05
Average monthly standard line rental[63]	£17.77
Lowest available monthly price for a basket of 'standard' broadband and landline services (including line rental where appropriate)[64]	£22.49
Lowest available monthly price for a basket of 'superfast' broadband and landline services (including line rental where appropriate)[65]	£29.27

Fixed broadband services are currently affordable for most people, but there is a minority potentially excluded on price

6.7 The high take-up of fixed broadband (78% of UK households have a broadband connection, and 31% of UK households have a superfast broadband connection)[66] suggests that, in most cases, cost is not likely to be a barrier to connecting to and using broadband.

6.8 We survey consumers' views on the affordability of communications services on an annual basis, including fixed broadband.[67] This research found that of those

[59] The postcodes profiled were based on Connected Nations 2015 data as this was the latest information available at that time.
[60] Source: PurePricing, November 2016. At the time of accessing, only one of the seven featured providers had a connection charge for standard dual play (with broadband speeds of <30Mbit/s). Upfront charges were more common for superfast dual play packages (with broadband speeds of >=30Mbit/s).
[61] Ofcom, CMR 2016, Figure 4.34. https://www.ofcom.org.uk/research-and-data/cmr/cmr16
[62] Ofcom, CMR 2016. Figure 4.34.
[63] Ofcom, Consumer Experience 2015, page 3. https://www.ofcom.org.uk/__data/assets/pdf_file/0012/51105/cer_2015_final.pdf Simplifydigital data as at end of 2015; figures are average of the prices offered by BT, Sky, TalkTalk and Virgin Media.
[64] Ofcom, Consumer Experience Report 2015 Research Annex, Figure 8. https://www.ofcom.org.uk/__data/assets/pdf_file/0023/38543/annex.pdf
[65] Ofcom, Consumer Experience Report 2015 Research Annex, Figure 8.
[66] Ofcom, Connected Nations 2016, https://www.ofcom.org.uk/research-and-data/infrastructure-research/connected-nations-2016
[67] Kantar Media Affordability of Communications Services Omnibus: data pack, December 2016.

consumers with some responsibility for deciding what communications services to pay for and use[68]:

- Only a small minority (3%) reported having difficulties paying for fixed broadband in the last year (broadly similar to recent years). This is split into 2% when paying for standard broadband, and 1% when paying for superfast broadband. There is no significant variation across nations in 2016;

- Around 1% of consumers had some sort of fixed broadband debt. This is similar to those respondents claiming to have gas, electricity or water utilities debt [69];

- 4% claimed not to have broadband at all due to 'cost'[70], and 6% had standard broadband but not superfast due to 'cost'. A higher proportion of those in Wales (11%) and Scotland (8%) than those in England (3%) or Northern Ireland (4%) claimed not to have any fixed broadband at all due to cost. When it comes to having standard broadband but not having superfast due to cost, a greater proportion of those in Wales (14%) than in all the other three nations said cost was a barrier (England 6%, Scotland 1%, Northern Ireland 2%).

6.9 To better understand the socio-economic status of people living in premises not able to receive 10Mbit/s, we asked Experian to assess the demographic and financial situation of postcodes where 50% or more premises had a predicted download speed of less than this in 2015.[71] This analysis suggested that people living in these postcodes tended to be older than the UK population as a whole. They also tended to have higher household incomes and suffer less financial stress than the UK as a whole. In terms of geography, these postcodes were more likely to be classified as rural than urban.

6.10 However, the analysis also indicated that 8% of individuals in premises that did not receive 10Mbit/s in 2015 had high or very high Experian financial stress indicators – suggesting the potential to become over-stretched and struggle with further payments.[72] These individuals were predominantly situated in urban areas. Of those with high or very high financial stress indicators, 12% had a household income of under £20,000, and 82% were in social housing.

6.11 Concluding, our research suggests that, if prices for universal decent broadband were set at current levels across the UK, affordability would only be an issue for a small proportion of consumers. There is therefore a risk that vulnerable and low income groups may be socially excluded. We explore the option of a social tariff for these consumers later in the section.

[68] Questions on difficulties paying for communications services, debt, and not having broadband due to cost were asked of those with financial responsibility for the decision (76% of UK adults).
[69] Data for gas, electricity and water is primarily useful as context to the communications debt, rather than a measure of the utilities themselves. Sample sizes were too small to distinguish between standard and superfast fixed broadband.
[70] This does not necessarily mean that respondents could not afford the service – there may have been other factors that influenced their decision or ability to take up the service.
[71] Ofcom, Socio-economic analysis of 2015 postcode data, December 2016 – see Annex 8.
[72] Experian's financial stress indicator is based on a model that ranks individuals on their level of debt commitment. This uses Experian consumer survey information on the number of credit cards, personal loans and payment behaviour; and publicly available information on previous bad debt e.g. County Court Judgments. The scale ranges from very low, low, medium, high to very high.

Policy options for pricing

6.12 It is essential that universal decent broadband is affordable, and this may be achievable using either differential or uniform pricing. Any constraint on pricing is likely to result in a greater net cost which may not be recovered by the provider through pricing alone. This could place a heavier burden on funding options and consumers in turn.[73]

Differential pricing

6.13 In the absence of any measures to restrict the ability of the USP(s) to price as it wishes, there is a possibility that it may choose to set up-front and/or ongoing charges at higher levels in the areas not currently served by decent broadband to reflect the higher cost of serving these areas. Indeed, a number of industry respondents to our CFI advocated pricing should be different by location, reflecting the differing costs of serving different geographies. To ensure affordability under differential pricing there may be a need to set an upper bound.

Uniform pricing

6.14 An alternative approach would be to require a USP to offer uniform pricing for upfront and ongoing charges. This would ensure that those in areas not currently served would pay no more than those in the rest of the UK. To the extent that those prices are affordable, a uniform pricing requirement would ensure that prices were affordable everywhere. A number of respondents to our CFI[74] advocated this, suggesting it would be fairer that pricing and service standards should be the same across the UK, regardless of where the customer lives.

6.15 A benefit of this approach is that it would avoid setting a specific price, as the price would be linked to existing prices for a similar or equivalent broadband products. It would also ensure consumers are not disadvantaged by virtue of where they live.

Consumer views on uniform vs. differential pricing

6.16 To help inform our advice on pricing, we commissioned qualitative research to provide an indication of consumer reactions to geographically-uniform vs. differential pricing.[75] While the vast majority of participants were positive about the concept of decent broadband for everyone, this was overshadowed by feelings of resentment at consumers having to financially contribute at all.

[73] For example, lower prices could result in lower revenues to be netted off against any costs in a net cost calculation, see section 9 on funding.
[74] Mainly public sector respondents and consumer groups, along with the majority of individual respondents.
[75] See Jigsaw research, Consumer reactions to potential pricing models for the broadband universal service obligation (2016) – Annex 7. This report is based on the views and experiences of 152 residential broadband consumers in the UK. The research was qualitative in nature and findings are indicative and are not intended to be a comprehensive national picture of consumers' views. Differential pricing was described to participants as meaning those consumers receiving universal decent broadband paying higher prices, i.e. an additional amount compared to the prices paid by everyone else for a similar service. Uniform pricing was described as meaning that all broadband consumers would contribute to the costs of connecting consumers of universal decent broadband via a uniform price increase to everyone's monthly bills. In practice, the impact on bills could vary across consumers.

6.17 Before any illustrative price increases were shown, participants were largely evenly divided in their views between uniform and differential pricing. Most that could potentially benefit from a policy intervention preferred uniform pricing and most already with access to decent broadband (10Mbit/s or higher) preferred differential pricing. However, when example price increases were shown to them, most (irrespective of their own predicted broadband speed) supported uniform pricing as long as any monthly price increase was not higher than £1, and ideally 50p or less.[76]

6.18 Participants were later asked for their opinion, should the Government look to introduce universal superfast broadband, of potentially contributing towards funding such a scheme. There was general agreement among participants that a differential rather than uniform pricing model would be more appropriate for a superfast broadband scenario, as it was only fair that those wanting significantly higher speeds should pay for these themselves.

6.19 The choice of pricing policy is important to ensuring affordability of universal decent broadband while also having some potential regard to the impact on consumers more widely. While the consumer research above provides an insight in this regard, the decision is necessarily one of judgment.

Social Tariff

6.20 While broadband prices may be affordable for the majority of consumers, our research suggests there may be issues of affordability for a small number of consumers. This may include those on low incomes. We have therefore considered the need for a social tariff.

6.21 Article 9 of the USD envisages that Member States may introduce special tariff schemes for those on low incomes or with special social needs to ensure that they are not "*prevented from accessing the network*". Ofcom has the power[77] to impose conditions on USP(s) requiring special tariffs, including broadband where broadband is determined to be part of a USO.

6.22 Ofcom has imposed obligations on BT and KCOM to offer social tariffs for telephony.[78] Universal Service Condition 2 for each of BT and KCOM requires them to make available schemes to assist consumers who have difficulty affording telephony services including, in particular, consumers on low incomes or with special social needs. The existing condition is not prescriptive as to how such a scheme should operate. Each of BT and KCOM have put in place schemes to comply with their obligations. BT and KCOM also voluntarily give consumers the option to add a lower-priced fixed broadband connection and service.[79]

6.23 Ofcom set out in its Strategic Review of Digital Communications that the starting point for any future communications strategy must be to ensure that everyone shares

[76] This compared with example differential price ranges which included between £5-£9 per month and £20-£24 per month, which the majority of participants felt would be prohibitively expensive.
[77] Section 68(2) of the Communications Act 2003.
[78] https://www.ofcom.org.uk/phones-telecoms-and-internet/information-for-industry/telecoms-competition-regulation/general-authorisation-regime/specific-conditions-entitlement/universal-service-obligation/designation-of-bt-and-kingston
[79] BT's current scheme is called BT Basic and is offered to those meeting certain eligibility criteria relating to the receipt of certain social security benefits: http://www.btplc.com/inclusion/HelpAndSupport/DocumentsandDownloads/BTServices/BTBasic/BT_Basic.pdf. KCOM has an equivalent telephony scheme called Social Access Package: https://www.kcomhome.com/media/2451/supporting-vulnerable-customers.pdf

in the benefits of a modern digital society. In response to our CFI, several local government and consumer groups felt a social tariff would be appropriate to ensure everyone can access broadband services. Some in industry were also broadly supportive of the need for a social tariff.

6.24 Current evidence suggests that a small proportion of both current broadband consumers and potential consumers of universal decent broadband may face difficulties affording broadband. Therefore, the imposition of a requirement for a broadband social tariff for low income users is likely to be appropriate. A social tariff will ensure that low income groups are not socially and economically excluded if broadband prices serve as a barrier to digital participation.

6.25 In designing a social tariff, we consider it would be important to ensure that it, at minimum, was consistent with any universal decent broadband offering. Implementing the social tariff via the USD framework would mean it would need to comply with the USO specification and be fit for purpose. For example, the size of any attached data allowance should meet the needs of the consumers it is designed for.

6.26 A social tariff should be targeted towards those consumer groups where the price of connection and/or ongoing service would otherwise be unaffordable. It is important to ensure a social tariff is well targeted in order to ensure value for money, and that it is not offered to consumers who do not need it. This would be based on eligibility criteria that are transparent, and a process generally that is straightforward to use in order to support take-up of the tariff. Consumers should be made aware of the tariff's existence.

Section 7

How to deliver decent broadband to those currently excluded?

7.1 Before providing detail on the potential costs of universal, decent broadband, it is necessary to consider what networks might be required to deliver it, and how they might be built in practice. These considerations have a direct bearing on the outcomes of the policy, including the effectiveness of meeting consumer demand and the efficiency of costs incurred.

7.2 This section considers two issues:

- What are the viable technologies to deliver a broadband universal service?
- How would new networks be built to maximise availability and efficiency?

Technologies capable of meeting the technical specification

7.3 A number of different network technologies can be used to deliver decent broadband. Some, such as FTTC, reuse existing fixed network assets, while others require an entirely new network to be deployed independently of existing networks. This evaluation considers the technical feasibility of currently available network technologies to meet the requirements set out in our three scenarios.

7.4 We have examined in detail the capability of four technologies to deliver the three scenarios for the technical specification set out in Section 3. Details of their characteristics and capabilities are provided in Annex 4. The technologies were:

- **Fibre to the cabinet (FTTC).** This, along with cable broadband, is presently the predominant method of delivering superfast broadband in the UK. It involves installing active broadband electronics in the street close to the existing BT cabinets, and connecting individual telephone lines of premises requesting service. By placing electronics very much closer to the customer, FTTC can greatly increase the broadband speeds available. However, for those premises that remain distant from the cabinet, FTTC may not be able offer high speeds, and so FTTC may not be able to meet the requirements in all cases.
- **Fibre to the Premises (FTTP).** This technology comprises optical fibre being installed all the way to the customer's premises. While this is likely to be the most expensive option to deliver a broadband connection, it does have the advantage of being future-proofed to increases in technical specification up to and beyond ultrafast speeds[80] (higher than our superfast scenario).
- **Fixed wireless and mobile.** Wireless technologies avoid the difficulties in installing physical connections to premises, which can often be the most expensive aspect of broadband delivery. However, the bandwidth offered by an individual mast may be limited by the amount of spectrum available, and this bandwidth is typically shared by a number of users. This could either cause the

[80] Ofcom currently defines ultrafast as download speeds of 300Mbit/s, Connected Nations 2016, https://www.ofcom.org.uk/research-and-data/infrastructure-research/connected-nations-2016

speed of connections to drop in busy periods (leading to poorer quality of experience as the number of customers or committed data rate increases), or require more masts to be built (with cost implications). Mobile and wireless technology technically has the capability to deliver headline speeds consistent with a USO. However, providing a service equivalent to that of a fixed network requires a substantial amount of capacity per user. For example, our Connected Nations 2015 report indicates that a typical fixed broadband customer uses around 82GB per month whereas the typical mobile user consumes around 0.87GB per month, around 100 times less. Whilst wireless has been used to deliver broadband, mobile and wireless technology would not be able to deliver a USO on a national basis to all eligible premises without significant investment on additional capacity.

- **Satellite**. Current satellite broadband systems use geostationary satellites to transmit and receive signals from premises across a very wide geographic area. Most premises in the UK would be able to receive satellite broadband today, with only a few exceptions (e.g. where the location of a property does not allow visibility of the right part of the sky). However, satellite systems share capacity between users in each of its beams. As with fixed wireless and mobile, this can cause consumer experience issues as the number of customers or committed data rate per customer increases. In addition, current satellite systems relative to other systems are more likely to suffer from significant latency (delay) due to the distances involved in transmission of signals to and from the satellites. These delays may not be an issue for some internet services such as email and streaming video, but could be significant for real-time and interactive services such as video calling and gaming. In addition, existing consumer satellite broadband may struggle to meet the bandwidth requirements of Scenario 3.

7.5 In summary, the suitability of different technologies will depend on their technical capabilities, their ability to deliver a good quality of experience when there are substantial numbers of end users, or higher committed information rates (guaranteed speeds), and the ease with which capacity can be upgraded.

7.6 On this last point, satellite services are the hardest to scale up as a large investment is needed to add a significant increase in capacity (i.e. a new satellite). Fixed and mobile wireless services can be scaled more easily, but still require new build costs and geographic and topological limitations. Finally, fixed technologies, while initially expensive to build, offer easier shared capacity upgrades (i.e. fixed backhaul).

7.7 These factors were taken into account in Analysys Mason's cost modelling work on the most effective way to deliver levels of different broadband services.

7.8 For each technology, there will be a roadmap of further technical development that is likely to increase its capability and reduce its cost. For example, 5G technologies may expand capacity per base station further, reducing congestion issues, or G.FAST and Long Reach-VDSL technologies will enhance the service speeds deliverable over copper. Where possible, we have taken into account such developments that may occur in the timeframe of a broadband USO implementation.

7.9 Taking into account the capabilities and costs of different technologies, it is clear that one technology will be not be suitable for all circumstances. This highlights the need for a technology mix to address different local circumstances.

Figure 7.1: Summary of the technical capabilities of different technologies to meet the scenario requirements

Technology	Scenario 1: 10Mbit/s download speed	Scenario 2: 10Mbit/s download + 1Mbit/s upload	Scenario 3: 30Mbit/s download + 6Mbit/s upload
FTTC[81]	Yes	Yes	Yes
FTTP	Yes	Yes	Yes
Fixed Wireless and mobile	Yes	Yes	Potentially
Satellite	Potentially[82]	No	No

7.10 There are a number of alternative technologies and approaches that could be used for the delivery of decent broadband (such as the use of low-earth orbit satellite or TV 'white spaces'). However, in this report the technologies examined in detail have been selected because they are available now, they offer the opportunity to provide coverage across the UK and the costs associated with them are relatively well understood. This does not mean that alternative solutions are prohibited from being adopted, provided that they meet the criteria finally set out by Government.

7.11 Figure 7.1 summarises our assessment of the capabilities of different technologies to meet the three scenarios from a purely technical perspective; it does not take consumer experience or cost into account. FTTP and Fixed Wireless and mobile network technologies are technically capable of delivering a network which meets any of our scenarios, subject to the network design. In particular, fixed wireless networks can potentially meet the requirements of even the superfast broadband scenario, but it would require very localised cells which target a small number of premises, so that the available capacity in the cell is shared between a small number of users.

7.12 We consider that currently available satellite services are suitable only for Scenario 1, where the requirement is for a 10Mbit/s sync speed only, whereas the other scenarios include stricter latency tolerances.

7.13 Although FTTC may not be able to meet the most highly-specified technical specification in all circumstances, it is less expensive than FTTP, which may make it more suitable for serving the hardest-to-reach, most expensive premises, which are the premises targeted by the intervention to deliver universal decent broadband. As such, we consider FTTC will be suitable in most parts of the country, but it cannot be assumed to be the sole network technology to provide broadband in all circumstances.

7.14 In practice, it is highly likely that any USP will use a mixed technology approach, weighing up the different factors that affect the cost of provision. In Section 8, we explore the costs of deploying networks which use these network technologies. In addition to the use of alternative approaches as described above, developments in

[81] There are some limitations of FTTC where the line between the cabinet and the premises is very long, which might require alternative technologies to be used in certain circumstances.
[82] Satellite's and mobile's ability to meet (respectively) the requirements of scenario 3 and 1 depends on the number of potential customers being addressed. A significant number of customers will result in a risk of poorer consumer experience than '10Mbit/s'.

existing network technologies may make it cheaper to provide a broadband connection in the future.

How would networks be built to maximise availability and efficiency?

7.15 Under the USD, the universal service is intended to be provided on reasonable request. This could mean that the USP(s) could be required to consider each request for a USO connection on a case-by-case basis, in comparison to a roll-out programme where funds are used upfront to build a network in preparation for future demand for a connection.

7.16 However, many of the technologies share at least some element of the networks among all the users of that network. In order to provide broadband to one particular premises, it would (in many cases) be necessary to build a network that would also be capable of delivering broadband to a number of nearby premises. As such, many of the costs of deploying the USO service are likely to be common across multiple premises, and many premises have similar cost economics of high up-front costs (fixed costs) and lower ongoing costs driven by the numbers of customers connected (variable costs).

7.17 Given the shared nature of broadband networks, the 'on-demand' aspect of a universal service obligation differs from how the underlying network would be built. Delivering broadband on a purely on-demand basis could raise the following issues:

- **There could be risks to network build efficiencies.** A purely on-demand approach could limit the USP(s)'s ability to:
  - exploit economies of scale and scope through the use of shared network components serving premises in the same neighbourhood.[83]
  - optimise the network design to meet expected future demand in a local area to reduce future deployment costs.
- **There could be implications for any reasonable cost threshold introduced.** If costs are considered simply on a premises-by-premises basis, one premises requesting the broadband USO early in the implementation process is likely to be above any reasonable cost threshold[84] set. Where more than one premises requests a connection, the average cost for all requesting premises may come down to a level below any reasonable cost threshold, given the shared fixed costs of deployment.

