BROADBAND DELIVERY UK
THEORETICAL EXERCISE

Conclusions and lessons learned

DECEMBER 2010

Contents

Executive summary

BDUK's Theoretical Exercise was launched at its Industry Day in July 2010. Its purpose was to understand the choice of cost effective solutions available to provide a minimum level of coverage to all premises without access to at least 2Mbps broadband.

BDUK identified three areas with challenging economics and connectivity issues (in South Wales, North of Scotland and in the North West of England). Suppliers were invited to explain what solutions they would deploy in those areas to provide coverage, how much it would cost and what revenues they would forecast over time, and a calculation of the subsidy needed to make the project viable.

26 responses were received in September 2010 from network suppliers and operators and engineering companies, and suppliers were given the opportunity to present to BDUK. BDUK has produced this report to summarise respondents' comments and BDUK's conclusions from the exercise:

- BDUK's Universal Service Commitment (USC) objective should not be seen as separate from the superfast broadband objective, but rather an integral part of pushing next generation networks deep into rural Britain.

- The investment needed for coverage is dependent on the needs of the region or locality. There is a clear role for local authorities to establish a formal requirement for broadband to the area in a strategy.

- The exercise clearly demonstrated the importance of scale: suppliers investing on the basis of, say, 20k+ end-users would significantly lower the size of the subsidy needed for a project / procurement.

- A solution to the challenge will involve a mix of technologies (fibre, wireless, copper, mobile, satellite). Geographic densities are a guide to options for cost-effective and sustainable solutions.

- BDUK are considering steps to ensure mobile broadband coverage is part of the mix of solutions used to deliver broadband to difficult rural areas.

- The provision of affordable backhaul in these rural areas as part of the government's delivery approach would positively impact the business case for private sector investment in fibre, fixed wireless and mobile solutions in those areas, reducing the subsidy needed to provide universal coverage.

- The level of competition for data backhaul and access in the marketplace is dependent on the availability and pricing of access to passive infrastructure (i.e. poles and ducts).

Introduction

Background

This document has been written as a summary output of Broadband Delivery UK's (BDUK's) Theoretical Exercise to understand the optimal mix of cost effective solutions available to provide a minimum level of coverage to all premises without access to 2Mbps.

The exercise was launched at BDUK's Industry Day on the 15th July 2010. More details about the BDUK approach and the exercise can be found by downloading the presentation given at that event (http://interactive.bis.gov.uk/comment/bduk/industry-day/).

BDUK identified three areas with challenging economics and connectivity issues (in South Wales, North of Scotland and in the North West of England). Suppliers were invited to explain what infrastructure solutions they would deploy in those areas to provide universal coverage, how much it would cost and what revenues they would forecast over time, and a calculation of the subsidy needed to make the project viable. BDUK provided suppliers with data on the existing supply infrastructure in these areas, and also local champions were available to provide additional local knowledge. Suppliers were asked to provide a response on an indicative basis only to inform BDUK's approach.

A significant number of suppliers responded and BDUK is very grateful for the time they invested in taking part in the exercise and especially in presenting their responses, which provided an opportunity to talk to the large number of industry specialists who have contributed to the exercise. BDUK found the exercise very useful, and is are grateful to the industry at large for demonstrating a willingness to help inform government thinking as we develop BDUK's overall delivery approach. BDUK is particularly grateful to BT, Virgin, Arqiva, and Wireless Infrastructure Group who provided information on their supply infrastructure to inform the exercise.

BDUK is also grateful to our local champions from each of the areas, the Broadband Stakeholder Group and Analysys Mason for their time in supporting the design and implementation of the exercise and making it a success.

Purpose of this document

This document sets out the key lessons learned by BDUK through the process, and the conclusions drawn from the exercise.

Suppliers responded to the exercise with commercially sensitive information, and to respect confidentiality agreements, this document does not summarise or specifically reference individual respondents' solutions, nor does it tabulate costs or subsidy-per-household quoted by individual respondents.

BIS will be publishing a National Broadband Strategy document in December putting BDUK's proposed delivery approach in the wider context of the government's overall broadband agenda.

This document does not itself describe BDUK's approach for delivering broadband, nor for any commercial activity to procure services related to BDUK's objectives. BDUK and BIS will communicate with the market separately and in due course on these topics.

This document is not intended to provide any information specifically regarding the commercial processes for the superfast broadband pilot locations or projects (also referenced in the Industry Day presentation), and suppliers (including all respondents to this exercise) will be informed of the related advertised processes once these begin.

Structure of this document

The remainder of this document is structured as follows:

- Section 3 contains lessons learned relating to the approach to the exercise and the choice of areas.
- Section 4 contains lessons learned relating to solution choice for universal coverage of rural areas. Information is categorised as it relates to fixed wireless, wireline, satellite and backhaul.
- Section 5 contains lessons learned relating to cost dynamics of the different solutions.
- Section 6 contains lessons learned relating to revenues and project returns.
- Section 7 contains a summary of BDUK's main conclusions from the exercise.

General observations

The exercise

BDUK found the exercise to be a particularly useful way to engage with a large cross-section of the marketplace. Suppliers were invited to submit responses using a response template issued by BDUK. Suppliers were also given the opportunity to present the key issues arising from their response to BDUK.

The exercise enabled many of those suppliers who are considering their potential role in serving the not-spot and slow-spot populations to understand how BDUK perceives the challenges to demonstrate how coverage could be provided in these areas and to outline potential ways of solving issues.

In particular, it was very helpful to be able to use the exercise as a common frame-of-reference and vocabulary in discussions with suppliers, either in illustrating particular points, or in being able to compare one supplier's response with others'.

Several suppliers also reported back that – as intended – the exercise had triggered many conversations within the marketplace, helping suppliers understand each other's capabilities and creating the exciting possibility of new partnerships at a future stage.

Supplier responses

Suppliers responding

In total, BDUK received 26 responses to the theoretical exercise from suppliers. The majority of these responses were from individual suppliers, but some were provided as joint responses from collaborating suppliers.

The suppliers providing responses were:

- Airspan
- Alcatel-Lucent
- Arqiva
- Avanti
- Babcock International Group
- BeyonDSL.net
- BT
- Cable & Wireless Worldwide
- Cobham Technical Services
- Ericsson
- Eutelsat / Skylogic
- Genesis Technology Solutions
- Geo
- Hughes Network Systems
- i3 / Fibrecity
- Magdalene

- IBN
- Motorola
- Networks by Wireless
- Nokia Siemens Networks
- Parsons Brinckerhoff / Balfour Beatty
- Power-line Technologies
- QiComm
- Relacom
- Relationship Engineering Management
- Rutland Telecom
- Telent Technology Services
- UK Broadband
- Virgin Media
- Vtesse Networks

Represented technologies and layers of the value chain

BDUK had hoped that the exercise would result in collaboration between different technology providers (i.e. fixed, wireless, satellite) to submit a combined response that identified the best solutions and technology mix.

Unfortunately different technology providers did not come together to show an integrated solution in an area – presumably due to the limited timescale for and nature of the exercise and lack of existing partnership arrangements. However a few suppliers were able to demonstrate how their technology solution and revenue model was dependent on the combined penetration and success of all competing technologies.

Although there was considerable collaboration between network equipment suppliers and network operators, very few suppliers collaborated with Internet Service Providers (ISPs) in their responses. And although one mainstream ISP had expressed an interest at the beginning of the exercise, none provided a response of their own.

