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An analysis of FTTP's role in UK connectivity. The evidence for a targeted approach

A report for BT

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About the author

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This is an independent report funded by BT.
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The UK has one of the highest levels of superfast coverage in Europe, and is a world leader in capturing the many social and economic benefits of broadband.

Several technologies are now being deployed to upgrade the speeds of UK broadband, by BT, Virgin and a number of other players. One of these technologies is FTTP (fibre to the premise).

FTTP has a clear and important role in the UK broadband market, and supporting the UK transition from a superfast leader to ultrafast. Clearly, its presence will continue to grow in the market. It is generally the right answer for greenfield sites, multiple dwelling units, or areas of high business demand, or as an "on demand" offering where any consumers are willing to pay for costs of deployment for instance.

However, beyond these targeted cases, some are instead calling for a near-universal deployment of FTTP. without consideration of economic, technological or customer context. For example, INCA has called on government to target 80% FTTP coverage in just over a decade and 100% coverage by 2030. We refer to such a deployment as 'blunt' FTTP.

Arguments proffered for 'blunt' FTTP include:

- **Growth in traffic** but traffic growth is slowing, and there is ample capacity in the access network, so (on a line-by-line basis) substantial increases in traffic have been possible without increased speeds
- **Growth in forecast bandwidth needs** but these forecasts are well within the capabilities of network upgrades already being deployed such as G.fast (by BT) and DOCSIS 3.1 (by Virgin)
- **Particular applications** that purportedly can only be met by FTTP, but almost always the proposed applications are equally possible without FTTP, and thus cannot be used to justify FTTP's blunt deployment
- **International league tables** but for fundamental reasons (such as the nature of the UK's housing stock), FTTP deployment here is more expensive than in most countries, meaning the cost/benefit trade-off is different. Moreover, those countries with the highest FTTP coverage have seen no greater tangible economic or societal benefits than countries that have deployed mixed technologies
- **Technical performance** but FTTP has no measured advantage in packet loss, and its advantage in latency is so low as to be immaterial even for advanced applications like remote surgery
- **Reliability** but while FTTP has some advantages in this area, it also has disadvantages. Fibre is more vulnerable to cuts and damage to the physical route, particularly if not buried deep and protected in duct.

1. Executive Summary *continued*

Thus, while FTTP will play an important role as part of an effective "mixed technology" strategy for delivering Britain's ultrafast future, the arguments for blanketing the UK with 'blunt' FTTP coverage are not compelling, and the investment case for it is likely weakening.

Competing technologies, such as G.fast and DOCSIS 3.1, continue to make rapid progress. Their increasing capabilities greatly reduces the incremental benefit of 'blunt' FTTP. In addition, these technologies are quicker and cheaper to deploy than FTTP. Wireless also shows increasing promise – Google Fiber is moving away from FTTP to wireless, for example.

We also have increasing evidence of the limits to demand for the very high speeds that are currently the preserve of FTTP, with narrow willingness-to-pay for these. In Australia, a majority of customers with FTTP available are actually taking speeds of 25 Mbps or less for example, and the proportion taking 100 Mbps or more is actually declining.

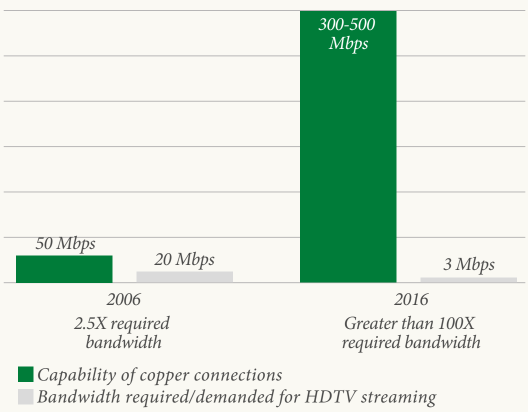
When historic FTTP networks were deployed, there was hope for a "killer app", but one has not materialised. Indeed, as application developers' attention shifts increasingly to mobile networks, they are investing heavily in reducing the technical requirements of their services. There has been a dramatic rise in patents related to video compression, for example. In the past the case for FTTP was made (in part) on the basis that HD video would require 20 Mbps – today it requires 3 Mbps, and in future it will require even less. Even more demanding future applications, such as virtual reality, require speeds within the capabilities of existing UK superfast broadband networks, and far below the capabilities of those currently being deployed such as G.fast and DOCSIS 3.1.

Figure 1 shows how the "coverage ratio" of mass deployment technologies such as G.fast against mass market applications like HDTV have dramatically increased over the past decade. Far from narrowing, the gap is actually widening between supply and demand.

In 2006, non-FTTP technologies were believed to have a limit to supply a bandwidth of around 50Mbps which was a modest 2.5X coverage of the bandwidth required at the time to enjoy HDTV streaming (20 Mbps as noted above). A decade later, this coverage ratio (or excess delivery factor) has increased significantly, both as bandwidth available to mass market deployment of non-FTTP technologies (such as G.fast) has expanded dramatically while compression technologies mean that HDTV requires only 3Mbps.

Figure 1: coverage ratio

In the last decade, innovation on both the supply and demand side has dramatically expanded the "coverage ratio" of non-FTTP technologies vs. intensive mass market applications



FTTP will play an important role as part of an effective mixed technology strategy for delivering Britain's ultrafast future.

The risk is that FTTP coverage, in and of itself, becomes the measure of success rather than the delivery of desired customer outcomes efficiently, rapidly and affordably.

Thus, other than a misplaced desire to "keep up with the (international) Joneses", there is remarkably little economic basis for a requirement for 'blunt' FTTP that substantially overbuilds other high capacity networks.

The risk is that FTTP coverage, in and of itself, becomes the measure of success rather than the delivery of desired customer outcomes efficiently, rapidly and affordably.

Moreover, if 'blunt' FTTP is set out as a long-term goal, then this has a chilling effect on deployment of other technologies. For example, the business case for immediate deployment of fixed wireless in rural areas is greatly damaged if in future years the region will be overbuilt with FTTP as a matter of policy. This means that pursuit of a long-term goal of FTTP can actually make consumer outcomes much worse in the short to medium term – this has been the experience in Australia.

NBN in Australia (and a number of companies around the world that were previously "blunt FTTP-focused") are now revising their plans to be smarter with a mixed-technology strategy as circumstances change; retreating from launching 'blunt' FTTP deployments – in the same way that many nations retreated from the development of supersonic passenger aircraft in the '70s.

The above caution about the case for 'blunt' FTTP does not argue against significant FTTP use in a targeted manner. As we have noted, there is no doubt that FTTP is the right technology in a number of situations, such as greenfield sites, high business demand areas and so on. Indeed, it is already being used in this way by multiple broadband providers, planning to serve over 2m UK homes. Moreover, if private companies wish to take on the risk of more widespread FTTP deployment, there is no reason not to facilitate this.

However, because the case for 'blunt' FTTP is highly uncertain, it would be a mistake to pursue it at the expense of heavy government intervention, with associated market distortion and/or cost to the taxpayer. It is better to encourage the use of the most appropriate solution that will meet realistic demand in a timely manner, while reflecting the UK's economic, technological and demographic context. This includes FTTP where appropriate, but also more cost effective solutions as well.

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2. Introduction

Broadband brings numerous social and economic benefits. Britain is well positioned to capture these benefits, with over 90% coverage of superfast (one of the highest levels in Europe).[1]

Moreover, BT, Virgin and other players are now deploying networks based on an array of technologies which will deliver speeds of hundreds of megabits or more. This fits well with Ofcom's objective to "encourage the large-scale deployment of new ultrafast networks".[2]

In this context, there is renewed debate about the role of fibre-to-the-premise in UK telecoms policy. Several of BT's competitors have called for Openreach to invest more in FTTP[3], and Ofcom has said:

"a good long-term outcome would be to achieve [through FTTP deployment] full competition between three or more networks for around 40% of premises, with competition from two providers in many areas beyond that".[4]

More informally, Sharon White (Ofcom CEO) has said:

"I want to be comparing ourselves with Japan or South Korea. If we look at FTTP, we're at 2%, Japan is at 70%."[5]

Others have gone further. INCA has suggested 80% FTTP coverage by 2026 and near 100% by 2030.[6]

There is no question that FTTP has a clear and important role to play in the UK's broadband future. There are a number of situations where it is the sensible economic and technical solution, including:

- **In greenfield sites.** For a new group of premises– such as a new housing development – where there is no pre-existing copper, it will generally make more sense to deploy FTTP. In this context the capital cost is broadly similar to that of new copper. (It is also considerably cheaper to deploy FTTP on greenfield sites than on brownfield sites – by 40% in Australia, for example)[7]
- **In "multiple dwelling units".** For MDUs (apartment blocks), deploying fibre can be attractive. A single connection to the basement (fibre-to-the-building, FTTB) can enable improved performance to multiple homes, greatly reducing unit capital costs. Thus, even relatively moderate extra revenue from fibre may justify the upfront cost
- **In locations with very long "copper tails".** While technological improvements are rapidly increasing the broadband performance of copper, the increase is far less for long copper tails (the final link to a premise). Such long tails are particularly common in remote rural areas, but exist elsewhere too. In these cases, FTTP may be the only technically viable way to deliver higher speed fixed broadband (though it may be uneconomic without subsidy)

- **For high demand business clusters,** such as business parks and high streets. These locations can have both relatively low unit costs and stronger revenue potential, making FTTP economical.

The idea that FTTP is well suited to such cases is more than theoretical. A number of companies are already using FTTP in just these situations. For example:

- BT has stated its ambition to reach an additional 2m premises of these types by 2020.[8]
- Virgin Media anticipates 1m FTTP connections within its network expansion[9]
- Sky and TalkTalk are working with Cityfibre to trial FTTP in York, and over two years have passed 11,000 homes.[10]
- Gigaclear specialises in providing FTTP to rural communities, and by the start of 2016 had connected over 15,000 properties.[11] In part thanks to £18m funding from the EIB, it expects to add another 40,000 by the end of 2016. It "estimate[s] that 1.5m properties in the UK could benefit from our services"
- Hyperoptic focuses on MDUs (apartments and offices) in urban areas that it believes currently have poor connectivity. It operates in 13 cities, but plans to expand to 20 and to reach over 300,000 homes by 2019.[12]

These companies (and others) are taking a targeted approach, deploying FTTP in the particular circumstances where it makes sense. Policy interventions to facilitate such investments (such as duct-and-pole access and simplified planning permission) are sensible.

However, some have argued for a blunt deployment – near universal FTTP across much of the UK – and for significant policy interventions to support it. For example, as we have noted, INCA has called for 80% FTTP coverage (approximately 22m premises) by 2026 and near 100% by 2030.

Blunt deployment will be much more economically challenging – it is unlikely to make a commercial return, as evidenced by the absence of any commercial player pursuing such a strategy themselves (as opposed to calling for others to pursue it).[13] Sky, for instance, has repeatedly ruled out plans to deploy its own fibre network.[14]

Absent a commercial investment case, implementing 'blunt' FTTP will have implications for a wide range of regulatory and policy decisions. It is, by way of example, being used to justify greater separation of Openreach and substantial government funding.

This paper examines the merits of the blunt approach in the UK context, and at this time. We consider the arguments being made in its favour; the rapidly changing context for the FTTP decision; the prospects of societal and economic benefits from 'blunt' FTTP, and whether 'blunt' FTTP is the most efficient way to achieve those benefits.