7.18 Therefore, regardless of the intervention used to deliver universal decent broadband, pre-build of a broadband network, and some consideration of wider demand projections, is likely to be required. If the mechanism to deliver universal decent broadband is a universal service obligation, the USP(s) could:

- **Consider forecast demand in an area when assessing the reasonableness of early requests.** This approach would allow for more future demand and requires an estimate of average costs from the outset of the USO's

[83] The extent to which connection costs can be reduced in this way is likely to vary across premises and will depend on the technology solution adopted. For example, if a connection is upgraded to FTTP this would not involve additional shared network elements.
[84] Reasonable Cost Threshold (RCT) detailed in Section 8.

implementation. However, forecasts can be uncertain and the possibility of over-forecasting may result in a more complex net cost calculation; or

- **Aggregate demand in an area before deploying any network.** This approach would have some administrative requirements but is relatively easy to implement. However, a period of time in which demand could be aggregated would need to pass before consumers received their requested USO connection. Additionally, third parties (could be the USP(s), local community schemes, etc.) would need to present demand on behalf of consumers, and it would need to be clear to consumers how this process worked and who would ultimately be responsible for ensuring a request is fulfilled.

7.19 It will be important to ensure that prospective customers of the broadband USO are aware of their right to request a connection. Increasing and aggregating demand for the USO would help lower the average costs per household of providing it. There may therefore be a role for initiatives to explain that the cost of connecting a premises (and therefore any excess construction charges) may be reduced if more customers sign up in the registration period, which may in turn, mean that more premises qualify for a USO because average cost per premises falls and is more likely to be below the reasonable cost threshold.

Section 8

Estimating the costs of delivering decent broadband

Introduction

8.1 This section sets out an overview of our approach to quantifying the potential cost of a broadband universal service and provides our preliminary estimates of those costs. It is based on assumptions using a number of different technologies. Given the range of different factors which will influence overall costs, the uncertainties around some of those key variables, and a number of data limitations, we consider these preliminary estimates to be indicative of the magnitude of the costs rather than precise values.

8.2 As indicated above, these are only preliminary estimates and more detailed analysis would be required to get a more detailed estimate of the costs once decisions about key aspects of any broadband universal service are taken (e.g. in respect of the technical specification and the date of implementation). Once those decisions are taken, it would be possible to get a better understanding of the number and location of premises potentially eligible so that the costs of a broadband universal service can be predicted more accurately.

8.3 Given the timeline of the project, the analysis in this document does not take into account any commitments made in this year's Autumn Statement about investment in fibre to the premises.

Previous research on costs

8.4 There are a limited number of studies which look at the cost of deploying broadband services across the UK. For example, a report by Analysys Mason in 2008[85] investigated the costs of rolling out fibre-based broadband on a national basis in the UK. However, the analysis is now over eight years old and so it is of limited use for the purpose of estimating the costs of a universal service obligation today. In particular, the costs of deploying infrastructure will have changed materially in the eight years since the analysis was undertaken and new technologies (such as LR-VDSL) have emerged.

8.5 More recently, BDUK has undertaken seven market test pilots to investigate the "opportunities, risks and costs"[86] of rolling out superfast broadband to the UK's hardest to reach areas, using a mixture of fixed and wireless technologies. Although these studies do investigate roll-out to areas that would likely be eligible for the purposes of intervention, the pilots were designed to test the feasibility of different technologies in a limited sample of areas.[87] As a result, the information on costs for these market test pilot areas has only a limited applicability to our modelling exercise which is a nationwide exercise.

[85] Analysys Mason, The costs of deploying fibre-based next generation broadband infrastructure, September 2008.
[86] DCMS, Emerging findings from the BDUK Market Test Pilots, February 2016, page 9.
[87] Fewer than 9,000 premises are covered or intending to be covered by the trial.

New research

8.6 We have, therefore, commissioned additional research to look into the technologies that could be used and to estimate the costs that would be associated with such technologies to inform our advice to government.

8.7 DCMS' letter to Ofcom requested that the analysis of the costs "*…include[s] an assessment of the likely timescale over which these costs will arise*". The additional research does not explicitly cost a profile of roll-out over time since this is very uncertain. Instead, it does consider how costs may differ depending on the point in time at which implementation takes place. In particular, we provide an estimate of costs at three points in time, 2016[88], the end of 2017, and the early 2020s.

Research based on 2016 network deployment

8.8 We commissioned Analysys Mason to undertake a detailed bottom-up modelling of the technologies and costs associated with implementing based on upgrading and/or extending fixed networks.

8.9 The basis for its modelling was postcode-level data on premises as at Q1 2016[89] for the three scenarios described in Section 3, producing an estimate of the total deployment costs using a range of different technologies.

8.10 A detailed exposition of the methodology used by Analysys Mason is available in Annex 6 but, in broad terms, its analysis involved:

- Identifying the postcode areas which contained potentially eligible premises;
- Aggregating these postcodes into groups defined by the area covered by the cabinets[90] which serve them (the cabinet serving area);
- Assessing the availability of existing fixed network infrastructure for premises in these areas;
- Assessing the network infrastructure that would need to be deployed under each of the different technological solutions in each cabinet serving area in order to meet a specific technical specification; and,
- Using the average cost per premises connected in each group of postcodes for each of the different technology options for each technical specification to derive an overall estimate of the total costs.

[88] Although we recognise that implementation will not take place in 2016, we consider it is still relevant to start by carrying out our modelling based on 2016 data. Firstly, because it is based on the most recently available data, it is likely to give us a more accurate view of the costs at this point in time. It also provides a base from which adjustments can be made to reflect projections for future years. Secondly, it provides a worst-case scenario for the number of potentially eligible premises so that, all else being equal, the cost of implementation should be lower if implementation takes place in subsequent years.
[89] We use 2015 data for KCOM and Virgin Media.
[90] Or exchanges in the case of exchange-only lines.

Impact of existing broadband initiatives on estimates of costs

8.11 As well as investigating the cost of a broadband universal service to premises that cannot get decent broadband as at 2016, we also estimate the impact of further BDUK and commercial roll-out on the costs of a broadband universal service. This helps illustrate how the costs of an intervention may vary depending on the point in time it is imposed. Specifically, we consider the costs as at the end of 2017 to take into account the completion of the current phase of the BDUK programme. We have also included an estimate of possible costs based on a projection of the number of potentially eligible premises as at the early 2020s to reflect commercial roll-out and additional public sector interventions. However, the estimates for the early 2020s are inherently more speculative.

8.12 Annex 5 reports the top-down methodology used for doing this in more detail, but in broad terms we have:

- Produced estimates of the projected numbers of eligible premises at the end of 2017 and the early 2020s as set out in Section 4; and
- Used the cost curves estimated in Analysys Mason's bottom-up modelling as the starting point, estimated how the reductions in the number of potentially eligible premises might reduce the overall costs of a broadband universal service for each of the technical specifications.

Estimate of eligible premises

8.13 The bottom-up modelling by Analysys Mason has been based on postcode-level data. This data was provided by Ofcom and was based on operators' estimates of the percentage of premises in each postcode unit which could receive a service above a specified threshold.

8.14 However, following the completion of the modelling by Analysys Mason, new premises-level data has become available as part of the Connected Nations 2016[91] analysis. This data used a different methodology to estimate the number of eligible premises (described in Annex 5). A comparison of the two datasets indicated that the postcode-level data has tended to overestimate the number of potentially eligible premises. In order to take this into account, Analysys Mason has refined its analysis by incorporating the new premises-level data into its model.[92] Due to the timelines in the project, this subsequent exercise has not been a full scale revised analysis but we believe it does provide a better estimate of the costs of a universal broadband service. This additional analysis is reported as an addendum to Analysys Mason's report (Annex 6). It forms the basis of the cost estimates we report in this document rather than the cost estimates set out in the main Analysys Mason report.

[91] The total number of UK premises is consistent with data used in Ofcom's Connected Nations report. For 2016, we use a premises base of approximately 28.8 million. This is comprised of UK residential and small business premises. It excludes PO boxes and large organisations.
[92] The premises-level data was aggregated to postcode level so it could be used in the Analysys Mason model. A premises-level analysis would require a new model to be built which was not possible within the timelines of the project.

Limitations of the analysis

8.15 Estimating future deployment costs is not always straightforward and, where data is limited, it may depend on various assumptions or simplifications. Therefore, in these cases, actual costs may reasonably be expected to differ from those which are modelled once deployment occurs. This has been seen in commercial deployments across our sectors. Some commercial deployments have seen providers materially change plans as a result of deployment experience: for example, BT's original plans to deliver 25% of its superfast rollout through FTTP[93] were adjusted as it learned more on costs and operational issues from actual deployments. Other providers have seen costs per connection for some technologies fall compared to their original business case: for example, TalkTalk reported in November 2016 that build costs for its FTTP trial network in York (a joint venture with Sky and CityFibre) have come in "significantly under" the target cost per home passed of £500.[94]

8.16 As indicated above, it is important to recognise that our cost modelling work does not give a precise cost estimate. Instead, it is designed to provide preliminary estimates of the order of magnitude of the costs and to identify the key cost drivers to inform policy formulation in this area.[95]

8.17 For instance, one significant assumption we have made is that there will be 80% take-up of the universal service offering.[96] This is intended to represent the long-term level of take-up of broadband services. Compared to an assumption of 100% take-up, this has the effect of increasing Cost per Premises Connected (CPPC) because it means that the fixed costs are spread over relatively fewer consumers. However, it does not significantly increase total deployment costs because the bulk of the costs associated with fixed line technologies tend to be relatively insensitive to the number of customers using them.

8.18 Analysys Mason did undertake sensitivity testing on a number of the underlying assumptions, including the assumption about the level of take-up. These are reported in Annex 6.

8.19 The assumption about take-up has the effect of meaning that the bottom-up model is not a strict 'on-demand' model as it presumes that network will be built in an area and then made available to whoever demands it. In effect, it is more like a network deployment undertaken with effective demand aggregation. We have discussed the issue of demand aggregation in more detail in Section 7.

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[93] BT Group, Annual Report 2010, https://www.btplc.com/Sharesandperformance/Annualreportandreview/pdf/BTGroupAnnualReport2010.pdf

[94] TalkTalk, Interim results for the 6 months to 30 September 2016, November 2016, https://www.talktalkgroup.com/dam/jcr:b15a5082-b720-45bf-bf06-07cfd7101ce4/H1%20FY17%20RNS%20FINAL.pdf

[95] We also note that there are potential linkages between this modelling and that which could be undertaken as part of the Wholesale Local Access market review consultation if we consider an estimate of the costs of deploying fibre networks is necessary to support the analysis or any remedies. However, we consider that the two pieces of analysis would be distinct as they look at deployment to different areas, have different purposes (setting a charge control versus estimating the preliminary costs of a universal broadband intervention) and will use different data sources.

[96] This is in line with the approximate current level of take-up of broadband services in the UK. It is rounded from 78% in Ofcom's *Connected Nations 2015* report (paragraph 4.26) and is also consistent with the level of take-up reported in the 2016 Connected Nations. https://www.ofcom.org.uk/__data/assets/pdf_file/0028/69634/connected_nations2015.pdf

Estimates of deployment costs

8.20 Combining the three different technical specifications and the three projections of deployment gives us a total of nine scenarios. In this section, we report the headline cost estimates for these different scenarios. Figure 8.1, below, provides a high-level summary of the estimated costs for each of our scenarios and deployment projections.

Figure 8.1: Estimates of total costs

Total cost	Scenario 1: 10Mbit/s download speed	Scenario 2: 10Mbit/s download + 1Mbit/s upload	Scenario 3: 30Mbit/s download + 6Mbit/s upload
2016	£1.1bn	£1.6bn	£2.0bn
End of 2017	~£1.0bn	~£1.5bn	~£1.7bn
Early 2020s	~£0.7bn	~£1.0bn	~£1.4bn

8.21 We start by summarising the results of the Analysys Mason bottom-up modelling before going on to discuss the results for the top-down modelling for the end of 2017 and the early 2020s.

Estimate of costs based on the number of eligible premises in 2016

8.22 Analysys Mason bottom-up model estimates the cost of serving the eligible premises under each technical specification based on extending and/or upgrading the existing fixed network. It explicitly modelled four technologies; Fibre to the Premise Gigabit Passive Optical Network (FTTP GPON), Fibre to the Cabinet Long Range Very-high-bit Digital Subscriber Line (FTTC LR-VDSL), Fibre to the Cabinet Very-high-bit Digital Subscriber Line 2 (FTTC VDSL2) and Fixed Wireless Access (FWA).[97] It also reported the least cost way of deploying to the eligible premises by using the combination of the least cost technologies in each cabinet serving area.

8.23 The Analysys Mason model enables us to look at a number of different aspects of the costs of different specifications of a universal broadband service. In particular, it enables us to look at:

- The total deployment cost of implementing universal decent broadband split by nation;
- The average cost per premises connected;
- The costs associated with the four different technologies;
- The optimal mix of technologies to serve eligible premises; and
- An annualised cost which allows us to also factor operating costs into the output.

8.24 Figure 8.2, below, sets out the estimates for the lowest-cost technology for each postcode-group together with the average Cost per Premise Connected. These are

[97] It also qualitatively considered a number of other technologies which were not modelled. For example, it considers that HFC has similar deployment costs to FTTP GPON and, so, only chooses to model FTTC GPON. It also or considers that satellite does not meet the latency requirements of the specifications.

the revised estimates produced by Analysys Mason to take account of the updated data on the number of potentially eligible premises.

Figure 8.2: Summary of estimated costs based on number of eligible premises in 2016

	Scenario 1: 10Mbit/s download speed	Scenario 2: 10Mbit/s download + 1Mbit/s upload	Scenario 3: 30Mbit/s download + 6Mbit/s upload
Potentially eligible premises	1.4m	2.6m	3.5m
Total cost	£1.1bn	£1.6bn	£2.0bn
Cost per premises connected (CPPC)	£950	£770	£680

8.25 These estimates show how overall costs increase as the technical specification threshold increases. This is predominantly driven by the number of premises potentially eligible in each specification. At the same time, average CPPC falls across the three scenarios. There are a number of reasons for this:

- Many premises which are eligible under Scenario 3 but not Scenario 1 are in less remote areas and are, therefore, cheaper to connect. This is reflected in our future deployment scenarios, below, where reducing the number of eligible premises by the end of 2017 to 1.9 million, removes many of the cheapest premises from the analysis and substantially increases the average CPPC of Scenario 3 to £990;

- There are economies of scale in the deployment of fixed technologies. For example, the costs of backhaul and cabinets can be shared over a greater number of customers in scenarios with a greater number of eligible premises;

- The requirements for all scenarios are met predominantly by FTTC rather than FTTP (see Figure 8.4, below). The similar technology mix across scenarios means that there are no large additional costs from needing to deploy more FTTP in Scenario 3. It also indicates that many premises in Scenarios 1 and 2 would receive download speeds above 10Mbit/s when the USO is met.

8.26 These effects are most pronounced for our cost estimates based on 2016 network availability and potentially eligible premises. By the end of 2017, we estimate that a significant number of homes may be able to receive superfast broadband as a result of commercial and public sector deployments. This reduces the number of premises eligible under Scenario 3 at the end of 2017 to 1.9 million from 3.5 million. However, costs only fall from £2.0bn to £1.7bn. This demonstrates the first effect set out above as a number of the 'cheaper' premises to serve are no longer eligible for a broadband USO given growth in superfast broadband network availability. This is set out in more detail in Figure 8.7.

8.27 Figure 8.3 splits the total deployment costs by UK Nation. Around 75% of these costs are accounted for in England.

Figure 8.3: Summary of estimated costs by Nation based on number of eligible premises in 2016 (core network costs cannot be split[98])

Costs by Nation	Scenario 1: 10Mbit/s download speed	Scenario 2: 10Mbit/s download + 1Mbit/s upload	Scenario 3: 30Mbit/s download + 6Mbit/s upload
England	£0.8bn	£1.2bn	£1.4bn
Wales	£0.1bn	£0.1bn	£0.1bn
Scotland	£0.1bn	£0.2bn	£0.2bn
Northern Ireland	£0.04bn	£0.04bn	£0.1bn
Core network costs	*£0.04bn*	*£0.04bn*	*£0.1bn*
Total	**£1.1bn**	**£1.6bn**	**£2.0bn**

8.28 The Analysys Mason model also indicates how meeting a particular technical specification is likely to involve deployment of a number of different technologies. Figure 8.4 reports the different technology mixes used in the model in terms of the proportion of lines deployed for each technology for each specification in its analysis.

Figure 8.4: Total number of lines in the lowest cost technology mix

Technology	Scenario 1: 10Mbit/s download speed	Scenario 2: 10Mbit/s download + 1Mbit/s upload	Scenario 3: 30Mbit/s download + 6Mbit/s upload
VDSL2	1m (74%)	2m (80%)	2.8m (83%)
LR-VDSL	0.3m (21%)	0.3m (11%)	0.3m (10%)
FTTP	0.1m (4%)	0.2m (9%)	0.2m (7%)
Total	**1.4m**	**2.6m**	**3.5m**

8.29 Figure 8.4 indicates that FTTC technologies are relatively more cost effective than others in most areas throughout the scenarios and, so, FTTC technologies make up the largest proportion of the modelled deployment. It also indicates that FWA is not the least cost technology in any area and so does not feature in the modelled USO deployment.

8.30 It is striking in that that the mix for Scenario 3 implies that, in the majority of cases, it would be cheaper to deliver this technical specification using FTTC technologies rather than FTTP. That is, the modelling suggests that it would be cheaper to meet this specification by building new cabinets to move FTTC equipment closer to end users rather than deploying fibre to their premises.

8.31 Figure 8.4 could, therefore, imply that if the baseline speed of any universal broadband specification were to increase from 10Mbit/s to 30Mbit/s over time, this would be predominantly done by further deployment of FTTC technologies rather than 'leap-frogging' to a completely new technology such as fibre. However, it does not imply anything about technical specifications above that of Scenario 3: a different network architecture altogether may be most efficient for specifications with download speeds above 30Mbit/s, such as ultrafast.

[98] We cannot break down core network costs by Nation in the analysis.

Differences between technologies

8.32 Analysys Mason's results highlight how the average CPPC differs depending on the technology used and the specification. In particular, they show that FWA tends to be very expensive to deploy in many areas and is particularly expensive for the superfast broadband scenario. This is because the capacity requirements of this specification result in a large number of sites needing to be built to meet the specification.

8.33 The average cost per premises of FTTC technologies is lower than other technologies throughout the scenarios. The economies of scale associated with this technology mean that, in contrast to FWA, the cost per premises connected of FTTC drops substantially as the specification in the scenarios increases. Average FTTP CPPC also drops substantially over the scenarios but remains high relative to FTTC technologies. Figure 8.5 reports the average cost per premises connected for each technology if it were to be deployed to all eligible premises and the average cost per premises connected where the most cost-effective technology is deployed in each postcode group (the 'lowest cost option').

Figure 8.5: Estimated cost per premises connected by technology in 2016

Technology	Scenario 1: 10Mbit/s download speed	Scenario 2: 10Mbit/s download + 1Mbit/s upload	Scenario 3: 30Mbit/s download + 6Mbit/s upload
FWA (low frequency)	£1,562	£1,807	£6,958
FWA (high frequency)	£1,506	£1,530	£4,878
FTTC VDSL2	£1,426	£964	£804
FTTC LR-VDSL	£1,127	£856	£723
FTTP	£6,536	£3,793	£3,119
Lowest cost option	£950	£768	£680

Deployment versus ongoing costs

8.34 The analysis so far in the document has presented the estimated one-off costs to deploy infrastructure to potentially eligible premises since this is the main factor that has previously constrained further commercial coverage. However, it may be that undertaking analysis purely on this basis might not completely reflect the differences in the structure of costs between technologies. For example, it may bias the analysis against technological options which have large upfront costs but low ongoing costs.