Where ISPs had contributed to responses – or where a network operator also sold wholesale or retail consumer ISP services itself – BDUK was more confident that the availability, channel, specification and price of wholesale products would be of interest to ISPs, and as such, retail broadband products would be available to consumers and SME businesses.

BDUK was disappointed that despite some original expressions of interest no mobile operators decided to participate in the process, meaning BDUK saw no practical illustrations from the mobile operators of how their current plans for mobile broadband can contribute to the coverage challenge.

Completeness of responses

Most suppliers provided solutions to all three areas in the exercise, although there was often duplication in many of the answers to common questions in the template provided.

In some instances, suppliers with limited resources chose to provide a more detailed analysis for a solution in one area (e.g. Wales), rather than spreading their effort on all three examples.

Take-up of site visits

A handful of suppliers also took up the opportunity to conduct site visits and, in particular, to have conversations with the local champions. In these instances, the solutions were typically more specific and incorporated additional resources and information found locally that was not provided as part of BDUK's information pack.

In particular, these visits identified some unusual 'real life' details about the existing infrastructure – e.g. distribution points maintained to inconsistent standards – or identified inaccuracies in the data set, which highlights the limitations of both model and inventory data.

Accuracy of data set

In general, the approach taken for the data set held up well, but there were a small number of material inaccuracies that would affect solution choices in the specific locations.

Postcode approximations

BDUK provided respondents with a data set that had been aggregated to a post-code level (reduced to a single geographic position) rather than providing data and locations for individual households, in order to simplify the analysis and to avoid any data protection or confidentiality issues.

Some suppliers undertook further analysis to develop and test their solution choices at a household level, and reported that the approximation to postcode level had broadly little impact on the solution. However, in some rural locations (including in the North of Scotland exercise) some postcodes consist of a number of households dispersed along a road, such that the distance between households in the same postcode could be of the order of 5km instead of more typically of the order of 500m outside of urban areas.

In these instances, actual broadband speeds would be widely spread around BDUK's modelled average broadband speed for that postcode – e.g. +/- 1Mbps. This illustrates how further time for due diligence would be required to develop and cost an accurate solution for coverage issues in sparsely populated areas. BDUK will need to consider this trade-off in the design of any subsequent procurement processes, and the implications for allocating this risk between the public and private sector.

Supplier information

Some suppliers spotted that the BDUK provided data on one of the BT cabinets in the Lancaster exercise was incorrect by about 1 mile, in that it was located closer to the exchange and further from the distribution points and premises it served.

This was material in analysing the viability of fibre to the cabinet (FTTC) as a solution to cover not-spots and slow-spots in the area. Again, BDUK will need to consider how the risk of inaccurate data is treated in the design of any subsequent procurement processes.

Scale and location of exercise

Difficulty and rurality

Several suppliers shared their perception that the areas BDUK chose for the exercise were atypical and particularly hard areas to solve – in the 3% of least populated areas in the UK, as

calculated by one supplier – and may not be typical of many of the not-spots and slow-spot locations. These suppliers warned BDUK against directly extrapolating costs from just these example areas for the whole of the UK's not-spots and slow-spots.

BDUK recognises that these areas may not be representative of the nature and cost of the most typical areas to be addressed, but maintains that there are a significant number of similarly difficult and costly areas in the UK, which in aggregate may require a significant proportion of an overall subsidy, if not of overall physical area covered. Nevertheless, the point about extrapolation of costs is noted.

Solutions and technologies

Fixed wireless access

The majority of submissions received by BDUK proposed fixed wireless technology to solve not-spots and slow-spots in the exercise areas. These suppliers saw fixed wireless having a role in all three exercise areas, although identified limitations of point-to-multipoint solutions below a minimum scale in a particular area. For example in the North of Scotland scenario, several postcodes that weren't clustered close together couldn't be served cost-effectively by wireless solutions in most respondents' solutions since the number of customers in a sector would generate too little revenue to make the service sustainable.

Access technology

Predominantly, access solutions were designed as point-to-multipoint solutions using Wimax standard, but some responses proposed using 4G Long Term Evolution (LTE) implementations instead. Those suppliers expected LTE to become more prevalent than Wimax, as the release of spectrum targeted for 4G mobile services will drive a large increase in the volume and choice of LTE devices, with a corresponding drop in costs.

One option available with an LTE solution would be the opportunity to develop roaming agreements with mobile providers as an additional source of revenue on top of that for selling fixed wireless broadband products

One solution proposed a broadcast wireless solution instead, but this had not yet been deployed or tested at scale, and was dependent on an ability to acquire suitable spectrum.

Access speeds

Suppliers showed how LTE and Wimax solutions could be designed to support headline access speeds of 10Mbps – although with the available cell resources, the potential access speeds are even higher – and can be configured to provide a minimum 2Mbps service to even more users.

In particular the design of the wireless Customer Premises Equipment (CPE) currently available means that fixed wireless can deliver predictable throughput, when necessary, in a way that equipment designed for mobile use cannot.

Suppliers also explained how fixed wireless technology is improving rapidly, lowering the cost of infrastructure and simplifying its deployment.

Spectrum

Suppliers presented solutions using either licensed or unlicensed spectrum, but only those using licensed spectrum could assure service availability.

Typically, suppliers believed they needed 2 x 10MHz tranches of spectrum to serve customers from their mast infrastructure, although others believed 2 x 20MHz tranches in the sub-1GHz band would be needed to serve these customers in rural areas.

A range of frequencies was seen in the solutions, including:

- For access: 600MHz, 800MHz, 2.3GHz, 2.5GHz, 2.6GHz, 3.5GHz, 3.6GHz, 3.9GHz, 5.8GHz;

- For backhaul: 3.3-3.8GHz, 5.8GHz, 28GHz, 42GHz, 60GHz, 80GHz.

The spectrum frequency band used affects the size of the cell able to offer a given throughput, and therefore the choice of frequency would be expected to have a direct impact on site/mast density, along with the demand for resources in an area. However in hilly and sparsely populated rural areas, cells are not distributed evenly, so the trade-off between frequency (i.e. cell resources and customer experience) and site density (i.e. cost) is not straight forward.

Macro versus micro sites

The East coast of Scotland exercise illustrated how macro wireless sites are able to provide wireless coverage to a great number of people with ease on coastal areas, but struggled to be effective in providing coverage down steep valleys where multiple microwave hops would be needed to extend coverage.

Two suppliers promoted the use of a chain of micro-sites placed on low-voltage (LV) power poles to access difficult areas such as these. Their proposed equipment used 800MHz LTE for local access, but also high-frequency radio to link to the adjacent site, using multiple hops to reach a suitable point of handover.

Re-use of masts

Suppliers proposed differing mixtures of site types taken from existing sites, potential Arqiva or Wireless Infrastructure Group sites and ‘theoretical’ sites. The assumption for ‘theoretical’ sites was that these could be acquired near to locations that optimally served the target users.

On one hand, it is relatively straight-forward to put up new masts because: i) monopoles are low-cost to build and well suited for these uses, ii) mast heights can be kept below planning limits, iii) land-owners may accept connectivity as payment-in-kind for way-leaves, and iv) masts can always be powered by renewable energy sources if necessary.

Conversely, it is capital intensive to build new infrastructure and not very environmentally friendly to create new sites where (especially in Scotland) many already exist.

However, there does tend to be a mis-match between the location of existing masts (predominantly near major roads for 2G/3G coverage for cars, or on high ground e.g. TV repeaters) and the location of not-spots and slow-spots, e.g. in villages. Even where high-voltage (HV) electricity pylons are available as options for site locations, the cost of developing new sites is often prohibitively expensive – ironically due to the cost of getting LV power to them, so construction of new masts may be necessary.

