BDUK NGA State Aid Assessment template (worked example)

February 2017

1. Introduction

The purpose of this document is to gather and present evidence supporting suppliers' claims for Next Generation Access (NGA) compliance in accordance with BDUK's NGA technology Guidance[1]

This template should be completed by suppliers that operate an NGA Broadband Network or have plans to build and operate such a network.

Suppliers are advised to engage the services of suitably qualified individuals when completing this template, i.e. with the appropriate detailed knowledge of the technical and commercial aspects of the solution proposed and of the state aid requirements that apply to that solution.

The evidence provided in the template will be used for assessment of NGA and State aid compliance by Broadband Delivery UK's (BDUK) National Competence Centre (NCC).

2. Requirement

The subsidised solution must deliver a 'step change' in network capability and service availability and consistently provide a high quality experience to end users.

[1] BDUK, 2016 NBS State Aid Guidance – NGA Technology, https://www.gov.uk/government/publications/2016-nbs-tech-guidelines.

2.1 This requirement ensures that where a basic broadband infrastructure already exists, State aid must only be used to deploy infrastructure that genuinely offers a significant new capability to end users.

2.2 In assessing projects for State aid approval, the NCC requires that NGA technologies that are used in NGA white intervention areas must provide the same outputs as those defined for other established NGA network deployments. Specifically, the NCC will expect to see that the technical solution:

- is capable of providing access speeds in excess of 30Mbps download, not only by reference to theory and technical standards, but also by evidence of calibrated performance measurements of an existing deployment within the area of interest or an demonstrably equivalent deployment in a similar geographical environment;
- provides at least a doubling of average download access speeds and substantially higher upload access speeds in the target NGA intervention area;
- must be designed in anticipation of providing at least 15Mbps download speed to end-users for 90% of the time during peak times in the target area, as demonstrated by industry-standardised or reliable independent measurements;
- must show how the solution would adapt to maintain capability and end-user experience in changes to key parameters such as increased take-up and increased demand for capacity, and be able to show using clear calculations that this is both technically and commercially viable;
- must have characteristics (e.g. latency, jitter) that enable advanced services to be delivered e.g. video-conferencing and High Definition video streaming to be provided to end users as evidenced by trials results not necessary obtained within the area of interest; and
- have longevity such that one might reasonably expect increases in performance within the next 7 years.

2.3 In assessing whether the requirement is being met, the NCC will require the applicant to provide evidence of the capabilities detailed above. That evidence might include:

- the Business case, including scenario analysis;

- planning consents having being obtained, or likely to be obtained, for the proposed developments;
- actual deployment of similar scale and end-user density;
- field trial or commercial deployment supplemented by modelling of different take-up scenarios;
- for wired NGA technologies: access network planning taking due account of wired line length and quality from existing or planned access nodes, to show that the access speeds are realistic in the geographic context;
- for fixed wireless NGA technologies: radio plans and interference analysis, using planning tools correctly calibrated for the target geography, to show that the access speeds are realistic and the spectrum to be used is appropriate for its geographic context;
- proposed product offerings and associated service level guarantees;
- network dimensioning calculations; and
- evidence that the enabling technology has a future development path, such as existing internationally accredited standards, on-going development of new versions of the standards, international research working groups, and diversity of the supply chain.

3. Evidence of compliance with BDUK NGA Guidelines

Suppliers shall present evidence in the following categories based upon the criteria listed above.

[The example responses in this worked example are derived from material prepared by The Technology Partnership and are reproduced with their kind permission. In order to protect confidentiality, however, some aspects have been replaced with illustrative and fictitious data. Real responses based on this example must include specific operational and network information and shall avoid the generalities inherent in this fictitious example e.g. a real network topology and dimensioning shall be used rather than notional or typical examples. Furthermore, missing appendix material that is not available for this fictitious example would need to be provided in a real case. This example should be regarded as illustrative only rather than a model of perfection: suppliers will be expected to present the most convincing professional evidence. Unwarranted duplication of this example material in a real response would lead to a poor assessment of NGA compliance. Further directives are included in square brackets below which should be removed and replaced with actual information]

<table>
<tr><th>Topic</th><th>Evidence [replace stated example with your evidence]</th></tr>
<tr><td>30Mbps capability</td><td>

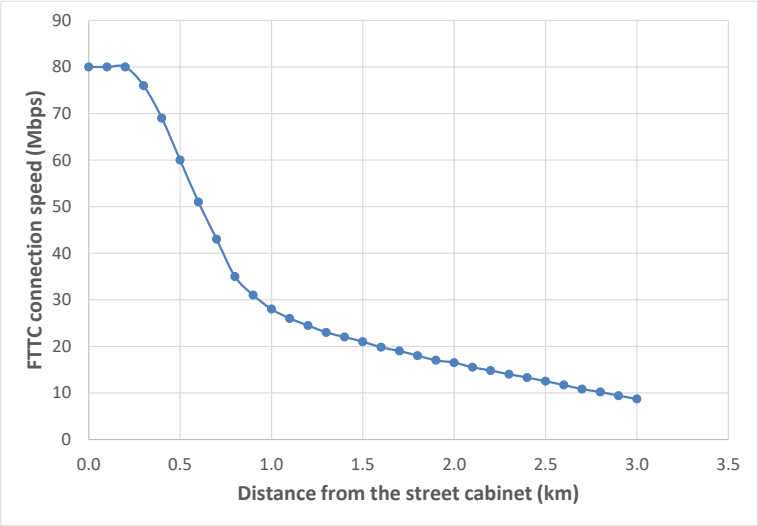
For example:

a. Evidence that physical/technological constraints are accounted for the planned coverage area (e.g. transmission line characteristics, radio propagation etc.); and

ExampleNet's proposes solution incorporates 3 access components to cover 5 891 premises across all of the different types of terrain within the target area in Exampleshire.

<table>
<tr><th>Solution</th><th>Premises Passed</th></tr>
<tr><td>FTTC</td><td>3 506</td></tr>
<tr><td>FTTP</td><td>637</td></tr>
<tr><td>FWA</td><td>1 748</td></tr>
</table>

</td></tr>
</table>

	The FTTP solution is based upon GPON with a downlink rate of 2.4Gbps which is equally split a maximum of 32 times to provide a minimum of 75Mbps per subscriber. Our company affiliate ComparativeNet had been operating this well-proven technology for the benefit of residents and business in Comparativeshire for 3 years. Full details of the GPON standard its ability to achieve 75Mps access speeds in a 32:1 configuration are included (see Appendix H – ComparativeNet Architectural Design). [The supplier shall include an actual architectural design in Appendix H] The FTTC solution is capable of 80Mbps at up to 300m from a street cabinet but decreases with distance (see chart). The SLU network access links are arranged so that all targeted premises can obtain 30Mbps or greater. In almost all circumstances that can be achieved within a straight line distance of 0.8km from an access point which (see Appendix A – FTTC Distance versus Speed). This distance is equivalent to 1.1km physical line length and is based upon a survey of 637 FTTC VSDL mapped straight line and line length distances from ComparativeNet's FTTC network, and the speeds are measured by the same cabinet DSL equipment that is planned for ExampleNet.  The FWA solution links are arranged so that target subscribers are within 5km of an access point. At this range a minimum downlink speed of 88Mbps can be supported in 5.8GHz Band B unlicensed spectrum (see Appendix B – Link Budget). This, however, represents the worst case

	because, where possible, ExampleNet's licenced Band C spectrum, using higher radiated power levels, will be used where possible allowing a minimum access of 97.5Mbps. A survey of 75 ComparitiveNet wireless access links, including 6 links exceeding 4.5km distance, showed that all links supported an access speed exceeding 90Mbps using the same equipment and design rules as are planned for ExampleNet. **b. Description of the network design's upgradeability to support 30Mbps in future; and** All planned access solutions are capable of greater than 30Mbps operations as described above. The full network solution including backhaul, core network and Internet connectivity also supports 30Mbps capability to each user as described in the following sections. **c. Manufacturers' product descriptions and configuration manuals; and** A full set of equipment specifications, data sheets, operating and service manuals downloaded from the equipment providers' websites has been included (see Appendix C – Equipment Specifications). These specifications are ordered by type within the ZIP file into the following categories: FTTP, FTTC, FWA and backhaul. [The supplier shall include actual equipment specifications in Appendix C] **d. Evidence of a commercially offered NGA-compliant 30Mbps product (e.g. on a web-site).** ExampleNet is not currently operating a commercial network. However the retail offer and products will be substantially the same as ComparativeNet's offer, including the Bronze, Silver, and Gold packages described there. The Gold Package will be available to all premises passed and will provide at least 30Mbps access speed and an unlimited monthly data cap priced at £30 per month plus a £100 initial installation charge. Please see http://www.comparativenet.fake/products.htm for further details.
Doubling of download access speed	**For example:** **a. A survey of current download speeds per premise/postcode referring to information provided in ITT Part 2 Appendix 3: Speed and Coverage Template; and**

Current Ofcom speed data per postcode was downloaded from the following location on 1/11/2015 from http://maps.ofcom.org.fake/broadband/broadband-data/ (see columns D to G in Appendix D – Access Speed per Postcode). Approximately 60 (1%) of postcodes were checked manually using BT postcode speed checker (http://www.productsandservices.bt.fake/products/speed-checker/) and these results were also included in Appendix D. According to this analysis, the average speed across all target postcodes is 7.5Mbit/s and the highest estimated speed is 29.6Mbit/s. See extract below and spreadsheet formulae within Appendix D itself.

