The impacts of a broadband USO in the UK

A report for the Broadband Stakeholder Group

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Foreword by the Broadband Stakeholder Group

Demand for broadband connectivity is increasing and becoming a necessity for consumers and businesses. Current public policy goals for superfast broadband coverage are set to be met by the end of 2017[1], but a proportion of premises will remain underserved. This is particularly the case for a number premises located in remote or rural areas (and some city centres). The cost and complexity of reaching them mean that these premises are unlikely to have access to superfast broadband through either commercial or Broadband Delivery UK (BDUK) rollouts.

Recognising the challenge of serving these premises, the Government announced in 2015 that it intended to give people the legal right to request a broadband connection that would deliver them a minimum speed no matter where they lived through a broadband universal service obligation (USO). Government has since indicated its preference for that minimum speed to be set at around 10Mbit/s, although the exact specification has yet to be agreed.

The Broadband Stakeholder Group commissioned a report from Plum Consulting to analyse the impact of the design considerations of this potential broadband USO in the UK. In particular, the BSG asked Plum to assess the effect of different cost thresholds for the delivery of the USO on the level of funding required. The cost threshold is the maximum cost per premise at which the Universal Service Provider (USP) would be required to provide the broadband USO service. Where the cost per premise is higher than the cost threshold, the USP could decline to provide the broadband connection, the customer could volunteer to pay the difference in order to be served, or the customer could choose a service with a lower specification than the USO might be offered.

The Plum report shows that the level at which the cost threshold is set is critical to the success of the USO and, in particular, to the scale of the total USO fund needed and to the number of premises that the USO service would ultimately connect. The cost threshold acts to ensure value for money and therefore has a direct impact on maximising net benefit to the UK[2]. In order to provide value for money, the threshold caps the money spent on individual premises. The upshot of this is that some premises would be faced with a large bill in order to access a good broadband connection and so would remain excluded unless they paid this bill. The tension between value for money and social inclusion goes to the heart of the USO debate. We believe that this report contributes to that discussion whilst recognising that there are no simple answers to resolving that tension.

[1] 97% of premises covered by 2020 thanks to reinvestment into the Broadband Delivery UK (BDUK) program and further commercial investments. 90% geographic coverage by mobile network operators

[2] Plum measures the 'net benefit' with the equation of: (economic benefit delivered to a premise of receiving the USO service multiplied by the number of premises that connect) minus the cost of the subsidy spent.

Universality and the USO

The USO is a construct of European Union law under the Universal Service Directive (USD)[3]. The Directive allows for the USO to be funded by industry, from public finances, or through a combination of the two. We do not put forward an opinion on who should fund the USO although we do note the impact of the funding source on net benefit.

In March 2016, Government tasked Ofcom to provide technical advice and recommendations on the specifications, objectives and funding mechanisms associated with the implementation of a USO. Ofcom published this advice in December 2016[4]. The BSG responded to the consultation and in addition, commissioned Plum to undertake this work.

We strongly support the goal of universally available, good quality, broadband access at a price that allows everyone to connect to the internet and use the range of services enabled by digital connectivity. The question as to whether a USO is the best tool to achieve universal good quality broadband coverage was, and still is, a subject for debate amongst the communications industry, businesses and users. Some are concerned that there are other more efficient tools open to Government, such as a new subsidy scheme building on the lessons learnt from the current BDUK programme. Others favour regulatory incentives to encourage more commercial roll-out or different Government funding options such as the vouchers currently used in the Universal Service Commitment[5]. There are also concerns about the potential for the USO mechanism to distort the market and lead to negative outcomes – for example fewer people accessing good quality broadband due to increased costs.

Overall, however, there is agreement that a broadband USO could be implemented as a safety net to prevent social exclusion, facilitate access to online public services and encourage social and economic development – but that such a service needs to provide value for money.

Model results

Plum estimates the net costs of delivering a broadband USO service set at 10Mbit/s (initial speed target announced by Government) and at 30Mbit/s (which Ofcom modelled in its advice back to Government) with various levels of data usage. The report illustrates the outcomes possible in terms of achieving universal coverage. These are sensitive to the chosen policy objective in terms of geographical coverage, target area, affordability of the USO and usage applications.

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[3] The Universal Service Directive (2002/22/EC) sets the framework for introducing a universal service, and with regard to the right to request access to an Internet access, the scope of intervention is narrowly defined under Article 4. The Directive is currently under review and European Commission proposals extend the scope of the legislation to broadband describing the universal service in this context as a safety net publicly funded. It is unclear whether the reviewed Directive will be implemented in the UK as it exits from the EU.

[4] Ofcom Technical Advice to Government – Achieving decent broadband connectivity for everyone - https://www.ofcom.org.uk/__data/assets/pdf_file/0028/95581/final-report.pdf

[5] Known as the Better Broadband Scheme

Measure	10 Mbps service	30 Mbps service
Number of eligible premises in the target area in 2019	500,000	1 million
Cost of providing the broadband USO service – no cost threshold	£930m	£1400m
USF subsidy required – no cost threshold	£869m	£1272m
USF subsidy required – £5000 cost threshold	£328m	£667m
USF subsidy required – £2000 cost threshold	£180m	£376m
Cost threshold which maximises net benefit to the UK	£1500 to £3000	
Percentage of premises passed – CT £2000, 40% take-up	45%	25%

As the table above highlights, the total cost of the USO service only provides part of the picture. Whichever provider(s) is designated as the Universal Service Provider(s) is likely to gain benefits such as future profits from the end-users of the service and potential network and reputational benefits, although these will vary depending on what services are already available. The Plum report therefore focuses on the level of subsidy that is required to provide the USO.

The total level of potential subsidy required depends to a great extent on the cost threshold and connection required. For example, it ranges from **a low of £180m** to provide a 10Mbit/s connection with a cost threshold of £2000/premise to serve a target area of 500,000 premises to **a high of £1.27bn** to provide 30 Mbit/s connection with no cost threshold to serve a target area of 1 million. As noted in the report, these estimates are subject to potentially large variation given the remoteness of many of the target premises.

Superficially, a USO of 30 Mbit/s can seem attractive. At a cost threshold of £2000/premise the total subsidy is £376m compared to the £180m of the 10 Mbit/s USO. However, this comparison fails to take into account the number of premises that would be served – just 25% of premises in the target area would come under the cost threshold with the USO at 30 Mbit/s. Even with mechanisms that we discuss later, this falls quite a way short of universality. Regardless of the cost threshold at which it is set, a 30Mbit/s USO delivers lower net benefit to the UK, to the point where a negative impact can occur.

These problems are also impacted by the source of the potential subsidy, with industry funding further lowering the net benefit to the UK. In light of this if Government decided to pursue 30Mbit/s as the USO then it would need to consider a public funding in the form of evolution of the BDUK scheme, building on the experience gained in BDUK phase three[6].

[6] BDUK organised market test pilots in 2015, testing options for extending the superfast broadband program beyond 95% - findings were published in February 2016 https://www.gov.uk/government/publications/superfast-broadband-programme-phase-3

Drawing on these results, the report raises six key design issues for the Government to consider for a USO;

1. The level of the cost threshold;
2. What constitutes a reasonable request;
3. How will Government ensure that subsidy is paid only for efficiently incurred costs;
4. Should Government consider a two-tier broadband USO;
5. What is the best relationship between the infrastructure and retail provider in the target area; and
6. What mechanism should be used to allow a community to pay above any reasonable threshold.

All of these issues require careful consultation with industry and wider stakeholders in order to ensure we strike the best balance between cost-effectiveness and the overarching policy goal of universality. Below we outline the BSG's views on some of these issues and highlight the sensitivity of the cost threshold.

The cost threshold and net benefit

Plum has modelled costs on the basis of a universal cost threshold. This is for two reasons: firstly all Government policies have to meet a value for money test and secondly, to ensure that the fund is proportionate and causes the least market distortion as defined under the USD.

Although the proposed broadband USO service is designed to be requested by individual users on a case-by-case basis, the report underlines the value of demand aggregation as a mechanism to drive the costs of deployment per premise down. We note that Ofcom also stressed the importance of demand aggregation in its report. Stimulating demand for the service within a community may prove a challenge but as noted by Ofcom[7], this approach could prove beneficial under the right conditions.

In examining what a reasonable cost threshold should be it is worth first considering the existing USO for telephony[8]. The cost threshold for this is set at £3400. However, we believe there is limited value in looking at the cost threshold for telephony as the benefits derived from network use for voice and for broadband are different.

The cost threshold will need to be derived from the evidence base, such as it is, as to what level will provide the greatest level of net benefit to the UK. Plum found that **a threshold set between £1500 and £3000 would maximise the net benefit.**

This large range is necessary due to the impact of some of the design considerations outlined above. A particular sensitivity is the mix of public or industry funding, which has a significant impact on net benefits. The report shows that the maximum net benefit for the UK would be reduced if industry funding were used rather than public funding. For instance a USO service

[7] Ofcom Technical Advice to Government on the broadband USO – Section 7

[8] Known as the voice or narrowband USO

set at 10Mbit/s and 100GB per month would produce a maximum benefit of £220 million when publicly funded, falling to £140 million if industry funded.

As noted above, the 'net benefit' is an attempt to calculate the positive impact against the cost. The costs themselves are hard to quantify given that we are now at the very edge of the network where small variances can lead to significant changes in outcome. An attempt to reflect the scale of the variation is captured in the report's sensitivity analysis.

What is also clear is the lack of evidence that exists around what the economic benefit is of each new USO connection. This meant that Plum relied on a number of relatively arbitrary levels which were based on subsidy provided in the BDUK programmes to date. **Further examination of the economic benefit per household issue is needed as part of the Government's approach to designing the USO in order to provide an accurate cost-benefit analysis.**

The cost threshold is critical to providing value for money but it does mean that some premises will be faced with paying significant additional costs to gain a USO connection. Where a premise exceeds the reasonable cost threshold, we believe that there should be two options.

First premises and communities should be able to pool their demand and if necessary, pool their individual additional contributions to costs over and above the individual cost threshold. For example it may be that to serve one premise would exceed the cost threshold of say £2500 but that the total cost of serving both that premise and three other neighbouring premises would be below £10,000. This of course requires demand aggregation.

Secondly, if premises are unable to aggregate demand in this way, then they should be offered a fall-back option. This would almost certainly be a wireless solution, and likely a satellite solution, given the dispersed nature of the target premises.

Together these measures would help ease the tension between what is the most economically efficient measure and the overall goal of delivering universally available good quality broadband.

Providing access to good quality broadband for everyone is a challenging target but one that we must tackle for social and economic reasons. The BSG believes that this reports adds to the evidence base on the best way that a USO can positively contribute to this goal and we look forward in engaging further in this debate.

Richard Hooper
Chair
Broadband Stakeholder Group
4 May 2017

Executive Summary

The UK Government announced in 2015 its intention to *"give people the legal right to request a* [broadband] *connection at minimum speed no matter where they live --- or indeed work --- through the implementation of a new broadband Universal Service Obligation (USO)*".

DCMS then asked Ofcom to provide advice on the best design of the broadband USO and invited the Broadband Stakeholder Group to provide additional inputs. The BSG commissioned Plum to help provide some analysis of the proposed USO; this report presents our findings.

The design considerations

Our findings are based on a model of the costs of delivering the broadband USO and the number of premises passed and connected to the USO service under a range of design choices. These include:

- broadband download speeds of 10Mbps and 30Mbps;
- data throughput allowance of 10 to 200 GB per month;
- consumer take-up of the service ranging from 40% to 80%;
- cost thresholds ranging from £1000 up to infinity (i.e. no threshold); and
- assumed economic benefits of connecting each additional premise to broadband at three levels - of £1000, £2000 and £3000[9].