In these instances, community support should be sought (e.g. waiving way-leaves) to provide low-cost locations to locate masts to serve these communities.

Type of receiver

In general, a mixture of CPE solutions was proposed: from simple dongles to fixed aerials for greater reach or throughput. Of course the choice of solution has a direct impact on the install costs for users and therefore on take-up. Innovative solutions, e.g. combining the aerial with existing satellite dish infrastructure, or by re-using the TV aerial, has the potential to reduce these costs.

Increased standardisation is needed for further development of equipment to simplify and reduce installation and maintenance costs and improve quality further.

Availability of licensed spectrum

Suppliers designing solutions using sub-1GHz licensed spectrum invariably didn't include any costs for the use of spectrum – either because they found it impossible to calculate a value or essentially on the basis that it was of zero opportunity cost to a mobile operator in rural areas where it wouldn't be expected to deploy services.

However there is currently no effective secondary market in such spectrum, nor is there any obligation to share it, so in the current market environment, there is a risk that the spectrum would remain unused but unavailable.

On the assumption that wireless has fundamental role in providing universal access in rural areas, respondents were frustrated that unused licensed spectrum is not commercially available, or that special provision has not been made for its use in rural areas.

Wireline access

Respondents proposing fixed line solutions were predominantly advocating fibre to the cabinet (FTTC) or – for some premises – fibre to the premise designs, but BDUK also received solutions using: broadband enabling technology, fibre to the distribution point, bonded copper lines, and power line access.

In the example areas, the long distances between the cabinet and the distribution point (D-side distance) in the current network architecture meant that FTTC had a limited role in the North West example, whereas it was a more effective solution in the Wales example where cabinets were sited closer to a larger number of premises.

Fibre to the premise (FTTP)

Very few suppliers included FTTP as part of their solutions to solve not-spots and slow-spots in the exercise areas, due to the higher cost of deploying to the premises relative to wireless or existing copper infrastructure in these sparse and rural areas.

However, some suppliers did investigate this solution, and still more communicated an increased appetite for considering FTTP for rural and low-density areas. This is perhaps because operators are beginning to see the operational cost benefits of fibre relative to the costs of maintaining their legacy infrastructure.

Virgin Media also considered the viability of using a passive optical network deployment, using the radio frequency over glass (RFoG) standard to remain compatible with existing head-end and CPE.[1]

Fibre to the cabinet (FTTC)

BDUK received several responses not only from network operators, but also engineering suppliers involved in the mass deployment of FTTC, which were very instructive.

From the responses, it is also clear that there is significant choice and competition between suppliers willing to supply different street cabinets and active electronics.

Suppliers proposing sub-loop unbundling (SLU) solutions highlighted that the SLU products or services from BT are not yet structured for volume deployment, which they say makes it harder to compete with BT performing programmatic upgrades. Furthermore, there is reliance by smaller suppliers on products – and prices – for passive access to their infrastructure (PIA products), which will not be launched by BT until mid-2011[2].

To increase the reach of the VDSL technology in the cabinets, and therefore to cover more not-spots and slow-spots, several suppliers proposed changes to the access network frequency plan (ANFP) so that more power could be used for the VDSL signal from the cabinet if ADSL signals from the exchange were ceased. In practical terms, most CPE is capable of operating at the necessary range of frequencies, however it has the potential to impact on

[1] More detail on this technical standard can be read in this EuroMedia article: http://www.advanced-television.com/PDF/EuroJune09.pdf

[2] A draft reference offer available for trial should be published on 14th January 2011.

existing services and will define the deployment options of future services, thus any change would need the cooperation/agreement of the industry.

At least one supplier proposed cabinet 'splitting', i.e. placing an additional cabinet closer to customers, as a way of increasing the reach of VDSL. Suppliers were told by BT Openreach that there is currently no product available from BT Openreach to enable them to 'cut into' the network to create / co-locate cabinets further out into the network, so at the moment this is an option that requires BT Openreach's cooperation to implement. However the existing regulatory environment does allow Communications Providers (CPs) to request the implementation of a new equivalent product from BT Openreach.

Fibre to the node (FTTN)

From supplier responses, we understand that several CPs are testing pushing fibre to distribution points (e.g. poles) as a potential product. This is logically similar to cabinet splitting with the 'split' taking place at the distribution point, and similarly no BT Openreach product is currently available.

This approach would appear to require a significant increase in the number of active electronic locations in the network, each of which would need to have access to power.

It is also not clear that the economics of an FTTN solution would be favourable compared to an FTTP solution in the long-term: as an operator deploys fibre into the network, fixed costs (capex and opex) at a node are shared between fewer end-users, and the relative difference in costs between a FTTN and FTTP solution reduces.

Bonded DSL

A number of suppliers proposed solutions that bond DSL signals down multiple copper pairs to a premise or node to maximise utility of the available bandwidth. Two suppliers had deployed these solutions to support business customers.

Given the reliance on the availability of a large amount of copper, BDUK sees this type of solution more suited to meeting business needs where a premium would be paid, and it is difficult to see it playing a strategic role to serving consumers in the long run.

Another supplier's more ambitious concept is to pool DSL capacity to create a local network between homes, but which would involve significant changes to the ANFP and operators' processes to deploy into the home.

Broadband Enabling Technology (BET)

A small number of suppliers envisaged BET as part of the solution mix in a scenario to minimise government subsidy, as opposed to a scenario to maximise upgradability of the network.

BET has a maximum range of about 12km, but this is dependent on a maximum range for both the distance between the cabinet and the exchange (E-side distance) and between the cabinet and the distribution point (D-side distance), so BET isn't suitable in all locations.

BET is a 1Mbps solution, but can be bonded with a second copper pair to create a 2Mbps service. In some rural areas, the presence of Digital Access Carrier System (DACS) solutions suggests that spare copper pairs are not readily available for this, and the additional wholesale cost of the extra copper pair would affect pricing of this service.

For BET to be a viable product to be offered in an exchange, a minimum take-up and threshold number of connections would need to be assumed in that exchange.

The limitations of BET are recognised, but it is a useful ‘tool in the box’ for providing coverage in rural areas. In particular, BET has a limited data throughput, but suppliers claimed that customers may prefer the predictable service and quality of BET to other access technologies offering higher access speeds.

Powerline access

BDUK received responses proposing the use of the electricity distribution network infrastructure to propagate broadband signals into the premise. Respondents were able to demonstrate the deployment of high-speed access over the power infrastructure into premises in other countries, and had the cooperation of the local electricity distribution network operator (DNO) in developing the solution.

However, this solution has been piloted before, but not yet been progressed in the UK, so respondents were unable to demonstrate the commercial sustainability or practical deployment of this technology in these rural areas. The robustness of power infrastructure would suggest that this is worthy of investigation again.

The powerline access technology must still connect to an appropriate backhaul route. This is not necessarily straight forward if the power infrastructure does not intercept the telecoms infrastructure locally, unless backhaul is provided via the DNO’s passive infrastructure back to an aggregation point – but these products are not yet available from the DNOs.

BDUK will monitor the progress of pilot deployments to assess the technology’s continuing viability.

Satellite access

All respondents recognised the potential role for satellite technology to provide coverage in very remote areas in each of the exercise areas where other technologies could not reach cost-effectively, and the role as a backup to other access methods.