	Exampleshire Postcode Analysis													
		Postcode	Village	Lines < 2Mbps	Average (Mbps)	Median (Mbps)	Max(Mbps)	Existing NGA	All Premises	Upgrade Postcode	Technology	Overspill Coverage	New NGA Speed	New NGA Premises
Total		593		74	7.5	7.5	29.6	0	5910	590		0	29.9	5891
Percentage		100.0%		12.5%				0.0%		99.5%		0.0%		99.7%
		Postcode	Village	Lines < 2Mbps	Average (Mbps)	Median (Mbps)	Max(Mbps)	Existing NGA	All Premises	Upgrade Postcode		Overspill Coverage	New NGA Speed	New NGA Premises
		ES1 0QV	Alphon	N	14.4	13.6	19.6	N	17	Y	FTTC	N	30	17
		ES1 0YP	Alphon	N	3.2	3.5	4.1	N	12	Y	FTTC	N	30	12
		ES1 1MP	Alphon	N	10.1	11.1	10.4	N	12	Y	FTTC	N	30	12
		ES1 2XO	Alphon	N	14.0	13.7	19.5	N	7	Y	FTTC	N	30	7
		ES1 3BS	Alphon	Y	1.5	1.4	1.9	N	7	Y	FTTC	N	30	7
		ES1 4QF	Alphon	N	7.8	7.5	13.7	N	1	Y	FTTC	N	30	1
		ES1 5MN	Alphon	Y	1.2	1.3	2.4	N	14	Y	FTTC	N	30	14
		ES1 6UX	Alphon	N	9.2	8.6	12.3	N	5	Y	FTTC	N	30	5
		ES1 7NH	Alphon	N	8.3	7.9	14.6	N	11	Y	FTTC	N	30	11
		ES1 7ZQ	Alphon	N	7.7	8.1	14.3	N	6	Y	FTTC	N	30	6

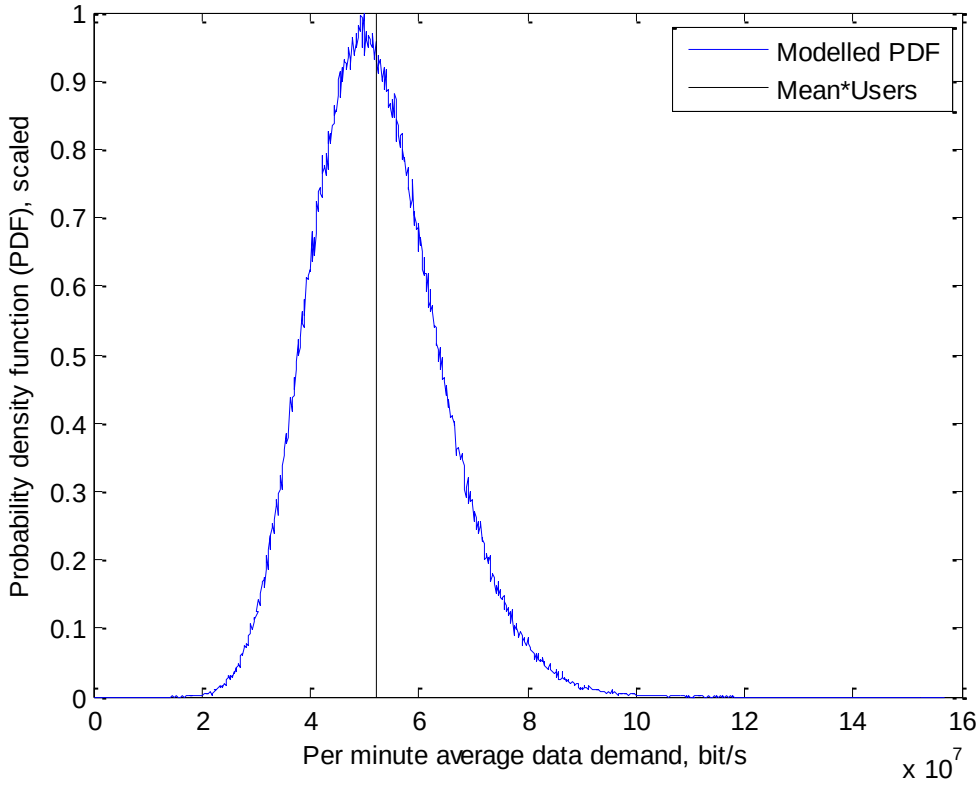
b. Design information showing that access download speeds will be or are doubled by the new network compared with current speed data.

Appendix D also shows the maximum range of each postcode from the serving cabinet or access point calculated from the network design data included below. 99.5% postcodes within the target area will receive 30Mbps according to the maximum distances described above, and similarly 99.5% of postcode speeds are doubled when compared with the Ofcom and BT data mentioned above. This corresponds to 99.7% of all target postcodes gaining new NGA service.

