Business Connectivity Market Review

Review of the retail leased lines, wholesale symmetric broadband origination and wholesale trunk segments markets

[✂Redacted for publication✂]

Consultation

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Contents

Section 1

Summary

Introduction

1.1 In this document we propose measures to address concerns we have identified about the extent of competition in the provision of leased lines in the UK.

1.2 Leased lines provide dedicated symmetric transmission capacity between fixed locations, and their overall value exceeds £2bn per annum in the UK. They play an important role in business communications services and are used to support a wide variety of applications, both in the private and public sectors. They also play a significant role in delivering fixed and mobile broadband services to consumers, because communications providers (CPs) use them extensively in their networks.

1.3 Our proposals are designed to promote competition in the provision of leased lines and the services which use them, and will affect the availability, choice, price, quality and value for money of data-transfer services throughout the UK. They are therefore important in furthering the interests of citizens and consumers.

Key trends in the market

1.4 The demand for leased lines bandwidth has increased steadily in the last few years, driven by sustained increases in both the penetration and the speed of business and consumer data services. Adoption of remotely hosted computing applications (often known as 'cloud computing'), growing consumption of video content and the rapid growth of e-commerce and of internet applications have all added to businesses bandwidth demands. At the same time, providers of consumer broadband services, both fixed and mobile, have required steadily increasing bandwidth to support the growth in traffic from their end-users.

1.5 Looking forward, the growth in demand for leased lines capacity seems set to continue as businesses demand more bandwidth, and as providers of mass market broadband services invest in fixed super-fast services and mobile next-generation (4G) services.

1.6 Modern technologies are driving down the unit costs of leased lines bandwidth. The number of services which use legacy time-division multiplex (TDM) technologies has been declining, although they still account for most installed leased lines. Modern Ethernet transmission equipment is now preferred in most new installations because it costs less and supports higher bandwidths.

1.7 The trend to lower unit costs is particularly evident in the increasing adoption of wavelength-division multiplex (WDM) technology. This technology can multiply by several times the bandwidth transmissible in an optical fibre. WDM equipment allows CPs to aggregate traffic from different services and to use optical fibres efficiently in the core of their networks as demand for bandwidth continues to increase. CPs are also deploying WDM equipment increasingly at their customers' premises if very high bandwidths are required.

The market review process

1.8 We review competition in some communications markets periodically, in accordance with the EU regulatory framework which is implemented in the UK by the Communications Act 2003 (the Act). Our review process has three formal stages. First, we define each relevant market in terms of its products and geographic scope. Then we assess whether any CP has a position of significant market power (SMP) in any of the relevant markets, which, in essence, means that it would be able to operate in the market without effective constraint from competition. Finally, we assess which regulatory remedies we should impose to address competition concerns that arise from any SMP we find.

1.9 We last reviewed these markets in 2007/8 (the "2007/8 Review"), and set out our findings in statements published in December 2008 and February 2009.[1,2]

Sources of information

1.10 Before starting our substantive analysis in this review, we published on 21 April 2011 a Call for Inputs (CFI) to gather stakeholders' views on the key aspects of the review such as market definition, SMP assessment and remedies. [3,4]

1.11 We then conducted market research, held extensive discussions with industry stakeholders and user groups, and analysed data which CPs provided in response to our formal requests for information. We have also reviewed relevant publicly-available information.

Summary of proposals

Retail market definitions

1.12 We propose to define a new market for very high bandwidth services, and refer to it as 'Multiple Interface' or 'MI' leased lines. This market includes services with bandwidths greater than 1Gbit/s and services of any bandwidth delivered with WDM equipment at end-users' premises. In the 2007/8 Review, we did not define a market for such services. Since then, the cost premium associated with WDM equipment has eroded and many major CPs now use WDM to provide high-bandwidth services.