New capability Ka-band satellites

Satellite responses invariably focused on the capability of new Ka-band satellite technology rather than existing Ku-band. New Ka-band satellite solutions are planned from Eutelsat, Astra and Avanti – all of which can provide access speeds of 6Mbps downstream and 2Mbps upstream for a typical retail price of ~£25 per month with limited monthly capacity (typically 2-4GB for basic packages).

One supplier proposed its Ku-band solution that re-uses an existing shared satellite on the basis that lower amortised fixed costs would result in a lower cost product. The supplier claimed that a suitably configured Ku-band service can compete with a newer Ka-band service.

With a ~70,000km round-trip communication path, the inevitable latency of satellite means that it is more suitable for broadcasting and multicasting and less suitable for real-time services (e.g. voice, virtual private networks, two-way video) needed for home-working, relative to ground-based technologies, despite optimising technologies that improve the browsing and downloading experience.

Coverage

BDUK understands that the geostationary orbit positions of the Ka-band satellites rarely results in coverage issues, even in the North-West of Scotland[3] – although a larger receiving dish may be needed in some circumstances.

Capacity

Satellites are being launched that will in part serve the UK broadband market Avanti's Hylas was launched in November 2010 and Eutelsat's Ka-Sat is scheduled for launch by January 2011, and both should be ready for service by April 2011, joining the ASTRA 3B satellite launched in May 2010. A further satellite, Hylas 2, for Avanti, will be launched in 2012;

Each satellite has many transponders to enable different uses for a single satellite and Ka-band transponders were reported to have a potential aggregated data throughput of up to 1Gbps. This bandwidth must be shared among the number of customers within the transponder's spotbeam, or footprint.

As a result, satellite could provide a service of over 2 Mbps to between 225,000 and 300,000 homes and businesses by 2014 at a contention ratio of 50:1 – i.e. an allocation of 40Kbps per customer.

[3] Where there is potential degradation of signal due to line-of-sight issues with satellite orbital positions

Backhaul

With previous generations of satellite, there have often been problems with hosting 'ground segment' services in mainland Europe (e.g. Luxemburg, Italy) instead of UK, in that a foreign IP address restricts access to some internet services.

Given retail demand for UK-hosted ISP services (e.g. email service, access to iPlayer), the industry is now beginning to offer this by using UK-based landing sites.

Take up & churn

The first generation of satellite broadband products had limited throughput using Ku-band transponders, and the products offered a poor service relative to today's standards, particularly with the incremental addition of new customers increasing contention.

With recent improvements to optimise traffic management, satisfaction with satellite is improving; however, satellite respondents were realistic that most consumers with a choice of satellite or wireline solutions would probably choose the latter.

Where satellite is the only available access solution, consumer take-up rates are strong. Nevertheless the satellite industry still needs to build customer confidence with the right products and with committed minimum service levels on these new satellites.

Broader uses

One supplier has proposed the possibility of combining the strengths of satellite (i.e. large download capability) with that of a minimum specification copper line (for real-time interactive services) as a means to provide a more effective home-working experience.

Additionally, satellite respondents also identified a potential for caching and pre-loading content on set-top boxes across the UK.

Backhaul

The availability of backhaul and the distance-dependent charges for bandwidth[4] were identified by many suppliers as a structural obstacle that inhibited broadband rollout in many rural areas – this is a key contributor to the reduced footprint of 3G mobile broadband relative to 2G mobile voice services in North Scotland, for example.

This problem was illustrated by the difference in the South Wales and the North of Scotland examples. With CP points of handover (PoHs) in Swansea, distance-related backhaul charges were low in the South Wales example, while with the nearest PoH in Scotland being Aberdeen, these distance-related backhaul charges in Scotland were very high.

A common supplier conclusion was that the provision of affordable backhaul in these areas would positively impact the economics of supplying wireline, fixed wireless and mobile technologies and so increase the business case for private sector investment.

Technology

In general, suppliers typically built the backhaul part of their solutions using private circuits and with managed broadband services for connectivity between, say, BT exchanges and CP nodes.

Alternatively, using microwave to create backhaul solutions has a long-term role in particularly difficult geographies.

Backhaul allowance

All networks are shared resources, engineered to accommodate busy-period loads. Operators size networks on the basis of a backhaul allocation per customer, which enables them to offer service levels for anticipated customer experience during the day, e.g. “2Mbps available 90% of the time during peak three hours of the day”.

A typical backhaul allowance from suppliers when designing solutions was 30-60Kbps per customer, which is consistent with mass-market products available today.

However, as the choice of backhaul infrastructure in these solutions was influenced by environmental, customer density and economic constraints, BDUK saw a wide spread in allocations: e.g. from <20Kbps for a wireline connection where backhaul would be very expensive to provision, to >200Kbps for wireless backhaul where the low density of customers on a mast meant that a significant per-customer backhaul allowance was available.

These examples would result in a significantly different customer experience in peak hours of the day, but this experience is also dependent on the allowance for data transport between the operator’s point of handover and the internet as well although this is generally a commercial decision for the CP.

[4] Peak hour bandwidth charges can be of the order of £100 per Mbps per month to connect from a handover point to a rural area, but as low as £2 per Mbps per month onwards from the handover point.

Passive infrastructure availability

Several suppliers had indicated that they hoped that Ofcom's wholesale local access (WLA) consultation might provide new opportunities for backhaul. However, the recent Ofcom decision following the WLA market review accepts that access to BT Openreach's passive infrastructure (their PIA product) should currently only apply to the access network up to the NGA access node (typically the nearest major town). Connections beyond this are provided via regulated products that sit within the business connectivity market, which are subject to cost orientation and other regulation.

Suppliers also noted that while the industry is able to develop fibre access products under Ofcom's general access obligation on BT Openreach, it is not obliged to provide dark fibre backhaul products in the current regulatory environment. This is in contrast to some other European countries, e.g. in Germany, Deutsche Telekom AG is required to offer dark fibre in certain circumstances. The use of BT passive infrastructure for leased lines and backhaul will be re-examined by Ofcom in the first half of 2011 as part of the business connectivity market assessment.

BDUK had hoped that this exercise – and the parallel dialogue with industry on infrastructure sharing – would have resulted in responses incorporating passive products from electricity DNOs. While there was some cooperation from DNOs in terms of information sharing that resulted in solutions that considered their infrastructure, none provided indicative specifications or pricing for passive infrastructure access products for input to supplier responses. BDUK believes that DNOs are likely to wait to see BT's PIA pricing before pricing their own infrastructure use, where they intend to offer this.

Public sector available networks

Responses that included Welsh schools or Pathfinder public sector locations highlighted the importance of previous investments in networking public sector locations; however it also became clear that there are still significant issues involved to make them accessible to public use.

Specifically, it can be a challenge to transform networks created for a single customer or purpose in order to set up services that can be offered and billed to individual members of the public. This requires a different operating and security model and also upgrades to the active components of the network, which represents significant additional cost.

In some instances, existing contractual arrangements may also prohibit the network operator from serving additional customers in their current form, particularly for commercial gain. Alternatively, extension of these contracts may be incompatible with public procurement regulations and also state aid guidelines for broadband.

Cost dynamics

This section sets out BDUK's learning in terms of cost components and their fixed and variable nature for the different key technologies in rural areas. Suppliers who are assessing their potential role in deploying networks in these rural areas will need a business model that can sustain all these costs.