It is important to note that a request by an individual premise for wireline or fixed wireless access to high-speed broadband is unlikely to be lower than any reasonable cost threshold. We therefore assume, in calculating USO costs and the impact of various cost thresholds, that there is demand aggregation within any eligible rural community (in the same way as Ofcom does in its advice to DCMS).

Our main findings

Our estimates of the costs of delivering the broadband USO service are similar to those estimated by Ofcom in its advice to government. Figure S1 shows that the two sets of estimates are not directly comparable but are consistent.

[9] The Government has subsidised BDUK Phase 1 at £300 per premise connected and Phase 2 at £575 per premise connected (assuming a long term take-up rate of 60% of premises passed). See also Section 3.4

Figure S1: Plum vs Ofcom estimates of USO costs

Measure	Plum[10]	Ofcom
Date at which target area measured	2019	Early 2020s
Target area (000 premises) – 10 Mbps service	500	300
Total cost – no CT – 10 Mbps service (£m)	955	700
Target area (000 premises) – 30 Mbps service	1000	1100
Total cost – no CT – 30 Mbps service (£m)	1392	1400

Key Plum findings are discussed below and selected findings are tabulated in Figure S2.

Figure S2: Key findings

Measure	10 Mbps service	30 Mbps service
Number of eligible premises in the target area in 2019	500,000	1 million
Cost of providing the broadband USO service – no cost threshold	£930m	£1400m
USF subsidy required – no cost threshold	£869m	£1272m
USF subsidy required – £5000 cost threshold	£328m	£667m
USF subsidy required – £2000 cost threshold	£180m	£376m
Cost threshold which maximises net benefit to the UK	£1500 to £3000	
Percentage of premises passed – CT £2000, 40% take-up	45%	25%

We estimate that, without any cost threshold constraints, it would cost £930 million to provide a 10 Mbps service to the eligible 500,000 premises in 2019. This would increase to £1400 million to deliver a 30 Mbps service to the eligible 1 million premises.

The universal service fund required to subsidise the broadband USO service is very sensitive to the cost threshold which is set. The cost estimates for the 10 Mbps service illustrate:

- at a cost threshold of £5000 per connected premise, around 400,000 of the 500,000 eligible premises might be passed by the USO service for a subsidy of just under £400 million; and
- at a cost threshold of £2000 per connected premise, 300,000 premises might be passed for a USF subsidy of around £200 million.

The USF subsidy required is also very sensitive to the data throughput required:

- with a constrained throughput of 10 GB per month it would be possible to connect all premises in the target area[11] for less than £100 million regardless of the cost threshold; and

[10] With Plum assumption on take-up of broadband USO service increased from central Plum assumption of 60% to 80% – the Ofcom assumption on take-up

[11] To a 10 Mbps service

- if the data throughput requirement is raised to 100 GB per month or more, then the subsidy increases substantially – to just under £400 million at a cost threshold of £5000 and to £869 million if there is no cost threshold.

The optimal cost threshold for the broadband USO will depend upon what economic benefit the government assigns to connecting an additional premise in the target area. Our analysis suggests that the cost threshold which maximises net benefits to the UK is likely to lie between £1500 and £3000. In addition:

- the broadband USO starts to generate net economic losses for the UK at a cost threshold of around £10,000[12]
- the cost threshold at which net losses are generated reduces to around £5000 if the service is financed by industry rather than publicly-financed.

The assumption we make about the proportion of premises passed which take-up the USO service over the next few years has a major impact. But this take-up rate is uncertain. It probably lies somewhere between 40% and 80%. If take-up is at the lower end of this range[13] then only 200,000 of the 500,000 premises in the 10 Mbps target area are passed. With this assumption a broadband USO service is some way from fulfilling its policy goal of providing *universal* broadband.

Implementing a 30 Mbps rather than a 10 Mbps service in 2019 would increase the unconstrained USF subsidy required by 46%, from £869 million to £1272 million (imposing a cost threshold of £5000 would roughly halve this subsidy required for the 30 Mbps service to £667 million). Moving to a 30 Mbps service would also reduce significantly the net benefit of the broadband USO for the UK.

Key design issues

Our work highlights six key issues for the Government to consider in designing the broadband USO:

- At what level should the cost threshold be set? We propose that the cost threshold should attempt to maximise net benefits to the UK.
- What constitutes a reasonable request for a broadband USO service? This raises questions as to the circumstances in which the Government will pay subsidy to the universal service provider and whether passive take-up of the USO service by premises in the target area should be included.
- How will the Government ensure that the subsidy is paid only for efficiently incurred costs?
- Should the Government offer a two-tier broadband USO which includes a subsidised satellite broadband service in the second tier?
- What is the best relationship between the infrastructure provider and the retail service provider in the target area?
- What mechanism should be used to allow a community to pay extra for the broadband USO service if the cost of providing it exceeds the cost threshold?

[12] If we assume an economic benefit of £2000 per additional premise connected,

[13] And a of cost threshold £2000 use

1 The assignment

The Broadband Stakeholder Group (BSG) is the UK Government's leading advisory group on broadband. Its sponsors include companies across the complete communications value chain. The BSG has been invited to provide input to the UK Government, via the Department of Culture Media and the Sports (DCMS), on the impacts of a broadband Universal Service Obligation (USO) planned for the UK.

The BSG engaged Plum Consulting London LLP to undertake a study, including economic modelling, to provide quantification of the costs and impacts of various policy choices that the government faces in the design of the USO.

1.1 Background to the study

DCMS policy on broadband has contributed to moving the UK into the top of the league of large EU member states in terms of the availability and take-up of high-speed[14] broadband. Ofcom reports[15] that the UK leads with:

- NGA broadband now available to 90% of households ; and
- 36% of household broadband connections greater than 30Mbps.

DCMS established BDUK to oversee the rollout of superfast broadband (with a download speed of 24 Mbps and above) in areas where deployment was not commercially viable. This has been a three-stage process:

- Phase 1 expanded superfast broadband (SFBB) availability from 70% to 90% of the population for a public subsidy of £1.2 billion. BT completed this phase using VDSL in early 2016;
- Phase 2 was designed to expand SFBB from 90% to 95% of the population. Currently underway and with expectations that coverage will reach 97% when finished, Phase 2 involved a public subsidy of £0.5 billion; and
- Phase 3 was designed to cover the remaining 3%. Pilot trials have been undertaken but the future of Phase 3 is uncertain.

In March 2016 DCMS published a consultation[16] explaining the rationale behind the Government's 2015 announced intention to: *"put broadband on a more equal footing to these services* [like electricity and water]*, and give people the legal right to request a connection at minimum speed no matter where they live --- or indeed work --- through the implementation of a new broadband Universal Service Obligation (USO)*". DCMS laid out its roadmap to implement the USO including the commissioning of Ofcom "*to undertake a detailed analysis of the key factors that will help inform the design of the USO*."

The rationale behind the scheme is that it is more cost-effective to supply on reasonable request than to build out in an area and wait for take-up to emerge (as in Phases 1 and 2 of the BDUK scheme).

[14] 'High-speed broadband' – broadband connections capable of offering headline speeds of more than or equal to 30Mbps. Also referred to as 'NGA broadband' Ofcom European Broadband Scorecard, December 2015 p14 https://www.ofcom.org.uk/__data/assets/pdf_file/0036/79956/european_broadband_scorecard_2015.pdf

[15] Ofcom, International comparison, Broadband EU 28 scorecard, 16 December 2016, https://www.ofcom.org.uk/__data/assets/pdf_file/0025/95713/ICMR-Broadband-Scorecard_EU28.pdf

[16] DCMS A new broadband universal service obligation consultation, 23 March 2016, "DCMS Consultation" https://www.gov.uk/government/consultations/broadband-universal-service-obligation

Ofcom published its Call for Inputs to *Designing the broadband universal service obligation*[17], in April. The BSG responded to both the DCMS and Ofcom consultations.

Responses to Ofcom's Call for inputs[18] showed that stakeholder opinion on the purpose of a broadband USO was divided:

- most market players saw the USO primarily as a safety net for end-users which would prevent social exclusion; and
- most end users who responded saw it as an opportunity to close the digital divide so that everyone had superfast broadband or better.

Ofcom developed its thinking, including undertaking economic modelling, and published its advice to Government in December 2016[19].

1.2 The DCMS proposal for a broadband USO

Under the DCMS proposal for a broadband USO, households and businesses in the target area – the population without access to broadband at a download speed of 10 Mbps or more – would have a legal right to demand a minimum broadband speed at an affordable price, subject to the cost of supply not exceeding some cost threshold.

This understanding of the proposed USO was confirmed in the DCMS's Statement of Intent published on 11 October 2016[20]. In addition the statement made it clear that the broadband USO:

- would enable anyone in the target area (premises with access to broadband at download speeds below 10 Mbps) to request broadband with a minimum download speed of 10 Mbps;
- should extend the reach of decent broadband connectivity as far as possible across the UK in both rural and urban areas;
- should give consumers the right to fast reliable broadband subject to a cost threshold. If this threshold is exceeded then consumers may have to contribute to the cost of connection or not be served;
- should be introduced by 2020 at the latest;
- may need to include demand aggregation if the USO is to be cost efficient; and
- would need to consider the impact on pricing if the net cost of the USO is industry financed.

A primary goal of the broadband USO is that it should be more cost-effective than continuing with BDUK Phase 3: replacing a '*build it and they will come'* approach with provision on a '*demand only to those who want it'* basis[21].

[17] Ofcom, Designing the broadband universal service obligation Call for inputs, 7 April 2016, https://www.ofcom.org.uk/__data/assets/pdf_file/0025/58336/broadband-uso.pdf

[18] Ofcom, Summary of responses to CFI, August 2016, https://www.ofcom.org.uk/__data/assets/pdf_file/0025/68335/summary_of_responses.pdf

[19] Ofcom, Achieving decent broadband connectivity for everyone: Technical advice to UK Government on broadband universal service, 16 December 2016 "Ofcom Technical Advice", https://www.ofcom.org.uk/__data/assets/pdf_file/0028/95581/final-report.pdf

[20] DCMS, A new broadband Universal Service Obligation Statement of Intent, 11 October 2016, https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/562484/USOStatementofIntentfinal11October__2__.pdf

1.3 The issues which our study tackles

The key questions tackled by the study are as follows:

- How much will the broadband USO cost and what subsidy will be required?
- What are the impacts of imposing a cost threshold – specifically:
  - How does the total cost of providing broadband USO service grow as the cost threshold is increased?
  - What percentage of premises in the target area are passed by the broadband USO service and what percentage are connected for a given cost threshold?
  - What cost threshold maximises net economic benefits to the UK?
- What are the impacts of different data throughput (GB per month per premise) allowances provided under the USO?
  - What technologies are feasible given different data throughput requirements?
  - How do costs and the percentage of premises connected change as the data throughput requirement grows?
- What is the impact if the USO subsidy is financed by the industry rather than from the public purse as is the case for BDUK Phases 1 and 2?
- What happens to costs and percentage of premises connected if the download speed for the broadband USO service is increased from 10 to 30 Mbps?

The following issues are excluded from the study:

- How to ensure higher speed broadband is available to low-income households.
- How to determine the mechanism for appointing USPs.
- When and how best to upgrade the broadband USO service specification over time.

1.4 The characteristics of the target area

The first task in considering the deployment of a USO and estimating the cost of deployment is to determine who is to be served and where do they reside.