8.35 Analysys Mason has, therefore, also estimated an annualised cost[99] of the different technological solutions to give another perspective on the potential costs of a broadband universal service. In particular, this highlights that the relatively large ongoing costs[100] of fixed wireless technologies make them significantly more

[99] This is calculated using a tilted annuity where, in simple terms, capital costs are spread throughout the lifetime of the infrastructure, factoring in the economic depreciation of those assets. This is added to its ongoing operational costs. More detail on how the annualised cost is calculated is reported in Annex 6.

[100] The scale of these ongoing costs is driven primarily by Analysys Mason's assumption that the majority of mobile sites are rented. This assumption has the impact of reducing deployment costs of FWA but increasing the annualised costs. Analysys Mason undertook a sensitivity test to test the impact of this assumption (see Annex 6.)

expensive compared to fixed technologies on an annualised basis, particularly for higher specifications.

Figure 8.6: Estimated annualised cost by technology (cost per year)

Technology	Scenario 1: 10Mbit/s download speed	Scenario 2: 10Mbit/s download + 1Mbit/s upload	Scenario 3: 30Mbit/s download + 6Mbit/s upload
FWA (low frequency)	£929m	£2,067m	£11,200m
FWA (high frequency)	£893m	£1,733m	£7,807m
FTTC VDSL2	£301m	£405m	£470m
FTTC LR-VDSL	£246m	£368m	£432m
FTTP	£936m	£1,069m	£1,209m
Lowest cost option	£273m	£385m	£512m

Estimate of costs based on projections of deployments in 2017 and 2020

8.36 The deployment assumptions used by Analysys Mason in its modelling are likely to be conservative as Analysys Mason itself recognises. As mentioned above, one such assumption is the estimates of the numbers of potentially eligible premises at implementation of a USO. Our 2016 estimates are conservative because we expect there to be additional commercial and government-funded broadband roll-out to some premises which currently do not receive the technical specifications in the near future. In particular, there could be a significant effect from ongoing investment in superfast broadband by BDUK together with the potential introduction of LR-VDSL by BT.

8.37 Given this, we have also produced preliminary estimates of the potential costs of delivering universal broadband when using assumptions which take into account projections for the future roll-out of broadband networks. We forecast what roll-out might be around the end of 2017 and in the early 2020s.

8.38 In order to produce preliminary cost estimates for these dates in the future, we have taken Analysys Mason's cost modelling and made assumptions about how roll-out of the BDUK programme and additional commercial roll-out might reduce the number of eligible premises.

8.39 Figure 8.7 below reports a summary of the headline estimate deployment costs to serve premises we have assumed to be potentially eligible at the end of 2017.

Figure 8.7: Estimated total costs at the end of 2017

	Scenario 1: 10Mbit/s download speed	Scenario 2: 10Mbit/s download + 1Mbit/s upload	Scenario 3: 30Mbit/s download + 6Mbit/s upload
Potentially eligible premises	~1.1m	~1.8m	~1.9m
Total cost	~£1.0bn	~£1.5bn	~£1.7bn
Cost per premises connected (CPPC)	~£1,060	~£940	~£990

8.40 We note that the reduction in the estimated total deployment costs is not proportional to the reduction in the number of eligible premises. This is driven by two separate and additive factors:

- We assume that the BDUK programme targets the cheapest premises to serve between now and the end of 2017. That means that the premises eligible for a universal broadband service at the end of 2017 are the costliest premises to serve; and
- Significant fixed costs mean that total costs cannot be reduced in proportion to a reduction in the number of premises.

Figure 8.8: Estimated total costs by Nation at end of 2017 (core network costs cannot be split by Nation)

Costs by Nation	Scenario 1: 10Mbit/s download speed	Scenario 2: 10Mbit/s download + 1Mbit/s upload	Scenario 3: 30Mbit/s download + 6Mbit/s upload
England	~£0.7bn	~£1.0bn	~£1.2bn
Wales	~£0.1bn	~£0.1bn	~£0.1bn
Scotland	~£0.1bn	~£0.2bn	~£0.2bn
Northern Ireland	~£0.03bn	~£0.03bn	~£0.03bn
Core network costs	*~£0.03bn*	*~£0.03bn*	*~£0.04bn*
Total	**~£1.0bn**	**~£1.5bn**	**~£1.7bn**

8.41 Figure 8.9 sets out the equivalent estimates of the total costs of a universal broadband service in the early 2020s.

Figure 8.9: Estimated total costs by early 2020s

	Scenario 1: 10Mbit/s download speed	Scenario 2: 10Mbit/s download + 1Mbit/s upload	Scenario 3: 30Mbit/s download + 6Mbit/s upload
Potentially eligible premises	~0.3m	~0.6m	~1.1m
Total cost	~£0.7bn	~£1.0bn	~£1.4bn
Cost per premises connected (CPPC)	~£2,650	~£1,990	~£1,470

8.42 The estimates of the costs associated with the projected number of premises at the early 2020s is inherently more speculative than the estimates of total costs at the end of 2017. Again, costs do not fall proportionally with premises for the same reasons as above. Given the disproportionately large cost to serve the most difficult premises, the estimates show that there would still be substantial costs to cover the remaining premises even if implementation was delayed by a number of years.

Figure 8.10: Estimated total costs by Nation by early 2020s (core network costs cannot be split)

Costs by Nation	Scenario 1: 10Mbit/s download speed	Scenario 2: 10Mbit/s download + 1Mbit/s upload	Scenario 3: 30Mbit/s download + 6Mbit/s upload
England	~£0.5bn	~£0.7bn	~£1.0bn
Wales	~£0.04bn	~£0.1bn	~£0.1bn
Scotland	~£0.1bn	~£0.1bn	~£0.1bn
Northern Ireland	~£0.02bn	~£0.02bn	~£0.03bn
Core network costs	*~£0.01bn*	*~£0.01bn*	*~£0.02bn*
Total	**~£0.7bn**	**~£1.0bn**	**~£1.4bn**

Reasonable cost threshold

8.43 The results of our modelling indicate that costs are not uniform across premises in each scenario. The cost curves, Figure 8.11 and Figure 8.12, below provide a good indication of this. For example, the Analysys Mason modelling estimates the final 1% of UK premises are materially more expensive to connect than the others. It also estimates that the most expensive premises to connect could cost approximately £45,000. This is only an indicative number – the real cost will depend on a number of factors, and cost modelling exercises become increasingly unreliable at the margins. However, it is a helpful indication that, given the potential scale of the costs of connecting the most remote premises, it may be too onerous for any intervention to include even the very most expensive premises. Figure 8.11 below shows the distribution of connection costs among the premises we estimate to be below the specification for Scenario 1. Figure 8.12 reports the same figure for the final 1% of UK premises, illustrating how much higher the relative costs are for the most difficult to reach premises compared to the others.

Figure 8.11: Cost per premises connected - Scenario 1, 2016

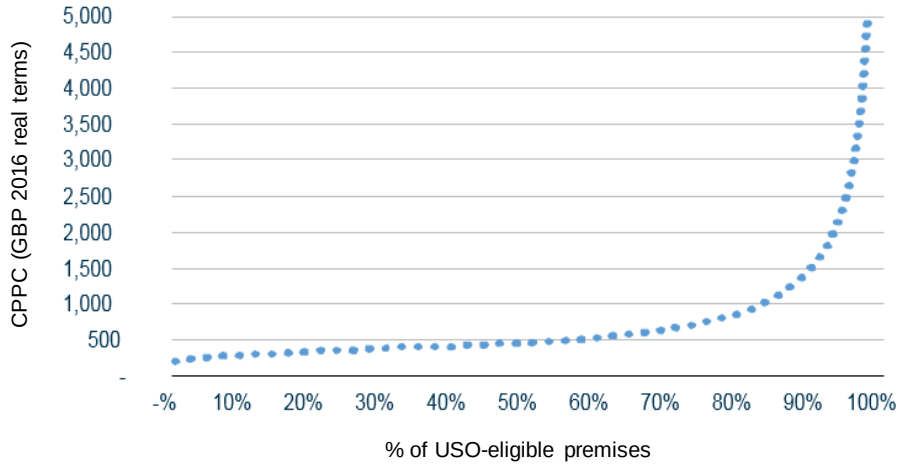
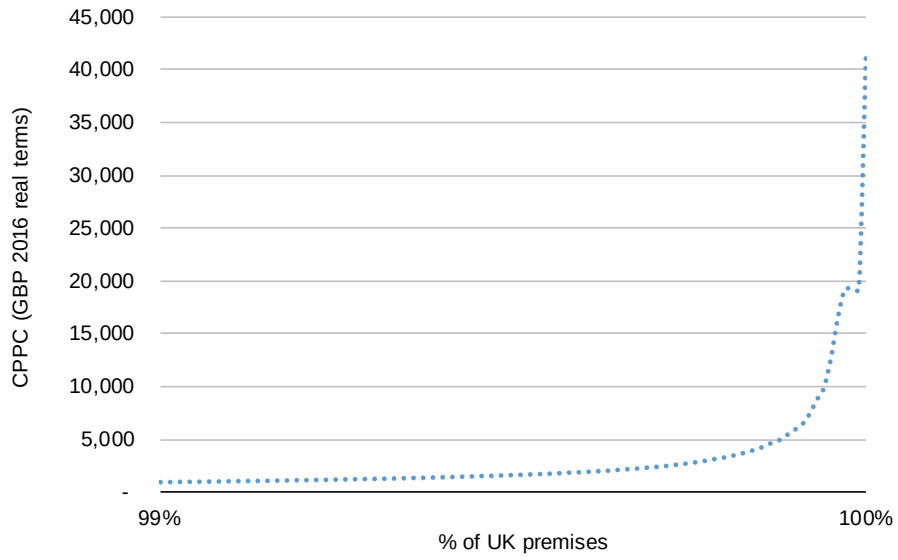


Figure 8.12: Cost per premises connected - final 1% of UK premises, Scenario 1, 2016



8.44 The potential cost of any intervention could be could be mitigated by introducing a reasonable cost threshold ('RCT'). Under such an arrangement, the appointed provider(s) would not be required to serve premises where the costs were above the RCT unless the customer was prepared to pay the difference between the RCT and the cost of building or upgrading a suitable connection. Where the customer is not prepared to pay the difference, there might then be the option of a lower specification service.

8.45 By way of comparison, for the voice telephony universal service, the RCT is £3,400. Where connection costs are above this threshold, consumers are given the option of paying the amount above it.[101] This is known as an 'excess construction charge'.

8.46 We note that limits on coverage obligations have been used in other sectors. We have already mentioned the RCT that applies in the case of the telephony USO. In other areas, policy makers determined Digital Terrestrial Television (DTT) coverage would reach 98.5% of UK homes, meaning 1.5% cannot receive Public Sector Broadcasting services over DTT. There is also an RCT in relation to the provision of water services.[102]

8.47 A decision about the level of any RCT would involve a trade-off between the aspiration for the policy to reach as many consumers as possible and the burden on any universal service fund, which would eventually be passed to some degree to people and businesses. We discuss the potential effect of any broadband universal service fund on consumers and industry further in Section 9.

[101] To be clear the consumer is only responsible for the amount in excess of the RCT.
[102] Water companies are entitled to recover the "reasonable costs" of making a water or sewerage connection - this varies by provider. For example, the 2015-16 maximum reasonable cost contributions that Scottish Water will provide for domestic dwellings is £1,555.31 for water and £1,805.35 for sewerage (http://www.scottishwater.co.uk/you-and-your-home/your-charges/2015-2016-charges/information-about-your-charges-201516/rcc-for-dwellings-201516). The water company will also only usually connect to the boundary of the road where the main is and the customer will then have to pay for the cost of connecting their property to this, including if it goes across a third party's land.

Impact of the cost threshold on outcomes

8.48 The level of any RCT will play an important role in determining the overall impact of the policy. In particular, the imposition of a RCT will mean that a number of the most expensive premises to connect would not be eligible. This would subsequently reduce the overall cost and thus the net cost to be met through any fund.

8.49 The imposition of a RCT which is uniform across the UK may lead to different outcomes in different areas of the country if cost conditions vary significantly. For example, the Analysys Mason modelling suggests that a slightly higher proportion of Welsh and Scottish premises are in the most expensive 1% of UK premises to connect than in the other Nations.[103]

Possible approaches to setting the cost threshold

8.50 The level of the RCT would need to be consistent with Government's policy objectives. Conceptually, to reflect economic efficiency, the RCT would be set at a level which took into account the wider social benefits derived from connecting these customers e.g. it would reflect not just any externalities from greater connectivity but also other benefits relating to social and economic inclusion, the delivery of government services etc. In reality, it is likely to be difficult to derive an estimate of the wider social benefits with any level of precision.

8.51 Against this background, given the wide range of potential costs per premises and the risk of actual costs exceeding predictions, a mechanism to set a total cost ceiling may be required. There are likely to be two main options in setting any RCT:

- Option 1. Following the example of the RCT for the telephony USO, a cap on the cost per premises might be set at a specified level;
- Option 2. The RCT is set at a level to achieve a specific policy objective in relation to the coverage of any broadband intervention. For example, it could be set so that 99.5% of premises are covered by the intervention i.e. only the most expensive 0.5% of premises would not be eligible.

8.52 Figure 8.13 below, sets out our estimates of the impact of different RCTs based on the cost curves derived by Analysys Mason. The table sets out, how, for both an absolute cost cap per premises and a defined policy goal in terms of coverage:

- the number of premises that might fall outside broadband universal service varies; or
- the overall cost of any broadband universal service might fall.

[103] Estimates indicate that 1.2% of Welsh premises and 1.1% of Scottish premises are in the most expensive 1% of UK premises to serve. This is compared to 0.9% of English premises and 1% of premises in Northern Ireland.

Figure 8.13: Illustrative effect of different Reasonable Cost Thresholds in 2016

	Scenario 1: 10Mbit/s download speed		Scenario 2: 10Mbit/s download + 1Mbit/s upload	
Reasonable cost threshold	# of premises left unserved	Reduction in costs of USO	# of premises left unserved	Reduction in costs of USO
>£3,400	49K	~£340m	59K	~£380m
>£5,000	30K	~£280m	34K	~£300m
>£10,000	12K	~£180m	12K	~£170m
Exclude last 1%	280K	~£620m	280K	~£690m
Exclude last 0.5%	140K	~£500m	140K	~£540m
Exclude last 0.1%	28K	~£270m	28K	~£270m

	Scenario 3: 30Mbit/s download + 6Mbit/s upload	
Reasonable cost threshold	# of premises left unserved	Reduction in costs of USO
>£3,400	72K	~£430m
>£5,000	38K	~£320m
>£10,000	12K	~£170m
Exclude last 1%	280K	~£750m
Exclude last 0.5%	140K	~£570m
Exclude last 0.1%	28K	~£270m

8.53 Figure 8.13 highlights that the cost of any intervention increases when a higher RCT is imposed. For example, in Scenario 1 the difference between an RCT at £10,000 rather than £3,400, is that an additional 40,000 premises are eligible, but overall costs would be approximately £160m higher. Alternatively, under Scenario 2, setting a coverage target of 99.5% (i.e. excluding the last 0.5%) could see 140k premises outside of any broadband universal service intervention. This would reduce the potential cost by £540m. Increasing coverage to 99.9% would see 30k premises left outside the intervention, and the cost reduced by £270m.

Options for consumers where the cost of provision is above a reasonable cost threshold

8.54 If the cost of delivering a broadband connection to a particular premises exceeds the RCT, one option would be for the consumer to pay the additional cost of delivering a fully specified connection (i.e. the amount in excess of the reasonable cost threshold). Alternatively, the consumer could choose to take an alternative broadband product with a lower technical specification (for example, satellite, which is already available to consumers on a commercial basis).

8.55 If the objective is to ensure every household, including those above the RCT, have access to broadband as part of this intervention, it may be desirable to help the most expensive-to-connect premises to access a lower specification broadband service which, although not capable of delivering the full USO technical specification, is still superior to their current broadband connection. While satellite broadband may not be attractive as a general solution, it may provide the ultimate backstop for the hardest-to-reach premises.

Section 9

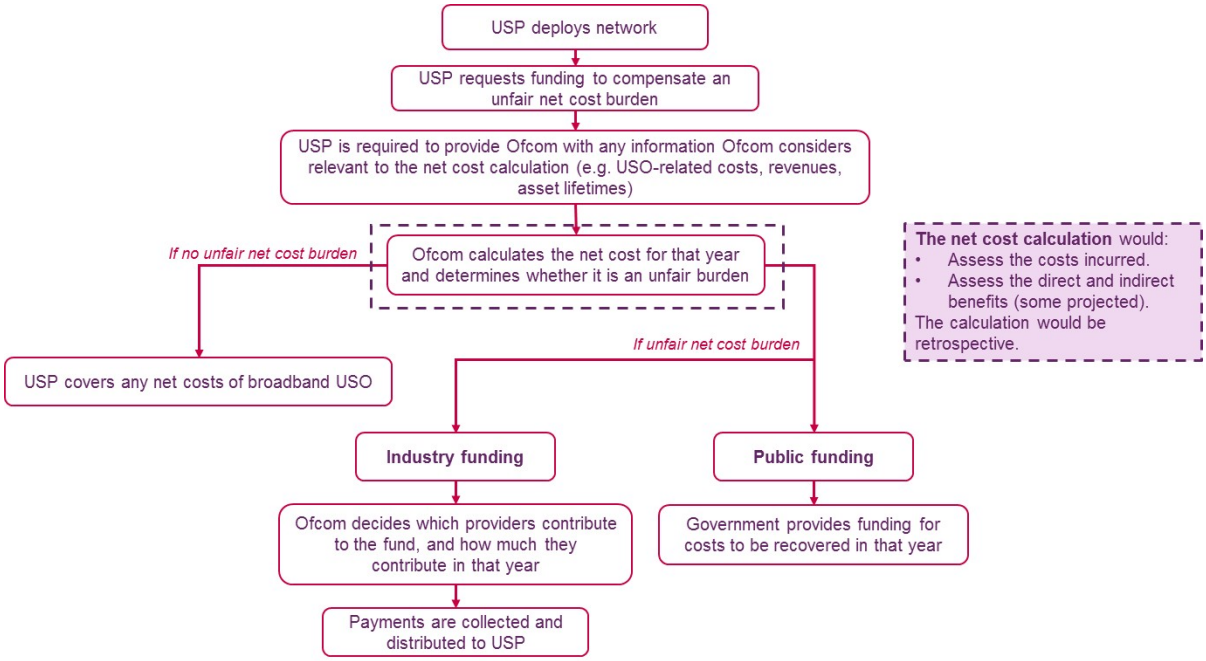
Funding universal broadband

9.1 Government has a range of options for funding interventions to deliver decent universal broadband. Some options, such as setting up an industry fund or providing public funding, sit within the scope of the USD and could be used to fund a formal broadband USO.[104] Some of the policy outcomes set out in this report could be delivered by further direct public procurement of new networks.

9.2 However, the Government has requested technical advice from Ofcom on the design of a broadband USO and has previously expressed a preference for industry funding.[105] We therefore focus on the design of an industry fund in accordance with the USD in this section. Figure 9.1 provides an overview of funding under the USD.

9.3 It should be noted that we would need to consult on the specific operation of the industry fund as part of any broadband USO implementation. Ahead of any such consultation, we do not suggest how an industry fund would work in detail. However, an industry fund could have result in some costs being passed on to consumers through higher retail prices for communications services. As such, we have outlined some of the main aspects of an industry fund to allow us to consider the potential effects of intervention.