Fixed wireless access

This report focuses on the drivers and behaviours of different cost components rather than their magnitude. More information on cost inputs for wireless networks is available in the BSG's report "The costs and capabilities of wireless and satellite technologies - a 2016 snapshot" available on their website.[5]

Fixed costs for a supplier

Licensed spectrum

Suppliers using licensed frequencies will need access to spectrum allocation to operate.

Several respondents didn't include spectrum costs in their solutions, either simply because of the difficulty of allocating such large fixed costs to such small projects, or on the assumption that they would be gifted spectrum, or that it would be freely available as it would have zero opportunity cost to a license holder who doesn't have a footprint in these rural areas. However both these latter assumptions are challengeable: it is inconsistent with BIS and HMT policy for UK assets such as spectrum to be gifted, rather than maximising the value it could achieve through its sale. If government is subsidising rural broadband then an inherent value is automatically created for the spectrum.

BDUK notes that UK Broadband has reseller agreements with suppliers such as Networks by Wireless for its 3.5GHz license[6] in various locations across the UK. As noted in above, there is no effective secondary market for mobile spectrum though. Mobile operators, however, have a limited incentive to lease spectrum to other providers. Therefore, should only mobile operators be successful in the forthcoming spectrum auction, there would be little likelihood of a secondary market to enable a wireless supplier to lease sub-1GHz spectrum and serve a rural area outside the licence holder's footprint.

Network operations & B2B platform

None of the respondents included costs for building or developing their business-to-business portal to reach the retail ISPs they needed for their revenue, despite only a small number already having access to such a channel.

While there are some SME organisations such as Fluid Data and Minuco Telecommunications who appear to supply such an interface, the cost of replicating BT's Equivalence Management

[5] http://www.broadbanduk.org/content/view/392/7/

[6] http://www.ukbroadband.co.uk/news/our-news/25-uk-broadband-signs-reseller-agreement-with-networks-by-wireless-nbw.html

Platform B2B portal with access to the biggest mainstream retail ISPs, and developing multiple interfaces into the range of alternative access networks would run into the millions of pounds.

Major suppliers would also need to have a significant backhaul network between points of handover across the country, operated by a team of specialist technical, test and development teams, and supported by strategic partnerships with the major equipment suppliers.

In addition, all operators incur further overheads associated with the management of customers (e.g. sales and marketing function, service delivery and support processes).

With the low margins and high customer acquisition costs for retail broadband, economies of scale are needed to be able to spread an allocation for these costs thinly over many customers. This represents a material barrier-to-entry for many operators considering serving the consumer market.

Costs that scale per project

Data transport

For each individual project / area, the supplier needs to provide backhaul from an aggregation point(s) back to its own point of handover.

Suppliers need a significant size of project and customers to ensure these significant transport costs are spread thinly.

Radio planning and ongoing management

Fixed wireless suppliers will incur design costs for the initial design of the radio plan, as well as ongoing costs for maintaining the radio plan.

Sales and marketing

No supplier explicitly built in a ‘cost of sale’ into their indicative costs: neither an allowance for a procurement process, nor for the subsequent marketing and awareness building necessary to attract ISPs and customers, although some of these customer acquisition costs would likely be shared with the retail ISP.

Costs that scale per mast / sector

Planning, wayleaves & site rental

Each mast will require planning permission, with associated application costs. However masts below 15m can be deployed by Communications Code operators outside of certain conservation areas under Permitted Development rights with default prior approval – assuming no local objections.

Mast infrastructure on privately owned land will require access wayleaves to be negotiated with property and land owners, usually involving a compensation / rental fee being negotiated.

Respondents shared BDUK’s hopes that through coordinated community involvement in the design and deployment of broadband infrastructure, planning issues can be minimised, and further, that the community may be able to present landowners willing to host a mast as payment-in-kind for their broadband services to improve the business case of serving an area.

Mast infrastructure and maintenance, including maintaining line-of-sight

Small masts (e.g. monopole structures), while relatively cheaper to install than large mobile base station sites, can still be troublesome to install – in particular if lacking significant clearance above trees and buildings, the supplier will incur additional cost to establish and maintain line-of-sight to the receiving premises.

The mast infrastructure itself also requires greater maintenance than fixed ground-level infrastructure – i.e. “things come loose” more frequently.

Active electronics

The active electronics serve a mast sector, so these costs actually scale with the number of sectors deployed on a mast rather than with the mast itself. Fewer sectors are needed in sparse areas, where the cell resources can be spread over a wider area/angle.

The electronic equipment must also be built to cope with the hostile environment in which it operates.

Power

Installation costs for powering the mast will depend on the difficulty of the location. For example, building a mast near farm buildings typically provides easy connectivity into a local three-phase electricity supply. As mentioned above, co-locating the mast with HV pylons does not necessarily simplify or reduce the cost of power provision.

However, high install costs can usually be mitigated in remote areas by using a mix of renewable energy sources (e.g. solar and wind) to charge batteries to power the infrastructure instead, so long as service continuity can be maintained.

Non-domestic rates for masts

The supplier will need to pay non-domestic rates for the mast infrastructure, calculated with reference to i) the rental value of the land/value of the asset, ii) the ‘plant and machinery’ and iii) the presence of site sharers, which is typically low for these types of deployment.

Backhaul to aggregation point

Backhaul for the mast is typically provided via microwave equipment for hops back to a fixed Ethernet connection. The use of licensed spectrum reduces the chance of drop-outs due to interference, but increases the opex costs if annual spectrum usage fees are included.

Additionally, there would then be an install and rental cost for private circuits back to the operator’s point of handover. As mentioned above, these distance-related charges are typically very costly in rural areas.

Decommissioning

One further cost that should be incorporated in suppliers’ business cases is a provision for future decommissioning of the infrastructure in accordance with health and safety and environmental requirements.

Costs that scale per customer

Customer premise equipment (CPE) and installation

The cost of CPE is very sensitive to the volumes procured – if suppliers are given the confidence to commit to 50k+ units, the unit cost they are able to secure falls dramatically (by 50% according to one respondent). Competition from bulk suppliers targeting the US and China markets is also driving down equipment costs.

Using a standard spectrum range further results in lower-cost and better quality components in the CPE.

Installation of an externally mounted aerial is relatively cheap, with networks of installers available nationwide.

Acquisition and churn costs

Costs of customer acquisition and churn are typically borne by the retail ISP rather than the network operator.

Some suppliers made the point that a lower connection charge – relative to wireline networks – may be necessary to overcome consumer doubt over fixed wireless technology and improve penetration to comparable levels.

Wireline access

This report focuses on the drivers and behaviours of different cost components rather than their magnitude. More information on cost inputs for wireline networks is available in the BSG's report "The costs of deploying fibre-based next-generation broadband infrastructure" available on their website[7]

Fixed costs for a supplier

Fixed costs for a wireline operator are similar in nature to those of a wireless operator, as set out above, including those for network operations and interface to retail ISPs, but excluding those relating to radio spectrum.

Costs that scale per project

Project related costs for a wireline operator are similar in nature to those of a wireless operator, as set out above, including those for data transport and marketing / awareness building, but excluding those relating to radio planning.

Costs that scale per cabinet / head-end / node

Passive infrastructure deployment / rental

The majority of costs for deployment of fibre-based solutions are in the distribution of the access layer to the customer and are civil engineering related.

Several responses suggested that micro-trenching techniques could lower these costs in some areas, potentially making FTTP relatively more viable than anticipated in higher-density population areas, or to serve premises currently with exchange-only lines (i.e. with a copper line that is not connected to the exchange via a cabinet).