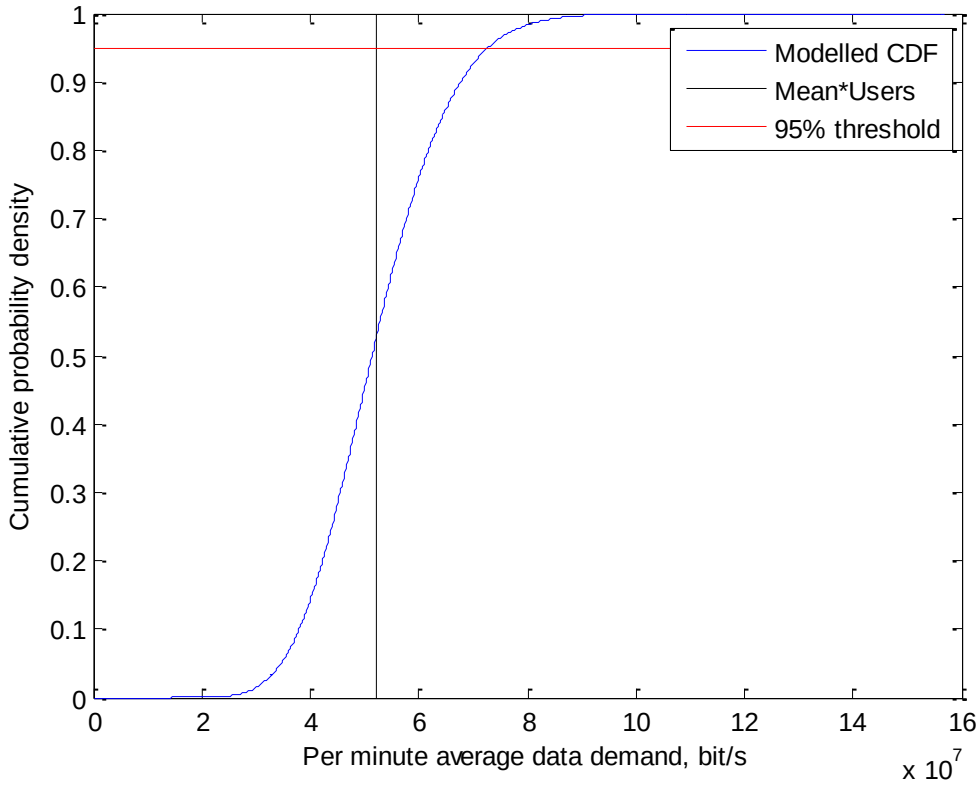
Substantially higher	**For example:**

upload access speed	**a. A survey of current upload speeds per premise/postcode e.g. from public data published by Ofcom; and** [Provide equivalent information to the doubling download speed section above] **b. Design information showing that access upload speeds will be or are substantially higher as a result of the new network compared with current speed data.** [Provide equivalent information to the doubling download speed section above]
15Mbps download speed 90% of time in busy hour	**For example:** **a. A forecast of the distribution (or average) traffic demand per user over time. Authoritative data from other comparative deployments and publically domain sources should support these forecasts; and** According to the Ofcom Fixed Broadband Map 2013 (reference http://maps.ofcom.org.fake/broadband/) the average data use in Exampleshire is 30.7 GB/connection/month. This equates to an average aggregate data rate of 95kbps. Measurements from ComparativeNet's network in Comparativeshire record an average of 87kbps per user over a month. The peak traffic in any peak hour in that month was found to be 348kbps averaged across all 5 600 users, as shown in the chart in Appendix H. It is assumed that the same 4:1 peak hour to average ratio of data usage will be found in Exampleshire, corresponding to a peak hour usage of 380kbps. From plotting the UK dataset of GB/connection/month against connection speed and performing curve fitting the Ofcom data, we estimate that the UK average data use for a 25Mbps connection is 40GB per user per month. This equates to 124kbit/s average, or 496kbps per user in the peak hour after applying the 4:1 ratio. This most conservative figure of 496kbps is used for the following analysis for year 2015, and it is also conservatively assumed that all traffic is in the downlink

	We assume a further 27% compound growth (reference http://www.cisco.com/c/en/us/solutions/service-provider/visual-networking-index-vni/index.html) and conclude that an expected average transfer rate during any minute in busy hour in Exampleshire in 7 years will be approximately 2.6Mbit/s. **b. Network dimensioning of links and nodes to meet these demands (including statistical multiplexing calculations and over-dimensioning where needed to manage statistical variations); and** A statistical analysis was performed to determine network dimension levels based on this busy hour average using the following approach: • Individual data usage follows a truncated exponential probability density function, a distribution widely used in telecommunications • Total data demand can then be obtained by adding the probability density functions for the given number of users, giving a graph such as the following (for 20 users).

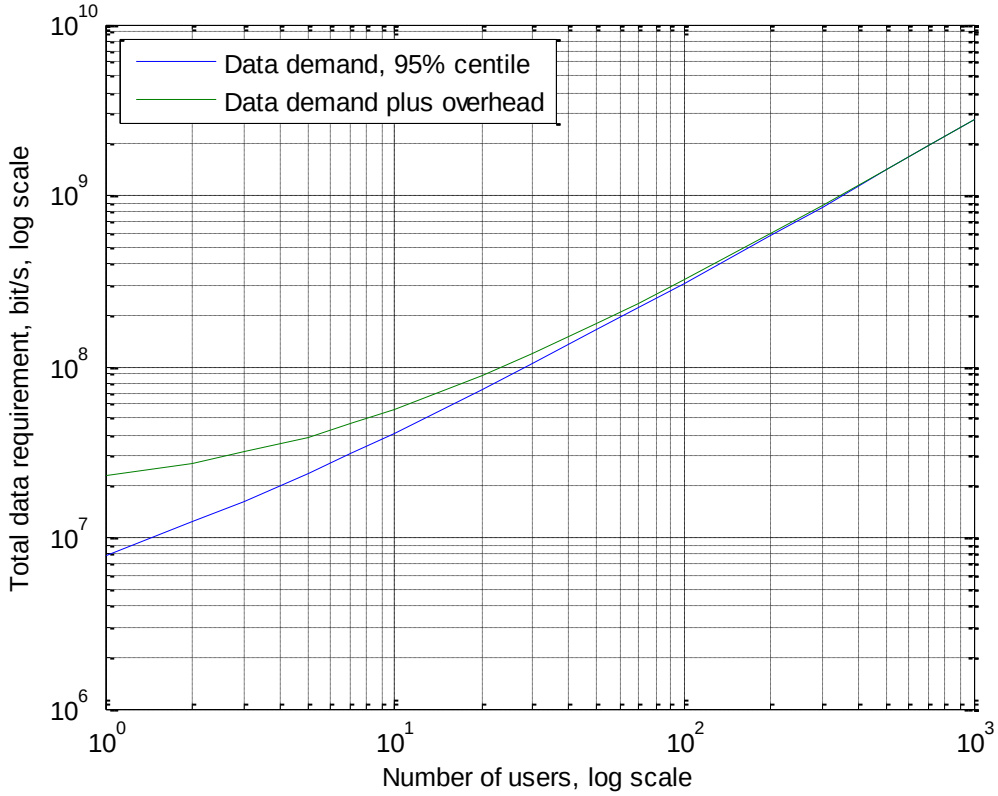


- The cumulative probability density function allows us to model the likelihood that the average demand will not exceed a particular value. For the same number of users this looks like the following (in this case, the 95th centile demand level is 73Mbit/s):



- We then over-provision by 15Mbit/s to ensure that at any time, any user is able to receive an additional 15Mbit/s; in this case, 20 users would require 88Mbit/s capacity.

- The process can be repeated for different numbers of users, illustrated in the following graph and table.


Data demand, 95% centile
Data demand plus overhead
Total data requirement, bit/s, log scale
Number of users, log scale
10^10
10^9
10^8
10^7
10^6
10^0
10^1
10^2
10^3

Subscribers	95% Demand, Mbit/s	95% Demand plus overhead, Mbit/s
1	8	23
2	13	28
3	17	32
5	24	39
7	31	46
10	42	57
20	73	88
30	104	119
50	163	178
70	221	236
100	306	321
200	586	601
300	859	874
500	1405	1420
700	1944	1959
1000	2754	2769

Thus, for a FWA base station (whether one or more sectors) that covers 57 premises, we would expect 20 subscribers at 35% take-up rate. In this case a minimum of 88Mbit/s backhaul will be provided, to ensure at least 15Mbit/s is available with 95% probability, based upon all of the conservative assumptions described above.

Similarly for FTTC and FTTC connections all aggregation nodes and links in the network will provide an amount of download capacity at least equal to the right hand column of this table, on the basis of 35% take-up rate, and according to the aggregate number of users supported at each node.

c. **Evidence of sufficient backhaul, core network and Internet transit capacity for forecasted user traffic demands over time.**

ExampleNet plans to deploy FWA base stations and FTTC/FTTP cabinets and provision backhaul and Internet transit to provide an amount of download capacity at least equal to the right hand column of this table, on the basis of 35% take-up rate. Full details are included in Appendix E – Network Dimensioning.

Future capacity	**For example:** **a. User and traffic growth forecast that are comparable with both the supplier's business model and public domain forecasts; and**