The Government's objective for the USO, as confirmed in its October 2016 Statement of Intent, is that "*It must ensure that everyone can access a decent broadband service which meets the needs of the majority of people and businesses" and a*s noted in the document, BDUK *"estimates that efficiency savings, coupled with clawback and further commercial roll-out, could extend superfast broadband coverage to 97% of UK homes and businesses by 2020".*

Based on discussions with BDUK, Ofcom and BSG members we have taken the view that:

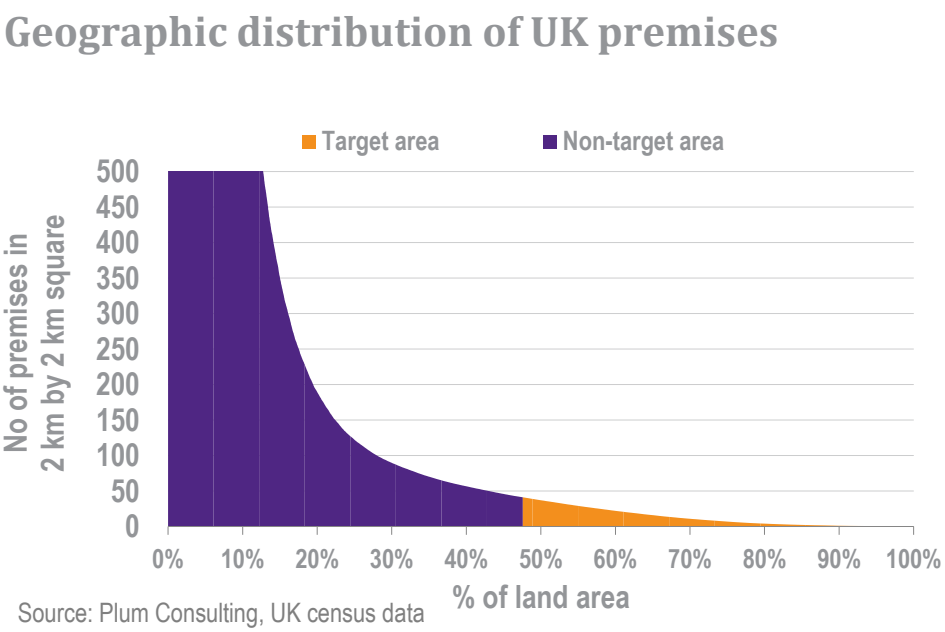
- The broadband USO is likely to come into operation in 2019;

[21] DCMS Consultation p10 "*Given the high costs of providing broadband access to premises in remote areas it is right that this is done on request, rather than rolling it out and waiting to see if people in those areas want to be connected."*

- There will be 500,000 premises in the UK without access to broadband at download speeds of 10 Mbps or more and 1 million premises without access to broadband at 30 Mbps at this date; and
- 85% of these premises will be in rural areas such as the edge of towns, villages, small hamlets and isolated houses.

The rural component of the target area represents less than 2% of premises in the UK but over 50% of the UK land area, see Figure 1–1 below. It is worth stating the obvious: these rural premises represent some of the most expensive (if not the most expensive) premises to serve with high-speed broadband connectivity.

Figure 1-1: The target area

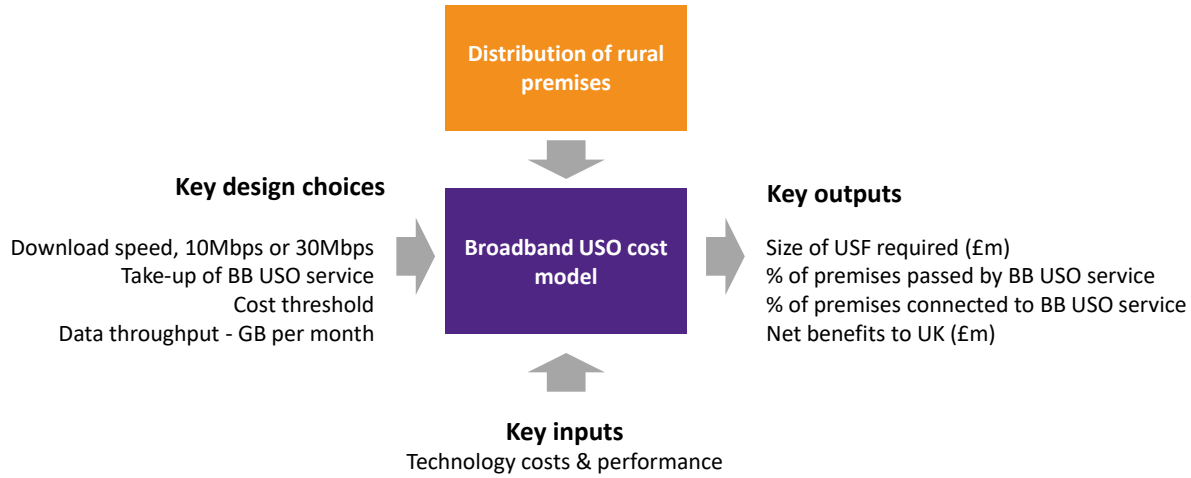


2 Our approach to modelling the broadband USO

2.1 Overview of our approach

To study the impact of setting a broadband USO, we developed the bespoke model shown in Figure 2-1. It allows us to explore the consequences (in terms of the key outputs) of varying a key set of design choices listed on the left-hand side of the diagram.

Figure 2-1: Overview of the Plum model



We have used this model to explore two scenarios:

- Providing a 10 Mbps USO service for target area of 500,000 premises.
- Providing a 30 Mbps USO service for target area of 1,000,000 premises.

We have elected to model deployment in 2019 as this reflects the likely timeframe for the imposition and operation of a broadband USO.[22] By this time the BDUK programmes currently in operation, as well as ongoing deployment by operators, are likely to have reduced the number of premises unable to receive a 10 Mbps or 30 Mbps service from the level observed today. As a result, we model a number of premises that is substantially smaller than Ofcom's base case (which uses 2016 premise population figures).

Our modelling procedure also differs from Ofcom's in a key respect – unlike Ofcom, we do not have access to the actual speeds available at each premise in the UK grouped by postcode, nor detailed data on BT's network topology. Instead, we have used census data, which we have sampled to a very fine resolution (5m x 5m squares). We use this census data to construct grids of population numbers, which we use as the basis for modelling the rural target area.[23]

A key assumption underpinning our model is the need for demand aggregation. Ofcom and Plum make the same assumption here regarding the provision of the USO: that it will depend upon demand

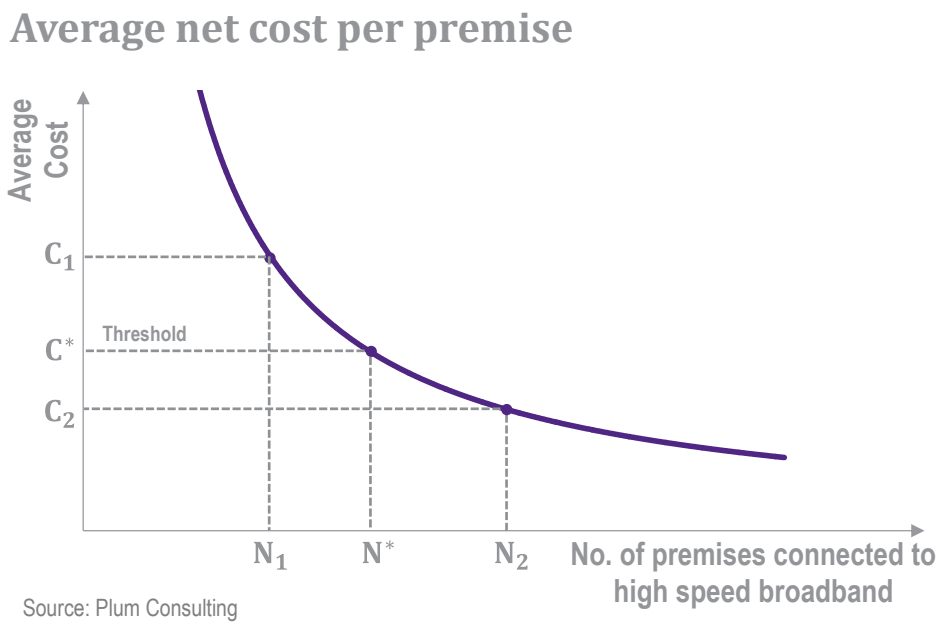
[22] We note that the Government intends to have the broadband USO in place by 2020 at the latest. DCMS, A new broadband Universal Service Obligation Statement of Intent, 11 October 2016.

[23] We divide the number of eligible premises into rural premises and urban not-spot premises

aggregation. Ofcom's modelling, as with Plum's, works on the basis that network is deployed or upgraded in order to serve a community of users (where that community may be a hundred or a handful of premises). This approach gives rise to the concept of the cost of premises passed as well as premises connected. It also brings into sharp focus the importance of the size of the cost threshold set.

There is a growing appreciation that serving premises based on individual demand is not practicable. An individual request for wireline or fixed wireless access to the broadband USO service is unlikely to fall under any reasonable cost threshold[24]. Demand aggregation allows the cost of network assets to be spread across a number of premises. This potentially brings the average cost per premise connected beneath the cost threshold and makes the premises eligible for the broadband USO. This is illustrated in Figure 2-2. As the number of premises connected rises from N_1 to N_2, the average cost per premise falls from C_1 to C_2 and falls below the cost threshold.

Figure 2-2: Cost per premise connected versus number of premises connected



There are several mechanisms by which demand aggregation could operate:

- Individual demand-led: the Universal Service Provider receives individual requests for connectivity, and builds out the network once it has received a certain number of requests;
- Community demand-led: a community bands together and guarantees a certain level of take-up; and
- Supplier-led: the Universal Service Provider builds out the network in the expectation that take-up will exceed a certain level.

For the purposes of our modelling, it does not matter which mechanism is used to aggregate demand. However, the practicalities of demand aggregation will need to be considered in the design of a broadband USO policy. We discuss this point further in Chapter 4.

[24] Except for satellite broadband.

2.2 Technologies modelled

In the process of our modelling we considered a variety of technologies that might be used to deliver a USO service. These included:

- Ka-band satellite;
- Fixed Wireless Access (FWA);
- Fibre to the Cabinet (FTTC), based of VDSL or long-reach VDSL;
- Fibre to the Distribution Point (FTTdp); and
- Fibre to the Premise (FTTP).

In our initial research we assessed the costs and capabilities of each technology. We found that FWA and FTTC shared a similar cost structure, as did FTTdp and FTTP. We therefore narrowed down our list of technologies modelled to satellite, FTTC and FTTdp. This does not mean that FWA and FTTP will not be used. We expect that the choice between FWA and FTTC, and between FTTP and FTTdp, to reflect what is appropriate to the local situation. However, the cost structures for each of these pairs of rival technologies are similar enough that the choice between the technology pairs is unlikely to materially change the outcome of the modelling.

In our model we have used estimates of the current cost-performance of the chosen technologies, even though we expect that the broadband USO will not be implemented before 2019. Our rationale is as follows:

- We know, from Ofcom's Connected Nation publications, that data throughput per month and broadband speeds will grow over time;
- Equally we know that the cost-performance ratio for the modelled technologies will improve over time as Figure 2-3 illustrates for satellite broadband; and
- These two trends are both uncertain but will tend to cancel each other out.

To minimise the level of uncertainty we model current speed/data throughput requirements on the one hand and current cost/performance parameters on the other.