1 House of Commons Library, Superfast Broadband Coverage in the UK, 18 August 2016
2 Ofcom, Progress update: supporting investment in ultrafast broadband networks, July 2016
3 See, for example: Sky, TalkTalk, Vodafone et al, A 10 Point Plan for a better Openreach, 7 July 2016
4 Ofcom, Strengthening Openreach's strategic and operational independence, 26 July 2016
5 Computer Weekly, After BT's Openreach reprieve, what now for the UK broadband roll-out?, 26 February 2016
6 INCA, Building Gigabit Britain, 8 September 2016
7 nbn co ltd, Annual Report 2015-16, 10 August 2016
8 BT, BT Capital Markets Day – Part 2: Seizing the convergence opportunity, 5 May 2016
9 Global Telecoms Business, Virgin Media has pledged that it will rollout fibre-to-the-premises (FTTH) to one million UK homes and businesses by 2020, 28 April 2016
10 TalkTalk, TalkTalk Telecom Group PLC: Trading update for the 3 months to 30 June 2016 (Q1 FY17), 20 July 2016
11 Gigaclear, Gigaclear secures €25m from EIB fuelling massive rural internet network expansion, 14 January 2016
12 Hyperoptic, Hyperoptic to expand 1Gbps network with GBP 21 million backing from EIB, 19 July 2016
13 INCA "suggests" that 80% coverage of FTTP on a commercial basis by 2026 is "an attainable goal". However, their own members in aggregate expect 40% coverage by 2026, and this figure is subject to making a range of regulatory and policy changes requested by INCA. See INCA, Building Gigabit Britain, 8 September 2016
14 The Times, Battle for Bundesliga rights weighs on Sky, 22 April 2016

3. The case made for 'blunt' FTTP

In some quarters there is a presumption that a general push for FTTP effectively everywhere and broad adoption of ultrafast is simply inevitable. Ofcom describes a future where:

"Most consumers and businesses will move from 'superfast' to 'ultrafast' broadband… the UK will move towards a new fibre future, with widespread availability of… 'fibre to the premise'"[15]

However, one needs to be careful that "widespread availability" does not actually mean 'blunt' FTTP, as the latter approach would have no real incremental value vs. a targeted approach and the rationale is surprisingly thin, and often ill-founded.

In this section we therefore review the arguments made for a blunt deployment of FTTP across virtually all the UK, and consider whether they are supported by evidence.

The case based on traffic growth

In discussing "A fibre future", the Commons Culture, Media and Sport Committee goes as far as to say:

"growth in trends in data consumption is conclusive in pointing to a need to future-proof networks"[16]

Continuing traffic growth is undoubtedly real, and Cisco predict a 19% annual growth in traffic per UK internet household between 2015 and 2020.[17] However, ongoing traffic growth and increased requirements for bandwidth to the home are two very different things.

Underutilisation of the access network

The first reason is that the UK's broadband access network is (in aggregate) operating far below its full capacity. As Figure 2 shows, even in the evening busy hours, the UK's broadband access network is carrying traffic representing just 1.4% of its total capacity. This is not to say that there are no individual connections operating at full capacity at certain points in time – certainly there are – but rather to highlight that extra traffic need not imply a need for extra bandwidth.

Strong actual growth in traffic for lines of a given speed

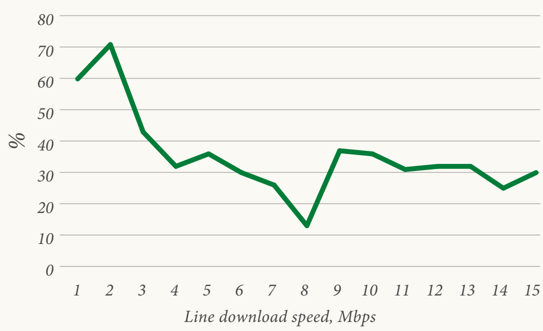
Further evidence for the lack of linkage between line speed and traffic comes from Ofcom data which shows that lines of a given speed see substantial traffic growth (without any increased bandwidth). This is true even of lines with quite low speeds (Figure 3). For example, for lines with a speed of 10 Mbps, traffic per line grew by 36% from 2014 to 2015.

Such growth is possible since much additional traffic comes from "stretching out" of consumption. To take a simple example, imagine a single person household whose peak demand for bandwidth is set by streaming

Figure 2: Busy hours utilisation of UK broadband (June 2015)

Data per connection per month[18]	*82 GB*
Of which in busy hours (6-12pm)[19]	*31%*
Data per connection in busy hours	*25.4 GB*
Equivalent bit rate	*0.31 Mbps*
Average UK line speed[20]	*26.3 Mbps*
Average utilisation[21]	*1.4%*

Figure 3: Traffic growth 2014-15 by line speed[22]



HD video. The fact that last year she watched 30 minutes per day, and this year she watches 60 minutes per day makes no difference to her bandwidth requirement, but it will substantially increase her traffic.

Thus it is simply wrong to assume that (undoubted) future traffic growth will lead to an equivalent increase in required bandwidth.

Finally, we note that traffic growth, while still significant, is expected to slow. TalkTalk, for example, anticipated growth of 23% in busy hour traffic this year, dropping to 7% by 2024/25 (Figure 4).

The case based on forecast increase in available speeds

In discussing "a fibre future" the Commons Culture, Media and Sport Committee also noted Cisco's forecast of a doubling of global fixed broadband speeds, reaching 47.7 Mbps by 2020.[26] Indeed, Cisco forecast a slightly higher speed for the UK, at 51.3 Mbps in 2020.[27] (In addition to Cisco's forecast, there is the more informal Nielsen's law – see Figure 5.)

However, as of June 2015, 83% of UK premises had access to superfast broadband, which had an average speed of 63 Mbps.[28] Thus across the UK an average speed of at least 52 Mbps was already available in mid 2015.[29] (Superfast coverage has increased to over 90% since then.)[30] In other words, the Cisco forecast could be met without any further investment in the broadband network.[31]

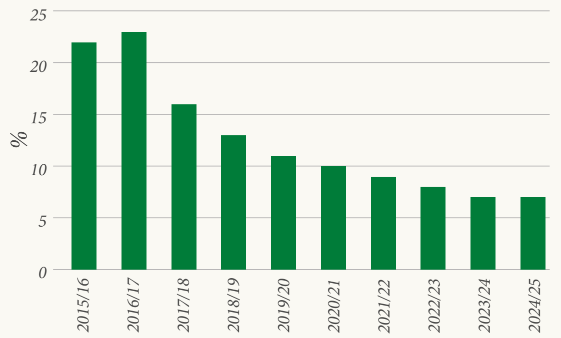
Of course in reality, substantial investment will be made in any scenario, not least through BT's deployment of G.fast and Virgin's of DOCSIS 3.1 (discussed in more detail below). These technologies will bring speeds in the hundreds of Mbps or more.

Thus, from the supply side there is no question at all that the Cisco forecast can be met under "business as usual", and it certainly does not represent a basis for remaking policy to pursue 'blunt' FTTP.

The case based on applications

Sometimes the case for 'blunt' FTTP is made on the basis that it is essential to enabling certain applications. There is no question that FTTP makes possible a wide array of valuable applications, but the critical question is whether these applications are *only* possible with FTTP. Very often it turns out that the cited applications are already possible with existing broadband, or well within the capabilities of much cheaper alternative technologies (such as G.fast, which brings 300 Mbps or more, and DOCSIS 3.1, which is enabling Gigabit speeds on cable). We consider two examples often cited in favour of FTTP – remote working and e-health.

Figure 4: TalkTalk forecast busy hour traffic growth[23]



[15] Ofcom, Making communications work for everyone–Initial conclusions from the Strategic Review of Digital Communications, 25 February 2016
[16] House of Commons Culture, Media and Sport Committee, Establishing worldclass connectivity throughout the UK–Second Report of Session 2016–17, 13 July 2016
[17] Cisco, VNI Complete Forecast Highlights Tool (accessed 7 September 2016)
[18] Ofcom, Communications Market Report 2016, 4 August 2016. Figure is for June 2015
[19] Ofcom, Infrastructure Report 2013 Update, 24 October 2013 (latest available data)
[20] Ofcom, UK Home broadband performance, 24 March 2016. Figures for November 2014 and 2015 interpolated to estimate line speed in June 2015
[21] The calculated utilisation also allows for the fact that available bandwidth may be 13-15% lower than sync speed
[22] Communications Chambers analysis of data from Ofcom, Connected Nations 2015, 1 December 2015
[23] TalkTalk, Network Overview, May 2016
[24] INCA, Building Gigabit Britain, 8 September 2016
[25] Jakon Nielsen [Nielsen Norman Group], Nielsen's Law of Internet Bandwidth (accessed 8 September 2016). The data used to demonstrate 50% growth per year is based entirely on Mr Nielsen's own purchases of broadband for his home. It is conceivable that he has a motive to time his purchases to fit the law bearing his name
[26] House of Commons Culture, Media and Sport Committee, Establishing worldclass connectivity throughout the UK–Second Report of Session 2016–17, 13 July 2016
[27] Cisco, VNI Complete Forecast Highlights Tool (accessed 7 September 2016)
[28] Ofcom, Connected Nations 2015, 1 December 2015
[29] This is an underestimate, since it ignores the capabilities of lines beyond the 83% superfast coverage
[30] BSG, BT-Openreach Fibre Network passes 25 Million UK Premises as UK Superfast Broadband Coverage hits 90%, 12 April 2016
[31] This is obviously not an argument for ignoring the needs of those currently without decent broadband, and (as already noted) FTTP may be part of the solution for such areas

3. The case made for 'blunt' FTTP *continued*

Remote working does not require FTTP

In making the case for FTTP Jeremy Darroch, (CEO of Sky) has spoken of "the 1Gb/s speeds Britain needs" and asks us to "[i]magine the benefits for working parents and small businesses if the network helped them work remotely".[32] However, 14% of the workforce already works from home as a base.[33] According to Vodafone, in a 2012 paper (before the UK had widespread superfast):

"The conditions are ripe then for the widespread deployment of flexible working. And a very sizeable vanguard has already forged the way. Three fifths of organisations now equip the majority of employees with remote working solutions."[34]

In the literature of remote working, broadband is little mentioned as a constraint. A study by Alcatel Lucent of remote office applications found no benefit for speeds above 6 Mbps.[36] Thus it is unclear why Mr Darroch believes 1 Gbps or FTTP is necessary to achieve these benefits.

FTTP not the only technology that can support e-health

INCA has discussed the benefits for e-health.[37] For instance, they cited a study suggesting $36bn global savings from remote patient monitoring.[38] However, they neglected to mention that the study was of mobile health monitoring (using smartphones), and certainly was not dependent on FTTP.

A Danish trial of telemedicine found "generally, both FTTH and other connections seem to perform equally well".[39] A Swedish trial found that a remote health monitoring system (including video, personal alarms and motion sensors) requires less than 300 Kbps.[40]

Certainly e-health holds promise, but domestic broadband is not a material constraint. For example, the European Society of Cardiology identified seven barriers to e-health adoption, such as "limited large-scale evidence of cost effectiveness" and "inadequate, or fragmented, legal frameworks".[42] Broadband was not even mentioned in their paper. This is a common pattern. When FTTP advocates discuss e-health, bandwidth looms large. When medical professionals and researchers discuss e-health, bandwidth is mentioned rarely if at all.[43]

Figure 5: Nielsen's law of internet bandwidth

Some have argued that this "law" demonstrates a need for FTTP. According to INCA, it "says top users will need 1 Gbps by 2019".[24] In fact, the law states that "a high-end user's connection speed grows by 50% per year".[25]

In other words, it specifies what users will have, not what they will need, a vital distinction. Given that gigabit offers are already available in the UK market, it is uncontroversial that some users will have 1 Gbps. The policy question is whether such speeds are *required*.

Figure 6: Bandwidth requirements of select types of health care providers, per ONC[41]

Clinic (5-25 physicians) – 25 Mbps
Supports clinic management functions, email, and web browsing. Allows simultaneous use of EHR and high-quality video consultations. Enables real-time image transfer. Enables remote monitoring. Makes possible use of HD video consultations.