Exampleshire Traffic Forecast and Network Dimensioning

			Max Capacity	2015	2016	2017	2018	2019	2020	2021	2022
Premises Covered	**FTTC**		*3,506*	1,753	3,506	3,506	3,506	3,506	3,506	3,506	3,506
	FTTP		*637*	318	637	637	637	637	637	637	637
	FWA		*1,748*	874	1,748	1,748	1,748	1,748	1,748	1,748	1,748
	Total		*5,891*	2,945	5,891	5,891	5,891	5,891	5,891	5,891	5,891
Takeup	**%**		*35%*	5%	10%	20%	25%	30%	35%	35%	35%
Customers			*2,061*	147	589	1,178	1,472	1,767	2,061	2,061	2,061
Maximum downlink traffic	**Mbps/user**		*2.64*	0.50	0.63	0.80	1.02	1.29	1.64	2.08	2.64
Total network traffic	**Gbps**		*15.57*	1.46	3.71	4.71	5.99	7.60	9.65	12.26	15.57
Deployment	**FTTx Cabinets**		*24*	12	24	24	24	24	24	24	24
	FWA Sectors		*72*	36	72	72	72	72	72	72	72
	200Mbps FWA links		*12*	6	12	12	12	12	12	12	12
	1Gbps FTTx Links		*12*	6	12	12	12	12	12	12	12
	10Gbps Backhaul Links		*6*	3	6	6	6	6	6	6	6
	10Gbps Core Links		*2*	1	1	1	1	1	2	2	2
Traffic/Subscribers per	**FTTx Cabinet**		*309*	9	17	35	43	52	60	60	60
	FWA Sector		*20*	1	2	5	6	7	8	8	8
	200Mbps FWA link		*50*	4	7	15	18	22	25	25	25
	1Gbps FTTx Link		*309*	9	17	35	43	52	60	60	60
	10Gbps Backhaul Link		*3,250*	74	295	589	736	884	1,031	1,031	1,031
	10Gbps Core Link		*3,250*	147	589	1,178	1,473	1,767	1,031	1,031	1,031
Traffic/Mbps per	**FTTx Cabinet**		*900*	52	80	133	158	184	209	209	209
(including overheads	**FWA Sector**		*88*	25	30	39	43	47	51	51	51
and 15Mbps headroom)	**200Mbps FWA link**		*180*	35	47	71	83	94	106	106	106
	1Gbps FTTx Link		*900*	52	80	133	158	184	209	209	209
	10Gbps Backhaul Link		*9,000*	247	860	1,659	2,058	2,455	2,855	2,855	2,855
`	**10Gbps Core Link**		*9,000*	454	1,659	3,263	4,079	4,894	2,855	2,855	2,855
Utilisation per	**FTTx Cabinet**		*80%*	6%	9%	15%	18%	20%	23%	23%	23%
(including overheads	**FWA Sector**		*80%*	28%	34%	44%	49%	53%	58%	58%	58%
and 15Mbps headroom)	**200Mbps FWA link**		*80%*	19%	26%	39%	46%	52%	59%	59%	59%
	1Gbps FTTx Link		*80%*	6%	9%	15%	18%	20%	23%	23%	23%
	10Gbps Backhaul Link		*80%*	3%	10%	18%	23%	27%	32%	32%	32%
	10Gbps Core Link		*80%*	5%	18%	36%	45%	54%	32%	32%	32%

	Results from the "15Mbps 90% of time in busy hour" section above was used to forecast total network traffic until 2022 (see rows 14 and 15 in above and in Appendix E – Network Dimensioning). **b. Design and dimensioning information demonstrating that network upgrade plans will match the user and traffic growth forecast; and** The network deployment required to meet this total traffic was estimated in rows 17 to 22 above. The (average) traffic on each network node and link was computed in rows 24 to 36. Network deployment is planned commences in 2015 and take 2 years. Only one further upgrade is forecast in 2020 for a 10Gbps Core Link (see cell K22). The additional core link will, however, be built at the earliest opportunity to provide additional network resiliency in the unlikely event of a failure of the primary link. **c. Definition of triggers for individual link/node upgrades (e.g., when the use of x% of capacity is measured over a specific period).** The network design rules are such that any individual link or node approaching 60% of its total capacity will be scheduled for an upgrade to bring utilisation below 40% before this capacity limit is exceeded. This provides for network redundancy and resiliency and some non-uniformity in the geographical take-up of service. This necessitates a 10Gbps Core Link upgrade in 2020 (see rows 38 to 43). FWA systems and backhaul are forecast to approach this threshold in 2020 and the actual utilisation will be closely monitored with upgrades being made if and when required.
Latency and jitter	**For example:** **a. Calculations of end-to-end latency and jitter from manufacturer's or suppliers' specifications; and** The solution is designed to be low latency. A latency budget, for a system operating below maximum capacity and thus excluding buffering delays, can be estimated as follows:

Latency	FTTC	FTTP	FWA	Source
Internet transit	2ms	2ms	2ms	ComparativeNet measurements
Fibre/backhaul	2ms	2ms	2ms	ComparativeNet measurements
DSLAM	1ms			Equipment specifications (see Appendix C)
VDSL model	1ms			Equipment specifications (see Appendix C)
FWA link			15ms	Equipment specifications (see Appendix C)
Microwave link			10ms	Equipment specifications (see Appendix C)
TOTAL	**6ms**	**4ms**	**31ms**	

Manufacturers do not generally specify jitter, as it is largely driven by traffic loading and is strongly influenced by whether traffic shaping and/or prioritisation is being performed on the network links. ExampleNet's network is not designed with any traffic shaping or prioritisation, and network loading on individual elements is kept below 60% by design. Latency measurements of ComparativeNet show a variation (jitter) of less than 5ms in 99% of measurements.

b. Measurements of latency or jitter from a reference network; and

Latency (including any jitter) on ComparativeNet is below 40ms for 99.9% of measurements for the latest monthly monitoring interval (see Appendix H).

c. Demonstration that latency and jitter performance meets the requirements of typical applications (e.g. video conferencing, telephony).

The total buffering delay (latency plus jitter margin) is expected to be significantly less than 100ms as is considered acceptable for real time voice and video communication.

Supporting business case	**For example** **a. A business case that demonstrates that revenue versus cost of the proposed network provides a positive return on investment for different take-up scenarios; and** See Appendix G – Business Case. [The example Appendix G is highly simplified: the supplier shall include all necessary complexity while maintaining clarity. The supplier shall provide a business case sensitivity analysis considering different take-up scenarios. In its assessment, the NCC assessment will consider both the reasonableness of the take-up scenarios themselves as well as the related business case sensitivity results.] **b. Evidence of sufficient funding availability (including an assumption of any government subsidy where appropriate) to build the network as planned.** Evidence of funding is included in Appendix G. [The supplier shall include actual evidence of funding]
Planning consents	**For example:** **a. Sample planning consents or applications; and/or** The proposed network requires a significant number of new radio masts. As all are in national park areas, they cannot be built under the new notification-based General Permitted Development Order process. As a result planning applications are expected to be needed for all new sites. Planning applications are currently in preparation, with a view to submitting planning applications in November 2015, and initial discussions have already been held with the two planning authorities as well as the relevant district councils and parish councils.

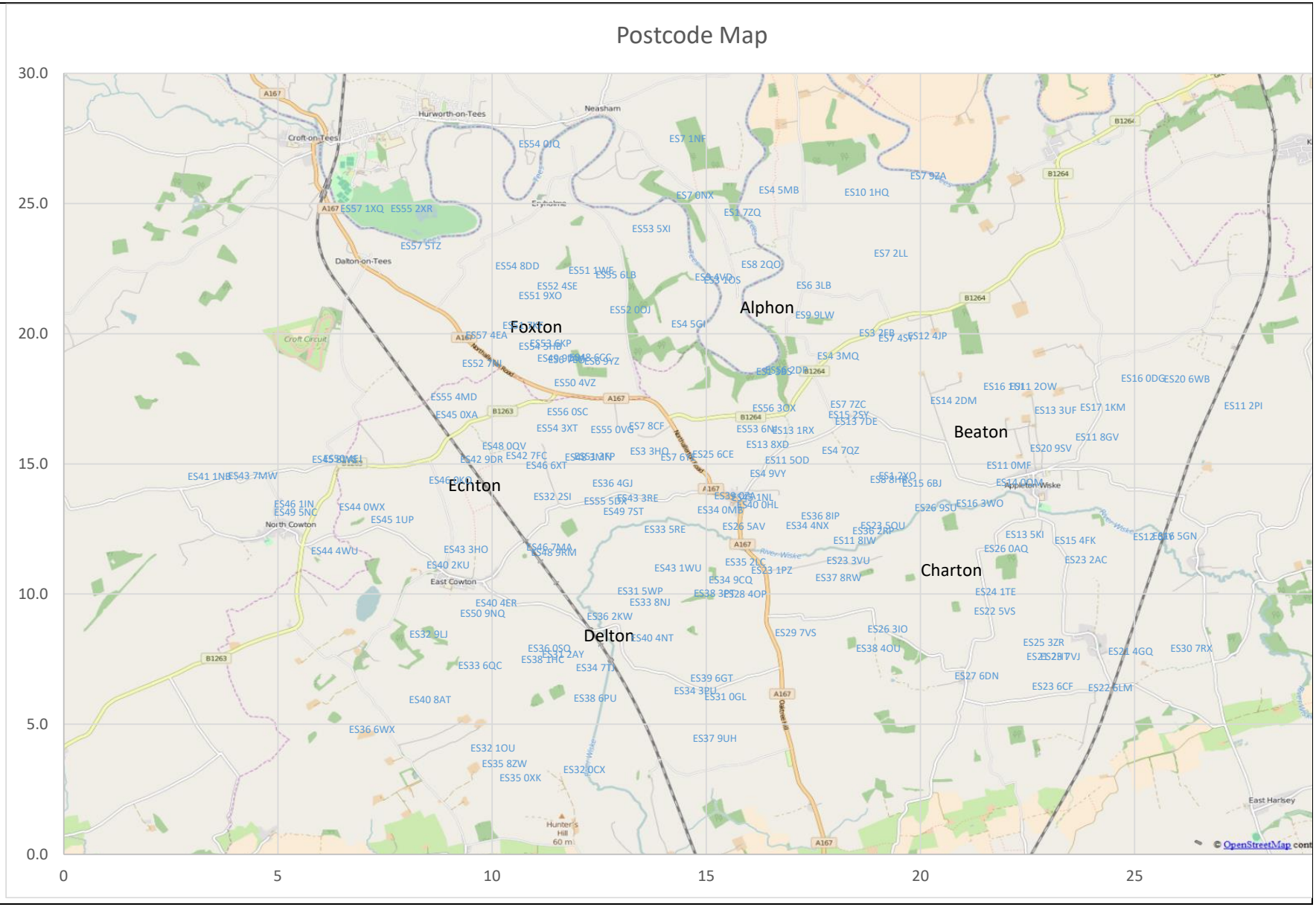
	In addition, steps are being taken to mitigate potential issues: masts are being designed to be low profile, will be concealed against trees where this is possible, and will be coloured according to advice from the planning authority. We are also taking steps to comply with the national park planning guidelines, specifically: • using existing masts where these are available (two sites in total), and; • where the cost impact is negligible, specifying spare structural capacity for all new mast sites so that another operator or operators would be able to use them in future. There is also recent precedent where local wireless ISPs have been able to construct the masts that they need in both national parks (as reported recently in the Alphon Gazette). The planning application process is currently in progress: • Pre-application: for the Alphon area, a meeting will be held with County Council, National Park/District Council and Parish Council representatives in Alphon on 20 November 2015 (see attached correspondence in Appendix H – Planning Applications). The corresponding meeting in Beaton will be scheduled shortly after this (25 November has been tentatively set as a date); • The full set of planning applications will be submitted as soon as practicable after these pre-application meetings, taking into account that minor modifications such as colour or materials may be requested. A sample planning application has been included (see Appendix I – Sample Planning Applications); [The supplier shall include actual planning applications in Appendix I] • Because of our early engagement, we are expecting that the planning applications will not receive substantial opposition and will be approved within the statutory timescale for decisions. **b. Letters of support from local authorities and landlords; and/or**