Figure 2-3: Expected cost performance of Ka-band satellite broadband

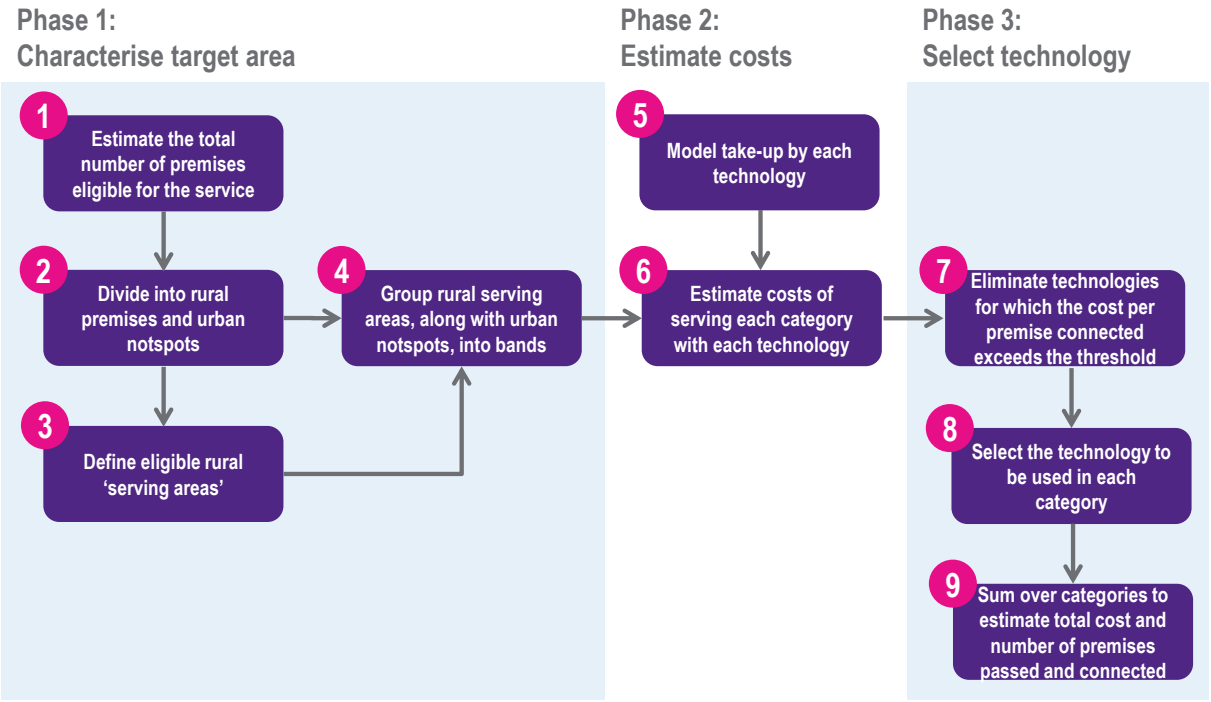
Launch date	Transponder capacity	Launch and payload cost
2011	100 Gbps	£250m
2017	350 Gbps	£250m
2021	>1000 Gbps	<£250m

Source: Plum review of literature

2.3 Modelling methodology

The modelling process we have used for this study follows a number of steps which can be divided into three phases – see Figure 2.

Figure 2: Diagram of the modelling methodology



These steps are described in greater detail below.

Step 1. Estimate the total number of eligible premises

In our base case, we assume that 500,000 UK premises will not be able to receive speeds in excess of 10 Mbps in 2019/early 2020. This figure is based on discussions with BDUK and BSG stakeholders, and reflects the likely state of connectivity in the UK after the conclusion of the BDUK programmes. These premises will be eligible for the broadband USO.

Similarly, we estimate that one million premises will not be able to receive speeds above 30 Mbps in 2019/early 2020.

Step 2. Divide these premises into rural premises and urban not-spots

The eligible premises are likely to consist of rural premises and premises in urban areas that are unable to attain the minimum speed (for example, they may be on a long copper loop or use exchange only lines). As the costs of providing universal service are likely to differ greatly between urban not-spots and rural areas, we treat them separately in our model. We assume that 15% of the total number of eligible premises will be in urban not-spots.

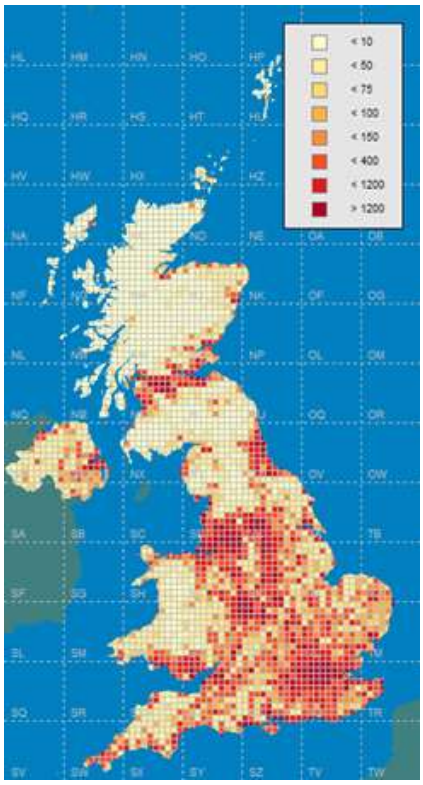
Step 3. Define rural 'serving areas'

Using UK census data, we define the rural target area using the following steps.

- overlay a high-resolution (5m x 5m) grid onto the UK and count the resident population that lies within each grid square;[25]
- aggregate this population data into larger contiguous squares (2km x 2km for our 10 Mbps model) and convert the population figure to premises, based on the average UK household size;
- rank these squares in terms of the number of premises; and
- add up squares until the number of eligible rural premises is reached, starting with the least densely-populated square.[26]

These squares form the rural target area which, for 425,000 premises,[27] represents around 53% of the UK's land area. Figure 2-5 gives an indication of this area.

Figure 2-5: Illustrative map of UK population density based on 100km^2 grid



The next step is to aggregate these grid squares into *serving areas*. We do this by looking at the most populated square in the target area, then examining the eight surrounding squares in turn. If they are also in the target area, they are incorporated into a serving area, and marked as 'served'. We then look at the next most populated square, and repeat until all squares in the target area are 'served'.

[25] A resolution this high is necessary, as some census areas consist of a single building.

[26] We thus assume that the rural target area consists of the least densely-populated areas of the UK.

[27] Total eligible premises to be served less the 15% assumed to be in urban not-spots.

This process yields serving areas that are a maximum of 6km by 6km, and so could conceivably be served by a single LR-VDSL cabinet[28]. In practice, most serving areas are significantly smaller than this, as they adjoin non-eligible squares or the sea. While this approach may not result in the most efficient overall placement of network assets, we consider that it is likely to reflect the practicalities of network deployment[29] (it also does not require the assumption that network nodes are placed in 'idealised' positions away from population centres).

For our 30 Mbps scenario, we follow the same process of aggregating the population census data, but use a 1km x 1km grid. From this we construct serving areas that are a maximum of 3km x 3km. This reflects the shorter range at which a LR-VDSL cabinet can supply 30 Mbps[30].

Step 4. Group the serving areas into bands

We rank the rural serving areas in descending order of premise population and then assign each of them to one of 30 serving area bands. Each band has an equal number of serving areas. The first few bands of serving areas have the largest average number of premises and correspond in many cases to villages; the last few bands correspond to remote and isolated hamlets and individual premises. Urban not-spots form a 31st band, with an assumed average number of premises in each not-spot.

Step 5. Estimate take-up for each technology

We estimate what the take-up is likely to be for each of our modelled technologies by using a stylised demand model. In the base case we assume that, if the service offered by a technology is affordable, 60% of premises passed in a serving area will take up the broadband USO service. But we also note that high data consumption pushes up the user price of a connection, which reduces demand for connectivity (i.e. reduces take-up). If the price of a connection rises above a certain level – the *choke price* – then we assume that take-up falls to 0%. We use a choke price of £120 per month[31] and assume that the end user price rises by the incremental cost of data supply once data usage exceeds the data cap offered in a typical retail offer.

The incremental cost per GB is negligible for wireline connections and modest for fixed wireless access, but significant for satellite connections. As the data usage required by the broadband USO service (an input to the model) increases, satellite broadband becomes increasingly unaffordable and demand falls to zero when data throughput reaches 100 GB per month.

[28] We assume that long-range VDSL will perform as expected.

[29] For example, consider a town by the sea. Under a 'scorched earth' network design approach, it may be more efficient to place, say, a cabinet outside the town, to cover more of the surrounding area while still – just – supplying the town with the required 10 Mbps. In practice, the cabinet is more likely to be located in the town.

[30] We estimate that long-range VDSL will deliver 10 Mbps on loops of up to 3.7 km and 30 Mbps on loops of up to 1.8 km in length.

[31] The choke price is set at four times the affordable price. We have looked at the impact of changing this assumption on our findings. This is discussed in Chapter 3.

Step 6. Compute the net cost of serving a premise in each band with each technology

We then compute the total cost of supplying connectivity with each technology for a typical serving area in each band. This cost comprises a fixed cost of network deployment plus a cost per premise connected. Dividing the fixed cost of deployment by the number of premises connected and adding the incremental cost per premise to connect, yields the cost per premise connected for each band and each technology. We then adjust the cost per premise connected to calculate the net cost by subtracting the net present value of the operating profits which flow to the universal service provider[32]. This net cost represents the subsidy required before a profit-seeking operator would provide the broadband USO service.

Step 7. Eliminate technologies where the cost per premise connected exceeds the cost threshold

The cost per premise connected for each band and technology is compared to the cost threshold. If the cost of serving a given band of serving areas with a particular technology is above the threshold, that technology is removed from consideration for that band. If a technology is not an affordable means of delivering a USO service (see Step 5) it is also excluded from consideration.

Step 8. Select the technology to be used in each band

From the viable technologies remaining, we select the technology that provides access to the most premises for the lowest cost. If no technology is viable, the premises in that serving area are not passed or connected.

Step 9. Sum over serving area bands

Finally, we sum over serving area bands to obtain, for any given cost threshold:

- The total net cost of providing the broadband USO service. This is the universal service fund required to subsidise the supply of the USO service.
- The total number of premises connected.
- The total number of premises passed.

[32] We do not consider here how these operating profits might be split between the wholesale and retail functions which make up the universal service provision.