Hospital – 100 Mbps
Supports hospital management functions, email, and web browsing. Allows simultaneous use of EHR and high-quality video consultations. Enables real-time image transfer. Enables continuous remote monitoring. Makes possible use of HD video consultations.

Academic/Large Medical Center – 1,000 Mbps
[as above].

The US government's Office of the National Coordinator for Health Information Technology notes that even for a hospital, the bandwidth requirement is only 100 Mbps (see Figure 6). Given this, it is hard to see what meaningful health benefit a gigabit per second to the home could have. Even a sequenced human genome is a datafile of 3 GB,[44] which would download on a 400 Mbps G.fast connection in around a minute. Saving a few seconds on a genome download is unlikely to be a priority for most home users.

(There is of course no debate that major medical institutions should have very high speed and reliable broadband available – indeed, they already do.)

The case based on international comparisons
International comparisons loom large in recent UK concern regarding its lack of FTTP. However:

- International league tables are a dangerous basis for policy making
- The costs and benefits of FTTP deployment differ by country
- Governments have made different trade-offs regarding FTTP
- FTTP coverage has had limited impact on broadband speeds
- It has also had limited impact on use of socially or economically valuable applications.

We discuss these issues below.

League tables a poor basis for policy decisions
However, taking league tables (particularly those based on a technology rather than an outcome) as a basis for broadband policy making simply begs the question whether higher coverage of FTTP yields commensurate societal and economic dividends.

League tables have been a trap for policy making in the past. For example, in the 1960s France and the UK led the world in supersonic passenger aircraft. Alarmed by this, both the US and the Soviet Union invested heavily in programmes to catch up. However, for all four countries these investments were financial disasters with little if any wider economic benefit. Germany's place at the bottom of the league table of supersonic passenger aircraft was actually ideal.

There are in fact reasons to doubt whether other countries' investment in FTTP have paid "societal" dividends (as we discuss later). However, even if they have, it does not follow that the UK should blindly follow the same strategy.

Differing cost/benefit trade-offs by country
For FTTP to be worthwhile, its incremental benefits need to exceed its incremental cost of deployment. But these benefits and costs vary significantly from market to market. Thus, even if the balance is positive in (say) Sweden, it does not follow that it is good policy to push 'blunt' FTTP in the UK.

[32] Sky, The simple quick fix that can take Britain out of broadband's slow lane, 22 February 2016
[33] ONS, Home workers rates and levels: Jan to Mar 2015, 8 April 2016
[34] Circle Research (for Vodafone), Exploring the shift in employee expectations, January 2012
[35] See for example: The Work Foundation, Working Anywhere–A Winning Formula for Good Work?, 24 February 2016
[36] Alcatel Lucent, Virtual Desktop Performance and Quality Of Experience, 2013
[37] INCA, Building Gigabit Britain, 8 September 2016
[38] Fierce Healthcare, Remote patient monitoring to save $36B globally by 2018, 17 July 2013
[39] Connected for Health, Newsletter 2, 22 June 2016. Note that a single patient in the trial did have technical problems, which the authors speculate may have been related to the lack of at FTTP connection
[40] NM Khio et al (Luleå University of Technology), An Efficient IoT-based Remote Health Monitoring System for Smart Regions, February 2016
[41] HealthIT.gov (website of the ONC), What is the recommended bandwidth for different types of health care providers? (accessed 18 September 2016)
[42] Martin Cowie et al, "e-health: a position statement of the European Society of Cardiology", European Heart Journal, 24 August 2015
[43] See for example Elin Børøsund, Aspects of uptake, use and effectiveness of eHealth interventions for self-management support and patient-provider communication, 2014; David-Zacharie Issom, Investigating needs and barriers in developing eHealth tools supporting self-management of people with Sickle Cell Disease, Spring 2015
[44] FCC, Health care Broadband in America: Early analysis and a path forward, August 2010

3. The case made for 'blunt' FTTP *continued*

We here focus on some of the drivers of costs, which have meant that FTTP is significantly cheaper to deploy (and hence more economically viable compared to the alternatives) in markets other than the UK.

One important FTTP cost driver is the nature of a country's housing stock. As we have noted, MDUs (apartment blocks) are relatively cheap to connect with FTTP/B. Therefore if much of a country's housing is of this type, FTTP is much more likely to cover its costs. Figure 7 shows the relationship. A high proportion of MDUs does not guarantee high FTTP coverage – as the case of Germany shows. However, those countries which do have high coverage almost all also have many MDUs. Indeed, few countries have coverage that is meaningfully higher than their MDU percentage. (Norway is the sole exception, likely due to implicit subsidies from municipal energy companies which have led deployment, and due to some of the highest broadband prices in Europe – second only to Cyprus, and more than 40% more expensive than the UK.)[46]

Ireland aside (which also has little FTTP), the UK has the lowest proportion of households in MDUs of any country in the EU28. This clearly weakens the case for 'blunt' FTTP deployment (both from the perspective of investors and the economy as a whole).

Another important cost driver is the quality of a country's duct network. If the duct network has high capillarity[47] and capacity, then the cost of FTTP is greatly reduced. The new fibre can be simply installed down the existing ducts. This has been a major factor in Portugal's fibre deployment. The country has an excellent duct system, and this meant that Portugal Telecom was able to spend less than 5% of its FTTH capex on civils (construction work). This was a critical factor in reducing PT's cost per premise to a quarter of the European average.[48] Some countries have alternate infrastructure which can reduce civils costs. In France, for example, the high quality sewers in several major cities have been used to deploy fibre.

A third factor is whether fibre optic cable must be buried, or can be deployed aerially (on poles). The latter is far cheaper. In Israel 70% of FTTH mileage is aerial.[49] Aerial fibre is also common in Japan, since ducts are difficult to repair in the event of earthquakes. (In most markets aerial fibre is avoided since it can be visually intrusive, and is more vulnerable to damage – until recently new aerial routes were explicitly disallowed under UK planning rules.)

This view that the UK may be a particularly unattractive market for 'blunt' FTTP investment is consistent with Analysys Mason's view. In a report for the ITU/UNESCO Broadband Commission, they found that the level of commercially viable coverage for FTTH in the UK was one of the lowest in Europe:

Figure 7: MDUs and FTTP coverage, Europe[45]

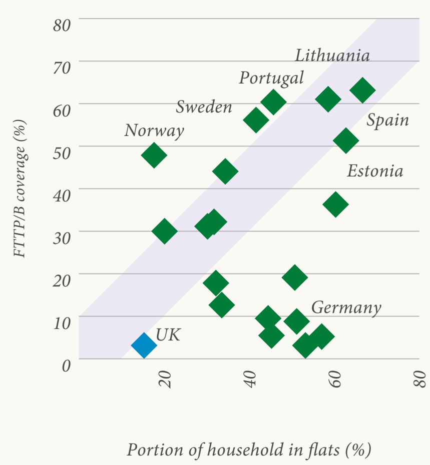
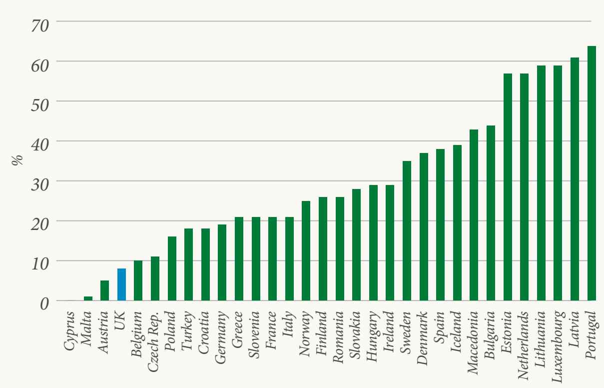


Figure 8: Commercially viable FTTH coverage[50]



Finally, a number of countries have effectively been forced down the FTTP route, since there were significant impediments to upgrades using the copper network, such as:

- Poor quality copper cables in Lithuania
- Long local loops in Sweden
- Lack of street cabinets in Croatia
- Rudimentary legacy networks in Bulgaria and Romania.[51]

The UK is fortunate that such constraints are rare in this country.

Differing government trade-offs

In addition to fundamental factors such as national cost variations, differences in FTTP coverage are materially driven by policy and regulatory decisions.

Several countries have chosen to sacrifice a degree of competition in order to secure FTTP. For instance, in Korea the Ministry of Information and Communication exempted Korea Telecom from any obligation to wholesale fibre deployed after 2004.[52] The government also "supervised the time and the place of players' competition and even guaranteed a certain amount of revenues for service providers".[53] In Europe, Portugal Telecom, Telekom Slovenije and (until recently) Telefónica are examples of operators that have been similarly exempted.[54] By contrast, in the UK and some other European countries incumbents are obligated to provide their fibre networks to third parties – in addition to their copper networks – which can reduce the returns to deploying those fibre networks considerably by limiting the retail margin retained. (Alternative providers in the UK rolling out FTTP have no such obligation.)

Moreover, the UK's historic pro-competitive approach means that BT has one of the lowest retail fixed broadband market shares in the EU – 32%, compared to an EU average of 41%.[55] This means that BT has a smaller retail "anchor tenant" than the great majority of EU incumbents, increasing the risk of FTTP deployment. (Theoretically third-party access seekers could pre-commit to purchase FTTP from Openreach, but in practice this hasn't happened.)

A move to structurally separate Openreach would deprive it of even this anchor tenant. It is perplexing that some argue that this would increase the likelihood of Openreach deploying FTTP, when many regulators have taken the exact opposite view – namely that FTTP deployment was maximised by allowing the builder to retain all the retail margin.

Aside from providing favourable regulation, several governments have provided direct financial support to FTTP deployment. Japan provided government grants, interest subsidies, debt guarantees and tax breaks for FTTP deployment.[56] France is putting €6.5bn of public funds towards FTTP outside big cities.[57] Iceland supported FTTP roll-out at the time of the global

[45] Coverage per Analysys Mason, as quoted in Ofcom, Making communications work for everyone–Initial conclusions from the Strategic Review of Digital Communications, 25 February 2016. Housing stock per Eurostat

[46] Based on comparison of double plays with speed in the range of 30-100 Mbps. Data from EC, Study on retail broadband access prices (as of February 2015), 22 October 2015

[47] That is, density and reach out to the edge of the network (towards end user premises)

[48] Analysys Mason (for ECTA), The digital single market and telecoms regulation going forward, 18 September 2015

[49] YNet News, Viaeuropa to build Israel fiber optic network, 18 June 2013

[50] Analysys Mason (for Broadband Commission), Broadband Policy Briefing Paper, 22 September 2015

[51] BEREC, Challenges and drivers of NGA rollout and infrastructure competition (Draft), 2 June 2016. BEREC also note the impact of improving mobile broadband, which acts as an anchor product upon superfast broadband

[52] OECD, Fibre Access–Network Developments in the OECD Area, 16 June 2011

[53] Kang Sun-moo (Korean National Information Society Agency), Korean broadband policies and recommendations for the Asian information super highway, 2 December 2013

[54] Arthur D Little, FTTH: Double Squeeze of Incumbents – Forced to Partner?, 2010

[55] EC, Digital Scoreboard. Figures for June 2015

[56] Sato Kenji, ICT Strategies in Japan, April 2010

[57] France très haut debit, Qu'est ce que le Plan France Très Haut Débit? [accessed 9 September 2016]

3. The case made for 'blunt' FTTP *continued*

financial crisis, since "the state and the municipalities… considered it to be their role to promote employment with manpower intensive projects".[58] New Zealand, Australia and Singapore also have all put substantial state funds to work (with higher levels perhaps required due to the structural separation imposed in parallel in each of these markets).

In summary FTTP is likely to be more expensive in the UK (due to issues such as the relative lack of MDUs and quality of existing duct), and has received far less government financial and support than in many markets. It also operates under a regime promoting strong retail competition, which can act as a disincentive. It is therefore perhaps unsurprising that FTTP coverage here is relatively low. However, this only matters if FTTP delivers great benefits compared to the alternatives. We now turn to the impact FTTP has had (or more to the point, has not had) in the markets where coverage is higher.