1.13 In other respects, our retail market definitions are similar to those identified in the 2007/8 Review. We recognise the growing capabilities of current generation asymmetric broadband services and the advent of super-fast broadband, but do not consider, based on our analysis, that leased lines and broadband services are in the same economic market. We also propose to continue to distinguish between services presented to the end-user with traditional interface (TI) technologies, either TDM or analogue, and those with alternative interfaces (AI), mainly Ethernet. While there is migration from TI to AI products, the evidence on relative pricing and patterns of demand suggests that they are not sufficiently close substitutes for us to consider

[1] http://stakeholders.ofcom.org.uk/binaries/consultations/bcmr08/summary/bcmr08.pdf

[2] http://stakeholders.ofcom.org.uk/binaries/consultations/bcmr08/statement/statement.pdf

[3] http://stakeholders.ofcom.org.uk/consultations/bcmr-inputs/?a=0

[4] Annex 2 lists the respondents.

them as parts of the same economic markets. Similar distinctions lead us to define separate markets for TI products at different bandwidths.

1.14 We have analysed the markets both in terms of the products or services that make them up and in terms of their geographic scope, in accordance with the principles of competition law and as appropriate to the circumstances in the UK. We summarise below the product markets we believe can be identified at the retail level generally.

Proposed retail leased lines product market definition

Service interface	**Retail product markets and bandwidth breaks**			
Traditional (TI)	**TI low bandwidth**: Up to and including 8Mbit/s (including analogue services)	**TI medium bandwidth**: Above 8Mbit/s up to and including 45Mbit/s	**TI high bandwidth**: Above 45Mbit/s up to and including 155Mbit/s	**TI very high bandwidth**: 622Mbit/s
Alternative (AI)	**AI low bandwidth** - Up to and including 1Gbit/s			
Multiple (MI)	**MI** – services with bandwidth greater than 1Gbit/s, and services of any bandwidth delivered with WDM equipment at end-users' premises.			

1.15 In light of our analysis of the geographic scope and of the corresponding wholesale markets (see below), we propose to identify the retail market for TI low-bandwidth leased lines in the UK (excluding the Hull area) as susceptible to SMP regulation. We do not propose to identify any other retail markets outside the Hull area as susceptible to SMP regulation, because we consider that addressing any competition concerns in the wholesale markets which we propose to identify for AI, MI and higher-bandwidth TI leased lines will address any concerns in the corresponding retail markets.

1.16 In the Hull area, we propose to identify two separate retail markets as susceptible to SMP regulation: one for TI low-bandwidth leased lines and the other for AI low-bandwidth leased lines. We consider that addressing any competition concerns in the wholesale markets for higher-bandwidth TI leased lines in the Hull area will address any concerns in the corresponding retail markets. No MI leased lines services are currently supplied in the Hull area.

Wholesale market definitions

1.17 In many respects our proposed wholesale market definitions reflect those of the retail market. Our analysis also indicates that:

- combined markets exist for wholesale access and backhaul products, particularly because, in general, CPs are likely to continue to purchase access and backhaul together. These markets are referred to as TI Symmetric Broadband Origination (TISBO), AI Symmetric Broadband Origination (AISBO) and MI Symmetric Broadband Origination (MISBO);

- wholesale services used to provide backhaul for Local Loop Unbundling (LLU) and Radio Base Station (RBS) services still fall within the markets for wholesale symmetric broadband origination; and

- the bandwidth breaks we defined for TI and AI wholesale services in the previous market review still hold.

1.18 The main differences between our analysis now and that of the 2007/8 Review are:

- There are separate markets for regional and national TI trunk connectivity. In our previous review of the market we defined a single TI trunk market. We now consider that the characteristics of the regional trunk market are very similar to those of symmetric broadband origination, and are significantly different from those of national trunk routes.

- Consistent with our provisional view in relation to the retail market, we are proposing to define a wholesale MI market which includes any service faster than 1Gbit/s and any service delivered with WDM equipment at the end-user's premises, irrespective of bandwidth and interface.