2.4 Modelling assumptions

Table 2-1: Users, take-up and operating profit assumptions - 10 Mbps USO service

Parameter	Value	Notes
Users		
Number of eligible premises	500,000	*Based on discussions with BDUK/BSG stakeholders*
…of which, % in urban not-spots	15%	*Based on discussions with BSG stakeholders*
Average size of urban not-spot (premises)	50	*Based on discussions with BSG stakeholders*
User data usage/month	10 to 200 GB	*Range modelled*
Take-up and Demand		
Take-up % if affordable - FTTC	60%	*Based on discussions with BSG stakeholders and BDUK*
Take-up % if affordable - FTTdp	60%	
Take-up % if affordable - Satellite	60%	
End user choke price/month	£120	*Take-up falls to 0% at this price*
Affordable price per month	£30	*Based on average price of fixed broadband*
Monthly data allowance in affordable price - FTTC	1000 GB	*Based on discussions with suppliers and analysis of retail prices. An allowance of 1000 GB per month is in practice equivalent to unlimited usage*
Monthly data allowance in affordable price - FTTdp	1000 GB	
Monthly data allowance in affordable price - Satellite	10 GB	
Cost per incremental GB - FTTC	£0.01	
Cost per incremental GB - FTTdp	£0.01	
Cost per incremental GB - Satellite	£1.00	
NPV of operating profits		
FTTC	£200	*Based on analysis of BT's investments in BDUK Phase 1. NPV is per premise connected*
FTTdp	£200	
Satellite	£200	

Source: BDUK, BSG stakeholders, Ofcom, Plum

Table 2-2: Cost parameters by technology and serving area band - 10 Mbps USO service

Parameter	Value
FTTC - rural areas	
Fibre cost per metre (£)[33]	20
Cabinet + electronics cost (£)	10,000
Power (£)	5,000
Average length of fibre backhaul – cabinet to local exchange (km)	3
Copper rearrangement costs per cabinet (£)	40,000
Total cabinet – LR VDSL add on to existing VDSL cabinet (£)	10,000
Total cabinet cost - new LR VDSL cabinet (cabinet + power + backhaul) (£)	75,000
Total cabinet cost - new VDSL cabinet with copper rearrangement (£)	115,000
% of serving areas using LR VDSL add on	20%
% of serving areas using new VDSL cabinet	60%
% of serving areas requiring copper rearrangement	20%
Blended total cab cost (£)	70,000
Connect cost per premise (£) - router plus cross connect	65
FTTC - urban not-spots	
% of UNS premises served from new VDSL cabs	50%
% of UNS premises served from VDSL cab upgrades	50%
Cost of new VDSL cabs for UNS (£)	20,000
Cost of VDSL cab upgrade for UNS (£)	10,000
Blended UNS cab cost (£)	15,000
Connect cost per premise (£)	65
FTTdp - rural areas and urban not-spots	
Fibre cost per metre (£)	20
Distribution Point (DP) box + electronics cost (£)	5,000
Power (£)	5,000
Backhaul - DP to cab (km)	Number of DPs + 2
Premises per DP	14
DP cost, excluding backhaul (£)	10,000
Connect cost per premise (£)	65
Satellite	
Connect cost per premise (£)	500

Source: BDUK, BSG stakeholders, NAO, Ofcom, Plum

2.5 Sensitivity analysis

We have based the cost estimates of Table 2-2 on network rollouts to date including those of the BDUK Phase 2 and 3 programmes. We recognise that, as broadband reaches out into the most rural

[33] Blended rate of new dig and reuse of existing ducts

areas of the UK – our target area – diseconomies of small-scale grow and the fibre backhaul required lengthens. These effects are explicitly modelled. But there are other effects, such as the cost of powering cabinets and poles in very remote areas, the cost of fibre digging in very remote locations, and the costs of serving premises on remote islands which are not explicitly modelled. To take account of these uncertainties we have carried out sensitivity analysis in which we have, for the target area as a whole:

- increased the cost of fibre backhaul by 50% (to £30/m);
- increased the average length of fibre backhaul by 1km; and
- doubled the cost of power to £10,000.

The impact of this sensitivity analysis is discussed in Section 3.7.

3 The findings from the model

3.1 Plum versus Ofcom

Ofcom has produced estimates of the cost of the broadband USO which it delivered to DCMS at the end of December 2016[34]. When we compare these estimates with those from the Plum model we find that the two sets:

- are not directly comparable. In particular Ofcom has modelled different sizes of target area from Plum. These reflect different assumptions about the time at which a broadband USO service might come into operation. We model a target area of 500,000 premises assuming a 2019 start date; the nearest Ofcom equivalent is a target area of 300,000 premises in "*the early 2020s*". Given the different time frames the two sets of estimates are consistent; and
- offer broadly similar estimates of total costs and premises connected and passed by the USO service – despite the fact that the two modelling exercises use different approaches and sources of assumptions and were carried out independently of each other.

Figure 3-1 provides a numerical comparison. In our base case we assume a 60% take-up by premises passed (as discussed further in Section 3.5). Ofcom assumes an 80% take-up. So in comparing the Ofcom and Plum findings the reader should use the right-hand Plum column in Figure 3-1.

When we use an 80% take-up assumption for the 10 Mbps case we find that:

- Ofcom's estimate of the total cost of connecting premises in the target area (when there is no cost threshold and all premises are passed) is lower than the Plum estimate. This reflects the smaller size of the Ofcom target area;
- The average cost per premise connected with no cost threshold is similar for the two models; and
- The number of premises which remain unconnected with a cost threshold of £5000 is also similar.

In the case the 30 Mbps broadband USO service costs are substantially higher in both models but again, after adjusting for different take-up rate assumptions and the slightly different size of the target area, the Ofcom and Plum models produce similar results.

[34] Ofcom, *Achieving decent broadband connectivity for everyone*, December 2016, "Ofcom Technical Advice" https://www.ofcom.org.uk/__data/assets/pdf_file/0028/95581/final-report.pdf

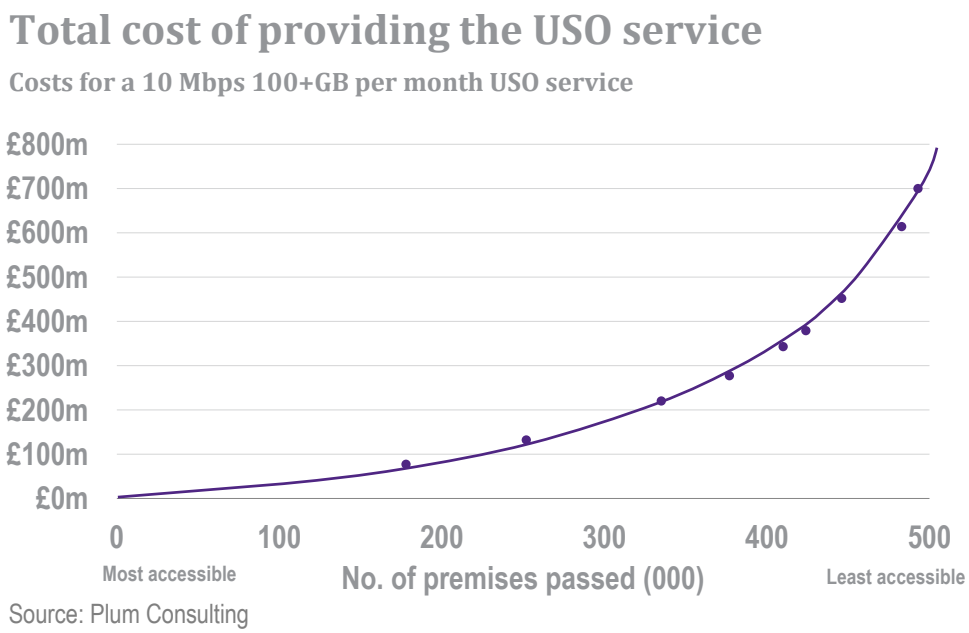
Figure 3-1: modelling outputs compared

10 Mbps BB USO service 100+ GB per month	Ofcom	Plum	Plum
% take up assumed - central case	80%	60%	80%
Date at which target area measured	Early 2020s	2019	2019
Target area (000 premises) at that date	300	500	500
GB/month	130	100	100
Total cost of connecting premises in target area (£m) no CT	700	929	935
Ave. cost per premise connected (£) no CT	2650	3097	2338
No. of prems (000) not connected - £5000 CT	30	76	37
30 Mbps BB USO service 100+ GB per month	Ofcom	Plum	Plum
% take up assumed - central case	80%	60%	80%
Date at which target area measured	Early 2020s	2019	2019
Target area (000 premises) at that date	1100	1000	1000
GB/month	130	100	100
Total cost of connecting premises in target area (£m) no CT	1400	1392	1392
Ave. cost per premise connected (£) no CT	1470	2320	1740
No. of prems (000) not connected - £5000 CT	30	76	37

3.2 The total cost of providing the broadband USO service

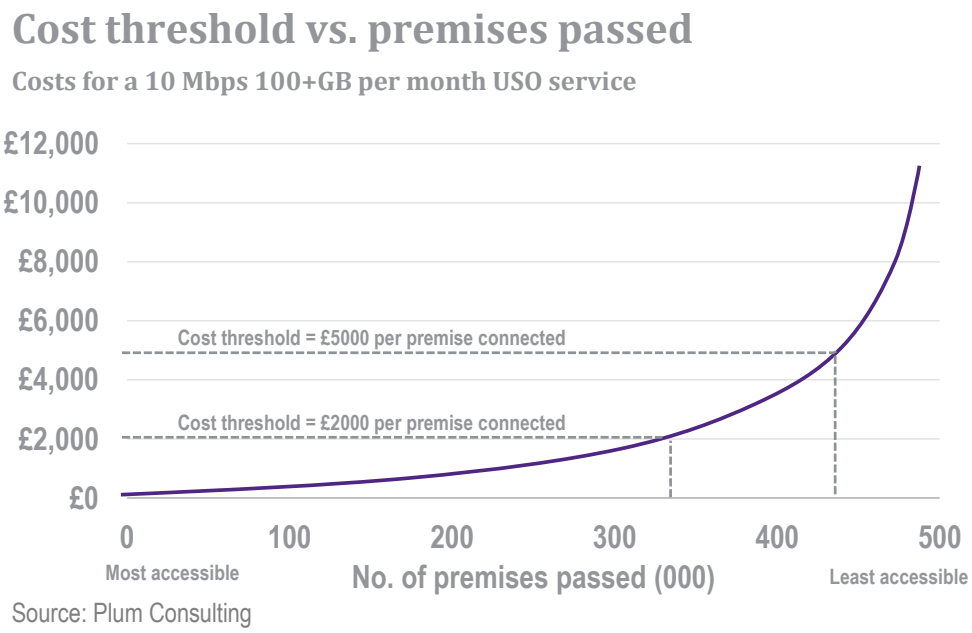
Figure 3-2 shows how, without any cost threshold constraints, the total cost of providing a 10 Mbps broadband USO service grows as a number of premises passed by the service increases from zero to the full 500,000 eligible premises.

Figure 3-2: the total cost of providing a 10 Mbps broadband USO service[35]



The curve is far from linear. For example, it costs around £200 million to pass the first 350,000 of the 500,000 eligible premises in the target area but it costs over £800 million to pass all 500,000 premises. This reflects the fact that the most rural premises in the target area, often isolated households, are extremely expensive to serve. Figure 3-3 illustrates this effect. It plots the incremental cost of connecting premise against the number of premises passed.

Figure 3-3: the impact of the cost threshold on the number of premises passed



[35] Assumes 60% take-up of premises passed

If a cost threshold of £2000 per premise connected is imposed, premises which cost more than £2000 are not served. In that case, the number of premises passed by the USO service is limited to just over 300,000, at a total provisioning cost of around £200 million. If the cost threshold is raised to £5000, then the number passed grows to 450,000 - but the total provisioning cost rises to £450 million. For these examples, a 50% increase in premises passed generates a 125% increase in total provisioning costs.

This behaviour raises the question of what constitutes a "value for money" cost threshold. Should it be set at a high level to maximise the number of premises passed or at a low level to minimise the universal service fund required? We consider this question further in Section 3.4.

3.3 The impact of data throughput on the size of the universal service fund required

Figure 3-4 shows that the data throughput which is required for the broadband USO service has a fundamental effect on the size of the USF required.

Figure 3-4: the impact on total USF costs of increasing cost thresholds for two data throughput requirements

Source: Plum Consulting

If the requirement is for 10 GB per month,[36] satellite broadband can provide 100% connectivity to all premises in the target area at an USF subsidy of just under £100 million and falls below a very low cost threshold. Note that we distinguish here between the cost of providing the broadband USO service and the USF subsidy required. This is discussed further in Box 3-1

[36] Note that the average residential household now generates 132 GB of data per month according to Ofcom's *Connected Nation 2016*

Box 3-1: cost of provision versus subsidy required

We assume that the USF which subsidises the provision of the broadband USO service will compensate the universal service provider for the ***net*** cost of provision only[37]. This means deducting from the total cost of providing the service:

- the net present value of expected future profits generated by end users of the USO service;
- any brand value from being the universal service provider. It is not clear if there will be a significant brand value in the case of a broadband USO. It is also unclear how any brand value will be distributed between the wholesale infrastructure provider and retail service providers; and
- any network externality value from being the universal service provider. This value can be significant when calculating the net cost of a narrowband USO[38]. But it is likely to be small in the case of a broadband USO where the bulk of applications involve access to the Internet rather than person-to-person communications.