FTTP coverage has limited impact on actual speed

One cause to be cautious about the dividends from FTTP coverage is that it has relatively little impact on actual measured broadband speed. As Figure 10 shows, though the UK does have one of the lowest FTTP coverages of the comparator nations chosen by Ofcom, its actual broadband speeds compare quite well. For instance, the UK's average of 14.9 Mbps is greater than that of European FTTP leaders Spain and Portugal (13.3 and 13.1 Mbps respectively).[61] Nor is there a material speed gap between the UK and Japan (at 18.2 Mbps). South Korea, at 29 Mbps, does have much higher speed than the UK. However, the fact that Korea's speed is almost 60% higher than Japan (which has similar FTTP coverage) just underlines how weak is the linkage between fibre deployment and actual broadband speeds.

Many factors play into these actual speeds, and very often it is not bandwidth in the last mile which is the weak link in the chain. If other factors are the binding constraints, then investment in FTTP will bring minimal benefit. TalkTalk, for instance, believe that these other factors have indeed been an important constraint:

"In FY16 we completed the first phase of our backhaul upgrade to deliver significant improvements in network performance for fibre [to the cabinet] customers."[62]

Google has found that for its Google Fiber customers, wifi was an important constraint. For example, even for those with faster 5 Ghz wifi, approximately 80% were achieving wireless speeds of 200 Mbps or less.[63] More generally, a US academic study found that for access links of 20 Mbps or more, 80% or more of bottlenecks were caused by wifi, not the access link.[64] For this great majority of congestion events, upgrading to FTTP would make no difference at all.

Figure 9: Select FTTP government subsidies[59]

Country	*Support (£/covered household)*	*Coverage*	*Type*
Australia	*1,931*	*100% (mixed tech)*	*Debt, equity*
New Zealand	*699*	*75%*	*Cheap debt, equity*
France	*445*	*58% → 100% (mixed tech)*	*Grant & other subsidies*
Singapore	*355*	*100%*	*Grant*

Another factor in the weak link between FTTP coverage and end-user speeds is that consumers frequently choose not to take the higher speeds enabled by that FTTP. In Norway, for instance, just 8% of broadband consumers have chosen speeds of 100 Mbps or more, despite one of the highest FTTP coverages in Europe.[65]

Poor societal results from international FTTP investments

So the technical benefits from high FTTP coverage have been limited. So too have been the societal and economic benefits. Japan and Korea are often highlighted as international leaders in FTTP, and both countries were early and heavy investors in the technology. However, there has been far less attention to the benefits delivered, which have been disappointing.

From a financial perspective, NTT (the Japanese incumbent telco) has had very poor results from taking a blunt approach to nationwide FTTP deployment. NTT launched FTTP in 2001, and by FY2006 had already invested ¥1.9trn (£14bn).[66] The service did not break even until FY2012 and in FY2013 it made ¥59.8bn (£44m) profit.[67] This disappointing performance – with a payback period likely to be beyond two decades – is despite Japan's lower costs thanks to aerial deployment, and a higher proportion of MDUs than the UK (42% vs 14%).[68]

Nor have there been great benefits to Japanese citizens. Kenji Kushida (of Stanford University), wrote in *Communications and Strategies* that:

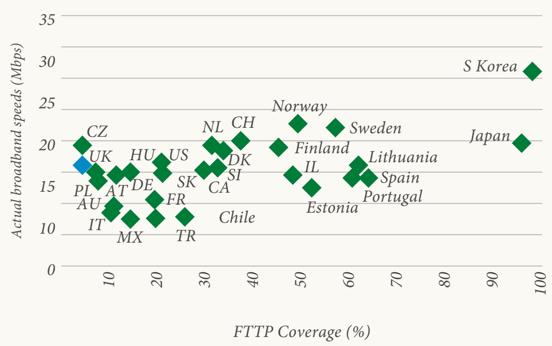
"Japan quickly discovered that taking advantage of the broadband environment to produce innovation, productivity growth, and economic dynamism, was far more difficult than facilitating its creation… Like Europe, Japan was not home to the ICT lead-user enterprises and industries that drove the ICT revolution, producing innovation and productivity gains."[69]

NTT has lamented that:

"Japan truly has one of the world's leading broadband environments. However, Japan lags behind other countries in the use of ICT in such areas as education, medicine and government services".[70]

The UN has noted that the UK leads in e-government, well ahead of Japan at #10.[71]

Figure 10: FTTP coverage and broadband speed[60]



[58] Gagnaveita Reykjavíkur, Fiber Optics & Green Energy–A Match for Reconstruction, 11 June 2009
[59] Various sources, Communications Chambers analysis. Note that figures are not available for Japan and Korea
[60] Coverage per Analysys Mason, as quoted in Ofcom, Making communications work for everyone–Initial conclusions from the Strategic Review of Digital Communications, 25 February 2016. Speeds per Akamai, State of the Internet, Q1 2016, 29 June 2016
[61] Note that Akamai's speeds are measured on a different technical basis than Ofcom's (higher) measures of UK line speed. Akamai measures the end-to-end speed available to a particular application. Ofcom measures the total capacity of the access link. We use the Akamai figures here since they are available on an international basis
[62] TalkTalk, Network Overview, May 2016
[63] Avery Pennarun , GFiber Wifi Data, February 2016
[64] Srikanth Sundaresan et al, Home Network or Access Link? Locating Last-mile Downstream Throughput Bottlenecks, 24 March 2016
[65] PTS, Telecommunication Markets in the Nordic and Baltic Countries 2015 [accessed 9 September 2016]
[66] Hiroya Izumi [Ministry of Internal Affairs and Communication, Japan], Japan's Broadband Development, 22 March 2007
[67] NTT, IR Presentation Appendices, July 2013. Latest available figures
[68] Official Statistics Japan, Dwellings by Type of Building (4 Groups), Construction Material (5 Groups), Stories of Building (9 Groups) and Year of Construction (14 Groups) – Japan (accessed 27 September 2016; Eurostat
[69] Kenji Kushida, "Public Private Interplay for Next Generation Access Networks: Lessons and Warnings from Japan's Broadband Success", Communications and Strategies, 2013.
[70] NTT, Annual Report 2010, 24 June 2010
[71] UN, UNPACS Data Centre (accessed 19 September 2016)

3. The case made for 'blunt' FTTP *continued*

Korea presents a similar story. The country's FTTP access network has not translated into tangible benefits. According to the OECD:

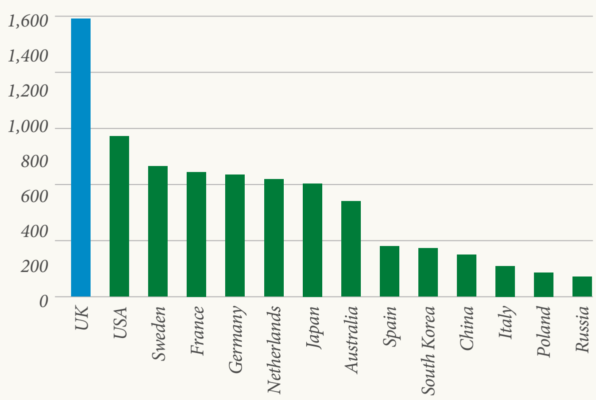
"While Korea… benefits from extensive broadband deployment, the share of firms with less than 50 workers that engaged in e-commerce in 2013 was only 15%, one of the lowest in the OECD. For large companies, the share is higher at 25% but still below the OECD average of 40% ... Similarly, the share of Korean small firms using cloud computing was the fourth lowest in the OECD in 2014".[72]

The OECD has also found that Korean consumers are significantly less sophisticated in their use of the internet than citizens of almost all other OECD countries.[74]

Japan and Korea are also well behind the UK (and many other countries) in use of e-commerce. Indeed, amongst the countries examined by Ofcom, the UK was a leader by some margin. (Figure 11)

Thus while these countries top the FTTP league table, the tangible socio-economic benefits for consumers and citizens are far from clear.

Figure 11: e-commerce per capita, 2014[73]



Conclusion

The arguments made for 'blunt' FTTP in the UK turn out not to be well founded. Neither traffic growth nor applications are likely to create requirements that can only be met by FTTP. While other countries have deployed more FTTP than the UK, in many cases they have faced materially lower costs (changing the cost-benefit analysis). Moreover, while in several countries governments have invested substantial public money, the resultant societal and economic gains have – to date – been disappointing.

While the costs and benefits of 'blunt' FTTP vary across countries, they also vary over time. Some argue that even if 'blunt' FTTP does not have unique value today, it will in future. We now turn to the dynamic environment around 'blunt' FTTP, considering how trade-offs will develop in the future.

[72] OECD, OECD Economic Surveys: Korea, May 2016
[73] Ofcom, International Communications Market Report 2015, 10 December 2015
[74] OECD, OECD Science, Technology and Industry Scoreboard 2015 – Korea Highlights, October 2015

4. A dynamic environment

The balance of the costs and benefits of FTTP vary not just across countries, but over time. A number of relevant factors are changing rapidly, and thus the case for 'blunt' FTTP can grow stronger or weaker. In this section we discuss four key factors, namely:

- The availability of alternate high bandwidth networks
- New broadband technologies
- Development of customer needs
- Focus of application development.

Alternate networks

As we have noted, the cost of FTTP cannot be justified purely on the basis of the applications it enables. Rather, it must be justified based on what it makes possible beyond those applications already possible on existing networks. This is the key reason why the case for FTTP is so much stronger in "not spots" where the existing network is poor.

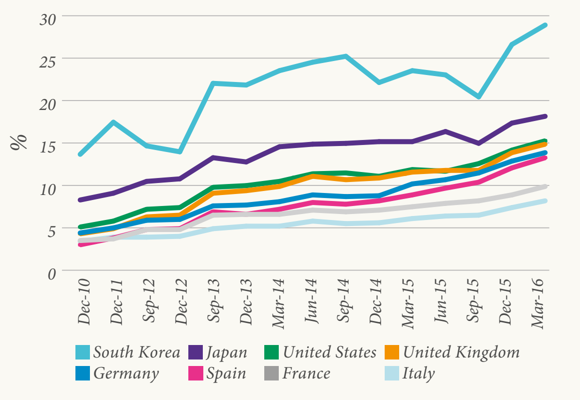
When the decision was made to deploy a number of FTTP networks globally, the alternative was far less capable. For instance when NTT's Japan chose to invest in FTTP and launched a 100 Mbps service in 2000, its strongest competition was 1.5 Mbps ADSL.[75] This difference had tangible impact on a household's experience of the internet and what applications were possible.

However, the more capable the existing network, the lesser the incremental benefit of FTTP. In 2016 in the UK, highly capable networks are already in place. As of March this year, superfast (30 Mbps or more) is available to over 90% of UK premises,[76] and the average speed of those on superfast connections as of June 2015 was already 63 Mbps[77] – enough for 22 simultaneous HD iPlayer streams.[78] Deployment of fibre-to-the-cabinet by BT (in part with £1.7bn government support[79] in uncommercial areas) and of DOCSIS 3.0 by Virgin Media has already substantially upgraded the UK's speeds. BT offers "up to 76 Mbps" speeds to much of its superfast footprint, and Virgin offers 200 Mbps to 45% of the country (with the coverage of its network expected to increase to 65%).[80]

As a result, UK achieved speeds have been growing substantially, doubling in three years. Further, the UK's relative performance has been strong (Figure 12). While the UK still lags Korea, the global leader, it has caught up to the US, is gaining on Japan, and is pulling away from France and Italy.