Proposed wholesale product market definition

<table>
<tr><th></th><th colspan="4">Product markets</th></tr>
<tr><td>Traditional Interface Symmetric Broadband Origination (TISBO)</td><td>Low bandwidth TISBO:

<= 8Mbit/s</td><td>Medium bandwidth TISBO:

>8Mbit/s, <=45Mbit/s</td><td>High bandwidth TISBO:

>45Mbit/s, <=155Mbit/s</td><td>Very high bandwidth TISBO:

622Mbit/s</td></tr>
<tr><td>Alternative Interface Symmetric Broadband Origination (AISBO)</td><td colspan="4">Low bandwidth AISBO: <=1Gbit/s</td></tr>
<tr><td>Multiple Interface Symmetric Broadband Origination (MISBO)</td><td colspan="4">MISBO: >1Gbit/s irrespective of interface, and services of any bandwidth delivered with WDM equipment at the end-user's premises</td></tr>
<tr><td rowspan="3">Trunk / core connectivity</td><td colspan="4">TI regional trunk at all bandwidths</td></tr>
<tr><td colspan="4">TI national trunk at all bandwidths</td></tr>
<tr><td colspan="4">National core conveyance at all bandwidths</td></tr>
</table>

1.19 We propose that separate geographic markets exist (i) in the Hull area for all wholesale leased lines, and (ii) in a defined area of London (the Western, Eastern and Central London Area, or 'WECLA') for all the defined wholesale leased lines product markets other than the low bandwidth (up to and including 8Mbit/s) and very high bandwidth (above 155Mbit/s) TISBO markets. We summarise below our proposed wholesale markets (both product and geographic), each of which is susceptible to SMP regulation.

Proposed wholesale market definitions

Product market		Geographic markets		
TISBO	Low bandwidth	The UK excluding the Hull area		The Hull area
	Medium Bandwidth	The UK excluding the WECLA and the Hull area	The WECLA	The Hull area
	High bandwidth	The UK excluding the WECLA and the Hull area	The WECLA	The Hull area
	Very high bandwidth	The UK excluding the Hull area		The Hull area
AISBO	Low bandwidth <=1Gbit/s	The UK excluding the WECLA and the Hull area	The WECLA	The Hull area
MISBO	>1Gbit/s, and any services with WDM equipment at end-users' premises	The UK excluding the WECLA and the Hull area	The WECLA	The Hull area

1.20 Our analysis has not found separate geographic markets for any other parts of the UK for any other wholesale services.

Market power assessment

Overview of proposed findings

1.21 We summarise below for each relevant market our proposal for making a market power determination or, as the case may be, our proposal to find the market in question effectively competitive.

Overview of proposed SMP determinations

		Retail Services		Wholesale Segments			
				Symmetric Broadband Origination			Trunk
Interface technology	**Bandwidth (Mbit/s)**	**UK ex Hull**	**Hull**	**The WECLA**	**UK except the WECLA and Hull**	**Hull**	**UK**
Traditional ("TI")	Low: <=8	**BT**	**KCOM**	**BT**		**KCOM**	National *No SMP* Regional **BT**
	Med: 34,45			*No SMP*	**BT**	**KCOM**	
	High: 45-155			*No SMP*	**BT**	**KCOM**	
	V High: 622			*No SMP*		**KCOM**	
Alternative ("AI")	Low <=1,000		**KCOM**	**BT**	**BT**	**KCOM**	
Multiple ("MI")	>1,000, and any if WDM at user's site			*No SMP*	**BT**		

Retail markets outside the Hull area

1.22 Consistent with the 2007/8 review, we propose that BT continues to have SMP in the retail low bandwidth TI market outside the Hull area. In our last market review we said that impediments to competition largely arose as a result of upstream bottlenecks because of weaknesses in BT's wholesale products. We also said that at some point in the future, once these concerns had been fully addressed, it might be possible to deregulate this market.

1.23 We are now proposing to find that BT has addressed remaining concerns relating to the wholesale remedies upstream of this market, to the extent that other CPs should be able replicate BT's digital retail services effectively. We note, however, that there is no upstream wholesale product in the case of analogue services, and that such services still account for a significant part of the volumes in this market.

1.24 We consider that upstream wholesale remedies have stimulated competition for provision of 2Mbit/s retail digital services. We have found that BT's share of this part of this market has now reduced to 45% compared with the 60% we found in the 2007/8 Review. However, BT continues to have a very high share (73%) of the supply of services with bandwidths below 2Mbit/s. We have found that, overall, BT has a 68% share of the overall retail market for TI services below 8Mbit/s, and this share is well above the level which the European Commission (Commission) suggests should create a presumption of dominance. In the light of this and the existence of barriers to entry and expansion, we propose to find that BT has SMP in this market. We also note that demand is declining in this market, and therefore CPs are less likely to be willing to make the necessary investments to overcome the barriers to entry and expansion.