We ignore these latter two components in our modelling and estimate only the first. Based on published information on BDUK Phase I we estimate the NPV of the operating profit at just over £200 per connected premise.

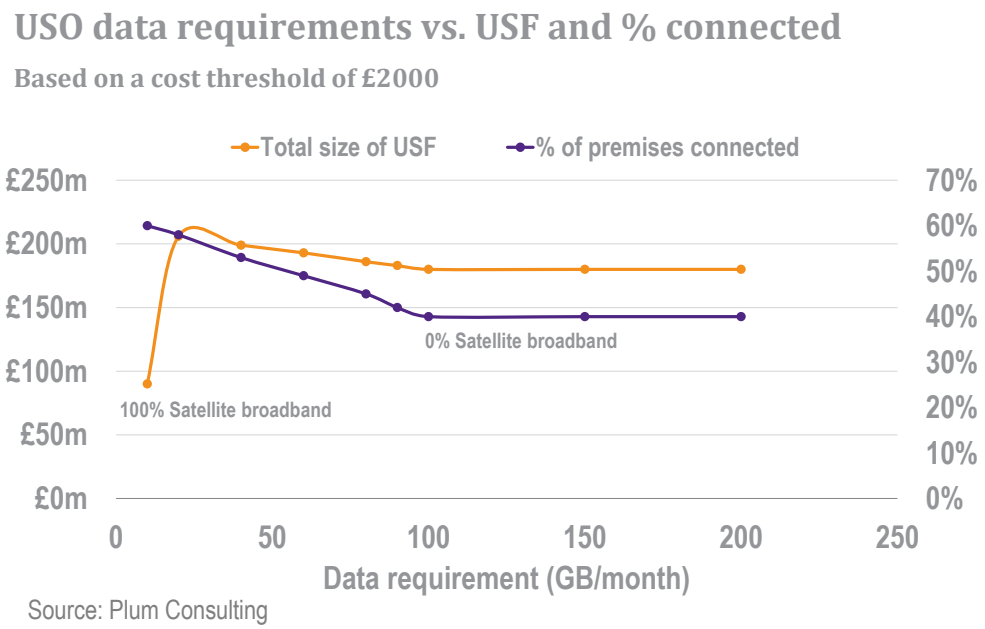
Regardless of the level of the cost threshold, satellite broadband is the lowest cost technology for delivering 10 GB per month. But if the data throughput required is increased then the scale of the USF subsidy required rises substantially. At 100 GB per month or more, terrestrial technology solutions are the only ones which are affordable and the USF required rises - from around £200 million at a cost threshold of £2000 per premise connected, to £400 million at a cost threshold of £6000 per premise connected, and to £870 million if there is no cost threshold.

This effect is shown in a different way in Figure 3-5 (where we set a cost threshold of £2000 per premise connected).

[37] Ofcom note that were it to calculate a "cost burden" to be funded by the industry, it too would calculate a "net cost". Ofcom Technical Advice, paragraph 9.8

[38] For example through profits on calls to universal service users.

Figure 3-5:



Source: Plum Consulting

We can see that:

- If the data throughput required from the broadband USO service is set at 10 GB per month, then all of the premises are passed and those which want to can be connected for a USF subsidy of less than £100 million using satellite broadband;
- As the data throughput increases from 10 to 100 GB per month the proportion of satellite broadband users falls to zero (as usage charges make satellite broadband service increasingly unaffordable) and users require terrestrial broadband solutions (where the incremental cost of carrying an additional GB of data is two or more orders of magnitude lower);
- Once data throughput exceeds 100 GB per month terrestrial solutions are the only affordable option[39]; and
- At this point the USF subsidy is just under £200 million while the proportion of premises connected has fallen from 60% to under 40% in terms of premises connected (or from 100% of premises passed to 67% of premises passed).

Figure 3-5 is the only finding which is materially sensitive to our assumptions about the choke price for the broadband USO service. If the choke price is reduced from £120 per month to £60 per month then use of satellite broadband would reduce to zero at a data requirement of 60 GB per month rather than 100 GB per month.

[39] Premises using satellite broadband contend for the scarce capacity of the satellite transponder. In contrast wireline broadband access is largely dedicated. This means that wireline technologies are much more suitable for a broadband USO service with a high data throughput requirement.

This analysis suggests that the UK might generate greater economic and social welfare if it were to consider a two-tier broadband USO in which:

- the data throughput requirement of the Tier 1 service is set at 100 GB per month with an appropriate cost threshold; and
- premises in the target area which are excluded from the Tier 1 service because of the cost threshold are entitled to a subsidy for a Tier 2 service – where the data throughput requirement is set at (say) 10 or 20 GB per month.

Subscribers to the Tier 2 service would then have access to an affordable 10 Mbps broadband service which would enable them to carry out virtually all of the broadband applications listed in the proposed European Electronic Communications Code[40] while being restricted in their use of applications which generate particularly high volumes of data throughput.[41]

3.4 Maximising the net benefits of the broadband USO service

What is the cost threshold which will maximise the net benefits of a broadband USO service for the UK? We can calculate the net benefit as:

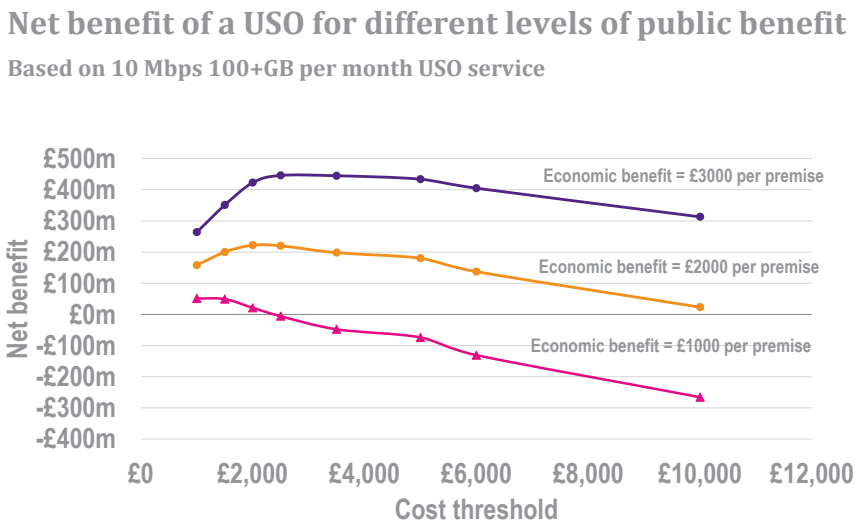
- the economic benefit per premise connected within the target area; *multiplied by*
- the number of premises in the target area which are connected; *less*
- the USF subsidy required.

It is beyond the scope of our study to estimate the first of these parameters. But we set out an analysis in Appendix A which suggests that the economic benefit per premise connected is likely to be in the range £1000 to £3000. Figure 3-6 shows what happens to net benefits to the UK as we vary the cost threshold using an economic benefit per premise connected in this range.

[40] *Proposal for a directive of the European Parliament and of the Council establishing the European Electronic Communications Code*, European Commission, September 2016, COM(2016) 590 final.

[41] Chapter 4 of Ofcom's *Connected Nation 2016* report highlights applications such as online video services, video calling services, and cloud-based services as being important in generating additional requirements for data throughput..

Figure 3-6: the net benefit to the UK of a broadband USO

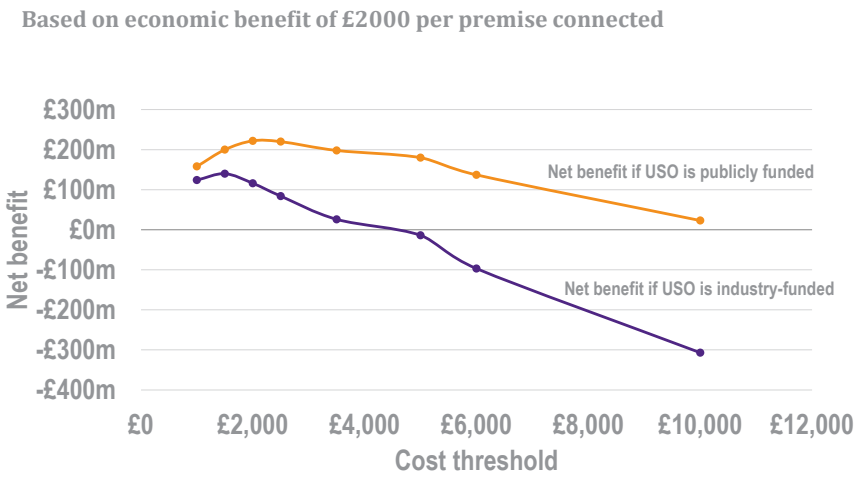


We can see that:

- The cost threshold at which the net benefit is maximised varies between £1500 and £3000 depending on the economic benefit assumed;
- The net benefit becomes a net cost to the UK at a cost threshold of just over £2000 if we assume an economic benefit of £1000 per connected premise; and
- There is little danger of a net cost if the assumed economic benefit is set to £2000 or higher per connected premise.

However the analysis of Figure 3-6 ignores the impact of industry financing of the USF. This might be significant as shown in Figure 3-7. This suggests that moving from public to industry financing substantially lowers the net benefits generated by the broadband USO service.

Figure 3-7: the impact of industry funding on net benefits



Here we look at what would happen to the net benefit if:

- the USF is funded by the telecommunications industry rather than from the public purse;
- the industry passes on the costs of the USF to commercial end users of its fixed high-speed broadband services in price rises so as to maintain current levels of profitability using the assumption set out in Box 3-2; and
- the economic benefit lost when a marginal high-speed broadband subscriber in a commercial area downgrades to basic broadband or mobile broadband is the same as the economic benefit created when a premise in the target area subscribes to the broadband USO service.

Box 3-2: Assumptions used to estimate the loss of commercial high-speed broadband premises with industry funding broadband USO

5 years for recovery of USF costs.

Average price of £360 per annum for commercial high-speed broadband.

80% of premises use broadband services and 40% of these premises use high-speed broadband.

Industry generates a profit margin of 20% on revenues from high-speed broadband.

60% of the costs of supplying high-speed broadband are variable.

The price elasticity of demand for high-speed broadband with respect to basic broadband is -0.4.

Taking account of this scenario we can see from Figure 3-7 that, if we assume an economic benefit per connected premise of £2000:

- The maximum net benefit is significantly reduced – from around £220 million to around £140 million;
- The cost threshold at which the net benefit is maximised is also reduced – from around £2000 to around £1500; and

- The cost threshold at which the net benefit turns into a net loss to the UK reduces from over £10,000 to around £4000.

There is an important message here: if the cost threshold is set too high then there is a danger that the broadband USO will generate net economic losses for the UK, rather than net gains.

3.5 The effect of varying take-up assumptions

The central assumption used in our modelling is that 60% of premises passed by the 10 Mbps broadband USO service take it up over (say) the five-year period following its introduction. But this assumption is far from certain. On the one hand:

- Many premises in the target area may already enjoy download speeds of just below 10 Mbps. This would suggest a take-up rate closer to 40% than 80%;
- The BDUK Phase III trials[42] suggest a five-year take-up rate of around 45%;
- The universal service provider might be wary of assuming a take-up rate higher than 40% when judging whether a request for the USO service was "a reasonable request"; and
- At the same time many communities might struggle to generate an advanced commitment from more than 40% of premises for demand-side aggregation.