Figure 9.1: How the broadband USO could be funded under the USD



[104] Under the USD three options are available for compensating the USP for any unfair burden: public funding; an industry fund; or a combination of the two.
[105] Letter from DCMS to Ofcom, March 2016
https://www.ofcom.org.uk/__data/assets/pdf_file/0027/53676/dcms_letter.pdf

9.4 In the rest of this section, we consider:

- An indication of how an industry fund might operate; and
- The potential implications for consumers of an industry fund, particularly the impact on consumer bills, based on the cost estimates outlined earlier.

The design of an industry fund for the broadband USO

9.5 The USD requires any industry fund to be **transparent**, **non-discriminatory**, **proportionate**, and **cause the least market distortion**. It defines 'least market distortion' as meaning the costs should be recovered in a way that minimises the impact on end-users of communications services, and suggests this could be achieved by spreading costs as widely as possible.[106] This would be the guiding principle for any fund design.

9.6 The main concerns raised by respondents to the CFI were the potential for an industry fund to:

- Cause **distortions to competition**, by affording pricing advantages to competitors that are not required to contribute to the fund; and
- Cause **distortion to consumers' purchasing decisions** by increasing retail prices.[107]

9.7 We outline below how contributors and contributions to the fund should be designed to mitigate the risk of market distortion, and we discuss potential market distortion more broadly in Section 10.

Calculating the unfair net cost burden

The net cost calculation

9.8 As noted above, the USP(s) can receive funding to compensate any unfair net cost burden associated with providing the broadband USO. The net cost is the total cost of providing the broadband USO, less any direct or indirect benefits derived by the USP(s). Benefits can include:

- revenues from new customers who switch to the USP(s);
- incremental revenues from existing customers who choose to take up a higher specification service over the USO connection e.g. superfast broadband; and
- indirect benefits such as brand image.

9.9 We would calculate the net costs of the broadband USO following a request for funding from the USP(s). The USP(s) would be required to provide Ofcom with any information we consider relevant to the calculation of the net cost. For example, this may include detail on its costs and revenues, as well as any other relevant

[106] The Universal Services Directive, http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32002L0022
[107] Ofcom, Summary of responses to the CFI, August 2016 https://www.ofcom.org.uk/__data/assets/pdf_file/0025/68335/summary_of_responses.pdf

information.[108] The calculation would take care to assess only the costs that the USP(s) would have chosen to avoid had there been no broadband USO.[109] We would then determine whether any net cost of providing the broadband USO was an unfair burden on the USP(s).

The cost recovery period

9.10 It is likely that the USP(s)'s level of expenditure would vary over time. For example, in the early years of implementation the USP(s) would likely need to provide upfront capital expenditure required to meet reasonable requests for connections. In future, it would also incur ongoing operating costs and periodic expenditure on replacing network infrastructure. The level of the unfair net cost burden could therefore similarly vary from year to year.

9.11 There are three broad approaches that could be adopted for net cost recovery:

- **Recovery year-by-year:** Costs would be recovered in full close to when they were incurred (with a one-year delay). Given the changing costs from year-to-year, the amount of funding required could vary significantly between different payment periods.

- **Recovering over the economic lifetime of the asset:** Annualised costs (plus a reasonable return) would be recovered by the time the invested assets reached the end of their useful life.[110] The amount of funding required would be broadly steady year-to-year, but this may result in the longest period for a universal service fund to operate: some network assets have very long lives, offset by relatively shorter lives for other assets.

- **Recovering costs over a defined period:** The recovery period could be limited to mirror typical expected 'payback' timescales for commercial network investment projects.[111] This could reduce the length of time that the fund would need to operate, but could result in costs being recovered before the end of the assets' economic life, meaning the USP(s) may continue to make return on assets that were initially partially funded through the universal service fund.

9.12 For the purposes of our illustrative analysis of the potential impact on consumer bills below, we have assessed the effect of limiting the cost recovery period to a relatively short payback period of seven years. This has allowed us to consider the upper bounds of any impact on consumer bills. A longer cost recovery period would reduce the impact on consumer bills.

9.13 In all cases, funding would stop after any unfair net cost burden, including financing costs, has been paid in full. In line with the USD, payments would be determined and distributed to the USP(s) retrospectively. No funding would be available in advance.

[108] Ofcom would gather this information using our powers under Section 135 of the Communications Act 2003.
[109] As set out in Annex IV of the Universal Service Directive http://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX:32002L0022
[110] The lifetime of the assets deployed to deliver a broadband USO will depend on the 'blend' of the different types of infrastructure used to deliver the broadband USO.
[111] For example, BT has claimed in its response to our Strategic Review of Digital Communications that payback on its NGA investment is around 12 years. BT's response to our Strategic Review of Digital Communications, 2015, https://www.ofcom.org.uk/__data/assets/pdf_file/0029/37937/bt.pdf

Contributions to and payments from an industry fund to the USP(s)

9.14 If we determine there is an unfair net cost burden requiring funding to be met by industry, we would need to identify which providers should contribute to the fund and the level of payments required from each contributor.

Contributors to an industry fund

9.15 Ofcom would need to make regulations establishing which providers will be required to contribute to an industry fund. Contributions may only be sought from companies providing electronic communications networks or services.

9.16 There are broadly three sets of providers that could be required to contribute: fixed broadband providers; fixed broadband and mobile providers; or all providers of an electronic communications network or service.[112] The factors we would consider when deciding which providers to include are set out in Figure 9.2.

Figure 9.2: Which providers should contribute to an industry fund?

Contributors	In favour	Against
Fixed broadband providers only	Mitigates the risk of potential distortions of competition between fixed broadband providers if all fixed broadband providers (including providers of copper, fibre and cable broadband) are required to contribute. No provider would have a pricing advantage over another.	A small base of contributors could increase the financial burden on contributors. If contributors passed the cost on to their customers, the impact on customers would be greater. Risks distortions to competition if higher prices in the fixed broadband market cause consumers to substitute fixed broadband for mobile broadband.[113]
Fixed broadband and mobile providers only	Spreads the costs more widely, reducing the incentive for contributors to pass costs on, or the impact on retail prices if contributors do pass costs on. Mitigates the risk of distortions to competition.	Impact on households is broadly similar if mobile is required to contribute compared to if only fixed broadband providers are required to contribute, given most households have more than one mobile subscription. The impact per household would vary depending on the number of mobile subscriptions.

[112] Essentially, all providers that contribute to Ofcom's networks and services budget.

[113] We have previously said, as part of our market definitions for our programme of market review work, that mobile services are not currently in the same market as copper, fibre and cable fixed broadband services. However, determining whether services should contribute to the industry fund on the basis of existing market definitions may not reflect in entirety the potential for competitive distortions to arise. Market definition for competition assessment purposes results in a binary outcome. That is, services are either "in" a market or they are not and this does not allow for the fact that there could be a degree of substitution between fixed broadband and mobile services without the services necessarily being in the same market for the purposes of our market reviews. Therefore, it is possible that excluding mobile providers from the fund based just on standard market definitions could cause competitive distortions.

All providers of an electronic communication network or service	Spreads costs widely and addresses any potential distortions to competition between, for example, fixed broadband, mobile broadband, satellite and fixed wireless services.[114]	Possible implications for the efficiency and simplicity of the fund; would require the collection of many small payments from many small providers.

9.17 In general, spreading contributions as widely as possible across providers would reduce the potential for competitive distortion and the potential burden placed either on providers or their customers.[115] We would also aim to avoid placing an excessive financial and administrative burden on providers, and may not require providers to contribute to the fund if their revenues are below a certain threshold.

9.18 If Government's preference remains for an industry-funded broadband USO, we would have to consult which types of providers should be required to contribute when implementation of the policy passes to us.

How would contributions be judged?

9.19 Contributions to any universal service fund could be judged on a number of bases:

- **Number of subscribers:** this approach could risk market distortions by favouring providers with fewer, high-value customers.
- **Profitability:** given variability in providers' profits, this could result in less predictable costs for providers, and might enable providers to manipulate their cost base to reduce profits liable for the fund contributions.
- **Total revenues:** this could include revenues potentially not deemed relevant to the broadband USO, for example revenues from pay-TV customers or other parts of the business.
- **Relevant revenues** (e.g. broadband revenues): this might have the least effect on competition, given it is targeted at the specific service being provided by the universal service. However, as providers increasingly bundle services, identifying relevant revenues may be difficult.

9.20 We would also aim to ensure the impact of contributing to the fund was similar for competitors to avoid disproportionately impacting any individual provider or creating any distortions to competition.

[114] Again, although in our market reviews to date we have determined that mobile, fixed wireless and satellite services are not in the same market as fixed broadband providers, this may not reflect the possibility for some degree of substitution at the margins if fixed broadband prices were to rise, without this necessarily meaning these services are in the same market.

[115] For example, reducing providers' contributions to the fund (by spreading the costs more widely) could reduce contributors' incentives to pass costs on to their customers. Alternatively, spreading costs across more customers would reduce the cost to each customer.

Illustrative analysis of the potential impact on consumer bills

It is likely that contributors would pass on at least some of the cost of contributing to the fund on to their customers

9.21 We expect that contributors to an industry fund would pass at least some of the cost of the broadband USO on to their customers through retail price increases. This could result in higher bills for broadband customers in areas that are currently served commercially to cross-subsidise delivery of the USO.

9.22 To assess the upper bounds of any impact, we have considered how consumer bills might be affected if industry were to pass on the full costs to consumers. In practice, the extent to which contributors are able to pass on costs would be determined by the demand- and supply-side conditions (i.e. the responsiveness of consumers to price increases and the extent of competition between providers). For example, in a competitive broadband market where prices may already reflect costs, it might be expected that an increase in costs which affected all providers equally would result in an increase in consumer prices (all other things being equal). The design of any fund would take into account the need to minimise competitive distortions, i.e. limiting the opportunity for providers to avoid participating in an industry fund and so receiving a competitive advantage from lower underlying costs, and therefore prices.

9.23 Whether and how to actually pass on any costs to customers would be a commercial decision for contributors. This analysis is therefore illustrative only. Communications providers offer a range of services across different sectors, and some may seek alternative ways to recover contribution costs, for example across a range of services they provide.

9.24 To carry out this analysis, we have assumed that:

- **BT is the USP for the majority of the UK (and KCOM in Hull):** We set out in Section 11 why we believe this is a reasonable working assumption, but in summary lack of willingness from industry to come forward to be designated as a USP suggests this is the most likely outcome.
- **The unfair net cost burden is the same as the total cost of deployment:** This is a simplifying assumption to provide a view on the potential upper bound of possible costs for consumers.
- **Contributors to the fund pass 100% of the cost on to their customers.**
- **There is no further broadband deployment after August 2016:** The cost estimates considered in this analysis are based on our measure of the number of premises that could be eligible for the broadband USO today. However, as outlined in Section 4, we anticipate that further roll-out could in future reduce the number of eligible premises and the overall cost of the USO.
- **There is no reasonable cost threshold (RCT) in place to limit costs.**[116]

[116] Setting a reasonable cost threshold (RCT) would place a ceiling on the costs it is deemed 'reasonable' for the USP to incur to serve any individual premises. If a RCT was set, the USP(s) would not be required to meet requests for connections where the cost of providing the connection was higher than the RCT.

- **The costs are recovered over seven years:** Again, this allows us to assess a more extreme scenario. In practice, the costs could be recovered over a longer period reflecting the economic life of the assets.

Figure 9.3: Illustrative impact on consumer bills per month[117]

Cost recovered from:	Fixed broadband subscribers only[118] (per subscription)	Fixed broadband and mobile subscribers[119] (per household)
Scenario 1	£0.87	£0.75
Scenario 2	£1.33	£1.14
Scenario 3[120]	£1.60	£1.38

9.25 By way of context, our Communications Market Report sets out typical household spend on communications services is £82.17 per month on fixed voice, fixed internet and mobile voice and data services.[121] The impact on bills in Figure 9.3 would represent an increase on typical monthly household spend on fixed voice, fixed internet and mobile services of between 1-2%, depending on the technical specification.

9.26 However, there is a wide range in monthly spend on communications services between different groups of customers. For example, we track retail prices of five different 'baskets' of communications services, which are designed to reflect five 'typical' household types. Analysis of the prices required to fulfil the usage requirements of these households, based on the tariffs offered by the largest residential communications providers in July 2016, shows that the lowest possible monthly spend for these households (excluding the TV licence and mobile handsets) ranged from:

- £44 per month for a household with basic needs (medium use of fixed voice, two mobile phones with low use, free-to-air-TV and no fixed broadband connection); to

- £181 for a family household (medium use of fixed voice and superfast fixed broadband, four mobile phones with medium-to-high use and pay-TV with premium sports and film content.[122]

The above is intended as an illustration of the different prices different households could pay; in reality, there are many different packages available to consumers, and households may pay significantly above or below the prices outlined above.

9.27 As a result, a fixed cost passed through by industry on to consumer bills would affect households on specific packages and with different spend profiles differently. This variation in potential spend by consumers indicates the need for special consideration for the lowest-income households to ensure they are not

[117] Includes illustrative cost of capital and VAT.
[118] Includes SMEs.
[119] Mobile subscribers are post-pay only and may include some corporate subscriptions. Assumes an average of 1.8 mobile subscriptions per premises.
[120] An industry fund could only be used to pay for a broadband USO within the scope of the USD. We discuss in Section 3 the considerations with delivering a superfast USO under Scenario 3.
[121] Ofcom, Communications Market Report 2016: Key Market Trends, Figure 1.2, https://www.ofcom.org.uk/__data/assets/pdf_file/0021/39315/charts_cmr_uk_2016.pdf
[122] Ofcom, ICMR 2016, https://www.ofcom.org.uk/research-and-data/cmr/cmr16/international See link for comparative international pricing methodology, including components of the households.

disproportionately impacted. We discuss the possibility of introducing a social tariff for broadband in Section 6.

How different policy choices may affect consumer bills

9.28 Across the three scenarios, the impact on bills was on average around 18% lower if the USP(s) was not required to provide a broadband USO connection to the final 0.1% and around 36% lower if the final 0.5% were not included. Our analysis in Section 8 highlights the challenges with delivering the broadband USO specification to the final 1%, which are the most expensive to serve. Some premises may potentially cost tens of thousands of pounds to upgrade.

9.29 Our analysis suggests the impact on consumer bills at a household level is reduced by c.14% if both fixed and mobile providers contribute to cost of a universal service compared to fixed providers only.[123] This is because most households tend to have more than one mobile phone subscription. If mobile providers were required to contribute to the fund, the impact on bills per connection (as opposed to per household) would range from around £0.28 to £0.52. This is in effect the 'price' increase users would see on each of their bills. This is around 68% lower per subscription than if only fixed providers contributed. However, from a policy perspective, the more relevant number is the effect on household, not per subscription, bills. This takes into account multiple subscriptions in a household, and is the actual cost consumers could face.

9.30 For completeness, a further option could be to recover the cost of the broadband USO from those customers who benefit from it. However, this would not be practical: it would undermine the purpose of a USO, which is to share the costs of inclusion more widely across all consumers, and it would result in a disproportionate cost per connection for USO households (for example it could cost an additional c.£12-£16 per month if costs were recovered over seven years, which would not be affordable for many).

9.31 Finally, our analysis highlighted how the cost recovery period impacts consumer bills. A cost recovery period of 10 years, for example, reduces the impact on consumer bills by around 20% per month compared to a cost recovery period of seven years. However, it clearly extends the period over which consumer bills would be affected by this policy.

[123] This compares the impact per subscription for fixed broadband only to the impact per premises for fixed broadband and mobile (assuming that each premises has on average 1.8 mobile subscriptions). We consider this is a reasonable simplifying comparison, given that premises have one fixed broadband subscription.

Section 10

Mitigating potential market distortions through effective policy design

10.1 A broadband USO would be a significant market intervention but it should bring benefits for people and businesses. In responses to our call for inputs, stakeholders raised a number of concerns about the USO's potential to cause a range of market distortions.

10.2 Specifically, stakeholders raised a number of concerns about possible market distortion caused by the USO:

- USO funding might diminish the USP(s)' incentives to invest in areas which may in fact be commercially viable;
- the USO could lead to inefficient overbuild of existing networks, distorting competition;
- any USO risks crowding out potential private sector investment in broadband infrastructure by third parties given the risk that a USP could use USO funds to deploy at a lower private cost (given the costs were in part covered by USO funds);
- the USO could lead to competitive distortions in the retail market, for example through a marketing advantage in being able to offer its services to every premises in the country, or alternatively through market power that allowed the USP to set higher prices to USO customers;
- technologies used to fulfil the USO such as Long-Reach VDSL could have an adverse effect on retail competition.

10.3 Such factors could have effects on network investment incentives, potential network or retail competition and innovation.

10.4 In this section we discuss how any such negative effects could be minimised. It is important to remember, however, that the aim of the USO is to provide decent broadband for all. While the risks around market distortion are an important concern that should be taken into account in designing the USO, there is a likely trade-off between these risks and the importance to consumers of getting a decent broadband service.

Mitigating potential market distortions

10.5 Throughout this advice to Government, we have considered how potential market distortions can be mitigated through the design of any broadband USO. We summarise the risks of market distortion, and these mitigations here.

Potential distortion	Mitigations
Diminished incentives for the USP to invest in network upgrades in potentially commercial areas	This risk can most effectively be addressed through the net cost calculation. Where the USP(s), over the life of the investment, makes an actual commercial return, then the net cost calculation will take that into account and limit (or remove entirely) the ultimate contribution made by the USO fund. However, in cases where the net cost / return calculation is run over shorter periods (for example shorter than the economic life of the assets deployed) there is a risk that the USP(s) will receive USO funds in the early part of the asset life, but also make commercial returns in the period after the net cost calculation has ceased. This is why a policy position of costs (plus a reasonable return) recovered over the full economic life of the assets may be preferable. However, where network deployment involved civil works and physical ducts or fibres, this could be a long period of time (20 years+).
Risk of inefficient overbuild of existing networks	As we set out in Section 5, there are several ways which to avoid overbuild. Most notably, limiting eligibility to those premises where there is no network capable of offering the USO technical specification. In order for this to work in practice, other providers would need to make available, on a voluntary basis, those areas where they had network and affirm these networks met the USO technical specification. They would have an incentive to do so in order to avoid overbuild from the USP(s). The USP(s) would need a clear incentive to ensure that it took the availability of other networks into account. This could be achieved by allowing it to only claim funding from the USO fund for rollout of its network to localities where other networks were not available.
Crowding out new third party investment through the risk of prospective 'subsidised' USP network build	It may be possible to take into account existing plans for, or the potential for, future investment by third parties in determining whether a particular premises qualifies for a USO connection. However, this runs the risk of significantly complicating the USO process for consumers, and may only allow a relatively short term forward view. It may be preferable to give all network operators a clear timetable for implementation of the USO within an area. This would offer a period of time to invest in extending coverage, removing the need for a USO in that area, as in the case above.
Distortions in retail competition	If the USO conferred any material benefits to the USP at the retail level (for example in terms of marketing and therefore market share), we would seek to capture these in the net cost calculation.

	There are two broad ways to address any abuse of market power by a USO allowing it to increase prices to USO customers. Firstly, either a uniform pricing position or price cap, imposed on connection or service prices would constrain the USP's pricing options. Secondly, where the USP had market power, we could impose SMP based wholesale access obligations and associated charge controls to promote effective retail competition.
New USO network technologies could have an effect on retail competition	Long-reach VDSL (LR-VDSL) is one of the technologies that could be used to fulfil the USO. Some stakeholders expressed concerns that its deployment could lead to market distortions. As discussed in our Digital Communications Review[124], there is a possibility that LR-VDSL could prevent the deployment of local loop unbundling services from other providers on adjacent lines. While in such cases we would consider the pros and cons for consumers on a case-by-case basis, it is likely that the deployment of LR-VDSL is likely to have significant net benefits for consumers.