Of course, noting the wide availability of superfast speeds and improvements in average broadband speeds does not minimise the challenges faced by users needing superfast outside coverage areas. Targeted FTTP will (in some cases) be the right solution for such users. However, our focus is on the merits of 'blunt' FTTP.

Figure 12: Actual Broadband Speed (per Akamai)[81]



[75] Masaru Fujino [Counselor for Communications Policy, Embassy of Japan], National Broadband Policies: 1999-2009, Japan, October 2009
[76] House of Commons Library, Superfast Broadband Coverage in the UK, 18 August 2016
[77] Ofcom, Connected Nations 2015, 1 December 2015
[78] HD iPlayer has a requirement of 2.8 Mbps. BBC, What internet speed do I need for playing programmes on Connected TVs? (accessed 19 May 2016)
[79] House of Commons Library, Superfast Broadband Coverage in the UK, 18 August 2016
[80] Ofcom, Connected Nations 2015, 1 December 2015
[81] Akamai, State of the Internet reports (various dates)

4. A dynamic environment *continued*

The coverage of 'blunt' FTTP will, by definition, heavily overlap with the superfast coverage of BT and Virgin. The economics of network deployment mean it is the more dense areas that were attractive for cable TV deployment that will also be (relatively) more attractive for FTTP deployment.

Thus given that the UK already has two superfast networks, the logic for overbuilding these entirely with FTTP is far weaker than would be the case if such networks were absent. (As was the case in Japan, for example.)

New technologies

Moreover, it is not just the existing networks which matter, but also those we know are coming. If network upgrades are pending that will greatly improve speeds and quality (at lower cost and in a shorter time than FTTP), then this is the baseline against which any *incremental* customer benefits of FTTP must be measured.

Again, when historic investments in FTTP were made the situation was very different from that facing the UK today. When Orange in France first started deploying FTTH in 2006, it did so in the belief that copper technologies had a maximum speed of 50 Mbps.[82] As we will see, a copper/fiber hybrid approach is now expected to deliver gigabit speeds.

In 2011 Australian Communications Minister Stephen Conroy advocated his government's preference for FTTP on the basis that speeds of 60-80 Mbps were simply impossible over that country's copper.[83] Today Australia's national broadband network is already delivering 100 Mbps over copper, with significant increases expected.[84]

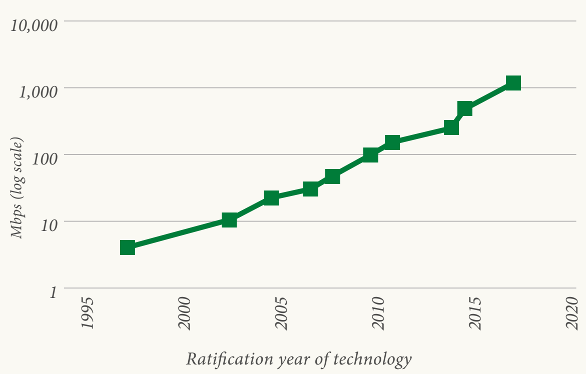
In the UK, there are several planned or potential upgrades which could bring faster speeds, at lower cost and with much quicker deployment times than 'blunt' FTTP.

G.fast

The first is G.fast. This is the next generation of technology (after ADSL and VDSL) for carrying data over copper pairs from a fibre enabled cabinet. Copper broadband data rates have seen sustained and substantial improvement (Figure 13). This is in part because they depend on the processing power of the relevant electronics, and thus they have benefited from Moore's Law (and will continue to do so).

Depending on circumstances, G.fast is capable of up to 1 Gbps and beyond.[86] Moreover, there is the potential to dynamically allocate this bandwidth between upstream and downstream, enabling users to receive near-gigabit upload speeds if (for example) they are backing up a hard drive to the cloud.[87]

Figure 13: Copper (xDSL) data rates[85]



BT has trials under way, and plans to launch services within a year. By 2020 it has committed to pass 10m homes with G.fast.[88] Initial speeds are likely to be up to 300 Mbps, rising to 500 Mbps. While BT is a leader in G.fast, it is far from alone. Other operators trialling the technology include Eircom, Telecom Italia, Telekom Austria, TeliaSonera (the incumbent in Sweden and Finland) and Swisscom.[89]

Swisscom was a pioneer in FTTP, and has 30% coverage. However, its experience with G.fast and other copper technologies led their Head of IT and Networks to say at an investor day earlier this year:

"Don't start [FTTP] if you haven't done it yet. Put all your efforts on to FTTS [Fibre To The Street] or FTTD [Fibre To The Distribution point]"[90]

Beyond G.fast, an even more powerful technology – XG-FAST – is being developed. Lab tests last year showed this could deliver 5.6 Gbps (up plus down) over 35m of copper, and 1.8 Gbps over 100m.[91] While use of XG-FAST would likely require fibre to be pushed closer to the premise, it would obviate the need for the final tap into each premise. This tap is a significant part of the cost of FTTP, and it also causes disruption to roads, pavements and so on.

DOCSIS 3.1

Nor is it only BT's network which can be substantially upgraded at relatively low cost. Virgin's cable network also will benefit from new technologies. DOCSIS 3.1 is the new standard for cable broadband, and is already seeing commercial launches. Widespread deployment is expected in 2017.

DOCSIS 3.1 is already being used to offer consumers 1 Gbps downstream services.[92] Symmetric 1 Gbps services are imminent, with Vodafone in Spain expecting to launch such an offer in 2017, for example.[93] Even higher speeds are on their way – 10 Gbps symmetric speeds have already been demonstrated in the lab.[94]

Virgin has not announced launch dates for DOCSIS 3.1, but its parent Liberty Global has said it expects deployments in its portfolio companies to begin this year.[95]

DOCSIS 3.1 is a strikingly cheap upgrade. Liberty expects it to cost $22 (£17) per home.[96] This compares to hundreds of pounds for an FTTP deployment, even in relatively densely populated areas.

Wireless technologies

Both G.fast and DOCSIS make use of existing fixed networks. But there is a growing belief that new wireless networks may also be able to provide high quality broadband.

> "Don't start [FTTP] if you haven't done it yet. Put all your efforts on to FTTS [Fibre To The Street] or FTTD [Fibre To The Distribution point]"
>
> Heinz Herren, Head of IT and Networks, Swisscom

[82] Orange, Lessons learned from our FTTH pilot in France, 16 December 2006
[83] Sen. Stephen Conroy, Speech to the National Press Club, 13 December 2011
[84] NBN, What Fibre To The Node technology will deliver for Australia, 21 September 2015
[85] Bell Labs Alcatel-Lucent, The Future of Copper, May 2014
[86] Analysys Mason, Gigabit access will influence G.fast technology choices for operators, May 2016
[87] The Register, Sckipio touts fibre-like symmetrical G.fast kit, 12 October 2016
[88] BT, Q1 2016/17 results–investor meeting slide pack, 10 August 2016
[89] NBN, Assessing the NBN rollout & the opportunity the NBN presents the telecom industry, 31 October 2014
[90] Heinz Herren, Head of IT and Networks, Swisscom. Quoted in Redburn, Copper into Gold–the Sequel, 5 February 2016
[91] BT, The future of G.fast – an ultrafast update, December 2015
[92] Comcast, Comcast to Deliver Gig Internet Over Existing Network Infrastructure, Chicago Area Trial Begins Today, 17 August 2016
[93] Advanced Television, Spain: Vodafone to launch symmetric 1 Gbps, 6 September 2016
[94] CableLabs, Full Duplex DOCSIS 3.1 Technology: Raising the Ante with Symmetric Gigabit Service, February 2016; Nokia, Nokia Bell Labs achieves world's first 10 Gbps symmetrical data speeds over traditional cable access networks, May 2016
[95] Liberty Global, Q2 2015 Investor Call, 5 August 2015
[96] Fierce Telecom, Liberty Global will trial DOCSIS 3.1 in early 2016, 11 August 2015

4. A dynamic environment *continued*

Facebook recently announced "Terragraph", a technology using 60 GHz spectrum to deliver gigabit speeds in urban areas. Facebook explicitly positioned Terragraph as an alternative to FTTP, since:

"the high costs associated with laying the fiber makes the goal of ubiquitous gigabit citywide coverage unachievable and unaffordable for almost all countries."[97]

Google too is looking at wireless. Google Fiber has long been cited as a leading example of FTTP deployment, but according to the Wall Street Journal:

"Google ... is rethinking its high-speed internet business after initial rollouts proved more expensive and time consuming than anticipated, a stark contrast to the fanfare that greeted its launch six years ago.

Now the company is hoping to use wireless technology to connect homes, rather than cables, in about a dozen new metro areas, including Los Angeles, Chicago and Dallas, according to people familiar with the company's plans. As a result [Google] has suspended projects in San Jose, Calif., and Portland, Ore."[98]

Verizon, one of the pioneers of FTTP in the US, is trialling fixed wireless using 5G as a substitute, which it expects to be significantly cheaper.

These various wireless technologies are at an earlier stage than DOCSIS 3.1 and G.fast, and at this time there is limited data on the real-world speeds they will deliver. However, they are attracting substantial interest from major companies.

Ronan Dunne, outgoing CEO of O2, has pointed to the importance of 5G wireless for the UK, and commented:

"In the longer-term, we will forget this stupid debate about rolling out fibre cables".[99]

Implications for the FTTP investment decision

These various technologies, which can deliver many if not all of the benefits of FTTP have serious implications for the 'blunt' FTTP investment decision.

Firstly, they reduce the market share won by an FTTP-deploying company. Other companies using these alternate technologies will be able to attract away a substantial number of customers (particularly since those technologies are far quicker to deploy than FTTP).

Secondly, if these other companies can deliver a very similar product at far lower cost, this will feed through to consumer prices – the ability to charge a meaningful premium for FTTP will be much reduced.

Given that FTTP involves substantial up-front and fixed costs, even moderate changes to pricing or number of customers can have a drastic effect on return on investment.

> It is critical to recognise that maximising investment (in FTTP or anything else) is not an objective in its own right. On the contrary, delivering a desired outcome with the most efficient possible investment is fundamental to the productivity of an economy.

It is for this reason that 'blunt' FTTP is a high risk investment. Quite reasonably, those deploying FTTP have therefore frequently chosen to be highly targeted (that is, to invest in areas with more certain demand), or have sought financial support from government. As we saw in the discussion of international deployments, there has been relatively little 'blunt' FTTP globally without government subsidy and/or relief from obligations to wholesale the network. Moreover, where 'blunt' FTTP has been deployed, (for example, Japan) the economics have been disappointing, even before the availability of strong competing technologies such as G.fast and DOCSIS 3.1.

The increasing risk inherent in 'blunt' FTTP is one of the reasons that BT's investors are not keen on it (as presumably they would be if it offered a good return). As Stephen Howard of HSBC puts it:

"FTTN/VDSL is a highly cost effective upgrade, whereas FTTP is expensive. Not only does this mean greater economic efficiency, but it also implies that BT is likely to be able to drive more satisfactory returns from the investment programme".[100]

A related point is that an investment in 'blunt' FTTP is not "future proof", if by that we mean an investment we are unlikely to regret in future. If, as seems likely, several other technologies can deliver equivalent benefits at much lower cost, then to invest in 'blunt' FTTP now would be to lumber the UK with substantial excess costs that would either need to be written off by investors or picked up by consumers.

It is critical to recognise that maximising investment (in FTTP or anything else) is not an objective in its own right. On the contrary, delivering a desired outcome with the most efficient possible investment is fundamental to the productivity of an economy.

BT has been criticised by some for sweating its copper assets,[101] but in general this is seen as a virtue. According to the 2020 Productivity and Efficiency Commission:

"As high increases in GDP become more elusive for developed countries, British businesses will need to increase margins, 'sweat' their assets and drive up profits."[102]

Moreover, the existence of other technologies to deliver ultrafast means that a 'blunt' FTTP policy can have a considerable opportunity cost, since it can have a chilling effect on the deployment of those technologies.