On the other hand:

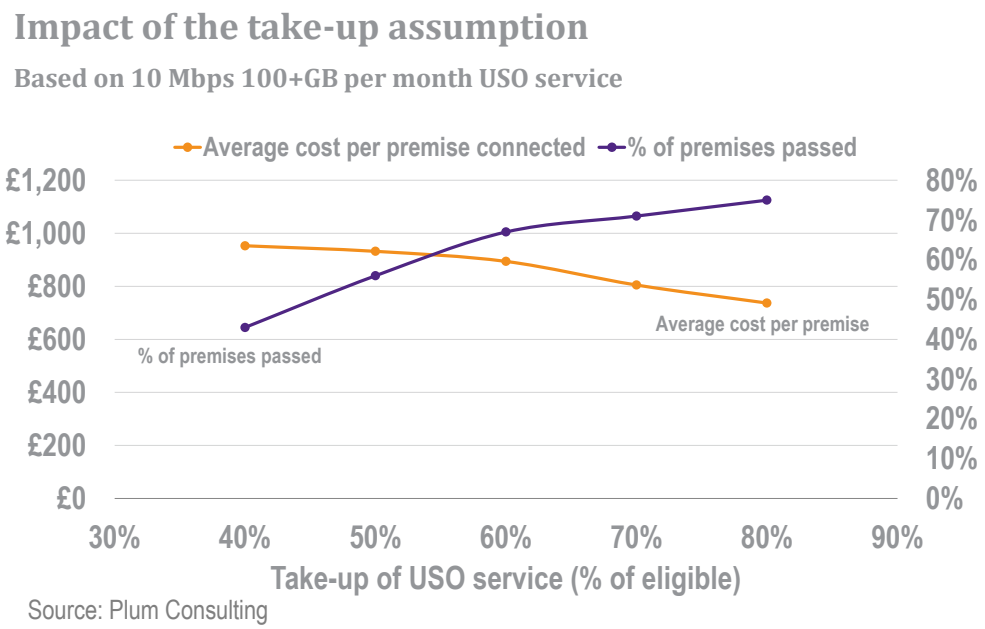
- The overall take-up of fixed broadband in the UK is around 80% of households;
- The need (and willingness to pay) for broadband may be higher in rural areas than in urban areas;
- If passive take-up [43] of the broadband USO service were included, this might lead to a take-up rate close to 80%; and
- An 80% take-up rate was used by Ofcom in its advice to government.

Figure 3-8 shows the impact of varying the take-up assumptions if we assume a cost threshold of £2000 - which Figures 3-6 and 3-7 suggest maybe close to the economically rational level.

[42] *Emerging Findings from the BDUK Market Test Pilots*, DCMS, February 2016

[43] Under passive take-up a universal service provider might automatically upgrade all premises currently connected to the network in a community within the target area to the upgraded broadband USO service without requiring the end-user to take any action. Such action would be possible for example if the universal service provider were upgrading premises currently served with VDSL2 to long-range VDSL

Figure 3-8: the impact of the take-up assumption on premises passed



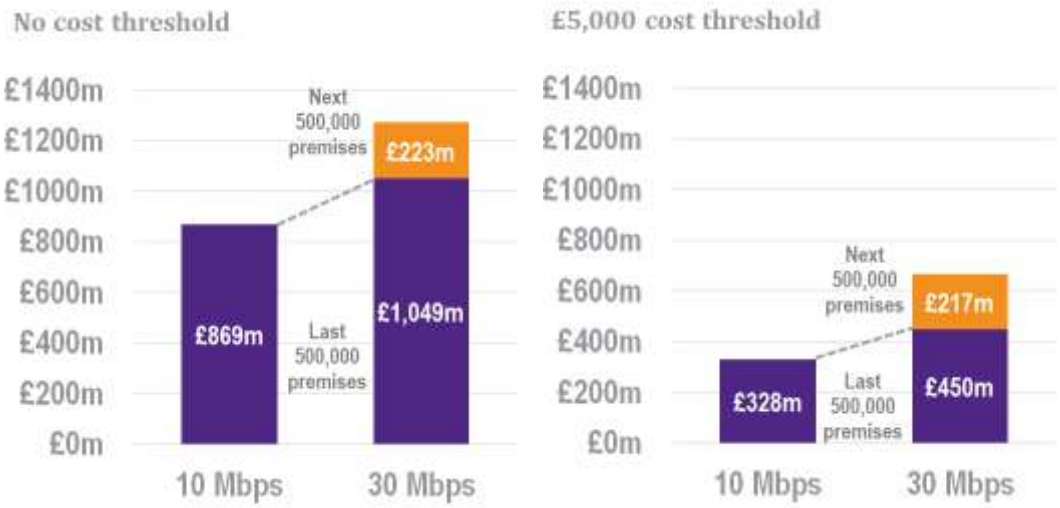
Source: Plum Consulting

The main impact is on the number of premises passed (and connected). At a take-up level of 80%, around 400,000 of the 500,000 premises in the target area are passed. But at a take-up level of 40% only 200,000 premises are passed. With this assumption the broadband USO service is a long way from fulfilling its policy goal of providing universal broadband on demand.

3.6 The impact of a 30 Mbps rather than 10 Mbps USO

Figure 3-9 shows how the USF subsidy needed increases if we implement a 30 Mbps rather than a 10 Mbps USO service.

Figure 3-9: the subsidy required for a 30 Mbps broadband USO service



The left hand graph shows the costs if there is no cost threshold. There are two main effects:

- The net cost of serving the last 500,000 premises, those receiving less than 10 Mbps in 2019, increases by just over 20% from £869 million to £1049 million. This increase in cost reflects the fact that the reach of long-range VDSL is reduced by nearly 50% at the higher download speed and significantly more fibre to the distribution point or fibre to the premise is required to supply the higher speed.
- The target area expands from 500,000 premises to 1 million premises as we move to the higher speed. An additional subsidy is required to serve this next set of 500,000 premises. But these premises are easier to reach than the last 500,000 and the cost per premise passed is lower. As a result the additional subsidy required is only just over £220 million.

In combination these effects lead to a 46% increase in the required subsidy – from £869 million for the 10 Mbps service to £1272 million for the higher speed service (when no cost threshold is applied).

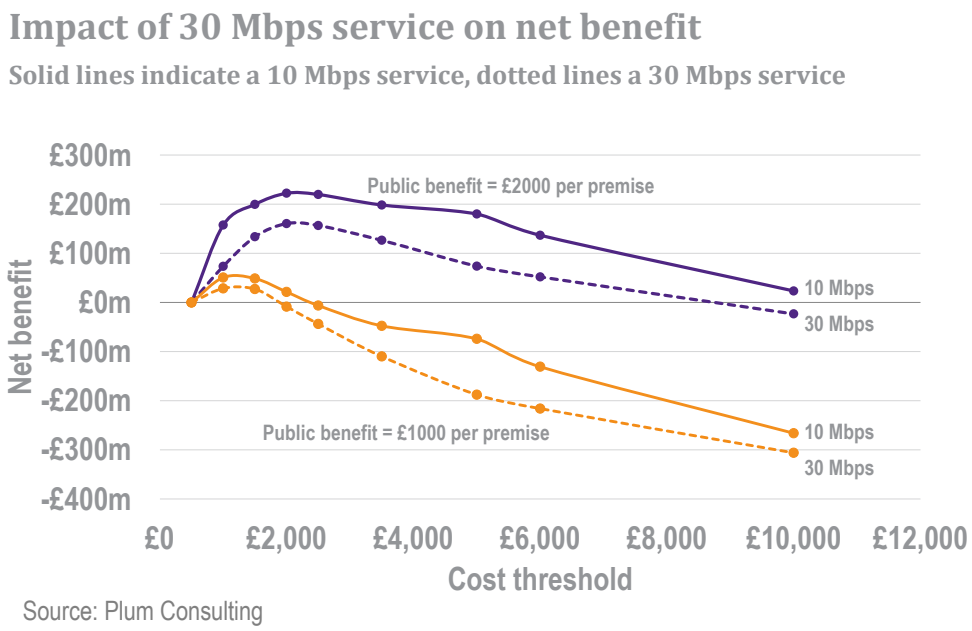
Applying a cost threshold of £5000 per premise connected halves the subsidy required for the 30 Mbps service – from £1272 million to £667 million – as shown in the right hand graph of Figure 3-9. But with this cost threshold the 30 Mbps service requires double the subsidy of the 10 Mbps service (£667 million versus £328 million) whilst there is a corresponding doubling in the number of premises passed by the 30 Mbps service. There are similar effects if we apply a £2000 cost threshold.

Implementing a 30 Mbps rather than 10 Mbps USO service also has two other important effects:

- It reduces further the net benefit of the USO service to the UK as shown in Figure 3-10[44]. If we assume an economic benefit per connected premise of £2000, the maximum net benefit reduces from £220 million to £160 million. This reflects the greater unit costs of delivering the higher speed service; and
- It reduces the proportion of target area premises passed as shown in Figure 3-11. The reduction is not especially significant if we assume an 80% take-up of premises passed. But if we assume a 40% take-up, the proportion of premises passed is much reduced. Only 25% of premises in the final 500,000 are then passed by a 30 Mbps service.

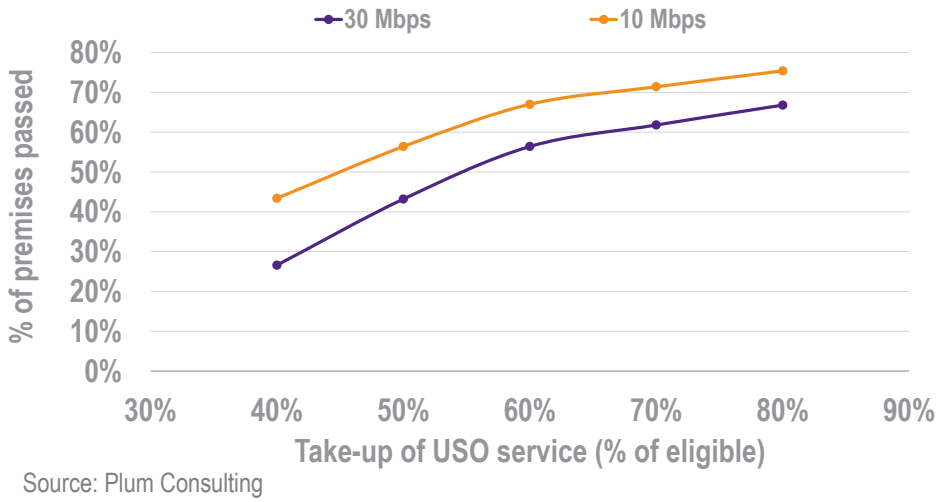
[44] All of the curves in Figure 3-10 assume public rather than industry financing of the broadband USO.