	See previous response. **c. Constructive correspondence with the relevant council's planning department.** See previous response.
Comparative deployments	**For example and if possible:** **a. Description of the comparative deployment, whether a commercial deployment or field trial, and why it is comparative (and the significance of any differences); and** ComparativeNet is mixed FTTC/FTTP and FWA deployment in the adjacent county of Comparativeshire having gained 2,500 new customers after 3 full years of operations. Comparativeshire is also predominantly rural but is coastal and less mountainous. Both network rely on line-of-sight wireless communication and while Exampleshire offers more severe terrain challenges the technology solution is otherwise very similar. The FFTC/FTTP network uses the same equipment and design rules as are planned for ExampleNet. The FWA network uses a previous version of wireless equipment which does not support the highest modulation scheme of the latest equipment to be used for ExampleNet: 256-QAM 1/2. This modulation scheme is not required in the design of ExampleNet either so the two networks are also functionally equivalent for wireless. Similarly, while the network topology is specific to Comparativeshire, the ExampleNet backhaul architecture and network dimensioning rules follow ComparativeNet closely. Measurements taken on ComparativeNet (e.g. for latency) could, therefore, except to be replicated on ExampleNet. There are some differences: for example ComparativeNet used 100Mbps microwave links rather than the 200Mbps links planned for ExampleNet. Nevertheless ComparativeNet can still offer the same NGA services as ExampleNet albeit with a larger proportion of Basic broadband subscribers. It should also be noted that both networks' microwave links could be upgraded to 400Mbps with a hardware modification if needed.

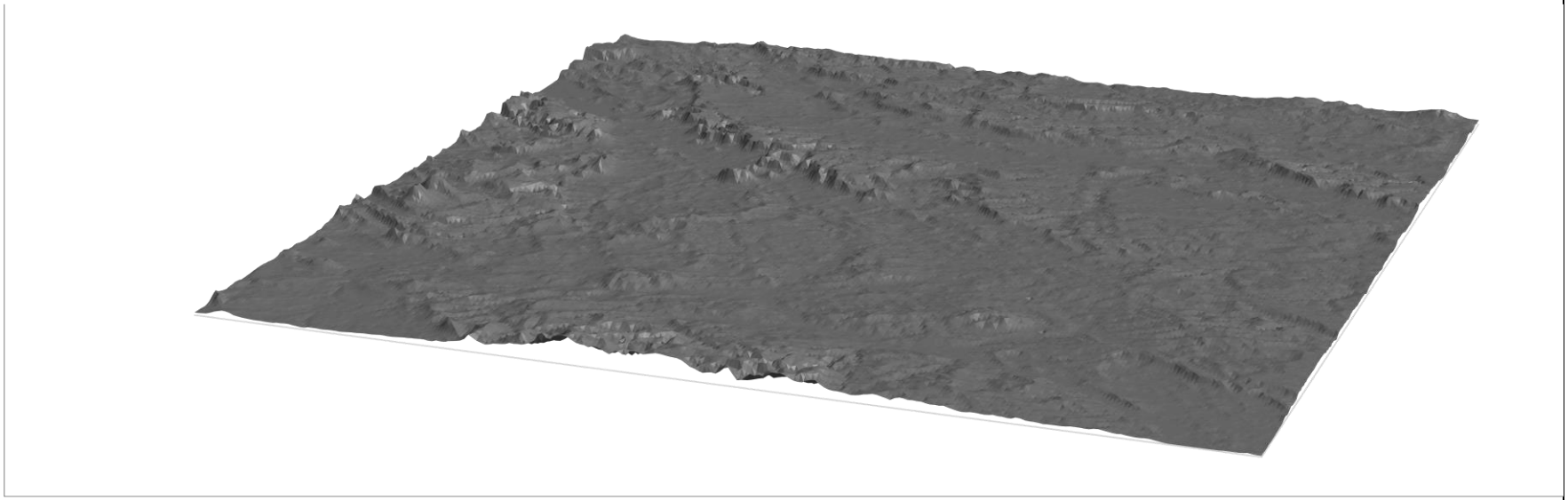
	b. Description of the comparative networks hypothetical ability to meet any or all of these NGA requirements. As described in the previous response, ComparativeNet and ExampleNet are functionally equivalent and both can provide NGA services (see Appendix H – ComparativeNet Architectural Design).
Radio and Interference plans	**For example:** **a. Radio and interference plans that show which premises and postcodes could receive NGA-compliance services (e.g. colour coded by service/grade); and** [The following highly illustrative examples were produced in Microsoft Excel. It is expected that in real networks Microsoft Excel would be inadequate for this purpose and industry standard radio planning tools would be used instead, however, no particular tool is favoured provided that it is fit for purpose. These examples indicate the kind of outputs required and the example appendices are highly contrived: the supplier would be expected to replace these with a robust and documented methodology together with further explanation of each output.] The network coverage area for the planned FWA access points in show below (note: coverage postcodes for FTTP and FTTC are not shown and the axes are marked in kilometres):