Passive infrastructure could be rented rather than dug, where it already exists. BT Openreach is the owner of most existing telecoms passive infrastructure in rural areas, and it is required to publish a draft reference offer for passive infrastructure access (PIA) products, including pricing, in January 2011. DNOs also typically have passive infrastructure (poles and duct) to rural locations and are currently being encouraged to consider providing passive access to this infrastructure too.

In a proportion of areas, and particularly where the route requires multiple duct sections, BT Openreach will not have existing ducts, or the duct will be overcrowded or unsuitable for re-use. In these cases, dig costs will be dependent on the surface type and the size and depth of duct required, as well as other costs including permits, traffic management and wayleave costs. Regardless of whether the duct is rented or constructed, an operator choosing to use passive infrastructure rather than the BT Openreach active products would need to purchase and install fibre in the duct.

One potential solution in an FTTx solution aligned to the BT infrastructure is to bypass – and ultimately enable removal of the costs associated with – BT's market 1 exchanges by "glassing through" the exchange, i.e. maintain the continuous fibre path through to the larger exchange (a 'Handover Point' in BT's terminology). It is important to note, however, that those costs will

[7] http://www.broadbanduk.org/fibrecosts

still exist until complete copper removal in the area, which would impact on LLU, Wholesale ADSL and voice services as well.

DNOs also have useable assets in the form of poles – in fact their strength and durability may make them more suitable for fibre in rural areas – but products are not yet available from DNOs, and their motivation to develop them is diminished due to current restrictions on the treatment of non-core income. Products aren't likely to be forthcoming until after BT's competing passive infrastructure access (PIA) product costs are determined, and after DNOs have refined their operating models from current pilot projects.

Sewers were not really proposed as a viable route to pull fibre in the solution areas, due to their limited diameter in rural areas and the lack of effective interconnection points between the sewer network and the main telecoms network. One supplier proposed footpaths as a potential route into communities.

Fibre rates

Non-domestic rates applied to next generation networks were identified as an additional cost. The Valuation Office Agency (VOA) has issued new guidance for the industry on the application of the rating system to next generation networks with the aim of giving operators greater clarity and certainty. VOA has indicated that it is open to discussions with operators on the valuation of their network. No suppliers provided suitably robust calculations to illustrate the impact of fibre rates on their choice / solution or the size of the subsidy required. While business rates are clearly a cost, BDUK does not have evidence from this exercise that quantifies a level or application of business rates that would act as a specific hurdle for investment.

Upgraded cabinets / head-end infrastructure and active electronics

The cabinet infrastructure generally represents a relatively low proportion of deployment cost (although in some cases where there are local installation issues these costs can be significant), with a reasonable level of supplier competition providing choice at low cost, improved by increased purchasing power for operators with critical mass.

There are also maintenance and insurance costs associated with each new piece of infrastructure – cabinet infrastructure is at risk of vandalism or damage from road accidents, for example. Suppliers proposing a fibre-to-the-node architecture (using the existing copper pair spans for delivery to the premise) would presumably require a greater field force to maintain the greater number of connection points.

A competitive supplier marketplace exists for equipment, but it is common for equipment suppliers to provide a 'complete' cabinet installation – which consists of a cabinet and its contents: DSLAM (plus cards), power supply, air handing/cooling, frames, etc.

Installation and planning

Similarly for installation, there is a choice of engineering companies, some of whom are effectively streamlining the deployment process, including planning, installing and commissioning, which is lowering these costs and making them more predictable for mass deployment, similar to the deployment of mobile mast infrastructure.

Suppliers are taking greater efforts in considering local wishes to expedite and avoid planning issues, but taking account of environmental considerations (e.g. moving the location of

cabinets) can also add cost, and for example, burying and cooling the cabinets would add significant cost to the build and operational costs that may make the upgrade unviable.

In the example areas, there were several opportunities for changing the location of existing cabinets to a more practical location for unbundling – i.e. closer to the community served – but it was reported that this network rearrangement also drives significant additional costs.

Power

Each cabinet requires the installation of a power supply, and will incur charges for energy usage. For larger cabinets (consuming over 500W) this must be a metered supply, and the energy charges will be variable instead of flat-rate, however the cabinet must be engineered to allow simple meter readings by the electricity company to avoid telecoms engineer visits for a meter reading.

Fibre splitters

Rather than a powered cabinet infrastructure and active electronics, the fibre splitters simply sit in cable pits under a manhole cover, and as passive optical networks require no power between the exchange and the premise, operational costs are significantly lower.

Commissioning

In the case of a non-BT Openreach supplier deploying an FTTC solution by sub-loop unbundling (SLU), it incurs costs due to the SLU products levied by BT Openreach to ensure the safe ongoing operation of its own network. These suppliers reported that the excess construction charges levied by BT in the commissioning increase the cost significantly and diminish the business case for SLU.

Costs that scale per customer

Active electronics

An optical distribution frame (ODF) will be required at each aggregation point in the network, but the majority of active electronic costs will scale broadly on a per subscriber basis, as they are associated with installing routers at the ODF to serve a set number of fibres. Each router will typically be able to serve five fibre ports, each connected to a multi-node service access point (MSAN) with 32 ports for end-users and thus costs will scale broadly per 160 subscribers.

Connection charges

SLU suppliers incur a per-user connection charge of approximately £127 from BT Openreach. Again, these suppliers reported that if these SLU products were used at scale then the current SLU charges may bear less relation to BT Openreach costs, and SLU suppliers perceived these charges may be an investment barrier to systematic deployment of SLU, rather than ad-hoc unbundling. Suppliers have requested a new product via the industry agreed standard process with BT Openreach to support systematic deployment, which could be priced differently and it is currently working with the industry on this request.

In the short term (i.e. until an at-scale SLU product is agreed with industry) BT – as a vertically integrated operator across the SLU boundary[8] – has a potential competitive advantage over

[8] As set out in the Variation to BT's Undertakings under the Enterprise Act 2002 related to Fibre-to-the-Cabinet, http://stakeholders.ofcom.org.uk/binaries/consultations/fttc/statement/statement.pdf

SLU suppliers when deploying at scale, since it incurs allocated time and materials costs for migrating customers to its VDSL service, rather than the £127 charge per-user.

CPE / installation

FTTC solutions require new CPE (i.e. VDSL modem/router) to be deployed into the home, but these can be consumer-installed (i.e. swapped with the old modem/router). However, VDSL installations are a lot more sensitive to home wiring (compared with ADSL) and this may reduce the ability to have a true self install solution.

FTTP solutions require the installation of a fibre connection to end-users' premises, therefore a specialist engineer will be required to install a fibre connection (overhead or underground plus drilling through a wall) and then install an optical network termination (ONT) unit.

Again customer acquisition and churn costs are incurred, usually paid by the retail ISP.

Satellite access

This report focuses on the drivers and behaviours of different cost components rather than their magnitude. More information on cost inputs for satellites is available in the BSG's report "The costs and capabilities of wireless and satellite technologies - a 2016 snapshot" available on their website[9]

Fixed costs for a supplier

Fixed costs for a satellite operator are similar in nature to those of a wireline operator, as set out above, including those for network operations – albeit these are reduced with a greatly simplified ground-based network – and interface to retail ISPs.

Costs that scale per satellite

Satellite build / launch / finance

The cost for building and launching a satellite with a 10 to 15-year life is enormous. This capital cost is of the order of £350m, but since they are externally financed, these costs are effectively amortised as monthly payments for the supplier with financing costs on top.