[124] Ofcom, Strategic Review of Digital Communications 2016, https://www.ofcom.org.uk/phones-telecoms-and-internet/information-for-industry/policy/digital-comms-review/conclusions-strategic-review-digital-Communications

Section 11

Designating the universal service provider(s)

11.1 In this section, we set out how a USP may be designated if a broadband USO (in accordance with the USD) is chosen as the means of delivering decent broadband. We consider:

- how the designation process should work under a USO; and
- whether it is appropriate to a single provider for the whole of the UK or a number of providers for geographic regions.

11.2 The designation of a USP must be made using "*an efficient, objective, transparent and non-discriminatory designation mechanism, whereby no undertaking is a priori excluded from being designated*" and only communications providers may be designated. This gives rise to two options for designation, a competitive process or direct designation.

A competitive process to designate would be preferable but may not be feasible

11.3 Our objective when designating the USP(s) is for a competitive, technology-neutral procurement process where possible.[125] A competitive process could encourage efficiencies and act as a means of establishing the net costs of the broadband USO for consideration in any future calculation of the net costs.[126] It could also allow smaller providers a chance to take part in the delivery of a broadband USO.

11.4 One of our objectives for the CFI in April was to understand the extent to which providers may be keen to be a USP, and how far such interest could support a meaningful competitive process. We asked stakeholders for indications of specific geographic areas they might be able to serve.[127]

11.5 While the majority of respondents to our CFI were in favour of a competitive designation process, few industry stakeholders expressed a willingness to become a designated USP. Although satellite providers indicated they could be willing, there are a number of reservations in respect of provision by satellite. These include: satellite is already available and yet consumer uptake is low, which may be indicative that it is an inappropriate primary solution given potential concerns about capacity and latency (depending on the technical specification).[128] A number of respondents wanted smaller regional providers to be involved in delivering the broadband USO,

[125] Ofcom, Strategic Review of Digital Communications 2016, https://www.ofcom.org.uk/phones-telecoms-and-internet/information-for-industry/policy/digital-comms-review/conclusions-strategic-review-digital-Communications

[126] The net cost is the cost of providing the USO minus any benefits derived by the USP (e.g. revenue from broadband services delivered over the USO connection). The USP(s) can only receive funding if the net cost of providing the USO is found to place an unfair burden on the USP(s). Funding is further discussed in Section 9.

[127] Ofcom, Designing the broadband universal service obligation: Call for inputs 2016, https://www.ofcom.org.uk/consultations-and-statements/category-1/broadband-uso-cfi

[128] These concerns are outlined in Annex 4.

but most did not explicitly express a preference to be designated as a USP for a specific geographic area.

11.6 In light of responses to the CFI, we now consider that a competitive process is unlikely to bring forward any interested providers, and therefore a more restricted process whereby all providers are considered and an appropriate provider is chosen (subject to a consultation process) is more likely. Our objective would be to designate the most efficient USP(s) to ensure overall policy costs policy are proportionate, and the minimum level of funding is required.

It is likely there would be only a small number of providers capable of providing a USO

11.7 Many respondents[129] to our CFI envisaged many different USPs being designated for different, often highly localised, regions. However, it may not be practical to designate multiple USPs. As noted above, few providers to date have expressed an interest in being designated as a USP. Although we may impose an USO on communications providers, we may not consider it is proportionate to impose it on smaller providers unless they have volunteered. This is because smaller providers may be less able to bear the initial up-front costs of deploying the broadband USO, given that, as noted in Section 9, funding for any unfair net cost burden is only made available retrospectively.

11.8 In addition, there could be a number of drawbacks to designating multiple regional USPs. The complexities of this approach could:

- Increase the administration costs;
- Lead to a longer implementation process;
- Increase costs and inefficiencies (given they may not be able to exploit economies of scale and scope in the way a larger USP might); and
- Require an additional administrative layer to provide consumers with a single point of contact for the broadband USO to avoid creating confusion.

11.9 As such, designating many regional USPs is likely to be disproportionate and potentially inefficient. We envisage that a very small number of USPs would be designated, that between them would be able to meet reasonable requests from across the UK.

11.10 The primary reason that premises cannot receive 10Mbit/s is because their broadband is delivered over a long copper line.[130] Existing UK network structures mean that the majority of these premises will be connected to BT's copper network or will live in areas where BT's network is present, except in Hull, where KCOM has an extensive presence.[131] As such, we expect the most efficient outcome would be that

[129] For example, NFU Scotland, the CLA, INCA, the Advisory Committee for Wales, Shropshire Council, Grey Sky Consulting, Northern Ireland Department for the Economy, the Scottish Government, the Local Government Association, Three, OneWeb, TalkTalk, ISPA and many individuals.
[130] We discuss the reasons why some premises cannot current receive 10Mbit/s in Section 3.
[131] For historic reasons, KCOM has an extensive network in the Hull area, where BT's presence is minimal. Hull is counted as a separate market to the rest of the UK in our market reviews.

KCOM is the designated USP for Hull and BT is the designated USP for the rest of the UK. BT and KCOM are also the designated USPs under the telephony USO.

11.11 Another provider with an extensive existing network and possibly the scale to bear the upfront costs of the broadband USO is Virgin Media. However, Virgin Media's cable network delivers speeds much higher than 10Mbit/s. Unlike with BT's copper network, we do not expect there are any premises in areas where Virgin Media is available that are not currently available to receive at least 10Mbit/s. It would be possible to designate Virgin Media as the USP for areas close to the edge of its existing footprint, but it could potentially be complicated to define the areas where Virgin Media would be responsible for meeting requests for the broadband USO. As such, we do not think it would be appropriate to designate Virgin Media as a USP.

11.12 There may be some areas where a compelling case can be made to designate a different local USP, for example in an area where a provider has an extensive existing network that either does not currently deliver 10Mbit/s or that currently does not cover every premises in that area. We would remain open to the possibility of designating some regional USPs in these circumstances although in practice we expect this will be rare.

11.13 Designating a small number of USPs has a number of associated benefits:

- **A quicker, more straightforward process** with **lower administration costs** in comparison to designating multiple USPs for different small localities. This could potentially lead to a quicker implementation process;

- **Efficiency gains** resulting from economies of scale given the substantial fixed costs required to deliver the broadband USO, for example from buying equipment for large network deployment;

- **USPs could apply the lessons learnt from deployment in one area to another.**

11.14 Given it is likely that most requests under the broadband USO would be met by BT and KCOM as the designated USPs, our objective would be to ensure that smaller providers are protected from overbuild of their existing networks by the USPs and are not disincentivised from further rolling out their networks. We discuss how to mitigate these risks in Section 10.

Securing value for money

11.15 Regardless of how the USP(s) is designated, it will be important to secure value for money. Some respondents to our CFI were concerned that a USP that was not designated by a competitive process might not be incentivised to deliver the broadband USO in the most efficient way. Although a competitive process could determine the net cost of the broadband USO, as it is only possible for a USP to recover from a USO fund in respect of an unfair net cost burden, we do not consider that the method of designation (direct or competitive) to have any bearing on whether the USP is incentivised or not to deliver it in the most efficient way. The net cost calculation to determine whether there is a net cost burden would also only take into account efficiently incurred costs.132 Depending on the size of its revenues, the USP(s) could also be a significant contributor to any industry fund.

[132] Section 9 outlines how the net cost calculation would work in practice in more detail.

Section 12

Review

Reviewing the universal service policy is a key benefit of a universal service obligation

12.1 Consumer demand for internet services evolves quickly and demand for connections that are faster, or more highly specified in other ways (e.g. contention) will grow in the future. The broadband universal service would need to be enhanced over time to ensure it continues to include consumers and small businesses who rely on it. Otherwise, consumers and businesses that rely on it could fall further behind, as society and business' use of online services evolve.

12.2 The main mechanisms available to ensure the USO remains effective net take two forms:

- Ongoing monitoring, to assess the performance and effectiveness after it is implemented; and
- A formal review, conducted less frequently with the aim of changing the technical specification.

We discuss these two mechanism in the rest of this section.

We would monitor the broadband universal service on an ongoing basis

12.3 After its implementation, it may be appropriate for Ofcom to monitor how the broadband universal service is meeting the needs of consumers and small businesses as communications networks and services develop over time. Ongoing monitoring will be a critical process to help us judge whether the policy is effective.

12.4 Ofcom gathers extensive data on the availability, take-up and use of broadband in our annual Connected Nations reports, which we report on to Government. Through this work, we track the performance of services delivered over all broadband connections, and analyse use patterns among consumers. This work could be an important tool to help inform our view of whether the broadband universal service is effectively meeting the needs of those who rely on it in future.

12.5 Another thing we may monitor is whether consumers are sufficiently aware of their right to request a decent broadband connection. We could also track the affordability of the universal service as compared to others commercially available.

A formal review would be a more significant undertaking

12.6 In addition to our ongoing monitoring work, from time to time it will be important to carry out a full-scale review of the technical specification, testing whether it needs to be enhanced to ensure it continues to meet the needs of consumers and small businesses.

12.7 While monitoring would allow us to track how the universal service broadband intervention is performing and what kind of results it is delivering for consumers, a

review would be a much larger undertaking. A review would be carried out less frequently, and may lead to the implementation of a change or enhancement to the technical specification in recognition of significant developments in the market or in consumers' behaviour.

12.8 However, changing the specification could have significant implications for all other aspects of its design, potentially altering which technologies are best placed to deliver the universal service and even making existing networks redundant. Changing the technical specification could affect which premises are eligible to receive the universal broadband and could require a change to the designated provider(s).

12.9 Given the potential scale of a review, it will be important to ensure its timing is appropriate and proportionate.

The timing of the first review would depend on the technical specification of the universal service

12.10 We have highlighted above the importance of enhancing the technical specification in future to ensure premises that depend on the universal service can continue to fully participate in digital society. However, this would need to be balanced against the potential for frequent, short-term reviews which might create inefficiencies and disincentives for investment in broadband.

12.11 Uncertainties for industry around the prospect of the specification being rapidly reviewed and enhanced could increase the overall costs of deployment and lead to inefficiencies, either by requiring the USP(s) to over-specify its initial deployment or by quickly making the initial deployment and investment redundant. In the case of a USO, the Digital Economy Bill intends to give the Secretary of State the power to direct Ofcom to review the broadband USO at any time, after consulting with Ofcom. The Government could indicate when the first review would be to give the USP(s) more certainty, allowing for a stable period of cost recovery and avoiding the risk of USP(s) having to hit a moving target.

12.12 The timing of the first review and the frequency of subsequent reviews would depend on the technical specification that is initially selected by Government. A more highly-specified service would be able to meet the needs of consumers and SMEs for a longer period of time than a more limited technical specification, but its initial deployment would cost more.

The technology deployed to deliver the universal broadband would preferably have headroom for growth

12.13 Over-specifying the technology deployed to deliver today's universal broadband intervention to ensure it is also capable of delivering any enhanced technical specification in the future would not be the most efficient way of delivering for today's needs, and could result in higher costs than necessary (furthermore if intervention is undertaken using the USO under the USD, there is a risk that it would not be consistent with a USO under the USD). For example:

- it is difficult to predict exactly how consumers' needs will change, and which aspects of the technical specification may need to evolve. For example, in future contention or latency may be more important than greater downstream bandwidths; and

- technological advancements could mean that cheaper technologies are able to deliver faster speeds in the future.

12.14 However, the need to enhance the technical specification could support the case for selecting a provider that is likely to deploy technologies that can be more easily upgraded in future.

We would consider a range of factors when deciding whether to enhance the technical specification

12.15 A review could be initiated in reaction to social, commercial, or technological developments. Below, we outline the range of factors that would inform how the technical specification should develop in future. This would help inform a wider careful assessment of the costs and benefits of a review to ensure any upgrade to the technical specification was proportionate.

Technical requirements to access essential online services

12.16 The universal broadband service would need to allow people to continue to access essential services to secure continued social and digital inclusion. It is possible that future essential online services could require changes the technical specification, for example, download speeds, upload speeds and latency.

12.17 Consumers' bandwidth or technical needs may grow over time, for example with more connected devices collectively requiring more bandwidth, particularly at peak times.

Following technical specifications in commercial areas

12.18 Some respondents to the CFI called for a broadband USO that tracked commercial broadband developments, e.g. average broadband speeds. The argument for this would be to ensure continued equality of outcome for those in commercial and non-commercial areas over time.

12.19 However, adopting a simple mechanistic approach raises risks of a potentially much higher technical specification in the future. For example, commercial deployments that deliver 1Gbit/s might become the norm in order to support services like multiple ultra-high definition video streams. This could therefore suggest the need for ultrafast broadband networks in non-commercial areas, with significant cost implications (or a significant number of homes excluded from this newly defined broadband USO given any reasonable cost threshold adopted).

12.20 A more proportionate approach may be to consider the services and applications being used over higher speed connections, identifying where consumers and businesses might suffer harm as a result of broadband networks that are not technically capable of supporting such services. This approach would take into account technology developments and any emerging technical 'gap' between USO and non-USO areas, but would overlay actual usage, and evidence of usage being curtailed in areas with slower broadband speeds.

12.21 A more mechanistic approach to USO evolution may also raise the risk of overbuild and market distortions. Unless networks in less densely populated areas were upgraded at the same pace as those in denser (typically more urban) areas, there is a risk of overbuild of existing networks.

Ensuring that everybody gets the same technical specification

12.22 Some respondents to the CFI felt that everyone should have access to the same broadband services, regardless of where they live, arguing this would be the only way to ensure fairness. However, this is not a requirement from the Government's intention to introduce a broadband USO to avoid digital exclusion.[133]

12.23 Intervention to deliver very highly-specified universal broadband would also carry the risk of significantly distorting the broadband market by inefficiently overbuilding existing commercial deployments, making widely-used technologies redundant before providers have had a chance to make a return on their investment, and by disincentivising future commercial investment.

[133] https://www.gov.uk/government/news/government-plans-to-make-sure-no-one-is-left-behind-on-broadband-access

Annex 1

The current legislative framework

A1.1 The current legislative framework for a broadband universal service obligation (USO) derives from the Universal Service Directive (USD).134 The provisions of the USD have been implemented in the United Kingdom through the Communications Act 2003 ("the Act") which sets out the process for the imposition of universal service obligations on providers. The Digital Economy Bill proposes to amend the Act to make express provision for a broadband USO.

A1.2 We note that the European Commission is currently reviewing the EU regulatory framework for electronic communications, which includes what is currently called the Universal Service Directive. However, proposals have not yet been adopted by the European Council and are subject to several months' discussion and debate at the European Parliament and Council before they are adopted. Timelines for a new framework to be in place are uncertain.

Universal Service Directive

A1.3 Under Article 4 of the USD, Member States may designate a universal service provider (USP) which is required to fulfil reasonable requests for a "*connection at a fixed location to the public communications network*" which must be "*capable of supporting voice, facsimile and data communications at data rates that are sufficient to permit functional Internet access, taking into account prevailing technologies used by the majority of subscribers and technological feasibility.*" Since amendments were made to the USD in 2009, functional Internet access includes broadband services and Member States are therefore able to impose universal service obligations to secure broadband access.

A1.4 Article 3 of the USD states that these services must be "made available at the quality specified to all end-users in their territory, independently of geographical location, and, in the light of specific national conditions, at an affordable price."

Communications Act 2003

A1.5 Under section 65 of the Act, the Secretary of State makes an Order setting out the extent to which particular services must be provided, made available or supplied throughout the UK.[135] The Digital Economy Bill (HC Bill 87)[136] proposes to amend section 65 to make express provision for the Secretary of State to include broadband connection and services within the Order.

A1.6 Subject to the passing of the Bill, the Order may contain guidance about matters relating to the speed or other characteristics of broadband connections or services

[134] European Parliament and Council Directive (EC) 2002/22 (OJ L108, 24.4.2002) on universal service and users' rights relating to electronic communications networks and services (as amended by European Parliament and Council Directive (EC) 2009/136 (OJ L337, 18.12.2009).
[135] The Secretary of State has, to date, made an Order under section 65, the Electronic Communications (Universal Service) Order 2003 (the "*2003 Order*").
[136] http://www.publications.parliament.uk/pa/bills/cbill/2016-2017/0087/cbill_2016-20170087_en_2.htm#pt1-l1g1

that it (as well as or instead of setting out any of those characteristics); and guidance about any other matters relating to those connections or services.

A1.7 Once this order is made, it will fall to Ofcom to impose conditions in accordance with sections 66 to 68 of the Act. Under those provisions, Ofcom designates providers to be universal service providers (USPs) and imposes appropriate universal service conditions (USCs) to comply with the Order. This may include obligations as to prices for universal services (only connection charge), in particular where the Order includes guidance on such pricing. As to funding of the USCs, under section 70 of the Act, Ofcom may from time to time review the extent (if any) of the financial burden of compliance with a USO for a particular USP. Where Ofcom concludes that the USO imposes an unfair burden on a USP we may establish an industry fund to compensate the USP. In doing so, Ofcom will decide who should contribute to the fund and how the fund should be administered.

Annex 2

Defining the USO technical specification

Download speed

A2.1 The focus of our work on download speed to date has been on sync speed, i.e. the maximum possible connection speed achievable between the ISP's access network and the consumer premises. In practice, a connection with a sync speed of 10Mbit/s will provide an actual speed that is lower. This is due to a variety of reasons, including the quality of the home network, the arrangements inside the ISP's network and also the demand at busy hours from other users on the same network. However, a connection with a sync speed of 10Mbit/s should still provide sufficient bandwidth for most internet applications, such as web browsing, use of social media, video calling and streaming one or two streams of video content at the same time.

A2.2 In order to support a connection that has a more stable 10Mbit/s connection, the download sync speed requirement may need to increase. We estimate the cost of this under our Superfast scenario, where sync speed is at least 30Mbit/s.

Upload speed

A2.3 General internet usage requires very little upstream bandwidth, as the most popular web applications, such as web browsing, emails, online shopping and e-banking[137] largely requires user interaction in the form of text content or static images. However, as consumers increase their use of more data heavy services, such as video conferencing and uploading large media files to social media, there is a growing demand for reliable upload speeds. There are two main types of content that a typical residential user might need to upload:

- Live streams – video is streamed live e.g. for video calls;
- On-demand streams – the video is uploaded prior to streaming, e.g. a video for YouTube or social media.

A2.4 Live streams are particularly sensitive to bandwidth limitations, as a slower connection would result in a greater number of dropped data packets. This affects the quality of the video received by the user at the other end of the call, and ultimately whether the call can be maintained. For example, Skype recommends a minimum upload connection speed of 0.5Mbit/s for a high-quality video call.[138]

A2.5 On demand streams, along with other static content such as images, are less sensitive to bandwidth limitations, as the files will be uploaded to a server before it can be downloaded or streamed by the viewer. A slower connection would mean that it takes longer to upload the file, but the quality of the content should not be

[137] Figure 5.21 CMR 2016, https://webarchive.nationalarchives.gov.uk/ukgwa/20160702162836/http://stakeholders.ofcom.org.uk/

[138] https://support.skype.com/en/faq/FA1417/how-much-bandwidth-does-skype-need

affected. A 2MB file may take 30 seconds to upload on a 0.5Mbit/s connection but will need less time on a faster connection.[139]

A2.6 Most consumer broadband lines are asymmetrical, in that more bandwidth is made available for download rather than upload as users tend to download more than they upload. In some cases, a broadband line may not be able to provide an upload speed above a specified threshold although it can support a download speed meets the broadband USO requirement. For example, 2% of ADSL lines that have a download sync speed greater than 10Mbit/s do not have an upload speed faster than 0.5Mbit/s.