Wholesale markets outside the Hull area

1.25 We have found little, if any, change in competitive conditions in wholesale TISBO markets, whose volumes, although significant, are declining rapidly. Our proposals for SMP designation are set out below. Having proposed to define separate regional and national markets for TI trunk services, we now propose that BT does not have SMP in the national trunk market. We summarise below our proposals on market power for the relevant markets at wholesale level outside Hull.

Proposed SMP findings for the TI wholesale markets in the UK excluding the Hull area

Product market	Geographic scope	Proposed SMP designation	SMP designation in 2007/8 Review
Low bandwidth TISBO (<=8Mbit/s)	UK excluding the Hull area	BT	BT
Medium bandwidth TISBO (>8Mbit/s, <=45Mbit/s)	UK excluding the Hull area & the WECLA	BT	BT*
	The WECLA	No SMP	No SMP*
High bandwidth TISBO (>45Mbit/s, <=155Mbit/s)	UK excluding the Hull area & the WECLA	BT	BT*
	The WECLA	No SMP	No SMP*
Very high bandwidth TISBO 622Mbit/s)	UK excluding the Hull area	No SMP	No SMP
Wholesale national TI trunk segments	UK excluding the Hull area	No SMP	BT**
Wholesale regional TI trunk segments	UK excluding the Hull area	BT	

** These relate to the market power designations in 2008 for UK excluding the Central and East London Area (CELA) and Hull, and for CELA.*
** *Ofcom defined a single trunk market in 2008 and found BT to have SMP.*

1.26 In the case of AI services, similar to our last market review, we propose that BT has SMP in the UK excluding the Hull area and the WECLA. We consider that outside the WECLA and the Hull area, despite growing CP investment, BT's 67% share of volume is almost unchanged from the 69% we estimate in 2007. We believe that these circumstances are not likely to change over the forward-looking period of this review. The costs of digging trenches and building duct network are unlikely to reduce significantly, and the ubiquity of BT's network means that OCPs will continue to incur higher average costs than BT to serve new customers. In the WECLA our analysis shows that there has been more infrastructure investment than in the rest of the UK. However, despite extensive alternative network infrastructure and despite strong growth in demand, BT has maintained its competitive position since the last market review with a volume share that we currently estimate to be in the range 45%-50%.

1.27 We therefore propose that BT has SMP in the WECLA but we believe that the prospects for competition are more favourable there than elsewhere in the UK.

1.28 We are proposing that BT has SMP in the MI market in the UK excluding the Hull area and the WECLA. Demand for services faster than 1Gbit/s has been growing very fast since the last review. We believe that circuit volumes have increased more than threefold since 2006/07, and we expect that this rate of growth will continue throughout the coming review period. We estimate that BT's share of volumes is 59%. The market appears to be highly concentrated, with BT supplying more than six times the volumes of the second largest provider. Whilst the high growth and high average revenue per customer suggest that the prospects for competitive entry in

this market may be favourable, BT derives a strong advantage from the ubiquity of its network. Most services in this market are delivered with WDM equipment whose technology currently does not support effective interconnection between different networks. Consequently CPs which use their own infrastructure need to do so throughout the entire route of such a service. This limits the extent of effective competition and gives BT a strong advantage.

Retail markets in the Hull area

1.29 We propose that KCOM has SMP in the retail low bandwidth TI market and the retail low bandwidth AI market in the Hull area. In the 2007/8 Review we found that no operator had SMP in either of these markets.

1.30 We now believe that our finding in the 2007/8 Review was based on incomplete submissions from KCOM, which resulted in a significant understatement of its shares of the retail (and wholesale) markets. Our current estimate of KCOM's share of the retail low bandwidth TI market of 67% is similar to the figure from the 2003/04 Review when we found KCOM to have approximately 76% of the market. Therefore, we now believe that KCOM's share is both high and relatively stable over time.

1.31 The retail TI market in Hull is small and declining. We therefore consider that there is little prospect of increased competition during this review period. Overall, we consider that even though a regulated wholesale input is available, KCOM is unlikely to be effectively constrained by competitors in the retail market, and therefore has SMP.