These one-off costs for the satellite need to be apportioned over the forecast number of subscribers over the lifetime of the satellite. If the venture is more successful, i.e. the number of users exceeds forecasts, then the costs apportioned per customer could be spread thinner and one could expect wholesale and retail prices to fall.

Spectrum licence costs

The satellite operator must pay a small administrative charge for the International Telecommunication Union (ITU) to agree the 'slot' or orbital position for the satellite, but the operator will also be required to pay Ofcom an annual fee for the spectrum licence.

Insurance

Operators will also pay a substantial amount for insurance of their satellite – the high costs driven in particular by the potential scale of third-party liabilities.

Data transport / transponder utilisation

Satellite access is a highly contended medium – the throughput of a transponder must be shared by a large number of customers, and products are designed based on a forecast customer utilisation. Although satellite ISPs sell different speed packages at different prices, the headline instantaneous download speed is much less of a lever on managing customers' demands of throughput than the aggregate monthly download allowances.

Costs that scale per customer

CPE / installation

CPE for satellite broadband is still currently expensive relative to other solutions (~£300). Installation of the satellite dishes, however, is comparable with other solutions (£100-£150), with networks of installers available nationwide – albeit the installation is more complex than a receive-only satellite dish.

[9] http://www.broadbanduk.org/content/view/392/7/

Revenue and project returns

Revenue

Typical take-up and price assumptions

Suppliers were asked to forecast project revenues by assuming an annual customer take-up rate and target product pricing. Suppliers' projections of take-up assumed that the government subsidy would also cover the higher costs of CPE and its install, so that the ISP products would be consistent with pricing of current wireline products and so that these one-off costs would not be an obstacle to customer take-up.

The take-up rates and prices seen in responses were typically in the following ranges:

Technology (Note: not comparable customer experiences)	Typical customer take-up (in terms of premises passed and assuming Government subsidy)	Typical wholesale pricing	Typical retail pricing
Standard wireline	70%-80% (although with a corresponding reduction if superfast also available)	£7	£15
Superfast wireline	20%	£14-15	£20
Wireless	40%-60% (although with a corresponding reduction if superfast also available)	£12-15	£20-25
Satellite	30%-40%	£15-20	£20-25

Most suppliers also modelled a pragmatic ramp-up in take-up over 2-4 years to the full revenue amount, rather than an assumption that all revenue would be available immediately.

Wholesale pricing and the retail ISP market

The majority of responses were received by network operators rather than the ISPs packaging their services to provide to the end-customer. Therefore most respondents had modelled wholesale prices / revenues, and only indicated the likely prices / products that would be paid / received by the end-customer.

Due to the success of local loop unbundling (LLU) products and the structure of the market for first generation broadband, the vast majority of retail ISP services in the UK are sold through BT's equivalence management platform (EMP) for a consistent wholesale price of £7 per month.

This standardisation has enabled the mainstream retail ISP market to operate on thin margins. If a wholesale operator does not charge the same £7 per month or through a similar business-to-business platform, mainstream ISPs will not be able to make money on these connections unless they segment their product in order to charge more to the user in these areas. The lack of availability of recognised, mainstream ISP brands risks lowering take-up among consumers and therefore an increase in demand risk for an investor.

The network operator may instead be able to attract smaller, niche ISPs with a business model and products designed to target these rural coverage areas.

This outcome could be expected to result in less competition and choice for consumers – although perhaps more services tailored closer to their needs – which is less likely to provide the same benefits of innovation and price competition that has been typical in the mainstream ISP market.

BDUK needs to ensure that the availability of ISP services that are valued by customers is incorporated into any procurement process or investment in the network.

SME business and public sector pricing

In calculating the revenue from their solutions, most respondents only modelled consumer revenues, and conservatively ignored the revenue from higher priced products sold to businesses and public sector customers in their models. A typical expectation for business product pricing was £40-£60 (reflecting the higher service and maintenance costs).

Even though many businesses will already have connectivity arrangements in place, they could be expected to quickly migrate to a newly available better or cheaper product that meets their needs – e.g. relinquishing a private circuit where a business broadband product becomes available.

The prospect of public sector revenues may be more limited and substantially dependent on the timing and structure of existing contractual arrangements. However, where the public sector can be relied on as an ‘anchor’ customer for a project for a significant duration – e.g. potentially through public sector network procurements – the certainty of these additional revenues makes a substantial improvement to the economics of an area.

Spill-over revenues from outside the exercise areas

BDUK provided data on premises outside the exercise areas, in the anticipation that respondents would recognise where additional revenues should be incorporated into their model where the infrastructure served a larger area. This would be particularly relevant for wireless solutions where some mast location choices result in serving additional not-spot and slow-spot market areas. In general, this was not accounted for by most suppliers, meaning that models may have been calculated conservatively.

Project returns and investment gaps

Project internal rates of return (IRR) and duration

Respondents were asked to forecast the costs and revenues over whatever period they believed to be appropriate to reflect their own organisation’s approach to investment appraisal, and calculate the subsidy needed based on an appropriate IRR (i.e. target return for the project to reflect the organisation’s cost of capital plus additional project-related risks). For

example, suppliers were typically modelling the economics of their solutions over 6-7 years providing a 15-20% project return (i.e. IRR).

In rural areas, once fixed infrastructure (duct and fibre) has been deployed and is being operated sustainably, there is unlikely to be further infrastructure competition – assuming other operators' open access to the infrastructure. Therefore an investor in fixed infrastructure could be reasonably confident about the future revenues for the ~20+ year lifetime of the asset, and a 12 year @10% IRR might be appropriate for this capital spend, in line with other long-term infrastructure assets, particularly if the asset can be isolated from demand risk.

Conversely, for some of the fixed wireless solutions, where much of the capital costs relates to shorter-life assets and which are at risk of competition from upgrades to the wireline network, investors generally expected to appraise the project over a shorter timescale. This is especially important given BDUK's parallel objective to roll-out superfast broadband, and for standard broadband solutions without a clear upgrade path, 3-5 years @25% IRR would be a more appropriate project return to model for their investors, before a fall-off in customers migrating to superfast broadband operators.

BDUK is generally unsure as to how comparable the target IRRs from suppliers are to their peers, as it cannot be sure which contain an allowance for corporate overheads or the different project risks, e.g. market risk or inflation, on top of the organisation's cost of capital.

Investment gap per not-spot / slow-spot

Respondents were asked to divide the investment gap amount (calculated from the target project duration and IRR) by the number of not-spot and slow-spot households that their solution addressed, to give BDUK an indication of the relative cost-effectiveness of a hypothetical government subsidy of the solution.

Note: this calculation considers the subsidy in terms of the number of not-spots and slow-spots that are 'solved' (i.e. with newly available infrastructure serving those premises) rather than either the total number of premises passed or provided a speed increase by the solution, or the total number of connections

In this form, a typical investment gap for a particular solution technology could be expected to be in-line with the ranges in the following table (based on a subset of supplier responses where BDUK was confident in their calculations):

Technology	Indicative subsidy range from respondents (project investment gap divided by number of not-spots / slow-spots covered)	Commentary
FTTP	£2,000-£3,000	The subsidy per premises amounted to a significant proportion (~90%) of the capital amount. These high costs are driven by the average cost of deploying fibre the typically long distances to the sparsely populated not-spots and slow-spots only.
FTTC	£250-£800	The range and number of solutions created a large spread in subsidy amount, indicating that the cost effectiveness of this solution is highly dependent on the local geography.
Fixed Wireless	£300-£800	Several suppliers believed their fixed wireless solutions were unsustainable in some areas
Satellite	£300-400	Given the high wholesale product rental costs and limited margin, there is little scope for cross-subsidisation of the capital – government subsidy would instead be directed at the CPE and installation.