For example, imagine a company considering using wireless technologies to provide better broadband in suburban or rural areas. Such services might be relatively quick to deploy, improving performance for end users within a matter of months.

"As high increases in GDP become more elusive for developed countries, British businesses will need to increase margins, 'sweat' their assets and drive up profits."

2020 Productivity and Efficiency Commission – UK

[97] Facebook, Introducing Facebook's new terrestrial connectivity systems — Terragraph and Project ARIES, April 2016

[98] Jack Nicas, "Google's High-Speed Web Plans Hit Snags", Wall Street Journal, 15 August 2016

[99] FT, UK must switch off "analogue" thinking or lose 5G race, says outgoing O2 chief, 18 September 2016

[100] Stephen Howard (HSBC), Reviewing the Review, 24 September 2015

[101] See for instance: Sky, The simple quick fix that can take Britain out of broadband's slow lane, 22 February 2016

[102] 2020 Productivity and Efficiency Commission, "Sweating our Assets": Productivity and Efficiency Across the UK Economy, 2014

4. A dynamic environment *continued*

However, if a policy decision meant that this deployment would be overbuilt with FTTP in (say) five years, then this would be immensely damaging to the company's business case. Telecoms investments often pay back over a decade or longer. An additional, high quality competitor in five years' time can thus greatly reduce rates of return. As a result, the company might well decide not to invest in the first place. In this case, whatever the benefits of FTTP five years out, there would be certain and immediate damage to consumers in the interim.

Customer needs

Technological progress is greatly increasing the supply of bandwidth (in most locations). We now turn to the question of future demand for bandwidth (starting first with consumers and then turning to businesses), and then consider other key technical parameters – latency, packet loss and reliability.

Demand can be considered from two perspectives:

- The technical demand, that is what consumers actually require to enable the applications they desire
- The market demand, that is what consumers might be willing to pay for (which could be more or less than their technical demand).

These two measures of demand are very different. Consumers (understandably) have little understanding of the technical requirements of their applications, nor is it easy to determine whether performance problems they experience are caused by their bandwidth or one of the many other constraints in the network.

BEREC has noted:

"The actual need for high speed broadband may often be overestimated by a low capacity user who might be influenced by internet service providers' commercials and society at large to believe that they require higher speeds than they actually do (at present), thereby creating demand".[103]

The distinction between market and technical demand is important for policy makers, because government has, generally, been focused on the latter. To take a parallel, the technical requirement for liquids is to have access to safe drinking water, though there is substantial market demand for mineral water. The government has focused on ensuring provision of tap water, but has left mineral water production to the market (and certainly does not worry that it is not universally available).

Current versus previously expected technical requirements for bandwidth

As the years pass, we have ever better evidence regarding consumers' requirements. Early FTTP networks were built in anticipation of a requirement of symmetric traffic (that is as much traffic from the consumer as to the consumer), which FTTP was well suited to serve.[104] There was also an expectation that once FTTP was available, applications would be created to take advantage of its unique capabilities – the "killer apps" which would persuade users to switch.

Today there are almost 200m FTTP connections worldwide,[105] but there is no evidence that traffic is growing more symmetric, nor that killer apps have been enabled.

As we have seen, Japan was one of the earliest countries to have FTTP, but it has not seen symmetric traffic. On the contrary, its ratio of downstream to upstream traffic has been going *up*, not down. In 2005 it was 1.4:1. Today it is 5.2:1.[106] FTTP's upstream capabilities are not being widely used. Ofcom has found similar results in the UK. In 2014 (the latest available figures) it reported a 4.7:1 ratio for FTTP lines, lower than the UK average of 7.3, but still *far* from symmetric.[107] Moreover, as we have seen, other technologies such as G.fast and DOCSIS 3.1 are now able to offer the very high upload speeds which were once the preserve of FTTP.

Killer apps have been conspicuous by their absence. Annual surveys for the FTTH Council used to note each year:

"No really compelling application that requires a fiber connection"[108]

By last year those working with the FTTH Council were suggesting:

"Forget about the killer app"[109]

More generally regarding the potential for bandwidth supply to create its own demand, Scott Marcus and Dieter Elixmann of WIK have noted:

"Whatever 'build it and they will come' effect might exist cannot be very strong. This in turn poses troubling policy questions as regards public policy to promote the deployment of ultrafast broadband."[110]

Future technical requirements for bandwidth

Even if there is no single killer app, it is possible that "application stacks" – that is, simultaneous use of multiple applications in a household – might drive needs for very high speeds. This was one of the key issues rigorously examined in BSG's forecast of domestic bandwidth demands (by the current author).[111] This forecast found that the median household will require bandwidth of 19 Mbps by 2023, whilst the top 1% of high usage households will have demand of 35-39 Mbps. These speeds are within the capabilities of (most) current UK superfast, and well within DOCSIS 3.1 and G.fast. Even a more aggressive forecast scenario found median and peak demand of only 38 and 71 Mbps, again well within DOCSIS 3.1 and G.fast.

"Whatever 'build it and they will come' effect might exist cannot be very strong. This in turn poses troubling policy questions as regards public policy to promote the deployment of ultrafast broadband."

Scott Marcus and Dieter Elixmann (WIK)

[103] BEREC, Challenges and drivers of NGA rollout and infrastructure competition (Draft), 2 June 2016. BEREC also note the impact of improving mobile broadband, which acts as an anchor product upon superfast broadband

[104] See for instance IDATE, FTTH: The European update, 24 September 2006

[105] FTTH Council Europe, FTTH coverage in Europe: future threats & possibilities, 27 April 2016

[106] Ministry of Internal Affairs and Communication (Japan), 我が国のインターネットにおけるトラヒックの集計結果 (2016年5月分), 22 July 2016

[107] Ofcom, Infrastructure Report 2014, 8 December 2014

[108] Heavy Reading, European FTTH Forecast, 2010-2015, 10 February 2011; Heavy Reading, European FTTH Forecast, 2011-2016, 16 February 2012; FTTH Council, Press Conference @FTTH Conference, London, 20 February 2013

[109] iMinds, FTTH Council Europe '15: Forget About the Killer-App, 12 February 2015

[110] Scott Marcus, Dieter Elixmann (WIK), Build it! ... but what if they don't come?, 13 March 2013

[111] Robert Kenny & Tom Broughton (Communications Chambers for the BSG), Domestic demand for bandwidth, 5 November 2013

4. A dynamic environment *continued*

While perhaps counterintuitively low, these numbers are a result of several factors:

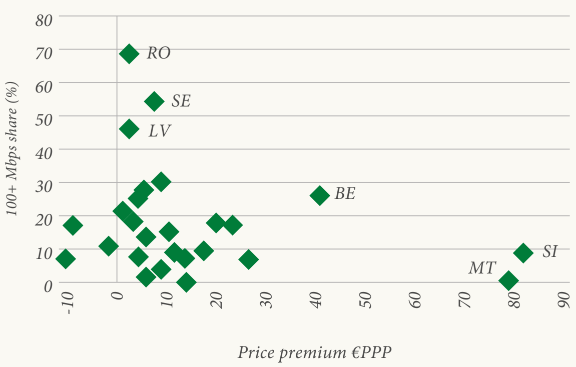
- Almost two-thirds of UK households contain just one or two people, inherently limiting the amount of simultaneous activity
- The probability that all the residents of a home are all multitasking online at the same time is low, reducing the "height" of app stacks
- Compression technology will continue to reduce bandwidth requirements for individual applications, notably video (discussed in more detail below).

While there have been a small number of challenges to individual assumptions in the model, none have material impact. (The version of the model prepared for the Australian government a year later gave broadly similar results.)

Of course, the forecast may yet prove inaccurate, but it has been widely cited in the current debate. Moreover, even if the model were out by an enormous factor – say 10x – this would still not create a (technical) justification for FTTP alongside G.fast and DOCSIS 3.1, since even speeds of 190 and 390 Mbps could be handled by these latter technologies.

That said, even if there is not technical demand for FTTP speeds, there may be market demand, which we now turn to.

Figure 14: 100+ Mbps share of BB in covered areas & price premium over 30-100 Mbps, 2015[113]



Consumer willingness to pay for higher speeds

There is now appreciable data on consumers' willingness to pay for higher speeds. In general, it turns out that only a small minority are prepared to pay a material premium for faster broadband. According to BEREC:

"a relatively low willingness to pay for higher bandwidths make in particular FTTP investments by the incumbent and alternative operators more difficult".[112]

Figure 14 shows the proportion of broadband households in EU countries buying speeds of 100 Mbps or more (where available) versus the price premium of such lines over 30-100 Mbps lines.

Belgium aside, no country has achieved more than a 20% share if their price premium was greater than €10 per month. This suggests that the pool of customers who place a material value on the incremental benefits of 100 Mbps broadband is low.

Belgium's outlier status is likely due to a free upgrade to 100 Mbps (or more) which Telnet, a leading provider, gave to all its customers in March 2015. Indeed, free upgrades are a common feature of superfast broadband strategy,[114] underlining the challenges of securing revenue commensurate with the investment cost.

Australian evidence points in the same direction. Within the FTTP footprint of the country's national broadband network, the portion of customers taking higher (greater than 100 Mbps) speeds is actually *falling* over time. Almost 80% are taking 25 Mbps or less. (The price premium for 100/40 Mbps offer over a 25/5 Mbps offer is approximately £11.)[116]

Investment implications

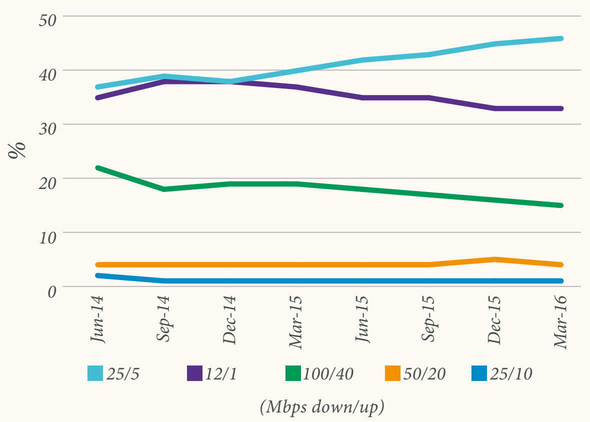
In its initial conclusions from the DCR, Ofcom claimed:

"[Services based competition] provides limited incentives for Openreach to upgrade the underlying fixed network"[117]

But this is misguided. If the incremental willingness-to-pay for the extra benefits of 'blunt' FTTP were greater than the incremental cost to provide it, Openreach would have every incentive to make the necessary investment, since that investment would be NPV positive. However, the fundamental problem is that the incremental WTP for FTTP is generally relatively low, and thus (in the UK at this time) does not outweigh the cost to provide it in most places.