A2.7 Therefore, introducing an upload speed requirement will mean that even more premises may be eligible for broadband USO, as they do not have a broadband service that meets the upload speed requirement although their download sync speed is fast enough. We explore this in scenarios 2 and 3, where we consider the impact of requiring a 0.5Mbit/s or an 1Mbit/s upload speed. In the Superfast scenario we consider the impact of an upload speed requirement that is the median upload speed for current superfast broadband services.[140]

Latency

A2.8 Latency is the delay in the transmission of data, which can affect the performance of live applications. Live TV, telephony and gaming in particular suffer badly when latency is a problem. Low latency results in more responsive web browsing and easier real-time communication. A delay of around one second or more has a noticeable impact on user experience. Video streaming can tolerate higher latency based on how much buffering the streaming application allows.

A2.9 Our research on the performance of fixed broadband connections shows that average latency on a fixed broadband connection is typically between 10-30ms. Latency in other networks, particularly satellite networks, tend to be higher. Setting a requirement for a fast response will limit the network technology options that are suitable for the broadband USO.

Contention and data usage cap

A2.10 Contention and data caps are two ways in which a Communication Provider (CP) can manage the cost of maintaining sufficient capacity their network. **Contention** is the degree to which bandwidth is shared between different end users at the same network node. As the CP decides the amount of backhaul that is suitable for their network, this will affect the amount of bandwidth available to an end-user on that network, particularly at busy hours. A low contention ratio means that the capacity of the network is shared between a smaller number of end users. This may mean that the costs of the network are also shared between a smaller number of users. A high contention ratio means that the capacity is shared between more end users

[139] Most service providers (such as cloud services or social media websites) will automatically compress the file prior to uploading to improve the consumer experience. For example, a 250kB picture file will be compressed to a 60kB file before upload. The degree of compression will vary between different service providers.
Also note that due to overheads and bandwidth resource allocation determined by the application, not all of the additional bandwidth may be used for uploading the file.
[140] This includes cable networks as well as lines on FTTC and FTTP.

reducing the per user cost of the network, but it also means that the average bandwidth available to users at busy hours may be lower.

A2.11 While contention affects the bandwidth that is made available to end users, **data caps** can help manage how much data consumers use, by setting a limit to the amount of data that user can download. It is most commonly used on networks where there is a high degree of sharing, such as mobile, fixed wireless and satellite networks, so that the CP can manage the overall demand on their network.[141] Without data caps, a CP may need to invest more in ensuring that there is sufficient capacity in their network to meet their customers' needs.

[141] Over 80% of fixed broadband lines do not have data caps. https://webarchive.nationalarchives.gov.uk/ukgwa/20160702162836/http://stakeholders.ofcom.org.uk/

Annex 3

Further detail on the scale of the problem

A3.1 Section 4 outlines our estimate of the number of premises that currently cannot receive each of the technical specifications outlined in Section 3. We have also provided future projections of the number of eligible premises for the end of 2017 and the early 2020s. This is to reflect ongoing publicly-funded and commercial broadband roll out programmes, which we expect to reduce the number of premises that cannot receive each of the three scenarios for the technical specification.

A3.2 In this annex, we provide further detail on our estimates of the number of premises that cannot receive each of the three technical specifications. We have split the number of premises by nation, and by rurality within each nation. We have also provided projections for the end of 2017 and the early 2020s. For the purpose of these future projections, we have made some broad assumptions about which premises might no longer be eligible at the end of 2017 and early 2020s (as set out in Annex 5). We consider that this is reasonable as a basis for producing indicative cost estimates in the absence of more precise information but recognise that it is unlikely to be reflective of reality.

Figure A3.1: Projected estimates of the number of eligible premises, by nation and by rurality: 2016, 2017 and 2020

	Million premises (*as % of total premises in Nation*)	Scenario 1: 10Mbit/s download speed	Scenario 2: 10Mbit/s download + 1Mbit/s upload	Scenario 3: 30Mbit/s download + 6Mbit/s upload
Today 2016	England	1m (*4%*)	1.9m (*8%*)	2.6m (*12%*)
	Rural	*0.6m (3%)*	*0.8m (3%)*	*1.2m (5%)*
	Urban	*0.3m (1%)*	*1.2m (5%)*	*1.5m (7%)*
	Scotland	0.2m (8%)	0.4m (*14%*)	0.4m (*17%*)
	Rural	*0.2m (6%)*	*0.2m (8%)*	*0.2m (9%)*
	Urban	*0.03m (1%)*	*0.2m (7%)*	*0.2m (9%)*
	Wales	0.1m (*9%*)	0.2m (*12%*)	0.2m (*16%*)
	Rural	*0.09m (7%)*	*0.1m (8%)*	*0.1m (10%)*
	Urban	*0.03m (2%)*	*0.06m (4%)*	*0.09m (6%)*
	NI	0.06m (*9%*)	0.08m (*10%*)	0.1m (*17%*)
	Rural	*0.06m (8%)*	*0.07m (9%)*	*0.1m (14%)*
	Urban	*0.00m (0%)*	*0.01m (2%)*	*0.03m (4%)*
	Total UK	**1.4m (*5%*)**	**2.6m (*9%*)**	**3.5m (*12%*)**
	Rural	***1.0m (3%)***	***1.2m (4%)***	***1.7m (6%)***
	Urban	***0.4m (1%)***	***1.4m (5%)***	***1.9m (7%)***
End of 2017	England	0.8m (3%)	1.5m (6%)	1.5m (6%)
	Rural	*0.5m (2%)*	*0.4m (2%)*	*0.7m (3%)*
	Urban	*0.3m (1%)*	*1.1m (4%)*	*0.8m (3%)*
	Scotland	0.1m (5%)	0.2m (9%)	0.3m (10%)
	Rural	*0.1m (4%)*	*0.09m (3%)*	*0.2m (6%)*

	Urban	*0.03m (1%)*	*0.02m (6%)*	*0.1m (4%)*
	Wales	0.1m (8%)	0.1m (8%)	0.1m (10%)
	Rural	*0.08m (5%)*	*0.06m (4%)*	*0.1m (7%)*
	Urban	*0.03m (2%)*	*0.05m (4%)*	*0.04m (3%)*
	NI	0.04m (6%)	0.03m (4%)	0.07m (9%)
	Rural	*0.04m (6%)*	*0.03m (4%)*	*0.07m (9%)*
	Urban	*0.00m (0%)*	*0.00m (0%)*	*0.00m (0%)*
	Total UK	**~1.1m *(4%)***	**~1.8m *(6%)***	**~1.9m *(7%)***
	Rural	***0.7m (2%)***	***0.6m (2%)***	***1.1m (4%)***
	Urban	***0.4m (1%)***	***1.3m (4%)***	***0.9m (3%)***
2020s	England	0.2m (1%)	0.5m (2%)	0.9m (4%)
	Rural	*0.1m (1%)*	*0.2m (1%)*	*0.4m (2%)*
	Urban	*0.1m (0%)*	*0.2m (1%)*	*0.5m (2%)*
	Scotland	0.04m (1%)	0.07m (3%)	0.1m (5%)
	Rural	*0.03m (1%)*	*0.04m (2%)*	*0.08m (3%)*
	Urban	*0.01m (0%)*	*0.03m (1%)*	*0.05m (2%)*
	Wales	0.02m (2%)	0.04m (3%)	0.08m (6%)
	Rural	*0.02m (1%)*	*0.03m (2%)*	*0.06m (4%)*
	Urban	*0.01m (0%)*	*0.01m (1%)*	*0.02m (2%)*
	NI	0.01m (2%)	0.02m (3%)	0.03m (4%)
	Rural	*0.01m (2%)*	*0.02m (3%)*	*0.03m (4%)*
	Urban	*0.00m (0%)*	*0.00m (0%)*	*0.00m (0%)*
	Total UK	**~0.3m *(1%)***	**~0.6m *(2%)***	**~1.1m *(4%)***
	Rural	***0.2m (1%)***	***0.3m (1%)***	***0.6m (2%)***
	Urban	***0.1m (0%)***	***0.3m (1%)***	***0.5m (2%)***

A3.3 We recognise that the premises numbers in Figure A3.1 show a lower number of eligible premises for scenario 2 at the end of 2017 than for scenario 1. This is a result of our modelling assumption (explained in more detail below in annex 5) whereby we assumed that in moving from 2016 to 2017, the premises which now received a 'decent' broadband connection were the ones which were cheapest to serve. We projected an overall reduction of 0.3 million premises between 2016 and 2017 for scenario 1 and a reduction of 0.8 million premises for scenario 2 over the same period for the UK as a whole. Inspection of the numbers indicates that a larger proportion of the 0.8 million premises removed between 2016 and 2017 for scenario 2 are in Northern Ireland than for the 0.3m premises dropped in scenario 1. The result of this is that there are fewer eligible premises remaining in Northern Ireland at the end of 2017 in scenario 2 than in scenario 1.

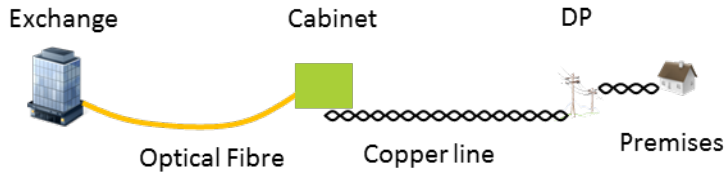
Annex 4

Overview of candidate technologies

FTTC (VDSL technology)

A4.1 Fibre to the Cabinet uses VDSL technology to provide faster broadband services to customers that are connected to an upgraded street cabinet. FTTC improves the sync speed that can be attained by upgrading the connection between the exchange and cabinet to optical fibre, as shown in Figure A4.1, to reduce the total length of copper that is used in the end to end connection.

Figure A4.1: FTTC connection



Scenario 1

A4.2 Upgrading to VDSL could be a suitable solution to upgrade lines to 10Mbit/s sync speed for consumers where the line length to their cabinet is less than 2.8km[142] and where that cabinet has not yet been upgraded to FTTC. Extending fibre to the local cabinet reduces the length of the copper line that connects to the premises, meaning that these premises can benefit from improved speeds. As of June 2016, 22% of cabinets had not been upgraded, although we expect a significant proportion of these to be upgraded in the next two years as BT continues its commercial and BDUK funded network upgrades.

A4.3 Where the consumer is connected to an upgraded cabinet but still cannot receive 10Mbit/s sync speed, it is likely that this is because they are too far from that cabinet. Some other lines that cannot received 10Mbit/s might be connected directly on a long line to the exchange. For some of these premises, it may be cost effective to install a new cabinet and reconnect the lines to this cabinet. Openreach are already doing this in parts of the network in a process called Copper Rearrangement (CuRe).

Scenario 2

A4.4 In Scenario 2 there is an additional minimum upload speed requirement. The vast majority of upgraded VDSL lines should be able to provide an upload speed that meets these additional requirements. Only a very small proportion (0.5%) of VSDL lines that currently receive at least 10Mbit/s sync speed do not have 0.5Mbit/s as an upload speed. This increases to 1.4% of lines for an upload speed of at least 1Mbit/s.

[142] The sync speed of a broadband service delivered over a copper line depends on the length of the line that connects the end user to the network. The sync speed decreases as the line length increases. Typically, copper lines that are longer than 2.8km will have sync speed below 10Mbit/s. Upgrading a cabinet to FTTC reduces the line length by replacing part of this connection with fibre (where sync speed does not decrease with increasing distance).

A4.5 VDSL networks tend to have low latency, typically around 10-20ms[143], meaning that they can meet the requirements set out in these scenarios for a medium response time. The CP can control the degree of contention in the network as it can choose the amount of backhaul it allocates to users. Similarly, the CP can set the data usage cap independently of the network technology. Therefore, contention and data usage cap are not dependent on the technology choice and relates to network architecture choices made by the CP.

Scenario 3

A4.6 As VDSL is capable of providing a sync speed of at least 30Mbit/s to lines that are 0.9km from the cabinet, it remains a suitable network technology for some areas in the Superfast scenarios. However, the number of premises that can receive this speed from a cabinet will be greatly reduced as only those premises that are sufficiently close to an upgraded cabinet will be able to receive 30Mbit/s. Premises that are further away will need new cabinets or a different network technology.

A4.7 As our SFBB scenario also sets a requirement for a minimum upload speed, even where the premises can receive at least 30Mbit/s sync speed, they may still need an additional upgrade. Currently, 18% of VDSL lines with a sync speed greater than 30Mbit/s cannot achieve an upload speed of at least 6Mbit/s. To ensure that these lines have 6Mbit/s upload speed, additional cabinets may be needed or an alternative network technology.

A4.8 Figure A4.2 summarises our assessment of FTTC against our scenarios.

Figure A4.2: Assessment of the technical capabilities of FTTC to meet the scenario requirements

	Scenario 1: 10Mbit/s sync	Scenario 2: 10Mbit/s sync + 1Mbit/s upload	Scenario3: 30Mbit/s sync + 6Mbit/s upload
Download speed[144]	Yes	Yes	Yes
Upload speed	Yes	Yes	Yes
Latency	Yes	Yes	Yes
Contention ratio/ Committed Information Rate	Yes	Yes	Yes
Data usage cap (monthly)	Yes	Yes	Yes
Ability to meet the overall requirements	**Yes**	**Yes**	**Yes**

FTTP

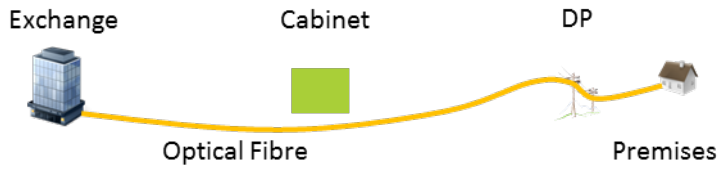
A4.9 In a Fibre to the Premises (FTTP) the consumer's broadband connection is provided by a fibre line that connects to the consumer's end premises, as shown in Figure A4.3. FTTP networks are usually deployed as either a dedicated fibre optic cable to the end user's premises (this arrangement is called Point to Point) or as a

[143] Ofcom, UK Home Broadband Performance report, Figure 2.8, March 2016 https://webarchive.nationalarchives.gov.uk/ukgwa/20160702162836/http://stakeholders.ofcom.org.uk/

[144] There are some limitations of FTTC where the line between the cabinet and the premises is very long, which might require alternative technologies to be used in certain circumstances.

shared GPON network, where a signal from the network is shared via an optical splitter to a number of end premises.

Figure A4.3: FTTP connection



All scenarios

A4.10 As fibre optic cables have very low attenuation, broadband speeds are not affected by distance (as in FTTC) and download speeds in excess of 100Mbit/s can be maintained over long distances, along with very high upload speeds. Therefore, FTTP is technically capable of providing a connection that meets the requirements of any of the USO scenarios.

A4.11 The installation of a new fibre connection to the customer requires the installation of fibre to every end premise. This can be very costly to implement, particularly in more sparsely populated areas where it is less likely that the costs of civils work can be shared among a number of users.

A4.12 Figure A4.4 summarises our assessment of FTTP against our scenarios.

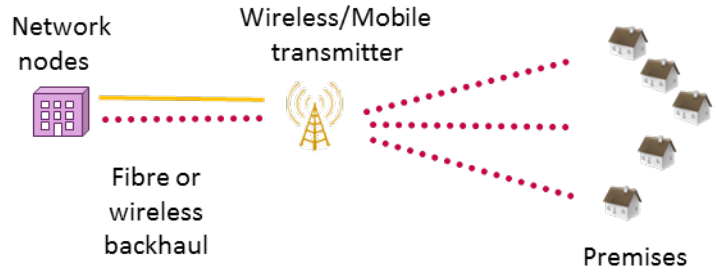
Figure A4.4: Assessment of the technical capabilities of FTTP to meet the scenario requirements

	Scenario 1: 10Mbit/s sync + 0.5Mbit/s upload	Scenario 2: 10Mbit/s sync + 1Mbit/s upload	Scenario 3: 30Mbit/s sync + 6Mbit/s upload
Download speed	Yes	Yes	Yes
Upload speed	Yes	Yes	Yes
Latency	Yes	Yes	Yes
Contention ratio/ Committed Information Rate	Yes	Yes	Yes
Data usage cap (monthly)	Yes	Yes	Yes
Ability to meet the overall requirements	**Yes**	**Yes**	**Yes**

Fixed Wireless and Mobile

A4.13 Fixed Wireless network technologies avoid the cost of the installation of a wired connection to each individual end premise. Instead, the service to the end premises is provided over a wireless connection, as shown in Figure A4.5. This connection can be shared with an existing mobile network, i.e. the mobile transmitter providing services is part of an existing mobile network, or it can be a network with dedicated spectrum serving fixed wireless users only. In both types of deployment, there could be improvements to make the best use of the available spectrum, for example, the installation of rooftop antenna.

Figure A4.5: Fixed wireless connection



A4.14 A wireless solution using an existing mobile network will need to ensure that there is sufficient capacity to serve the needs of mobile users as well as broadband USO customers.

A4.15 A fixed wireless solution using dedicated spectrum may need new network infrastructure or additional spectrum, but its spectrum capacity requirements will only need to cater for USO customers. Unlike mobile networks, where the network is designed to meet the needs of users as they move, the design of a fixed wireless network can be maximised to meet the requirements of a user in a fixed location. However, there is currently less spectrum available for fixed wireless access than is available to the mobile network operators and the spectrum that is available tends to be shared with license exempt devices[145] or is light licensed[146] which can make it harder to guarantee quality of service.

All Scenarios

A4.16 The download and upload speeds available to end users will depend on a number of factors; the spectral efficiency of the technology[147], the amount of spectrum that is used and the number of users served by a single sector. The speed available to an end user can be increased by reducing the number of users that share that cell's capacity.[148] Mobile operators reduce the number of users that share a cell's capacity by building more cell sites.

A4.17 While the network technology is technically capable of meeting the requirements for the USO scenarios, more spectrum and cell sites will be required for the scenarios which have a greater download and upload speed requirement. This limits the number of users in each cell. Therefore, it may be less feasible as an option for these scenarios.

A4.18 Mobile networks tend to have higher latency than fixed broadband networks. In the 'ping tests' that formed a part of our mobile broadband performance study, we

[145] For example, fixed wireless access shares with Wi-Fi in 2400-2483.5 MHz, 5470-5725 MHz and WiGig at 60 GHz
[146] For example, 5725-5850 MHz which is used for light licensed fixed wireless access. Light licenses do not guarantee any exclusivity of spectrum access and fixed wireless access must share with other users of the band.
[147] This is how efficiently data can be transmitted over a frequency range. A technology with greater spectral efficiency would require less spectrum to transmit the same amount of information as a technology with a lower spectral efficiency.
[148] For example, in a trial in February 2015, EE demonstrated that LTE could be used to provide 400Mbit/s to a single device, using a dedicated cell and combining a number of spectrum bands. http://ee.co.uk/our-company/newsroom/2015/02/27/ee-showcases-europes-fastest-live-mobile-speeds-as-wembley-stadium-gets-ready-for-4g-plus

found that 4G networks had slightly lower latency (around 50ms) than 3G networks (around 60ms).[149]

A4.19 Figure A4.6 summarises our assessment of Fixed Wireless and mobile against our scenarios.

Figure A4.6: Assessment of the technical capabilities of Fixed Wireless and Mobile technology to meet the scenario requirements

	Scenario 1: 10Mbit/s sync speed	Scenario 2: 10Mbit/s sync + 1Mbit/s upload	Scenario 3: 30Mbit/s sync + 6Mbit/s upload
Download speed	Yes	Yes	Yes
Upload speed	N/A	Yes	Yes
Latency	N/A	Yes	Yes
Contention ratio/ Committed Information Rate	N/A	Yes	Potentially
Data usage cap (monthly)	N/A	Yes	Yes
Ability to meet the overall requirements	**Yes**	**Yes**	**Potentially**

Satellite

A4.20 Current satellite broadband services use satellites in geostationary orbits, and the broadband data is transmitted via an uplink from the Earth to the satellite and then back to Earth to the end consumers, as illustrated in Figure A4.7. Satellite spot beams can cover large land areas[150], which means that available capacity can potentially be shared between a large number of end users.