1.32 In the retail AI market we consider that KCOM has a very high share and that, even though the market is growing, it does not offer sufficient potential for growth to attract a significant new competitive entry.

Wholesale markets in the Hull area

1.33 We propose that KCOM has SMP in all wholesale markets in the Hull area with the exception of MISBO in which no services are currently supplied. Our proposed findings are consistent with the conclusions of the 2007/8 Review.

1.34 We propose to find that KCOM has SMP because there is almost no alternative fixed network infrastructure in the Hull area, and KCOM's share in each of the markets is at, or very close to, 100%.[5] Entry at the wholesale level in the Hull area is very unlikely in the review period. It is therefore unlikely to be a sufficiently credible threat to constrain KCOM's behaviour.

[5] It is notable that we find no operator to have SMP in the very high bandwidth market in the UK excluding Hull, but find that KCOM has SMP in the equivalent market in Hull. The main reason is that we have no evidence to suggest that any other CP is willing to invest to supply these (or other TISBO services) in Hull. In contrast, in the market in the UK excluding Hull, we find a range of CPs supplying 622Mbit/s TISBO services.

Proposed SMP findings for wholesale markets in Hull

Product market	Proposed SMP designation	SMP designation in 2007/8 Review
Low bandwidth TISBO (<=8Mbit/s)	KCOM	KCOM
Medium bandwidth TISBO (>8Mbit/s, <=45Mbit/s)	KCOM	KCOM
High bandwidth TISBO (>45Mbit/s, <=155Mbit/s)	KCOM	KCOM
Very high bandwidth TISBO (622Mbit/s)	KCOM	No SMP
Low bandwidth AISBO (<=1Gbit/s)	KCOM	KCOM
MISBO (>1Gbit/s)	No SMP	No SMP**

** These figures show the growth since 2007/08, and both relate to difference of just one circuit.*

*** MISBO did not exist in 2008. However, there was no SMP in relation to circuits above 1Gbit/s throughout the UK.*

SMP remedies

Overall approach

1.35 In providing their customers with services, CPs currently often rely heavily on wholesale leased lines services which BT and KCOM (in the Hull area) provide on regulated terms. Having considered appropriate SMP remedies in this review, we propose regulations which would ensure that BT and KCOM continue to provide such services.

1.36 We have also considered the case for imposing an alternative or additional set of requirements known as passive remedies, such as requiring BT to provide access to its ducts, poles or dark fibre.

1.37 We are not proposing such passive remedies, because we consider that less intrusive remedies are likely to achieve similar benefits for consumers, while passive remedies would carry significant risks of worse outcomes, both for consumers and for effective competition, including adding costs and encouraging inefficient entry.

1.38 In October 2010 we completed a review of the wholesale local access market and found that BT had SMP nationally (except in the Hull area). One of the remedies we imposed requires BT to allow CPs investing in access infrastructure for super-fast broadband services use of its ducts and poles.[6] We termed this remedy Physical Infrastructure Access (PIA).

1.39 A number of stakeholders argued that we should extend the scope of PIA to include applications in leased lines. Mobile network operators (MNOs) have told us that PIA could help them to fulfil their requirements for backhaul from RBS for 4G services and to address their concerns that the costs of backhaul will escalate as demand for mobile data services continues to increase. Our current view is that if we were to continue, as we do now, to require BT to provide wholesale leased line services rather than access to its passive assets, the industry, including BT, is likely to meet MNOs' requirements for backhaul services in reasonable timescales, and with improving technical efficiency. We also consider that MNOs' concerns about the

[6] http://stakeholders.ofcom.org.uk/binaries/consultations/wla/statement/WLA_statement.pdf

future costs of backhaul could be addressed by price controls which we are proposing to impose on BT.

1.40 Other stakeholders argued that extending the scope of PIA to include leased lines is critical to generate the long-term cash flows needed to justify investment in fixed next-generation access networks. We recognise that, in contrast to the leased lines market, there is potentially insufficient investment in local access fibre to support super-fast fixed broadband services, particularly in areas outside BT's planned deployment of such services. We noted in our review of the wholesale local access market that PIA could be a more attractive option for deploying new next-generation access networks in such areas. We remain open to evidence that shows that investment in next-generation access networks could be unlocked if PIA could be used for leased lines services, to help us formulate our policy in relation to such investment.