Department for Culture Media & Sport

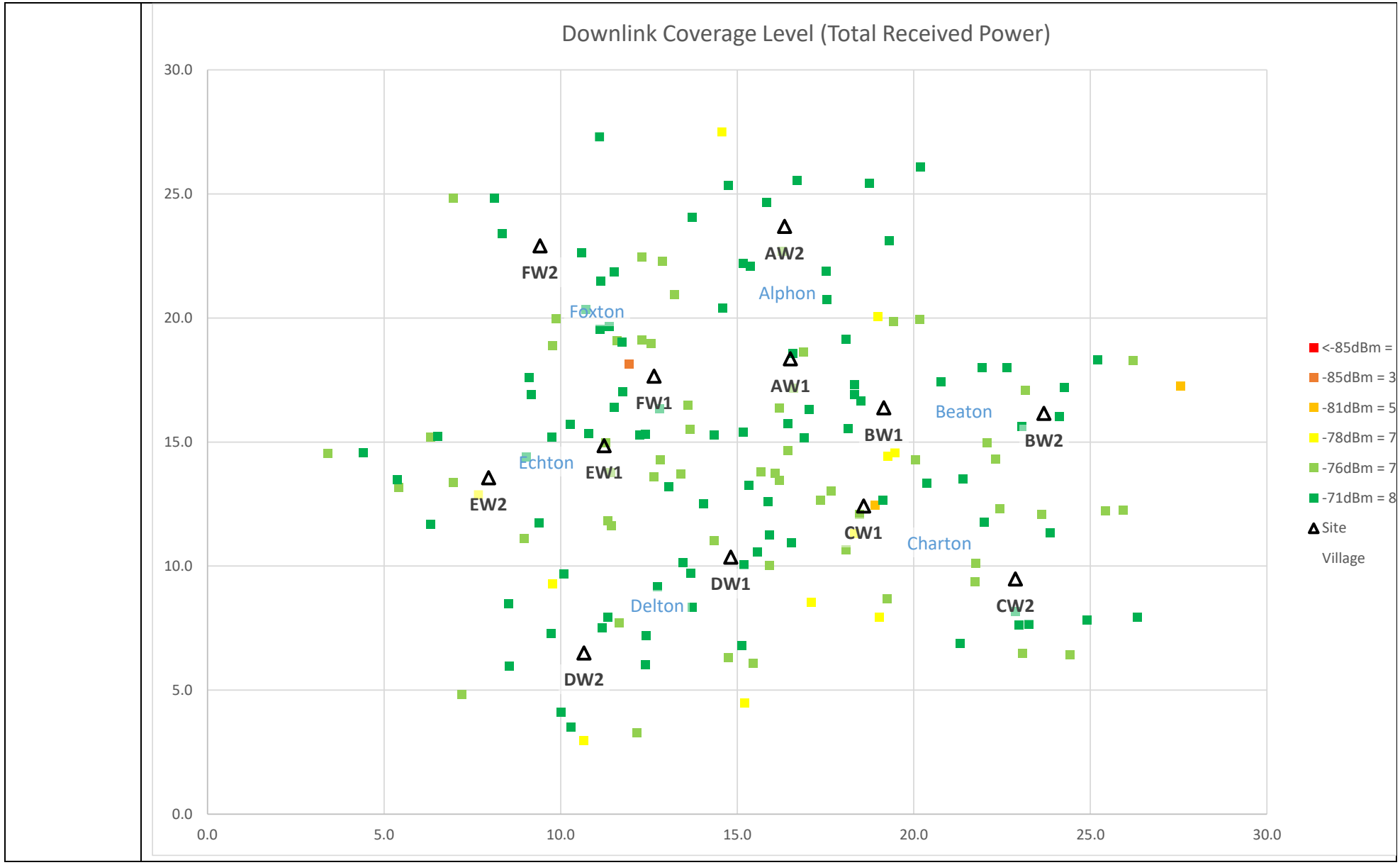
SUPERFAST BRITAIN



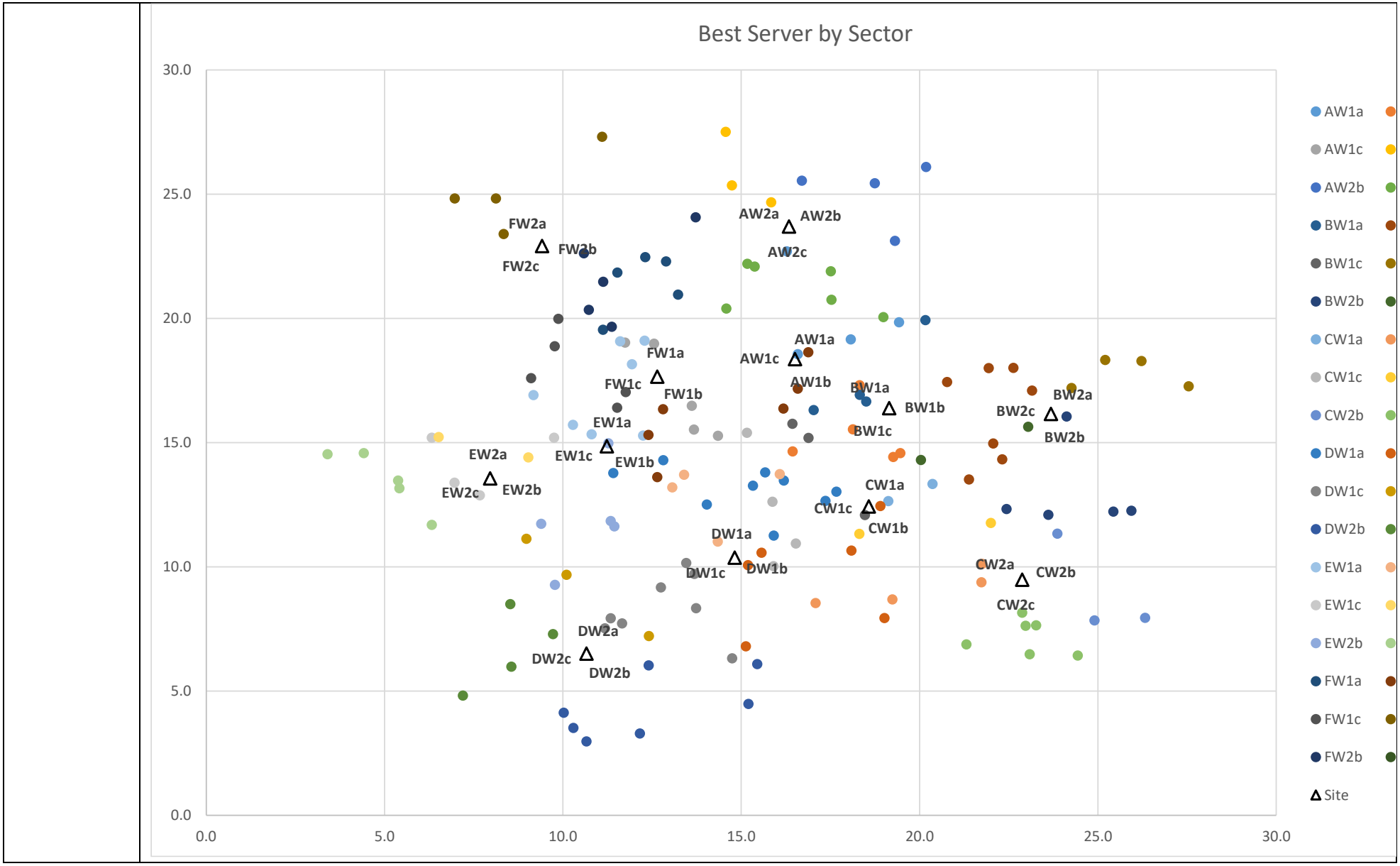
Digital elevation terrain and surface models for this area, used to model ground and clutter heights, were obtained from the Environment Agency (https://data.gov.uk/dataset/lidar-composite-dsm-1m1). The 1 metre accuracy data was down sampled to 25m accuracy (using bilinear filtering) for this rural application.