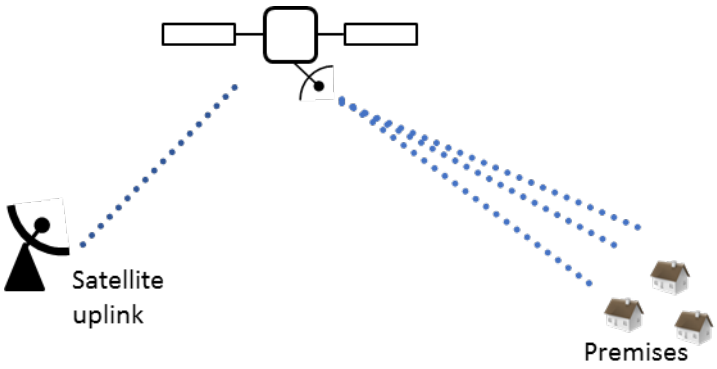
A4.21 As the capacity of a satellite service is shared over a large number of users, satellite broadband providers use data caps to manage their customers' use of data to ensure that the available capacity is shared efficiently.[151] In the short term, while we estimate that the number of USO eligible premises could be 5% of UK premises, existing deployed satellites will have insufficient capacity to serve all broadband USO premises. For example, we have estimated it would take ten geostationary satellites using the full bandwidth available in the Ka band to provide 0.7% of UK premises with 10 Mbit/s broadband (based on a 20:1 contention ratio and assuming some capacity is used for aircraft and ships).[152] However at present we believe that the capacity available from existing satellites serving the UK is significantly less than this scenario.

[149] Slide 50, Measuring mobile broadband performance in the UK, April 2015 https://webarchive.nationalarchives.gov.uk/ukgwa/20160702162836/http://stakeholders.ofcom.org.uk/

[150] For example, the Eutesat KA-SAT satellite that services Europe has four spotbeams over the UK. [151] Tooway satellite broadband services offer unlimited data use overnight between midnight and 6am. http://www.tooway.co.uk/packages-information/all-packages/

[152] p59, Space Spectrum Strategy consultation, March 2016 https://webarchive.nationalarchives.gov.uk/ukgwa/20160702162836/http://stakeholders.ofcom.org.uk/

Figure A4.7: Satellite connection



Scenario 1

A4.22 While the networks can provide very high peak speeds, as the capacity is shared between a large number of users, it is unlikely that these speeds can be sustained for all users. Therefore, satellite is suitable as a broadband USO solution where the speed is 'best efforts'[153], e.g. Scenario 1.

Scenario 2 and 3

A4.23 Current satellite broadband services have very high latency, around 600-700ms[154], which means it may not be able to meet the requirements of scenarios 2, 3 and the SFBB scenario. This is caused by the roundtrip distance travelled by the data packets, from Earth to the satellite and back to Earth. This journey time adds significant latency, affecting real time applications such as VoIP calls or gaming.[155] The launch of Low Earth Orbit satellites, which are due to be operational by the end of this decade, could reduce latency in the future.

A4.24 If BDUK and commercial investment continue, we expect the number of eligible premises to fall. If new satellites are launched commercially to increase the available capacity, there could be sufficient capacity to serve all broadband USO users under our 2020 scenario. This is where BDUK funding and commercial network roll-out extends coverage to 99% of premises, leaving 1% of premises in need of the broadband USO.

A4.25 Increasing capacity using satellite technologies requires the launch of a new satellite, therefore enforcing data caps is particularly important for satellite broadband services. Some of the most popular satellite broadband packages currently have caps of 25GB[156] or 50GB[157]. In comparison, over 80% of consumers

[153] A best efforts service does not provide any guarantees about a minimum level of service. [154] Understanding Satellite Broadband Quality of Experience, July 2011

https://webarchive.nationalarchives.gov.uk/ukgwa/20160702162836/http://stakeholders.ofcom.org.uk/

[155] Skype recommends a round trip latency of 100ms for their calls. https://support.office.com/en-gb/article/Media-Quality-and-Network-Connectivity-Performance-in-Skype-for-Business-Online-5fe3e01b-34cf-44e0-b897-b0b2a83f0917
For online multiplayer games, latency should typically be less than 150ms. http://support.xbox.com/en-GB/xbox-one/networking/slow-performance-solution

[156] http://avonlinebroadband.com/choose-your-package/choose-tooway-home/

[157] http://avonlinebroadband.com/choose-your-package/choose-avanti-home/

on fixed broadband services have no data caps.[158] Subscription fees for satellite broadband services increase for packages with higher caps. Some services will also currently apply traffic management to reduce the access speed at peak hours to manage their network.[159]

A4.26 Figure A4.8 summarises our assessment of current satellite services against our scenarios.

Figure A4.8: Assessment of the technical capabilities of current satellite services to meet the scenario requirements

	Scenario 1: 10Mbit/s sync speed	Scenario 2: 10Mbit/s sync + 1Mbit/s upload	Scenario 3: 30Mbit/s sync + 6Mbit/s upload
Download speed	Yes	Yes	Yes
Upload speed	N/A	Yes	No
Latency	N/A	No	No
Contention ratio/ Committed Information Rate	N/A	Partially	No
Data usage cap (monthly)	N/A	No	No
Ability to meet the overall requirements	**Potentially**	**No**	**No**

Future technology developments

A4.27 There are a number of technology developments which may make it easier to upgrade broadband services. On the Openreach network BT have been trialling a number of new technologies which seek to improve sync speeds on a fixed network. Although it is unlikely that these technologies will make a significant impact before the end of 2017, over the longer term, these could improve the sync speed and the reliability of the sync speed, available to end users on the Openreach network.

Vectoring

A4.28 Vectoring is a technique used to reduce the noise on the line. As the take up of superfast broadband increases, there will be increasing noise on a line due to interference between adjacent copper lines.[160] Vectoring helps to reduce the cross-talk and helps to sustain a higher speed in areas of high SFBB take up. Openreach is deploying vectoring as a part of its LR-VDSL upgrades.

[158] Figure 29, Connected Nations Report, December 2015
https://webarchive.nationalarchives.gov.uk/ukgwa/20160702162836/http://stakeholders.ofcom.org.uk/

[159] Viasat are due to launch an ultra-high capacity satellite platform in 2019, Viasat 3, which may reduce the cost of providing data capacity to satellite broadband users.
http://investors.viasat.com/releasedetail.cfm?releaseid=954123

[160] This is called crosstalk. An increase in crosstalk will affect the sync speed of the line as the crosstalk created by interference will reduce the amount of useful data that can be carried on that particular line.

G.Fast

A4.29 G.Fast provides very high speeds, up to 1Gbit/s, at very short ranges. It is designed to be deployed at a node in the network very close to an end user, such as a cabinet or a distribution point. As the speed profile of G.Fast decreases much more quickly with distance than with VDSL, it only benefits end users who live within a short range of the network node. It may be more suitable in superfast or ultrafast broadband deployments. BT are aiming to pass 10m premises with G.Fast by 2020.[161]

Other technologies

Low Earth Orbit (LEO) satellites

A4.30 Currently, satellite broadband uses geostationary satellites, which orbit the Earth at a height of 36,000km from the equator. The high latency experienced in satellite broadband services is due to this distance. Low Earth Orbit satellites will orbit the Earth at a height between 700 and 1200km above the Earth, significantly reducing the distance over which the satellite uplink and downlink have to travel. As a result, latency is expected to fall to around 50ms.[162]

A4.31 As a large number of users are expected to share the capacity from the satellites, it will remain expensive to provide sufficient capacity to meet the needs of all users, particularly data-intensive users. Therefore, contention and maintaining high data usage caps may continue to be an issue for these satellite systems.

A4.32 Commercial services on LEO satellites are expected to be available from 2020.

[161] BT Group Q1 2016/17 Results slidepack, August 2016 https://www.btplc.com/Sharesandperformance/Quarterlyresults/Investormeetingpack.pdf

[162] OneWeb response to Broadband USO Call for Inputs, June 2016 https://webarchive.nationalarchives.gov.uk/ukgwa/20160702162836/http://stakeholders.ofcom.org.uk/

Annex 5

Cost modelling methodology

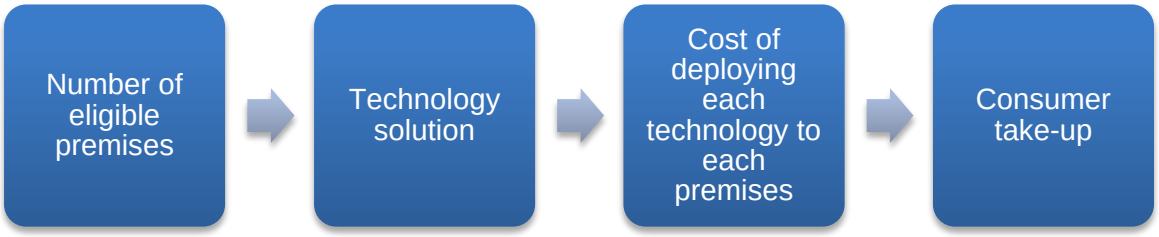
Introduction

A5.1 In Section 8 we present the preliminary estimates of the cost of deploying the USO. These estimates were based on a bottom-up cost model which we commissioned from Analysys Mason. Analysys Mason investigated the costs of serving the USO-eligible premises by upgrading and/or extending the fixed network deployed as at today. Analysys Mason's report (Annex 6) provides a detailed explanation of its modelling approach.

A5.2 We also considered the impact on the fixed-solution costs of further commercial deployment, together with the roll-out of community broadband schemes and the completion of the BDUK programme.

A5.3 In broad terms, the cost estimates depend on the four factors described in Figure A5.1, below.

Figure A5.1: Factors affecting USO costs



A5.4 In this annex, we discuss in turn:

- The data we used to generate estimates of the number of eligible premises in each of the scenarios under consideration;
- The subsequent analysis carried out to take into account more up to date data on eligible premises;
- A description of the top-down cost modelling that we have undertaken to investigate future network deployment scenarios.

Estimating the number of eligible premises - overview

A5.5 The development of the cost modelling took place in autumn 2016. At this time, the available data used to determine the number of eligible premises was a mixture of 2015 and 2016 data. This data was only available at the postcode level so Analysys Mason developed its modelling approach on this basis.

A5.6 The technical specifications (as reported in Section 3) require information both on download and upload speeds. Therefore, in estimating the number of eligible premises, we combined data on coverage (for download speeds) and average upload speed.

A5.7 If a USO is imposed, there will be a decision as to which technical specification scenario will be implemented. If a more precise estimate of deployment costs is required for the final technical specification, it may be necessary to undertake a cost modelling exercise where the modelling is based on premises-level data.

Our source data - coverage and upload speed data

Information about fixed broadband coverage

A5.8 We have collected information about fixed broadband coverage at the postcode unit level to allow us to estimate the percentage of premises that have access to a predicted download speed[163] in line with the technical thresholds in each of the scenarios (10Mbit/s or less, or 30Mbit/s or less). This is based on data from the operators which cover each postcode unit. We used June 2016 data on the percentage of premises served by BT Openreach lines and June 2015 for lines served by KCOM and Virgin Media.

Information about fixed broadband upload speeds

A5.9 We have collected information about average upload speeds at the postcode unit level. This allowed us to estimate the percentage of premises which have access to an upload speed below the technical specification of our scenarios from the operators that cover the postcode unit where those premises are located. We used average upload speed for both standard and superfast broadband lines served by BT Openreach, Virgin Media and KCOM based on June 2015 data.

Our source data - data about network infrastructure

A5.10 In determining the cost of deploying different technologies to different postcode areas, Analysys Mason required information about BT Openreach and KCOM's fixed network infrastructure. This is useful both to understand why premises in certain postcodes may not currently be able to receive the service required by different technical specifications and the costs of deploying each technology.

A5.11 In doing this, we collected the following data about BT Openreach's fixed network[164]:

- A list of exchanges, exchange locations and the number of exchange-only lines served by BT Openreach in each postcode;
- A list of cabinets and cabinet locations; and
- The status of FTTC deployment by cabinet.

A5.12 We also collected data which listed KCOM's exchanges and their locations for June 2015.

[163] As discussed in Section 3, the sync speed is the maximum speed that is achievable between the Internet Service Provider's (ISP's) access network and the consumer premises. In reality, the actual speed that is provided to an end user is typically lower than the sync speed, and this varies depending on the amount of contention in the network at that point in time, in addition to other factors such as poor in-home wiring.

[164] This data was predominantly collected in June 2016 apart from information on those cabinets which are not upgraded to FTTC nor planned to be. The data for these was collected in June 2015

Our source data – postcode unit data

A5.13 We have collected information about the total number of premises in and the area of each postcode unit. This was used to estimate the number of eligible premises for each specification and average distances from premises to network nodes.

A5.14 We also collect information on the rurality of the postcode and the Nation in which it is located. This allows us to disaggregate the cost estimates by these categories to understand the dispersion of costs and premises across rurality and Nation.

Caveats about our source data

A5.15 We consider that our source data allow us to make a reasonable estimate of the potential scale of the costs of deploying the USO to eligible premises. However, we recognise that there are a number of potential limitations with the data. In particular:

- Our source data is at the postcode level and based on forecasts of operators' coverage. This was the most precise data available at the time of the analysis and we consider that it was suitable to undertake the preliminary analysis that DCMS requested. Subsequent to completing the analysis, more precise premises-level data became available. Given the timelines of the project, it was not possible to produce a detailed bottom-up model that used this data. However, we were able to refine the original modelling results to reflect the new, more accurate premises-level data;

- For postcode units for which Virgin Media did not provide coverage data, we have assumed there is no (i.e. zero) Virgin Media coverage. This assumption might lead to an underestimation of the number of premises if some postcodes for which Virgin Media did not report coverage data could actually be served by Virgin Media;

- We have assumed all KCOM fixed lines are exchange-only lines. This assumption is likely to lead to an overestimation of the costs as some eligible premises in KCOM areas could potentially be served by KCOM cabinets. However, we consider this assumption is reasonable as KCOM's focus is on FTTP deployment, rather than FTTC deployment[165];

- We have not included the coverage information from alternative networks Gigaclear, Hyperoptic, INFL and UK broadband in our view of the extent of fixed networks roll-out as of today. This is because these data were not available to us in time to be considered in our analysis. However, we have estimated that, together, these alternative networks provide coverage to less than 1% of premises across the UK and, therefore, the effect on our cost estimates is likely to be minor;

- BT Openreach has not provided the list of postcodes served by cabinets that it did not classify as either 'FTTC upgraded' or "Planned to be FTTC upgraded'. We have, therefore, estimated which postcodes are served by those cabinets. This affects 16,667 BT Openreach cabinets out of the total of 97,504.

[165] See https://www.kcomhome.com/products/broadband/lightstream-rollout/

Relationship with the WLA market review

A5.16 We are also aware that there are potential linkages between this modelling and that which could be undertaken as part of the Wholesale Local Access market review (WLA MR) consultation which is due to be published in the Spring of 2017. Where we consider an estimate of the costs of deploying fibre networks (for example, FTTC deployment) is necessary to support our analysis and any remedies in the WLA MR, we may use a bottom-up model of the costs of FTTC roll-out (based on the model on which we consulted in May 2016[166]). This may rely on similar underlying assets to those modelled in the Broadband USO. Although we remain cognisant of this possible linkage, we consider that there are a number of valid reasons why these values may not always be the same between the two models. To the extent that the WLA market review requires a cost model, these are:

- The WLA cost model will estimate the cost of the commercial deployment of FTTC, whereas the analysis in this document investigates costs in areas which have not been reached by commercial operators. It is possible that some important costs (i.e. trenching) may not be consistent between the two models;
- The WLA cost model would use BT's actual costs in its detailed modelling. By comparison, the analysis presented here relies on Analysys Mason's significant industry knowledge and expertise to develop an estimate of the costs which the implementation of a USO would impose. These costs are based on a range of industry benchmarks (both nationally and internationally) and do not assume that BT would be the Universal Service Provider;
- The purposes of the models are different. While the WLA cost model would be a detailed model of FTTC costs, the analysis in this document, although still comprehensive, is intended to be more indicative of the broad magnitude of the potential costs and considers FTTC as only one of a number of candidate technologies.

Our estimates of the number of eligible premises and the average straight-line distance from eligible premises to nodes

Our estimate of the number of eligible premises

A5.17 We have estimated the number of premises eligible for our scenarios as at today based on the source data we collected about coverage, upload speeds and the total number of premises in each postcode unit.

A5.18 For postcode units which were not reported to have 100% coverage from Virgin Media's NGA network, we estimated the number of postcodes which included premises which fell below each specification threshold based on forecasts from BT Openreach and KCOM. They were considered below the threshold if either the download speed, the upload speed or both were equal to, or below, the threshold.

A5.19 We used our coverage and upload speed data to estimate the proportion of premises in these postcodes which could not receive service above the specified level. We were then able to estimate the number of eligible premises in each

[166] Ofcom, Wholesale Local Access Market Review – Possible approaches to fibre modelling, 9 May 2016. https://www.ofcom.org.uk/consultations-and-statements/category-3/wholesale-local-access-market-review-fibre-cost-modelling

postcode by applying this percentage to the total number of premises in each postcode.

Our estimate of the average straight-line distance from eligible premises to nodes

A5.20 The distance from a premises to a network node (a cabinet or exchange) determines the quality of broadband connection and, therefore, eligibility for a broadband USO. Our postcode-level data does not have information about where premises are located within each postcode and, therefore, distances to network nodes. Therefore, we have to derive an estimate of the average distance between premises in a postcode to the nearest network node in each postcode unit.

A5.21 In doing this, we assume that eligible premises are evenly distributed throughout each postcode unit and estimate an average distance between the uniformly distributed premises and the nearest cabinet. Where more than one cabinet serves a postcode area, we assume that premises are served by the nearest of these cabinets.

Assumptions made in estimating the number of eligible premises and the average straight-line distance from eligible premises to nodes

A5.22 We consider that our estimates of the number of eligible premises and the average straight-line distance from the evenly-distributed eligible premises to nodes make the best use of the data available to us. However, we necessarily needed to make a number of assumptions in doing so. In particular:

- In estimating the number of eligible premises we have categorised as 'eligible' the premises that receive up to and including 10Mbit/s (or up to and including 30Mbit/s) download speeds rather than strictly below these thresholds. This reflected the way the data were collected and may only lead to a marginal overestimation of the number of eligible premises and costs, as we have no technical reason to believe that there are a large number of premises which receive a speed exactly equivalent to the specification;

- We have made the assumption that eligible premises are distributed evenly across the postcode unit in which they are located. The effect of this assumption may be an overestimation of costs since, under this assumption, the whole postcode unit area must be provided coverage;

- We have manually removed the average straight-line from eligible premises to nodes for a small proportion of the total number of postcode units for which we estimated average straight-line distance to be greater than 10km. We have made this adjustment under the assumption that such long distances are most likely based on data errors.

Refinement of the Analysys Mason results to reflect newly available data

The Connected Nations 2016 dataset

A5.23 Analysys Mason carried out its bottom-up modelling using the postcode-level data that was provided by Ofcom (as described above). This was collated from operators providing estimates of the percentage of premises in each postcode unit which

could receive a service above a specified threshold. It also required Ofcom to estimate the degree of operator overlap in each postcode.

A5.24 Collecting data on this basis may, therefore, over or under-estimate the number of eligible premises in any scenario. However, we considered that the approach to calculating eligible premises was reasonable given that we were tasked with providing a preliminary estimate of the costs of the USO and that this was the best available data at the time of the analysis.