Retail low bandwidth TI services outside the Hull area

1.41 In relation to retail markets we have had regard to the fact that these are not included in the Commission's list of markets in which *ex ante* regulation is likely to be required.[7] We have therefore applied the so-called 'three criteria test' to assess whether such regulation is appropriate to national circumstances in the UK, and consider that the three criteria are cumulatively satisfied in relation to these markets.

1.42 We are proposing to remove all *ex ante* obligations on BT concerning the provision of retail 2Mbit/s services because we consider that upstream wholesale remedies are now working sufficiently well to support retail competition, which has increased since the 2007/8 Review.

1.43 BT intends to withdraw services at bandwidths below 2Mbit/s, including some analogue services by no later than March 2018. In the interim, we are concerned to ensure that CPs and end users will have certainty of continuing supply, appropriate notice of retirement dates of services, protection from potentially excessive pricing and protection from the risk of that groups of customers will be subject to undue discrimination.

1.44 The table below summarises the remedies we are proposing in order to address these concerns.

Overview of proposed SMP remedies in the retail low bandwidth TI market

Product type	Proposed remedies
Analogue circuits	• Obligation to supply existing services, with at least a year's notice of withdrawal • Obligation not to discriminate unduly • Requirement to publish a reference offer, including prices, terms and conditions • Safeguard cap on retail prices
Sub 2Mbit/s digital circuits	• Obligation to supply existing services, with at least a year's notice of withdrawal • Obligation not to discriminate unduly • Requirement to publish a reference offer, including prices, terms and conditions
2Mbit/s and 8Mbit/s digital circuits	None

[7] See Annex 7 for details.

Wholesale TI markets in which we propose that BT has SMP

1.45 As with retail markets, we have noted that TI regional trunk segments are not on the Commission's list of markets in which *ex ante* regulation is likely to be required. We have therefore applied the three criteria test to assess whether such regulation is appropriate to national circumstances in the UK, and consider that the three criteria are cumulatively satisfied in relation to these markets.

1.46 We are proposing that BT has SMP in the wholesale markets for low bandwidth TISBO in the UK excluding the Hull area and for TI regional trunk segments of leased lines in the UK. We are also proposing that BT has SMP in the medium and high bandwidth TISBO markets in the UK excluding the Hull area and the WECLA. The state of competition in these markets broadly mirrors that of our previous market review. We are therefore proposing to maintain the same set of SMP regulations that are in place today including the existing PPC and RBS Backhaul directions. We are proposing to regulate charges with a price control. We will consult shortly in a separate consultation document on the details of this control. We do not propose to apply cost orientation obligations to charges that would be subject to this control.

Overview of proposed SMP remedies in the wholesale TI markets

- Requirement to provide network access
- Requirement not to discriminate unduly
- Requirement to publish a reference offer
- Requirement to notify changes to prices, terms and conditions (28 days notice for new services and price reductions, 90 days for all other notifications)
- Requirement to publish quality of service information as required by Ofcom
- Requirement to notify changes to technical information with 90 days notice
- Requirements relating to requests for new network access
- Requirement to publish regulatory accounting information
- Charge control (detailed proposals to be published shortly in our forthcoming charge control consultation)
- A direction under the network access obligation requiring BT to provide Partial Private Circuits
- A direction under the network access obligation requiring BT to provide RBS Backhaul
- Requirements to provide accommodation in BT exchanges and to provide specific types of interconnection service:
    - Customer Sited Handover
    - In Span Handover
    - In Span Handover extension
    - In Building Handover

Wholesale AISBO markets in which we propose BT has SMP

1.47 We are proposing to impose new controls on BT's charges for wholesale AISBO services after the current controls expire in September 2012. A separate control would apply in each of the two geographic markets – one within the WECLA and the other outside it (except the Hull area) – which we identified for these products. The charges subject to the controls would include those for wholesale AISBO products and for ancillary services reasonably required, such as interconnection, accommodation and excess construction. We will set out the form, precise scope and level of the proposed controls in our forthcoming separate consultation referred to above. We do not propose to apply cost orientation obligations to charges that would be subject to these controls.