This is not a market failure (or even an unwanted outcome) – on the contrary, it is the market operating efficiently, with price signals ensuring that value-destructive investments are not made.[118]

Figure 15: NBN Fixed Line Speed Tier Mix [115]



Business demand for bandwidth

Above we have focused on consumer demand, but we now turn briefly to business demand. It is sometimes assumed that business demand will be higher than consumer demand, but this is very often not the case, for several reasons, including:

- Many businesses have very few staff. Of small and medium enterprises (those with up to 49 employees) over 90% have four or fewer employees. Business premises with more than 50 employees are just 3% of the total, and anyway are less likely to make use of "mass market" broadband[119], instead making use of commercial fibre Ethernet services specifically designed for the connectivity needs of business
- Employees generally have lower "per person" bandwidth requirements than consumers at home. For instance, they are less likely to be downloading large game files or streaming 4K TV
- Many business types – such as plumbers, hairdressers and restaurants – inherently have relatively little requirement for fixed broadband.[120]

Forecasts for the BSG (by the current author) found that in 2025 the median small business would have a requirement of 8 Mbps in 2025, though a minority would need much more – by that date the top 5% would require 41 Mbps or higher.[121]

[112] BEREC, Challenges and drivers of NGA rollout and infrastructure competition (Draft), 2 June 2016. BEREC also note the impact of improving mobile broadband, which acts as an anchor product upon superfast broadband
[113] EC, Digital Agenda Key Indicators [accessed 22 March 2016]; Communications Chambers analysis
[114] For a more detailed discussion, see: BSG, Demand for Superfast Broadband, November 2012
[115] nbn co, Half Year Results 2016 Presentation, 5 February 2016 (and earlier equivalents)
[116] See for instance Optus, NBN speed packs [accessed 24 March 2016]
[117] Ofcom, Making communications work for everyone–Initial conclusions from the Strategic Review of Digital Communications, 25 February 2016
[118] This could in fact be a market failure if in some way FTTP brought significant externalities – value for society beyond that to consumers. However, as we discuss in the next section, this is not the case
[119] ONS, Enterprise and local units in the United Kingdom by specified employment size bands and UK SIC2007 section, November 2015
[120] For a much more detailed discussion, see Communications Chambers (for BSG), The broadband requirements of small businesses in the UK, August 2015
[121] Ibid

4. A dynamic environment *continued*

The idea that business bandwidth requirements are moderate, is consistent with the available data on their current choices of speed. For instance, in Hong Kong very high speed broadband has been widely available for many years, and yet 35% of business broadband lines have speeds of 10 Mbps.[122] In Norway the figure is 36% (and almost 80% take less than 30 Mbps),[123] though superfast is available to over 80% of the country.[124]

Latency and packet loss

While bandwidth measures a flow rate of data, latency measures the time it takes for data to travel between two points. Measurements by French and Portuguese regulators found that in their respective markets, FTTP had roughly 10-15ms lower latency than cable and DSL.[125]

This doesn't necessarily prove that FTTP has a fundamental advantage at this level. It may be that lower latency for FTTH is because it is primarily deployed in cities, and thus customers are closer to test servers. Conversely, rural users may be more likely to be on ADSL with more "hops" from the servers. Looking ahead, G.fast is intended to have a latency (for the access element of the network) of less than 1ms, meaning that any advantage of FTTH over G.fast will be trivial.[126]

However, even if we take FTTH's current reported advantage of 15ms or less at face value, this needs to be seen in context. To take three examples:

- Trials of remote surgery found there was no impact on performance once latency was below 300ms[127]
- Cisco's professional telepresence systems have a target latency of 150ms, but will work at much higher levels[128]
- For online gaming, "delays under 50 milliseconds do not impact player performance. Delays over 50 milliseconds but under 100 milliseconds begin to have a slight impact… but are rarely noticed"[129]

Given this, even if FTTH's 10-15ms advantage is inherent (rather than driven by where it is deployed), it is in almost all cases likely to have no practical impact. Other sources of delay in the wider network are likely to be much more significant. According to the US regulator the FCC:

"The differences in average latencies among terrestrial-based broadband services are small, and are unlikely to affect the perceived quality [even of] highly interactive applications."[130]

Packet loss is a measure of the reliability of a network in delivering packets of data. Here too FTTP has no particular advantage. FCC figures found that US fibre networks (Verizon and Frontier) actually had *higher* packet loss than cable networks, and similar rates to a number of DSL providers.[131] This suggests that backbone network configuration is more important for packet loss, and the access network is not acting as a meaningful constraint.

"The differences in average latencies among terrestrial-based broadband services are small, and are unlikely to affect the perceived quality [even of] highly interactive applications."

FCC 2015 Measuring Broadband America Fixed Broadband Report

Reliability

Some argue for FTTP on the basis of reliability. Certainly as we become more dependent on broadband, its reliability is increasingly important, and there are some aspects of FTTP that are helpful. For example, fibre is less vulnerable when water gets into ducts, and the absence of street cabinets in FTTP networks removes one component in the access network that can go wrong.

However, FTTP networks have an extra component in the home which can cause faults – the ONT[132] which converts optical signals to electrical and breaks out voice, broadband and (if present) TV. This must be locally powered, and is mandated to have battery back-up. Unlike the cabinets in an FTTC network, ONTs are not centrally monitored by the broadband providers.

Fibre and copper are both vulnerable to line breaks (caused by traffic or digging). Indeed fibre may be more so, in that copper is stronger and in some instances fibre may be buried at a shallower depth. One 3.5km section of microduct fibre deployed for Cardiff University suffered 10 cuts in two and a half years.[133] Further, copper can be quicker to repair. Faults on fibre can be harder to locate, and repairs require more specialist skills.[134]

Thus the picture of reliability, FTTP versus other technologies, is a complex one and far from cut and dried. Moreover, the access network is just one component of the end-to-end network used by customers. Problems can also occur in the customer's in-home network, the ISP's core network or the wider network. Ofcom's research has found that approximately two-thirds of performance problems occur in these areas, not the access network (though end users may perceive these to be issues with their broadband).[135]

Focus of application development

Application developers' focus on minimising their requirements

One reason that technical bandwidth requirements will see only moderate growth is because application providers have powerful incentives to each minimise the requirements of their services. If a service uses less bandwidth (and traffic), then:

- It can address more users (for example, those in global markets with poor broadband connections)
- It is functional for a given user in more circumstances (for example, when using a mobile network rather than a fixed network)
- It costs less for the end user (in mobile traffic charges, for example)
- It costs less for the provider to deliver the relevant traffic (in CDN[136] charges, for example).

> Ofcom's research has found that approximately two-thirds of performance problems occur in these areas, not the access network (though end users may perceive these to be issues with their broadband).

122 OFCA, Statistics on Customers of Internet Service Providers ("ISPs") in Hong Kong (accessed 27 September 2016)
123 Norwegian Communications Authority, The Norwegian Electronic Communications Service Market 2015, 19 May 2016
124 Norwegian Communications Authority, Broadband in Norway 2015, 4 January 2016
125 ARCEP, Qualité du service fixe d'accès à internet–Mesures de la qualité du service effectuées au 1 er semestre 2015, November 2015; Anacom, Evolução dos acessos à Internet em Portugal, November 2015
126 dtran, Accelerating Gigabit Broadband, January 2014
127 Manuela Perez et al, "Impact of delay on telesurgical performance: study on the robotic simulator dV-Trainer", International Journal of Computer Assisted Radiology and Surgery, 8 October 2015
128 Cisco, Extended Reach: Implementing TelePresence over Cisco Virtual Office, 2010
129 Christopher Canfield, Latency & State Consistency in Networked Real-Time Games, 2013
130 FCC, 2015 Measuring Broadband America Fixed Broadband Report, 30 December 2015
131 FCC, 2015 Measuring Broadband America Fixed Broadband Report, 30 December 2015
132 "Optical network terminal"
133 E Wincott, A Morgan and T Franklin, Cardiff University – Microduct Dark Fibre to Link Cathys Park (main campus) to Heath Hospital Solution, 2005
134 Global Telecoms Business, FTTdp with G.fast can address operators' FTTH challenges, 19 February 2016
135 Actual Experience (for Ofcom), Measurement of Internet Quality of Service, 30 November 2015
136 Content Distribution Network. A service used by many content companies to host content and deliver traffic

4. A dynamic environment *continued*

These factors are relevant for all application providers, but particularly so for those serving global markets. Companies such as Google and Facebook are seeing countries such as India as key growth opportunities, but there consumers operate predominantly on mobile, and often with very limited data allowances. Thus these companies are seeking to pare down the technical requirements of their services as much as possible. Techniques developed are then deployed globally.

Mobile network as binding constraint

Application providers focused only on the UK operate under looser fixed network constraints. However, for these companies the relevant constraint is increasingly the mobile network, not the fixed.

Use of the internet is increasingly via mobile devices. According to an Ofcom survey, in 2016 almost as much time was spent on mobile devices as on computers (19% vs 22% of total media and comms time respectively).[137] Comscore's technical tracking in the US shows that 65% of digital time there is on mobile devices, and computer time (at 35% of total) is falling rapidly, down over 9% year-on-year.[138]

Obviously much of this usage is via wifi, but application providers do not wish their application to fail as the user steps out the front door. Thus applications are developed with the limits of mobile networks in mind. Mobile devices also impose their own limits – of processing power, battery life and so on.

Disincentives for gigabit apps

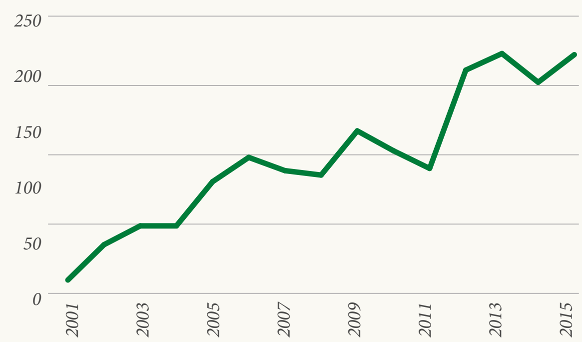
All this means that there is greatly reduced incentive to develop killer apps for FTTP. Any such app would, from the perspective of the developer, be inherently limited. It would not work out of home, and indeed would not be relevant for much of the time in-home, since the small screens, limited processing power and limited storage of a mobile device would generally have little use for a Gigabit stream of data.

Nor would it be relevant even for most PCs in the home. Even in markets with wide availability of FTTP, only a fraction of consumers have taken Gigabit services. Thus to design a service that requires them is to drastically collapse down your addressable market.

Light requirements of popular applications

Conversely, the applications that have widespread use have relatively light requirements. The augmented reality game Pokémon Go reached 45m daily users at its peak,[139] but used little bandwidth. One European mobile network found that in a three-hour period where 7% of their users were playing Pokémon Go, they represented just 0.1% of traffic.[140]

Figure 16: US video compression patents[142]



Video streaming applications such as Netflix use greater bandwidth than augmented reality, but their requirements are still moderate. In the UK, Netflix's streams typically run at 3-4 Mbps.[141] (Speeds in FTTP-rich Japan are identical, and they're actually lower in Korea.)

Requirements are kept low by ever-improving video compression. Indeed, as video has come to dominate internet traffic, there has been enormous investment in improving compression. Figure 16 shows the rapid growth in patent filings in this area.

Historically the bandwidth needed for a given video quality halved every seven years,[143] but this rate may be accelerating. For example, as of 2013 4K TV (higher resolution than HD) was typically stated to require 20 Mbps.[144] Developers are now demonstrating systems needing just 7-8 Mbps for 4K,[145] or even as low as 2 Mbps[146] (though it will take time for systems to be widely deployed in the field).

The impact of video compression is fundamental to future bandwidth requirements, since it is such a large portion of total traffic. However, it is frequently ignored. For instance, in making the case for fibre deployment in 2007, Ericsson claimed that HDTV required 20 Mbps.[147] Today, that same HD stream might require 3 Mbps – and is readily carried even on an average ADSL connection.

More recently, in 2012 McKinsey claimed that by 2015 average home requirements would be over 100 Mbps, driven by multiple streaming and 3D TV.[148] Average speeds are well below this, but do not seem to have been a meaningful constraint on streaming (and mass market 3D TV has not materialised).

Requirements of future applications

Requirements of future applications are inevitably more speculative, but we here consider two examples often cited as bandwidth drivers – telepresence and virtual reality (VR)/360° video.[149]

Telepresence is more mature, and already has moderate requirements. For example, the Cisco IX5000 is a high-end professional telepresence system for six people with three 4K video screens, yet requires just 11 Mbps (using H.265 compression)[150] – within the capacity of a typical ADSL line.