These substantial per-premise subsidy amounts are calculated on the basis of solutions covering an appropriate proportion of small, very rural, areas with no backhaul availability and prioritising the delivery of infrastructure to not-spots and slow-spots only and should not be seen as representative for the UK (as discussed in an earlier section).

In particular, one wireless operator used their model to illustrate the high sensitivity of these numbers to the i) number of masts, ii) take-up and iii) price, and in particular, iv) the size of the coverage area. Again, BDUK will need to consider the implications for risk management and allocation as part of the design of any subsequent procurement process.

BDUK expects to be able to generate comparator amounts from its superfast broadband pilot projects, where standard broadband solutions for minimum coverage will be deployed alongside investment in fibre backhaul and superfast access over substantial geographic areas.

Conclusions

Reconciling 2Mbps Universal Service Commitment and Superfast access objective

This theoretical exercise showed almost all the respondents' offerings delivered speeds of 2Mbps, and a BDUK intervention would upgrade connectivity to a whole area, while ensuring a minimum 2Mbps 'edge-of-network' experience during peak hours that enables quality home working, etc.

Note: it is important to differentiate between the individual user experience at the edge of the network and the capability – sometimes multi-gigabit data transport capability – some short distance away from which a network operator creates a service and proposition to deliver that user experience.

Recognising this interdependence between network capability and user experience, BDUK's achievement of the Universal Service Commitment objective should not be seen as separate from the superfast broadband objective, but rather an integral part of pushing next generation networks deep and wide into rural Britain.

Additionally, the indicative per-premise costs produced for this exercise shows that to only address the country's not-spots area-by-area, but without addressing provision of backhaul, would be inefficient and costly.

Importance of localism

In separate conversations and contributions from public bodies, it is apparent that the challenge of universal coverage has different priorities in different part of the country – i.e. the investment needed is dependent on the needs of the region or locality. Therefore the desired outcome for the intervention – i.e. the "edge of network experience" – should be discussed and prioritised through local engagement with communities in each area.

By determining requirements in conjunction with the affected communities, local assets or support (e.g. reduced site rental opportunities) may become available and demand for services will become clearer. Conversely, network providers will need to develop some additional community access interfaces to facilitate community initiatives including self build projects

Further, the role of public sector available networks in contributing to the wider roll-out of superfast broadband will be different in each region.

These multiple local dependencies point to a clear role for the relevant local bodies (e.g. parish council, local authority, county council, local enterprise partnership, devolved administration) to formalise the broadband requirement for the area in a local broadband strategy statement.

Importance of scale

However, notwithstanding the need for localism, the exercise clearly demonstrated the importance of scale. All respondents emphasised the need for a minimum order volume in order to create attractive and sustainable projects.

Even small operators stated circa 20-50k end-users per project / procurement are needed to meet affordability and sustainability criteria. One respondent illustrated the impact that scale would have on the calculated investment gap per not-spot / slow-spot. If intervening in an ad hoc manner in an area of the size chosen for the exercise, the funding gap per connection could be several multiples greater than if applied over a large area in a programmatic way.

The trade-off between localism and scale will need to carefully balanced as part of any commercial process.

Mix of access solutions

BDUK has concluded that a solution to the challenge of universal coverage will involve a mix of technologies and all 'bit-carrying assets' have a role to play. Geographic densities – expressed as premises per km^2 – begin to emerge as an approximate guide for determining the most cost effective network upgrade: e.g. fibre-based solutions are cost-effective in denser areas; areas with fewer than 350 premises per km^2 points towards a wireless solution; and deeply rural and hilly areas with fewer than circa 35 premises per km^2 may indicate satellite solutions. Note, these numbers are purely indicative, and would represent a UK average – the optimal solution will be dependent on characteristics of the local geography and clustering of customers.

At an aggregate level of all UK premises, rather than just the not-spots and slow-spots, BDUK could anticipate broadband access being delivered cost effectively by fibre solutions to 90-95% of premises, 5+% with high-speed fixed wireless solutions, and satellite being most appropriate for the last 0.5-1.0% of premises, at least in the near term and assuming the current market approach and technologies. In particular, the latest micro wireless cells and femto mobile cells offer a good opportunity to reduce the costs of and extend radio coverage in rural areas.

It should be noted that although wireless and Ka-band satellite support headline speeds of greater than 20Mbps and 6Mbps respectively, both still need to be engineered carefully to support a good home working experience.

BDUK is also considering proactive steps to ensure mobile broadband coverage (HSPA / LTE) is part of the mix of solutions used to deliver the edge of network experience in rural areas to complement the fixed network infrastructure.

The combination of the multiple responses proposing fixed-wireless solutions requiring the availability of sub 1GHz spectrum with the lack of any responses from the mobile network operators likely to be the owners of this spectrum demonstrates the benefits of a fundamental review in advance of the spectrum auction, possibly pointing to an industry agreement to deal with rural coverage before the auction takes place.

Further, this issue has illustrated a difficulty for BDUK in assessing value for money from any significant procurement prior taking place to the spectrum auction, where until the conditions and value of the auctioned spectrum are known, some suppliers are unable to provide a fully costed bid for their viable wireless solution to universal access in rural areas.

Importance of backhaul

A consistent message from respondents was that the cost of data backhaul in rural areas was one of their most significant costs and a major hurdle to achieving a sustainable business model. Suppliers agreed that the provision of affordable backhaul in these rural areas as part of a government intervention would be a valuable use of funds and would transform the business case for private sector investment in wireline, fixed wireless and mobile solutions in these areas.

Provision of backhaul will not make all areas economic for the private sector, but would reduce the per-household subsidy required from government for universal coverage. Additionally availability of affordable backhaul would be more likely to result in additional mainstream and niche operator investment, as well as enabling community schemes that would otherwise be unsustainable to operate.

Unfortunately the exercise did not prompt identification of fibre assets owned by organisations such as electricity DNOs, National Rail, or MOD for re-use – possibly because of a lack of appropriate assets in the area, or perhaps because they were not approached by respondents for offers. BDUK will be using the superfast broadband pilots to push for reference offers from these organisations, where appropriate.

The re-use of public sector available networks is frequently referenced, but the cost and practicalities of converting the potential of these assets into a service that can be productised and sold commercially has not been adequately dealt with in any of the responses. Each owner of public sector available networks resources should make clear their intentions as to the extent to which they are able to and intend for their asset to be used in offering services direct to end users.

Components for a competitive marketplace

The level of competition for data backhaul and access in the marketplace is dependent on the availability and pricing of passive infrastructure access. As the owner of the telecoms passive infrastructure in rural areas, BT's reference offer for PIA products due in January 2011 will be keenly anticipated by the industry.

Also as the owner of the customer connection in its cabinets, a range of effective and affordable SLU products from BT are essential if investments in FTTC solutions are going to be contestable as well as viable.

Any intervention to improve data transport capability in rural areas needs to ensure that the essential 'open access' terms of its supply are carefully designed to ensure that the hurdles or barriers to its use by other parties are minimised.

As well as effective competition between network providers, BDUK recognises the value of ISP competition, and the importance of providing a common and open platform for network operators to reach these ISPs to ensure effective competition at this layer as well.

This publication is also available on our website at http://www.bis.gov.uk

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