1.48 We consider that our proposals for charge controls should take into account that existing alternative infrastructure to BT's within the WECLA creates better prospects for competition in the provision of wholesale AISBO compared to elsewhere in the UK.

1.49 In all other respects, the remedies we propose for the two geographic markets which we have identified outside Hull are identical. They are summarised in the table below.

Overview of proposed remedies for wholesale AI services (both within the WECLA and elsewhere in the UK except the Hull area

- Requirement to provide network access on reasonable request, including (without prejudice to the generality of the network access requirement)
  - disaggregated Ethernet access and backhaul;
  - end-to-end Ethernet products
- Requirement not to discriminate unduly
- In addition, a requirement to provide all network access on the basis of Equivalence of Inputs (except for certain accommodation services and unless we consent)
- Requirements relating to requests for new network access
- Requirement to publish a reference offer
- Requirement to notify changes to charges and to terms and conditions
- Requirement to notify technical information
- Requirement to publish quality of service as required by Ofcom
- Requirement to publish regulatory accounting information
- Charge controls – separate controls to apply within and outside the WECLA
- Requirement to provide accommodation in BT exchanges and to provide specific types of interconnection service:
  - Customer-sited handover
  - In-building handover
- A direction under the network access obligation relating to service-level guarantees

1.50 Since we concluded the 2007/8 Review there have at times been differences in view between BT and CPs as to how BT should comply with its obligations in the market for wholesale low bandwidth AISBO. In our current proposals we are therefore seeking to achieve greater certainty. In particular, we propose to:

- require BT to provide network access on the basis of equivalence of inputs (EOI).[8] We propose that the EOI requirements should extend to BT's allocation of accommodation and power to CPs in its exchanges, but not to other aspects of provision of accommodation services or to interconnection services;
- specify explicitly that BT's wholesale Ethernet products must include separate access and backhaul services; and
- clarify the definitions of trunk segments and symmetric broadband origination in the AI markets, with the effect that BT would be required to provide an AISBO

[8] Equivalence of inputs is a remedy designed to prevent a vertically-integrated company from discriminating between its competitors and its own business in providing upstream inputs. The concept was established in the UK by undertakings offered by BT and accepted by Ofcom in 2005 under the Enterprise Act. In its undertakings BT committed to provide, in respect of particular products and services, the same product or service to all CPs (including BT) on the same timescales, terms and conditions (including price and service levels) by means of the same systems and processes, and includes the provision to all CPs (including BT) of the same commercial information about such products, services, systems and processes.

service even where it would cross a boundary between the catchment areas of neighbouring trunk aggregation nodes.

1.51 We also clarify that Openreach should process requests to develop AI products in accordance with the SMP condition which regulates new network access, and not in accordance with its own commercial process.

The wholesale MI market in which we propose that BT has SMP

1.52 We have not regulated this market under the EC Framework until now, although BT has, in Undertakings it agreed with us under the Enterprise Act, committed to provide wholesale services in this market on the basis of equivalence of inputs (EOI).[9] We summarise in the table below the remedies we propose to address BT's SMP in this market.

Proposed remedies for the wholesale MI services outside the WECLA

- Requirement to provide network access on reasonable request, including (without prejudice to the generality of the network access requirement):
  - disaggregated single-service Ethernet access and backhaul;
  - end-to-end single-service Ethernet products
  - end-to-end services with WDM equipment at the customer's premises
- Requirement not to discriminate unduly
- In addition, a requirement to provide all network access on the basis of Equivalence of Inputs (except for certain accommodation services and unless we consent)
- Requirements relating to requests for new network access
- Requirement to publish a reference offer
- Requirement to notify changes to charges and to terms and conditions
- Requirement to notify technical information
- Requirement to publish quality of service as required by Ofcom
- Requirement to publish regulatory accounting information
- Charge control on single-service Ethernet products

1.53 We recognise that CPs which invest in physical infrastructure compete with BT in this wholesale market, and that such competition could be sustainable, both because demand is growing and because the value of MI services is relatively high. We want to maintain their incentives to do so and yet protect consumers from the risk of excessive prices.