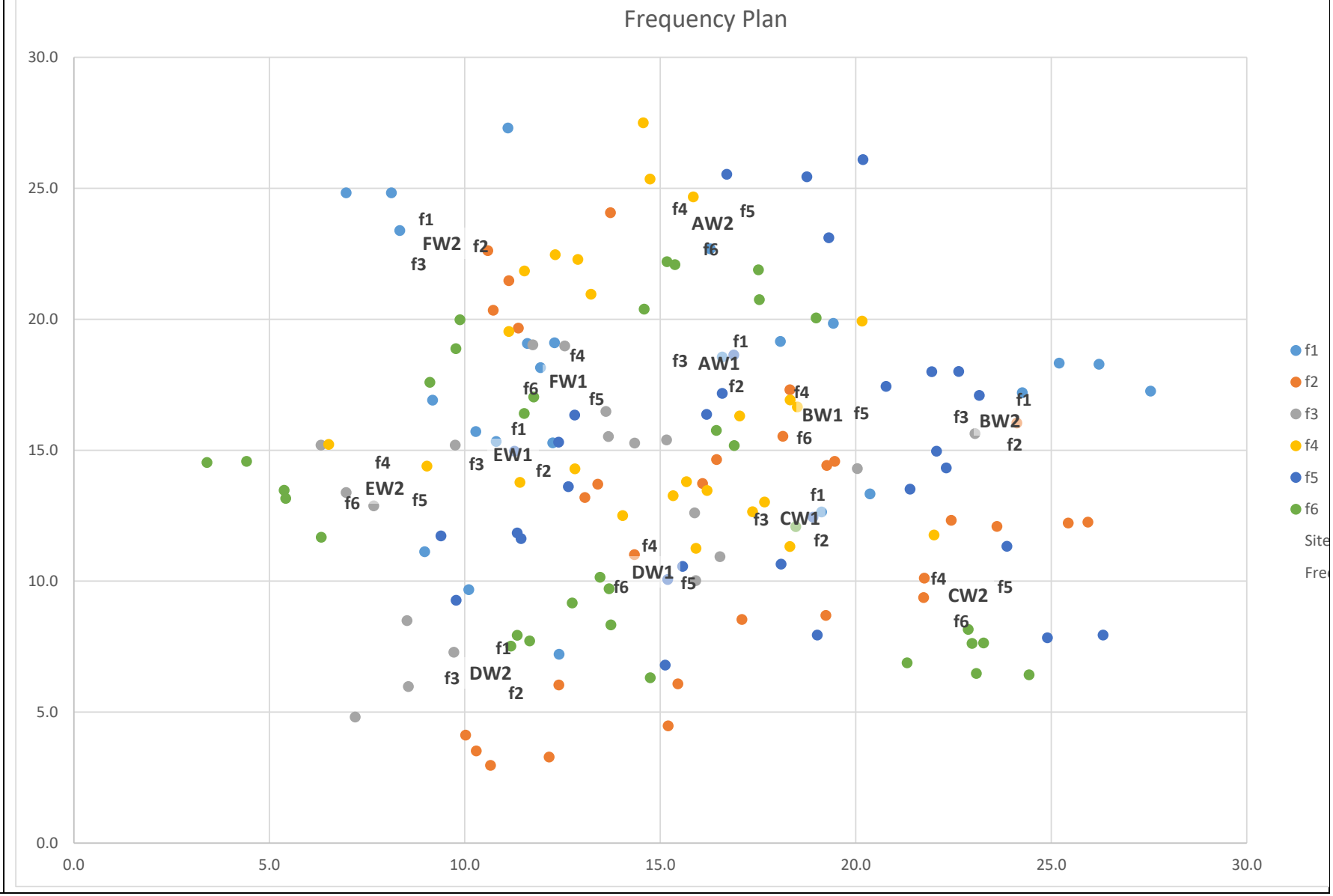
The FWA design relies upon line of sight visibility to access points, so ITU-R Recommendation P.525-2 (08/94) was used to calculate the free-space path loss. Access point antenna heights are tabulated in Appendix K and the CPE antenna heights were assumed to be 5m above ground level as would be typical for a wall-mounted installation. The following chart depicts the predicted received signal strength at postcode centroids. [An industry radio planning tool would also provide predictions for the intermediate points]. This chart also shows that 30Mbps is obtainable for all postcode centroids:


Downlink Coverage Level (Total Received Power)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
FW2
AW2
Alphon
Foxton
AW1
FW1
BW1
Beaton
BW2
Echton
EW1
EW2
CW1
Charton
DW1
CW2
Delton
DW2
<-85dBm =
-85dBm = 3
-81dBm = 5
-78dBm = 7
-76dBm = 7
-71dBm = 8
Site
Village

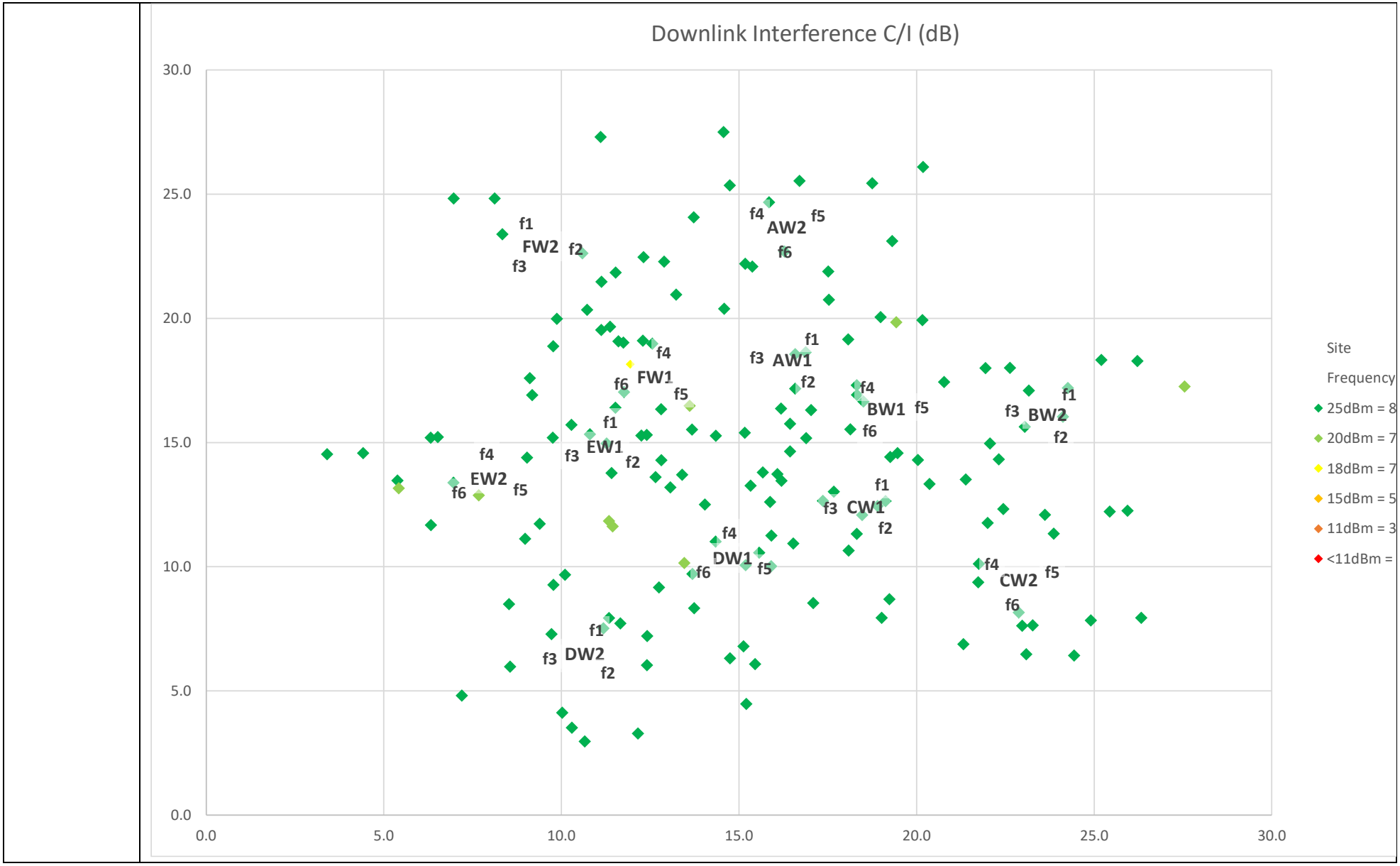
	A best server analysis was performed for each postcode centroid as a precursor to frequency planning. Second and third best servers were also analysed to assess alternative access points in the event of unforeseen blocking e.g. by tree growth.


Best Server by Sector
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
FW2a
FW2b
FW2c
AW2a
AW2b
AW2c
FW1a
FW1c
FW1b
AW1a
AW1c
AW1b
BW1a
BW1b
BW1c
BW2a
BW2c
BW2b
EW1a
EW1c
EW1b
EW2a
EW2c
EW2b
CW1a
CW1c
CW1b
DW1a
DW1c
DW1b
CW2a
CW2b
CW2c
DW2a
DW2c
DW2b
AW1a
AW1c
AW2b
BW1a
BW1c
BW2b
CW1a
CW1c
CW2b
DW1a
DW1c
DW2b
EW1a
EW1c
EW2b
FW1a
FW1c
FW2b
Site

	b. Frequency plan than minimises interference and demonstrates sufficient network capacity to meet the NGA requirement. The best server analysis (above) was used to allocate frequencies to particular access point sectors. In total six different frequencies were used. Spectrum monitoring at the six village centres using a 5m mast and the monitoring functions of the access point equipment showed (within the capability of the equipment) that none of the 14 available 20MHz channel was currently used [spectrum plots should be included]. This means that there are 8 spare channels for future use, however it should be noted that as unlicensed spectrum these spare channels could be used by any third party and any time. In fact, the FWA equipment uses Dynamic Frequency Selection to minimise interference, but only admitting 7 frequencies (including 1 spare) into this selection pool means that ExampleNet is only using half of the available spectrum resources, facilitating any future expansion and coordination with other users of this unlicensed spectrum. The nominal frequency plan is shown in the chart below:

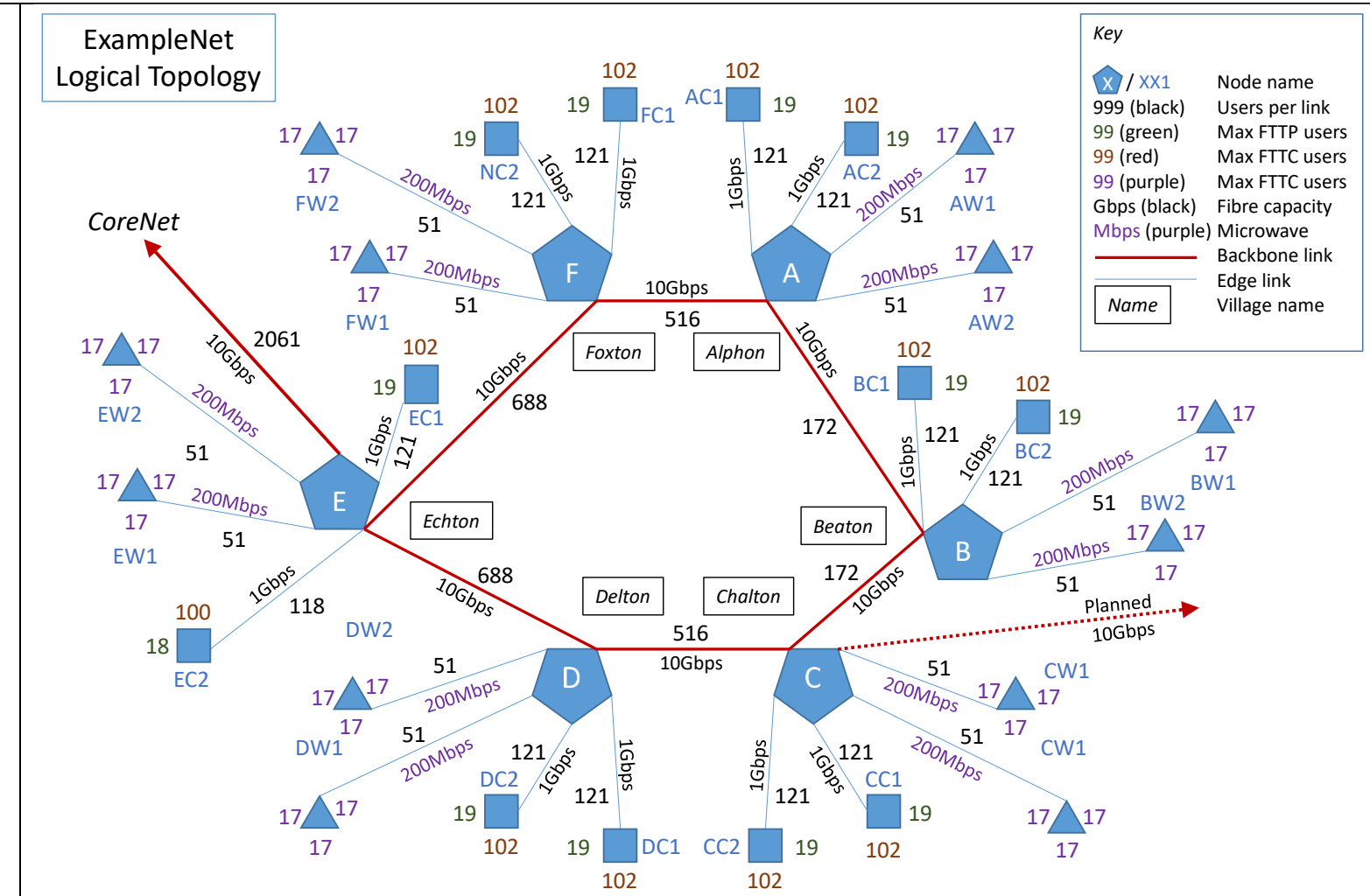

Frequency Plan
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
f1
FW2
f2
f3
f4
AW2
f5
f6
AW1
FW1
BW1
BW2
EW1
EW2
CW1
CW2
DW1
DW2
f1
f2
f3
f4
f5
f6
Site
Fre

	Finally, an interference analysis was performed to show that transmissions intended for one receiver did not interfere with any other. Careful planning of frequency reuse, and the inherently directional and narrow beam nature of the technology, coupled with time-synchronisation of transmissions, means that network self-interference should not be a major concern. The following chart for the downlink shows that any self-interference does not degrade capability below 30Mbps:


Downlink Interference C/I (dB)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
f1
FW2
f2
f3
f4
AW2
f5
f6
f1
f3
AW1
f2
f4
f6
FW1
f5
f1
BW1
f5
f3
BW2
f1
f2
f6
f1
f4
f3
EW1
f2
EW2
f6
f5
f1
f3
CW1
f2
f4
DW1
f6
f5
f4
CW2
f5
f6
f1
f3
DW2
f2
Site
Frequency
25dBm = 8
20dBm = 7
18dBm = 7
15dBm = 5
11dBm = 3
<11dBm =

Product offerings and SLAs	**For example:** **a. Publically available product description (e.g. from a web site); and** As shown on the ComparativeNet web site (http://www.comparativenet.fake/products.htm) ExampleNet broadband pricing is planned as follows: • Connection fee: £100. ExampleNet will select the serving technology (FTTC, FTTP, or FWA) and will supply and install Customer Premises Equipment (CPE). Customers requiring a specific technology that differs from ExampleNet's selection may face an additional charge based upon the actual connection costs (subject to feasibility). • Monthly service charge per subscriber: £30 for 30Mbps service including VoIP telephony service with unlimited data cap. This will be in addition to a monthly line access charge of £17 per month. [Note that all pricing here and in Appendix G Business Case is illustrative only: it does not represent any approved pricing.] **b. Sample contract terms and conditions.** Please see Appendix J – Subscriber Terms and Conditions. [The supplier shall include an actual subscriber terms and conditions in Appendix H]
Network dimensioning	**For example:** **a. Full end-to-end network capacity information including per-link and per-node capacities for access, backhaul, core network and Internet transit; and**

	Please see topology diagram below and in Annex L, and the response to the “Future Capacity” section above. Internet Transit will be leased to meet the traffic projection on multiple 10Gbps circuits as required. The ExampleNet core network interconnects with the Internet at ExampleIX’s node in Manchester. A redundant from the core network to ExampleIX’s node in Edinburgh is planned for installation by 2020 Q1 at the latest.


ExampleNet
Logical Topology
Key
X / XX1 Node name
999 (black) Users per link
99 (green) Max FTTP users
99 (red) Max FTTC users
99 (purple) Max FTTC users
Gbps (black) Fibre capacity
Mbps (purple) Microwave
Backbone link
Edge link
Name Village name
CoreNet
2061
10Gbps
Foxton
Alphon
Echton
Beaton
Delton
Chalton
516
688
172
118
Planned
10Gbps
A
B
C
D
E
F
AC1
AC2
AW1
AW2
BC1
BC2
BW1
BW2
CC1
CC2
CW1
DC1
DC2
DW1
DW2
EC1
EC2
EW1
EW2
FC1
FW1
FW2
NC2
200Mbps
1Gbps
121
51
102
19
17
100
18

	b. Demonstration that there are no bottlenecks anywhere in the network that would reduce performance below NGA requirements. See response to "Future capacity" section above. Capacity management will ensure that any network element that approaches 60% utilisation is upgraded.
Future upgrades and longevity	**For example:** **a. Future expansion plans (linked to the required capacity growth); and/or** See response to "Future capacity" section above. **b. Plans for new technology deployments in future; and/or** The network has been planned to require no technology upgrades before 2022. However, beyond 2022 equipment upgrades funded from earnings and/or new finance will be considered if needed for: • local capacity management or load balancing • longer term capacity management • new services **c. Technology roadmap to support forecast future capacity and user requirements.** Specific technology roadmaps are currently unavailable for ExampleNet equipment. However, per-unit link capacities for both fixed and wireless systems can be expected to roughly double every 5 years based upon past experience. Anticipated technology advancement would include 10GPON for FTTP, G.Fast for FTTC, antenna beamforming for FWA and higher capacity microwave equipment. It should be noted that none of these advancement are forecast to be needed by ExampleNet before 2022.