Figure 3-10: the impact of a 30 Mbps service on the net benefit to the UK



Source: Plum Consulting

Figure 3-11: the impact of the 30 Mbps service on percentage of premises passed



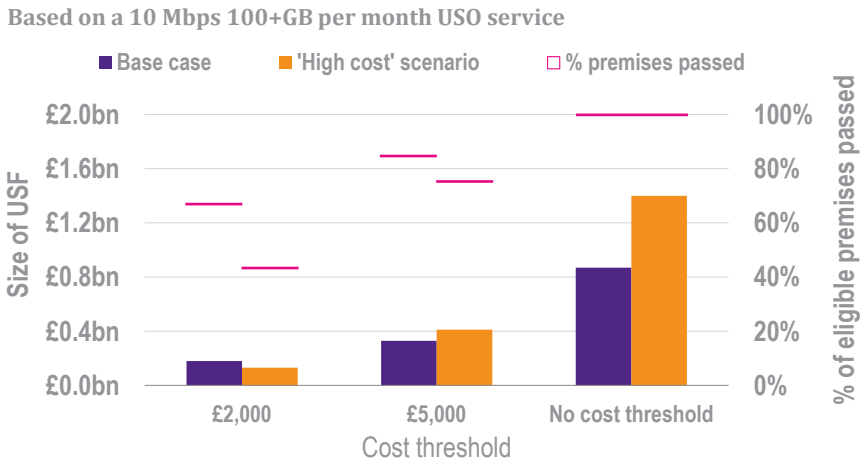
Source: Plum Consulting

Finally it is important to note that our estimates measure the costs of providing a 30 Mbps service *rather than* a 10 Mbps service. We do not consider the incremental cost of upgrading from a 10 Mbps service to a 30 Mbps service at some point in the first half of the 2020s. This would require further modelling.

3.7 Sensitivity analysis for the 10Mbps service

What happens to the USF costs and the proportion of premises in the target area which are passed by the broadband USO service when we carry out the sensitivity analysis specified at the end of Chapter 2?[45] Figure 3.12 illustrates.

Figure 3-12: The impact of higher unit costs



We can see that:

- if there is no cost threshold then 100% of premises are passed whether we use the base case assumptions or the high cost assumptions. But the USF cost grows significantly under the latter scenario to around £1400 million;
- with a cost threshold of £5000, there is little difference in the USF costs between the base case and the high cost assumptions, but there is a small decline in the % of premises passed under the high cost scenario; and
- with a cost threshold of £2000, the USF costs is actually smaller under the high cost scenario, but only because the proportion of premises passed by the broadband USO service declines significantly - to just over 40% of the target area.

In other words the cost threshold exerts a dampening effect on the overall size of the USF required under the high cost scenario. But the cost threshold also reduces significantly the proportion of target area premises passed.

[45] For the testing, we increased the cost of fibre backhaul by 50% (to £30/m); increased the average length of fibre backhaul by 1km; and doubled the cost of power (to £10,000).

4 Key issues in designing the broadband USO

The findings from Chapter 3 raise six key issues which need to be resolved if the 10 Mbps broadband USO is to be fully effective.

4.1 Issue 1: at what level should the cost threshold be set?

There is a balance to be struck here. If the cost threshold is set too high then the broadband USO may generate net economic costs rather than benefits for the UK. If it is set too low the broadband USO will fail in its policy objective of providing the bulk of the hardest-to-reach premises in the UK with a 10 Mbps broadband service.

It is for the Government to decide what cost threshold to set. In doing so we suggest it should take into account two main factors:

- The cost threshold should attempt to maximise net benefits to the UK. This requires the Government to estimate the economic benefit per connected premise based on the available evidence; to consider the impact of price rises for commercial high-speed broadband services which might be created if the industry were to finance the USF; and to take a robust view on the likely level of take-up of the USO service; and
- The cost threshold set should not take account of the cost threshold of £3400 per premise used for the current narrowband USO. There are fundamental differences between the broadband and narrowband USO which means that the narrowband threshold is not relevant. Specifically:
  - The narrowband USO generates significant network externality value: the service involves direct person-to-person communications, so any additional premises on the network generate significant network externalities. This effect is much weaker for broadband services where the bulk of the applications involve person-to-server rather than person-to-person communications; and
  - The cost functions for supply are different. The narrowband cost threshold is based on incremental costs of serving a single premise by extending the copper access network. The broadband cost threshold is based on the (largely) fixed cost of enabling service to a community and the level of take-up from that community.

4.2 Issue 2: what constitutes a reasonable request for broadband USO service?

The broadband USO was originally conceived to give individual end users in the target area a legal right to the USO service on demand. But it is clear from our analysis (and that of Ofcom) that some kind of demand aggregation is required in virtually all parts of the target area before the cost per premise falls below any reasonable cost threshold and therefore represents a “reasonable request”. There are two main ways of triggering a reasonable request:

- Through demand-side aggregation. Here a community may guarantee to the universal service provider a certain level of demand from premises in advance of the USO service being rolled out.

- Through supplier-led aggregation. The universal service provider may decide to provide the broadband USO service in response to an individual request even if the cost of meeting this request is well in excess of the cost threshold. It might take the risk that, given the characteristics of the area from which the individual request comes, demand for the broadband USO service will reach the level needed to drive the cost per premise connected in that area below the cost threshold.

In our view demand-side aggregation raises relatively few problems. Such a mechanism for triggering provision of the broadband USO service represents a reasonable request. The main issue here is whether a community can gather sufficient commitment from individual premises to pay for the USO service so as to get below the cost threshold.

Providing the broadband USO service based on supply-side aggregation may well be important in enabling wide rollout of the USO service in the target area. But it is more problematic. Specifically:

- The universal service provider decides whether to roll out the broadband USO service following an individual request and has substantial discretion over whether to do so. This is a long way from the original concept of a legal right on request.
- The extent to which provision based on supply-side aggregation takes place will depend on the rules which entitled the universal service provider to subsidy. For example, will Government pay subsidy on all premises which use the USO service within N years, provided that the average cost per premise then falls below the cost threshold? If so, what value should N take?
- Should passive take-up be included? Under passive take-up all eligible broadband premises in a community currently connected to the network might be upgraded to the broadband USO service without requiring action by the premise owners. The universal service provider would then receive subsidy for these premises regardless of whether the premise owner wanted the higher speed service or not.

4.3 Issue 3: how will the government ensure that subsidy is paid only for efficiently incurred costs?

Under a "*build it and they will come"* type scheme the issue of efficiently incurred costs can be addressed through competitive bidding – for example between a bidder offering fixed wireless access and another offering FTTC. Under a broadband USO scheme the assessment is made on a retrospective basis once the universal service provider is appointed. This raises the cost of administering the scheme. It could also lead a universal service provider to take a cautious approach to providing a service based on supply-side aggregation because it is worried that its costs of provision would not be met in full.

4.4 Issue 4: should the government offer a two tier broadband USO scheme?

The analysis in Chapter 3 suggests that, if the cost threshold is set to maximise net benefits to the UK:

- A significant proportion of premises in the target area will not be served by a 'Tier-1' 10 Mbps service offering (say) 100 GB per month data throughput at an affordable price; and

- These premises could be provided with a 10 Mbps service using satellite broadband for a modest subsidy. But this service would, if it is to remain affordable, allow only a modest data throughput of (say) 10 to 20 GB per month[46]. Of course the user of this 'Tier-2' service would be free to top up data usage by purchasing additional GB at the prevailing commercial price.

Should the government subsidise such a 'Tier-2' service for those premises in the target area which are excluded by the cost threshold from supply of the 'Tier-1' broadband USO service?

4.5 Issue 5: what is the relationship between the infrastructure provider and the retail service provider in the target area?

Our study makes no assumptions about whether the universal service provider will automatically assume the retail relationship with broadband USO customers or whether there will be separate retail service providers. Making such an assumption is not required in order to estimate the scale of the USF subsidy needed. But this issue is clearly an important one in designing the broadband USO. Our work highlights two points which are important to consider here:

- The USF subsidy is a subsidy of capital expenditure which needs to go to the infrastructure provider in the target area so that the broadband USO service is rolled out; and
- Premises in the target area who use the broadband USO service will want a choice of retail service providers and retail bundles.

How these two requirements are to be reconciled within the broadband USO design will need to be thought through.

4.6 Issue 6: designing a top-up payment mechanism for communities with a high willingness to pay

Our analysis suggests that a significant proportion of communities in the target area will not get access to the broadband USO service because the cost per premise connected will exceed any reasonable cost threshold. But such communities may be prepared to pay the difference between the cost threshold and the actual cost of provision. If the economic benefit from the broadband USO service is to be maximised, there needs to be some mechanism to allow this to happen.

We can foresee two possibilities. A community might either guarantee to the universal service provider a level of demand above the take-up level assumed in calculating the unit cost of provision. Or it might pay an additional lump sum to the universal service provider to provide the broadband USO service.

[46] Compared with the average UK household which now generates over 150 GB per month of data

Appendix A: the economic benefit per additional premise connected

What economic benefit is generated by connecting an additional premise to the broadband USO service? There are two components to this economic benefit:

- there is a public benefit in delivering improvements in services such as e-education, e-government and e-health to this community; and
- there is a consumer surplus created for those end-users which upgrade to the broadband USO service from their existing broadband.

To estimate the scale of this economic benefit we note that the government has subsidised high-speed broadband rollout in the past at a rate of:

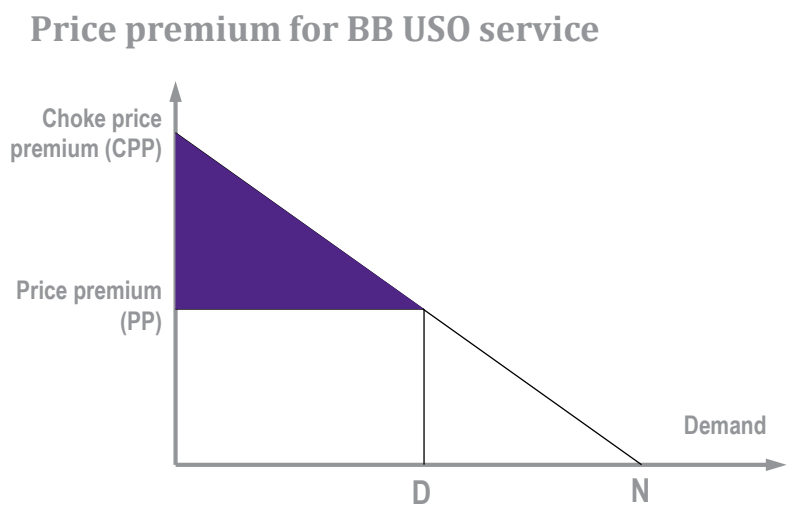
- £300 per premise connected for BDUK Phase I[47]; and
- £575 per premise connected for BDUK Phase II[48].

These estimates form a lower limit on the economic value per premise connected.

We can also make an order of magnitude estimate of the consumer surplus component of the economic benefit per premise connected. We do this as follows.

The total consumer surplus in a community of N premises is given by the shaded area below the demand curve in Figure A1. This monthly consumer surplus is given by [CPP-PP]*D/2 and the average monthly consumer surplus per premise by [CPP-PP]/2.

Figure A1: The consumer surplus generated by the broadband USO service



Quantifying this expression is challenging. But we might reasonably assume:

[47] £1020 million in subsidy/(5.8 million premises x 60% take-up).

[48] (£500 million in subsidy/(1.45 million premises x 60% take-up).

- a price premium over that charged for basic broadband of £5 per month. This is the price premium charged in the UK by BT and also that charged in Australia[49] in moving from the basic tier to the next tier of the NBNCo's broadband services. It is also a price premium used in the past when modelling BDUK Phase 2 demand; and
- a choke price premium of four to eight times this price premium. In other words we assume that demand for the broadband USO service drops to zero when the additional charge per month reaches between £20 and £40 per month.

With these assumptions[50] we estimate that the consumer surplus per premise connected lies between £450[51] and £1050[52]. Again these order of magnitude estimates form a lower limit on the economic benefit per premise.

Given this analysis we have modelled the net benefit of the broadband USO service on the assumption that the economic benefit per premise connected lies between £1000 and £3000.

[49] *The costs and benefits of high-speed broadband,* Vertigan Panel for Australian Government, August 2014

[50] And assuming a five-year period over which the consumer surplus accumulates

[51] (£20 -£5)/2×60 months

[52] (£40 -£5)/2×60 months)