Regarding VR, we first note that there are some key constraints on widespread VR quite aside from bandwidth. For example, VR requires powerful processors, and IDC estimate only 15m PCs *globally* have the necessary capabilities. A substantial upgrade of home computers is required to enable widespread VR.[151]

Figure 17: Cisco IX5000 Telepresence

[137] Ofcom, Digital Day 2016: Overview of findings, 5 August 2016
[138] Comscore, 2016 U.S. Cross-Platform Future in Focus, 30 March 2016
[139] Ars Technica, How long can we expect the Pokémon Go craze to last?, 25 August 2016
[140] Procera, Pokemon Go: The latest Internet craze – How is it impacting your network?, 14 July 2016
[141] Netflix, ISP Speed Index [accessed 13 September 2016]
[142] US Patent & Trademark Office, Patent Application Full Text and Image Database [accessed 19 March 2015]. Search for abstracts containing "Video coding" or "Video compression"
[143] ZetaCast, Technical Evolution of the DTT Platform, 2012
[144] See for example "HEVC goes beyond HD", TVBEurope, 4 June 2013. A wider range of sources are available in Communications Chambers, Domestic demand for bandwidth – An approach to forecasting requirements for the period 2013-2023, 5 November 2013
[145] BBC, V-Nova streaming tech produces 4K compression "worth watching", 1 April 2015
[146] The Online Reporter, Tveon Claims 4K Streams at under 2 Mbps, 19 October 2015
[147] Ericsson, FTTH: B-PON, GPON, EPON, 9 May 2007
[148] McKinsey, Choosing the right network technologies access mix, 23 May 2012
[149] Strictly, 360° video and VR are distinct, but we bracket them here for discussion purposes
[150] Cisco, Cisco TelePresence IX5000 Series Data Sheet, 20 October 2015
[151] Bloomberg, A reality check on virtual, augmented worlds, 10 March 2016

4. A dynamic environment *continued*

The bandwidth requirements are relatively uncertain, since VR over the internet is still in its very early days. YouTube report that 360° video requires 4-5x the bandwidth of traditional video, implying approximately 15 Mbps for 360° HD, for instance.[152] For VR, CableLabs estimate 30-40 Mbps.[153] Josh Courtney, CEO of production company SkyVR, suggests 20-56 Mbps with 4K resolution.[154]

Substantial investment is going into compression techniques for VR.[155] Unsurprisingly, these are at a far earlier stage than those for traditional video, but Facebook (for example) has used a technique called "pyramid geometry" to reduce file sizes by 80%.

Thus virtual reality is unlikely to be dependent on FTTP. While it may challenge ADSL lines, it is likely within the capabilities of today's superfast networks in the UK (with over 90% coverage), and well within DOCSIS 3.1 and G.fast.

Conclusion

The 'blunt' FTTP investment decision sits in a highly dynamic environment. As we have seen, key changes are:

- The high quality alternative networks that are already available in likely 'blunt' FTTP coverage areas
- The rapid technology progression that will enable even more capable networks to be deployed, at lower cost and more quickly than FTTP
- Increasing evidence that customers have limited willingness to pay for higher speeds
- Technical consumer requirements that are likely to be well within the capabilities of existing and planned networks
- The increasing focus of application developers on making their services work on networks with far lesser capabilities than FTTP.

All these factors suggest that the case for 'blunt' FTTP is *weakening* over time, not strengthening. Certainly the Australian government has moved away from FTTP. Previously it intended to extend FTTP to 93% of Australian households. However, after a rigorous cost-benefit analysis in 2014,[156] it concluded that the A$20-30bn (£12-18bn) additional expense of FTTP and the extra 6 to 8 years for full rollout could not be justified by the incremental benefits it offered.[157] FTTP will now be used for just 20% of premises (many of which were already committed prior to the cost-benefit analysis).

[152] Gizmodo,YouTube's Ready To Blow Your Mind With 360-Degree Videos, 13 March 2015
[153] Techpinions, Virtual Reality's $182 Billion Future, 18 January 2016
[154] Charlie Kraus (Limelight Networks), Distributing Live VR Video Content–The Reality behind the Experience, 6 June 2016
[155] See, for example, Facebook, Next-generation video encoding techniques for 360° video and VR, 21 January 2016
[156] Vertigan Panel, Independent cost-benefit analysis of broadband and review of regulation, August 2014
[157] NBN, NBN Corporate plan 2016, http://www.nbnco.com.au/content/dam/nbnco2/documents/nbn-corporate-plan-2016.pdf

5. A societal case for 'blunt' FTTP?

As we have noted, there are clear cases for using "targeted FTTP", particularly if it is the most effective way to get customers from poor onto good broadband.

However, this is very different from the blunt approach, which will mainly serve to offer an "extremely good" alternative to the "very good" and improving broadband most customers will have available anyway.

Commercial case ≠ societal case
There are of course legitimate reasons why private companies may wish to deploy FTTP in a blunt manner. For example, they may feel that the extreme speeds of FTTP give them a marketing advantage, even if they bring little actual benefit for the end user. Cincinnati Bell, which has deployed FTTP to over 400,000 premises in that city, appears to have taken this view. Its CFO has explained:

"I don't think most consumers really understand what a Gig gets them versus a 50 Mbps pipe. There are some technology savvy consumers out there that do understand that and we do have a few that have caught onto the 1 Gig and it's resonated with them, but it was really more of a marketing play to change how the consumers view us as a company."[158]

In response industry commentator Karl Bode observed:

"Most people know at this point that 1 Gbps is largely marketing hype, it's just rather rare for a company selling such services to admit it."[159]

Clive Carter, Ofcom's Director of Strategy, has made a similar point, observing at a Pictfor conference that it was hard to see 1 Gbps as a necessary speed. Asked why some customers nonetheless buy it, he responded:

"I think the reality is that people buy a BMW 7 Series when a 5 Series will do"[160]

To say that a particular product feature largely has marketing benefit is not to criticise – it is extremely common across many industries (as the BMW parallel shows). However, such product features do not justify regulatory or policy support. Such support must derive from societal benefits (or, more precisely, positive externalities).

"I think the reality is that people buy a BMW 7 Series when a 5 Series will do"

Clive Carter, Director of Strategy, Ofcom

[158] DSL Reports, Cincinnati Bell: 1 Gbps "Really More Of a Marketing Play", 11 December 2014
[159] Ibid
[160] Clive Carter, Ofcom, speaking at Pictfor "Session on digital connectivity & superfast broadband", 29 October 2015

5. A societal case for 'blunt' FTTP? *continued*

Externalities of broadband

The National Grid fallacy

There is no question that broadband brings positive externalities. It enables education, supports health, reduces isolation, reduces pollution, reduces the cost of government, supports engagement, and so on. However, it does not follow that more bandwidth brings greater benefits. To take a parallel, electricity has massive benefits. But it would be a fallacy to conclude that bringing pylons down every street to plug homes directly into the National Grid would have *additional* benefits.

Unfortunately, this is a very common fallacy in the debate over FTTP. For example, SQW, in a report for DCMS, claimed that faster broadband would add £17bn to UK GVA by 2024.[161] Fundamental to this figure was an assumption that a doubling in broadband speed brings a 0.3% increase in productivity. The sole evidence offered for this critical figure was a study by Chalmers University,[162] which looked at the impact of bandwidth growth between 2008 and 2010, when the average speed of the countries in question was 8 Mbps.

It is certainly plausible that a step up from 8 to 16 Mbps brings productivity benefits. But SQW assumes these benefits effectively continue forever, regardless of base speed. In other words they believe that stepping up from 100 to 200 Mbps (or indeed from 1 Gbps to 2 Gbps) is just as useful as going from 8 to 16 Mbps. This is a heroic assumption, and (if applied equivalently to electricity) would lead to pylons on every street.

Applications with and without externalities

In reality many of the drivers of higher bandwidth needs are applications with private benefits, and are unlikely to bring productivity benefits or other externalities. For example, relatively demanding applications such as 4K TV and the ability to download console and VR games may well be attractive to a given consumer, but they do not bring benefits to society more generally.

Conversely, the vast majority of applications with externalities, such as e-health, e-government and so on, actually have very modest bandwidth requirements, generally below 10 Mbps. (See Figure 18 for a small selection.)

Many of these applications are claimed as benefits of FTTP – and in one sense they are, in that they can undoubtedly be delivered over FTTP. But crucially, they are not *incremental* benefits of FTTP. They can be delivered over a reasonable ADSL connection, never mind existing superfast networks. As we have seen in the case of Japan, markets with high coverage of FTTP have no advantage in delivering such services, but rather lag the UK.

Figure 18: Sample applications with externalities and speed requirements of less than 10 Mbps

Education
Access to educational materials, e-learning/video lectures, professional development

Health
Remote HD medical consultations, remote medical monitoring, telenursing, emergency medical alarms, health information

Government
Online taxes, online benefits applications, online census, online business information filings

Other
Remote working, CCTV cameras, environmental sensing, social inclusion via video calling, smart electricity gridsmart electricity grids.

'Blunt' FTTP and externalities

Even if, hypothetically, there were societal benefits to FTTP, this would provide very limited government intervention in support of 'blunt' FTTP.

Imagine that in a decade FTTP coverage reaches 80%. However, coverage is not the same as adoption. Many consumers are likely to remain on non-FTTP lines, or subscribe to speeds well below FTTP's maximum, just as very many consumers today do not take available superfast speeds. Other consumers may use mobile networks instead of fixed. If we generously assume there is 25% take up of FTTP top-tier speeds (those beyond competing cable or G.fast networks) in coverage areas, this implies that top-tier FTTP represent just 20% of UK broadband lines.

This relatively low figure greatly reduces the likelihood of application providers (commercial or civic) offering applications which required FTTP, since 20% would be unlikely to represent critical mass. For instance, would the NHS focus on a programme to provide some form of remote healthcare that could only address 20% of broadband households (and a lower percentage of all households)?

[161] SQW (for DCMS), UK Broadband Impact Study, November 2013
[162] Ibrahim Kholilul Rohman and Erik Bohlin. Does Broadband Speed Really Matter for Driving Economic Growth? Investigating OECD Countries, 4 April 2012.

6. Conclusions

There is no doubt that FTTP is the right technology in a number of situations, such as greenfield sites, pockets of high business demand and so on. Indeed, it is already being used in this way by multiple broadband providers, planning to serve over 2m UK homes.

However, other than a misplaced desire to "keep up with the (international) Joneses", there is remarkably little basis for a requirement for 'blunt' FTTP that substantially overbuilds other high capacity networks.

Technologies such as G.fast and DOCSIS 3.1 bring speeds of hundreds of megabits and beyond, and are quicker and cheaper to deploy than FTTP. Such speeds are more than sufficient for virtually all consumers, and in particular for applications which are likely to bring societal or economic benefits such as e-health, remote working and so on. Ofcom's research has found that "above around 8-10 Mbps, speed generally ceases to become the dominant factor in determining digital experience quality."[163]

For such reasons organisations as diverse as Google, Swisscom and Australia's nbn are all moving *away* from FTTP.

'Blunt' FTTP *could* have competition benefits, though this needs to be seen in the context of existing competition from Virgin, increasingly capable mobile networks and potential new entrants based on new technologies. Moreover, 'blunt' FTTP may well be provided by a mosaic of providers, and such fragmentation will reduce their ability to act as a competitive constraint.

Light-touch regulatory changes to support players making commercial investments in FTTP are entirely reasonable. But the case for heavier intervention (with consequent market distortions or cost to the taxpayer) requires that FTTP brings *incremental* externalities – in reality, these are conspicuous by their absence.

Moreover, FTTP may come with a significant opportunity cost. Time and money devoted to 'blunt' FTTP by policy makers, regulators and companies risks detracting from other areas (such as ubiquitous high speed wireless networks or enabling the Internet of Things) which may have far greater incremental societal benefits.

[163] Actual Experience (for Ofcom), Measurement of Internet Quality of Service, 30 November 2015

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