A5.25 Subsequent to completing the analysis, new premise-level data became available. As it is at a more disaggregated level, this data is able to give a more precise prediction of the download and upload speeds at each premises. Furthermore, operators provided information on the maximum upload and download speed received by each premises in 2016 rather than relying on a prediction of the speeds above or below a pre-determined threshold.

A5.26 The premise-level data indicated that there were fewer eligible premises than estimated by the postcode-level data. For instance, in scenario 1, the estimate of the number of eligible premises fell from 1.6 million to 1.4 million premises. Figure A5.2 reports the number of premises used in the initial dataset and the updated dataset.

Figure A5.2: Differences in the number of eligible premises between datasets

	Scenario 1: 10Mbit/s download speed	Scenario 2: 10Mbit/s download + 1Mbit/s upload	Scenario 3: 30Mbit/s download + 6Mbit/s upload
Premises in initial dataset	1.6m	3.5m	5.5m
Premises in updated dataset	1.4m	2.6m	3.5m
% drop	15%	26%	36%

A5.27 We looked to refine the analysis to reflect the new data given the material reduction in premises between the two datasets. We have not been able to use the data at a premise level since it would require a new model to be built. This was not possible given the timescales of the project. However, we were able to aggregate the new data back up to postcode level, format it in the same way as before so that Analysys Mason could re-run its model with the new data.

A5.28 This analysis can only be treated as indicative as we were only able to run the analysis with postcodes which were included in the original dataset given the time limitations of the analysis. Since the postcodes in the new dataset were largely a subset of those initially used by Analysys Mason, this meant that only a relatively small number of premises (1-4%) ended up being discarded.

A5.29 The cost estimate section of the document reports the results on the basis of the updated dataset on the basis that this is the more accurate dataset for 2016. Figure A5.3 summarises the cost estimates of the analysis undertaken on this basis.

Figure A5.3: Estimated deployment costs in 2016

	Scenario 1: 10Mbit/s download speed	Scenario 2: 10Mbit/s download + 1Mbit/s upload	Scenario 3: 30Mbit/s download + 6Mbit/s upload
Potentially eligible premises	1.4m	2.6m	3.5m
Total cost	£1.1bn	£1.6bn	£2.0bn
Cost per premises connected (CPPC)	£950	£770	£680

Future deployment scenarios

A5.30 As set out in Section 8, the Analysys Mason cost estimates were based on estimates of the number of premises which do not meet each technical specification in 2016. This was the best available data at the time and, therefore, gave the most up-to-date estimation of the scope of the USO.

A5.31 We recognise, however, that this is a worst-case estimation of the number of potentially eligible premises because it is carried out in 2016. In reality, we do not expect a USO to come into force until the end of 2017 at the earliest. We expect, therefore, that the number of potentially eligible premises at implementation will be lower than in 2016 as coverage continues to expand in the interim.

A5.32 We have made indicative projections of the number of potentially eligible premises at the end of 2017 and in the early 2020s. The end 2017 scenario is used to indicate how costs may fall further to take account of the BDUK roll-out programme. The 2020s scenario reflects how we may expect the number of eligible premises to fall further over time. It is necessarily very speculative given that it is further into the future and we also note that technology may have moved on by then so 10Mbit/s may no longer be considered a 'decent' broadband connection.

A5.33 Our projections consider two main drivers of increased broadband coverage by end 2017 and the early 2020s. These are:

- **Government-led schemes.** In particular, we try to reflect BDUK's forecast rollout of superfast broadband by the periods we're focusing on;
- **Commercial deployment.** We also reflect that new technologies, such as LR-VDSL, are likely to improve the commercial case for coverage in areas which are not currently commercially viable.

A5.34 We do not make projections about other schemes which have been announced at a Nations level. In particular, we are aware that the Scottish government has committed to extending superfast broadband to 100% of premises across Scotland by 2021. We await further details of this commitment but given projections for the early 2020s and the stylised nature of our modelling, we do not expect this to have a material impact on our future cost estimates.

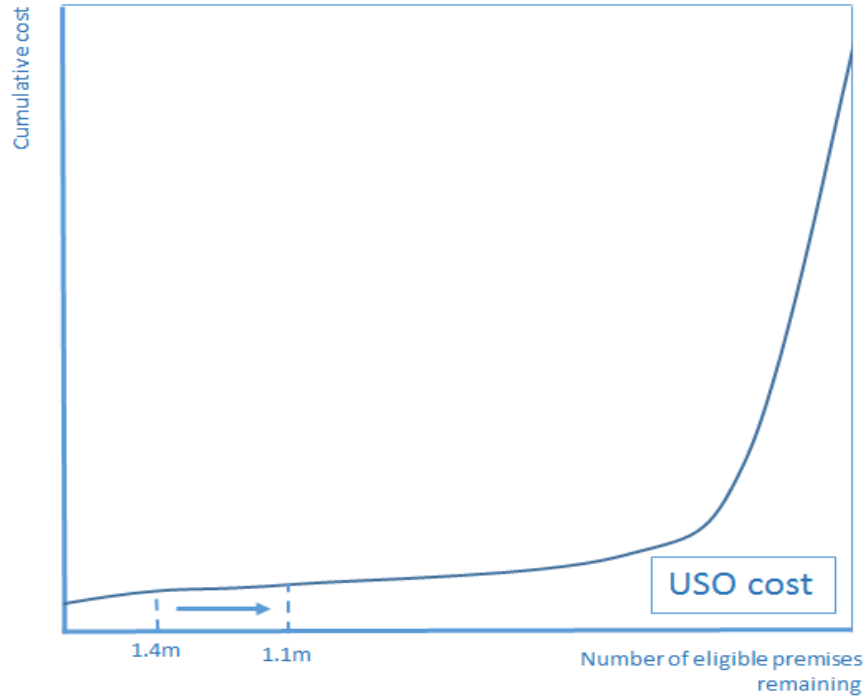
Top-down modelling

A5.35 We do not have information about which specific postcodes will be targeted by future BDUK or commercial deployment. Therefore, in providing estimates of costs for these future projections, we have used a top-down approach and have made

broad assumptions about what types of premises will no longer be eligible at these future points in time.

A5.36 Firstly, we assume that all else being equal, the cheapest premises to serve will be covered first by both BDUK and commercial suppliers. We consider this a reasonable assumption since these areas would represent the best value for money for BDUK and are more likely to meet the business case of commercial operators. This is illustrated, in the case of scenario 1, by the stylised cumulative cost curve below which illustrates the assumed change in costs between 2016 and 2017.

Figure A5.4: Reduction in premises by 2017, Scenario 1



A5.37 Figure A5.4 highlights our assumption that the cheapest premises to serve will become ineligible as the number of eligible premises falls from 1.4m to 1.1m, all else being equal.[167] Although the cost of any USO will fall with a reduction in premises under this assumption, it will not fall in proportion to the reduction in the number of premises. This is because the premises which remain eligible are the hardest to serve and, therefore, are disproportionately more expensive.

A5.38 We also make the assumption that BDUK rollout is exclusively focused on rural areas. Therefore, since we do not consider further commercial coverage between now and 2017, we assume coverage improvements in this time period occur in the least-cost rural areas. For the early 2020s scenarios, we assume that there is a split between rural and urban premises covered[168] as we expect that commercial operators are more likely to deploy to urban areas than rural ones.

[167] i.e. notwithstanding our assumptions about the urban/rural split of the discarded premises discussed in paragraph A5.37.
[168] This is notionally a 50:50 split but, for some projections, too many of the cheapest rural premises (i.e. those not in the final 1% of premises) are covered by scenario 1 to make this split. In this case, the split is weighted more towards urban homes – the scale of the weighting depending on the number of rural homes remaining to be covered.

A5.39 To move from the 2016 estimate to the 2017 projection, we remove the cheapest postcode groups for each technical specification until we reach the projected number of eligible premises at the end of 2017. We then use the outputs of the Analysys Mason model to estimate the costs of serving those premises which we have discarded and subtract these costs from the total cost of providing the USO calculated in 2016. We repeat this exercise to move from our projections for 2017 to our projections for the early 2020s for each technical specification.

A5.40 We recognise that these are simplifying assumptions which would not reflect the reality of future deployments. However, given the uncertainty about future rollout plans, we consider these to be reasonable for our stylised cost modelling.

A5.41 The estimated costs based on these projections are reported in Figure A5.5.

Figure A5.5: Estimated deployment costs in 2017 and 2020s

		Scenario 1: 10Mbit/s download speed	Scenario 2: 10Mbit/s download + 1Mbit/s upload	Scenario 3: 30Mbit/s download + 6Mbit/s upload
End 2017	Potentially eligible premises	~1.1m	~1.8m	~1.9m
	Total cost	~£1.0bn	~£1.5bn	~£1.7bn
	Cost per premises connected (CPPC)	~£1,060	~£940	~£990
Early 2020s	Potentially eligible premises	~0.3m	~0.6m	~1.1m
	Total cost	~£0.7bn	~£1.0bn	~£1.4bn
	Cost per premises connected (CPPC)	~£2,650	~£1,990	~£1,470

Annex 6

Fixed cost modelling report, Analysys Mason

https://www.ofcom.org.uk/__data/assets/pdf_file/0027/95580/annex6.pdf

Annex 7

Consumer research, Jigsaw

https://www.ofcom.org.uk/__data/assets/pdf_file/0035/95579/annex7.pdf

Annex 8

Consumer research, Experian

https://www.ofcom.org.uk/__data/assets/pdf_file/0034/95578/annex8.pdf

Annex 9

International case studies

Five countries in Europe have introduced a broadband USO

A9.1 Although several countries in Europe are considering introducing a broadband USO to improve coverage of decent broadband,[169] only five have done so to date. The European countries that have introduced a formal broadband USO are Finland, Spain, Malta, Croatia and Belgium.[170]

A9.2 Of these, Malta has introduced the most highly-specified broadband USO, with a download speed of 4Mbit/s. The other four countries have introduced broadband USOs with download speed requirements between 1Mbit/s and 2Mbit/s, although some plan to review and enhance the technical specification of the broadband USO in coming years. For example, Finland has an ambition for a broadband USO with a download speed of 10Mbit/s by 2021.[171]

A9.3 Outside the formal broadband USO, several countries across the world have introduced mechanisms to secure universal availability of affordable broadband. For example, Sweden attached an obligation to improve broadband coverage in rural areas to one of the spectrum licences it auctioned in March 2011. The spectrum licence was awarded to an MNO that is required to provide broadband of 1Mbit/s to premises in underserved areas, identified by the regulator.[172] In Singapore, the Next Generation National Broadband Network intends to roll out universal 1Gbit/s broadband using public funds. Broadband USOs or similar programmes are also in place in Australia, the US and New Zealand.

A9.4 Below, we briefly summarise intervention in four countries: Spain, Finland, the US and Australia. These case studies are intended as context to inform Government on the different approaches to delivering universal decent broadband.

Spain has set up a levy on industry to pay for the USO

A9.5 Spain's broadband USO was introduced in 2011 and requires the USP to provide a connection with a download speed of 1Mbit/s. The Spanish regulator has set up a levy on industry to fund any unfair net cost burden resulting from the USO. The regulator calculates the net cost of the broadband USO and defines which communications providers are required to contribute to a fund to compensate the unfair net cost burden. The regulator determines the contributions required on an annual basis.

A9.6 A competitive process was run to designate the USP, which required the USP to provide a connection capable of supporting voice and fax, as well as broadband with a download speed of 1Mbit/s. Telefónica, the incumbent in Spain, was the sole applicant to be the USP and is the only designated USP in Spain.

[169] Several others have universal service obligations in place in relation to the telephony network or to secure affordability of communications services.
[170] Sweden has an obligation to provide broadband with a download speed of 1Mbit/s in some underserved rural areas attached to the spectrum licence of one of its mobile operators.
[171] https://ec.europa.eu/digital-single-market/en/country-information-finland
[172] Cullen International Database

Finland has multiple USPs designated for different geographic regions

A9.7 Finland was the first European country to expand its universal service obligation to include access to broadband in 2010.[173] The obligation originally required the USPs to provide a connection capable of supporting speeds of 1Mbit/s but this was enhanced to 2Mbit/s in 2016, with the ambition of increasing this to 10Mbit/s by 2021.[174]

A9.8 In contrast to Spain, which has one national USP, the scope of the broadband USO in Finland is regional, with 10 different USPs designated for different geographic areas. The regulator first defined the areas where a USP was required by analysing the geographic coverage of mobile networks and supply of fixed network services, determining a USP was needed if commercial services did not serve 100% of premises in that area. The USPs were directly designated, with no competitive procurement process, based on which communication provider had the most extensive network in each area requiring a USP.

A9.9 This reflects that, in Finland, communication providers have different networks with varying geographic coverage. In comparison, in the UK Openreach's network has good national coverage and many retail providers offer services to customers over the network.[175] Virgin Media has a separate network, often overlapping the Openreach network in mostly urban areas.

A9.10 The USO in Finland is currently funded by the USPs. None of the USPs have to date requested compensation for an unfair net cost burden resulting from the broadband USO.

United States

A9.11 The Connect America Fund in the US focuses on the delivery of universal broadband with a download speed of 10Mbit/s.[176]

A9.12 The intervention is funded by industry through a Universal Service Fund (USF), administered by the Universal Service Administrative Company. Service providers are required to contribute to the USF based upon a percentage of their interstate and international revenues.[177,178] The amount of contribution changes quarterly, depending upon the requirements and demands of the programmes funded via the USF. Some service providers may choose to recover their costs of their contribution directly from consumers; should a service provider choose to do this, then the consumer will see a separate item for universal service appear on their bill.[179,180]

[173] Cullen International database
[174] https://ec.europa.eu/digital-single-market/en/country-information-finland
[175] For example, BT, Sky, TalkTalk and others.
[176] http://www.fcc.gov/document/fcc-releases-order-increase-connect-america-rural-broadband-speeds
[177] http://www.usac.org/about/about/universal-service/default.aspx
[178] http://www.fcc.gov/encyclopedia/contribution-methodology-administrative-filings
[179] However, a service provider cannot recover an amount which is more than its contribution. In addition, service providers cannot bill customers who are part of the Lifeline program for universal service (http://www.fcc.gov/guides/understanding-your-telephone-bill).
[180] For example, T-Mobile US charge its consumers with a USF fee on their bill (https://support.t-mobile.com/docs/DOC-3235#universal)

Australia

A9.13 Australia has in place a universal service obligation for telephony services and payphones. Broadband is not included in the scope of the USO. However, Australia's National Broadband Network aims to deliver broadband with a download speed of 25Mbit/s to 100% of premises with a multi-technology mix (using a combination of fibre, fixed wireless and satellite). Other technical standards, such as upload speed, latency or jitter, are not defined in the technical specification.

A9.14 Connections are provided by a wholesale-only infrastructure provider, which has an obligation to offer wholesale services to retail broadband providers.

Annex 10

Glossary

3G	Third generation of mobile systems. Provides high-speed data transmission and supports multi-media applications such as video, audio and internet access, alongside conventional voice services.
4G	Fourth generation of mobile systems. It is designed to provide faster data download and upload speeds on mobile networks.
Access network	An electronic communications network which connects end-users to a service provider; running from the end-user's premises to a local access node and supporting the provision of access-based services. It is sometimes referred to as the 'local loop' or the 'last mile'.
ADSL	Asymmetric Digital Subscriber Line. A digital technology that allows the use of a standard telephone line to provide high-speed data communications. Allows higher speeds in one direction ('downstream' towards the customer) than the other.
Backhaul	The part of the communications network which connects the local exchange to the ISP's core network.
Base station	This is the active equipment installed at a mobile transmitter site. The equipment installed determines the types of access technology that are used at that site.
BDUK	Broadband Delivery UK.
Broadband	A data service or connection generally defined as being 'always on' and providing a bandwidth greater than narrowband connections.
Committed Information Rate (CIR)	The minimum speed that the access network guarantees will be available between end points under normal conditions.
Core network	The central part of any network aggregating traffic from multiple backhaul and access networks.
Contention	The degree to which bandwidth is shared between different end users at the same network node.
Connection charge	The fee a broadband provider charges customers when it installs a new line to connect to their premises to its network, or the fee a broadband provider charges customers when it takes over the fixed broadband line serving their premises. This fee is often waived or reduced if customers also take up certain retail broadband packages with the provider.
Data caps	Monthly limit on the amount of data that users can download, imposed by fixed and mobile operators for some of their packages to manage the amount of data consumers use. Consumers tend to be charged more if they exceed their data caps.

DCMS	Department for Culture, Media and Sport.
DOCSIS	Data Over Cable Service Interface Specification. It is a standard for the high speed transmission of data over cable networks.
DSL	Digital Subscriber Line. A family of technologies generally referred to as DSL, or xDSL, capable of transforming ordinary phone lines (also known as 'twisted copper pairs') into high speed digital lines, capable of supporting advanced services such as fast internet access and video on demand. ADSL and VDSL (very high speed digital subscriber line) are variants of xDSL).
Excess construction charge	The fee a universal service provider may charge a customer to connect their premises to its network if the cost of the works to connect the premises is higher than the reasonable cost threshold.
Femtocell	A small base station, typically installed indoors to improve indoor mobile coverage. A residential femtocell uses the consumer's broadband connection to offload the mobile data onto the fixed network.
Fixed broadband	Broadband delivered over a fixed line to the customer's premises.
Fixed wireless systems	Terrestrial-based wireless systems, operating between two or more fixed points. FWS use mainly digital technologies, directional antennas and typically operate at very high levels of propagation availability. Fixed terrestrial links are used to provide network infrastructure and customer access applications across a wide range of frequency bands, currently ranging from 450MHz to 86GHz.
FTTC	Fibre to the Cabinet. Access network consisting of optical fibre extending from the access node to the street cabinet. The street cabinet is usually located only a few hundred metres from the subscribers' premises. The remaining segment of the access network from the cabinet to the customer is usually a copper pair.
FTTP	Fibre to the Premises. A form of fibre optic communication delivery in which the optical signal reaches the end user's home (also known as fibre to the home or FTTH).
IP	Internet Protocol. This is the packet data protocol used for routing and carrying data across the internet and similar networks.
ISP	Internet Service Provider. A company that provides access to the internet.
Latency	The round trip delay in the transmission of data.
MNO	Mobile Network Operator, a provider who owns a cellular mobile network.
Net cost	The cost of providing the broadband USO less any direct and indirect benefits.
Reasonable cost threshold (RCT)	A cost threshold that could be applied to prospective USO connections, beyond which the Universal Service Provider would not have an obligation to supply a connection. The USO would be

	provided where requests are ‘reasonable’. For some households the cost of providing a USO connection may be so high that the request is considered unreasonable.
Superfast broadband	The next generation of faster broadband services, which delivers headline download speeds of greater than 30 Mbit/s. The BDUK Programme defines superfast broadband as broadband services which deliver download speeds of greater than 24Mbit/s.
Sync Speed	The modem sync speed represents the highest possible speed at which data can be transferred across the line.
Universal Service Directive (USD)	European Parliament and Council Directive (EC) 2002/22 (OJ L108, 24.4.2002) on universal service and users’ rights relating to electronic communications networks and services.
VDSL	Very High Speed DSL. A high speed variant of DSL technology, which provides a high headline speed through reducing the length of the access line copper by connecting to fibre at the cabinet.
VOD	Video-on-demand. A service or technology that enables TV viewers to watch programmes or films whenever they choose to, not restricted by a linear schedule (also see ‘push’ VOD and ‘pull’ VOD.
VoIP	Voice over Internet Protocol. A technology that allows users to send calls using internet protocol, using either the public internet or private IP networks.
Wi-Fi	A short range wireless access technology that allows devices to connect to a network through using any of the 802.11 standards. These technologies allow an over-the-air connection between a wireless client and a base station or between two wireless clients.
xDSL	The generic term for the Digital Subscriber Line (DSL) family of technologies used to provide broadband services over a copper telephone line.