1.54 While most MI services are delivered by installing WDM equipment at end-user premises, WDM technology is still evolving rapidly, and we do not propose to impose price controls on BT's WDM-based wholesale products in this market. However, we do propose to impose a price control on BT's wholesale single-service Ethernet products. We consider that imposing such a control is likely to maintain CP's incentives to invest in physical infrastructure, while applying appropriate constraints on BT's ability to charge high prices. Our forthcoming separate consultation will set out our proposed price controls in detail.

1.55 At the same time, we want to promote greater competition by supporting development of solutions that could enable CPs to deliver WDM-based services by

[9] With the exception of WDM services longer than 70km where BT currently is exempted from providing services on an EOI basis

interconnecting their own core networks with BT's ubiquitous access to end-users' premises. Until recently, BT's WDM-based wholesale MI products only supported connectivity entirely over BT's physical infrastructure from end to end, and could not support interconnection effectively. BT has recently launched product variants which may support such interconnection, but it is too early to tell if those product variants will enable effective interconnection solutions.

1.56 Currently, BT has no need to consume the variants which could support interconnection. We consider that this gives BT the ability to discriminate between its competitors and its own downstream divisions in providing those variants. Noting that those variants are very similar to BT's other WDM-based wholesale MI products, we propose that:

a) in relation to matters other than price, BT should provide the interconnection variants of its WDM-based wholesale MI products on the basis of EOI with its other WDM-based wholesale MI products; and

b) BT should not discriminate unduly between the prices it charges for the variants of its products, which means that the difference in price between variants of the same product which do and do not support interconnection, and are of the same radial distance, should be no greater than the difference between their long-run incremental costs.[10]

1.57 We are also proposing a set of obligations on BT in relation to accommodation and other interconnection services which would support the remedies we propose above for this market.

Retail markets in the Hull area in which we propose KCOM has SMP

1.58 As noted above, the retail markets for TI low-bandwidth and AI low-bandwidth leased lines do not appear on the EC list of markets in which *ex ante* regulation is likely to be required. We have therefore applied the three criteria test to assess whether such regulation is appropriate to national circumstances in the UK, and consider that the three criteria are cumulatively satisfied in relation to these markets.

1.59 As there is very little competition in the retail low bandwidth TI and AI markets in the Hull area, our aim is to ensure that consumers have certainty of supply, are protected from exploitation through high prices and that there is no undue discrimination between different classes of customer. Our remedy proposals seek to achieve this aim while taking into account the relatively small scale of the market in the Hull area. We summarise them in the table below.

Proposed remedies for retail low bandwidth TI services and AI services in the Hull area

• Requirement to supply retail leased lines • Obligation not to discriminate unduly • Requirement to publish a reference offer

1.60 Whilst we are not proposing to control KCOM's retail charges, we would expect those charges to align with a reasonable benchmark of competitive charges. We consider

[10] The charge for the variant which supports interconnection is expected to be higher than the variant which does not support interconnection for a given radial distance.

that a suitable candidate for such a benchmark would be KCOM's wholesale charges with a reasonable allowance for gross retail margin. We also propose to require KCOM to publish maximum prices to facilitate monitoring.

1.61 We are proposing that KCOM also be allowed to offer bespoke pricing as long as prices are not unduly discriminatory and do not exceed the prices set out in its published reference offer.

Wholesale markets in the Hull area in which we propose KCOM has SMP

1.62 During the forward-looking period of this market review we foresee limited scope for competitive entry even in the fast growing AISBO market. However, to the extent that CPs require wholesale services in Hull to fulfil the requirements of customers outside Hull who may require connectivity in Hull (e.g. for branch offices), we consider it important that CPs are assured of access to wholesale services on non-discriminatory terms and of protection from excessive pricing. We are largely proposing to impose the same SMP obligations on KCOM as we did in the previous market review.

Proposed remedies for wholesale TI and wholesale AI services in the Hull area

- Requirement to provide network access on reasonable request
- Obligation not to discriminate unduly
- Requirement to publish a reference offer
- Requirement to notify charges, terms and conditions
- Requirement to notify technical information
- Accounting separation obligation

1.63 Whilst we are not proposing to control KCOM's wholesale charges, we would expect those charges to align with a reasonable benchmark of competitive charges. We consider that a suitable candidate for such a benchmark would be based on BT's wholesale charges for similar services. We also propose to require KCOM to publish maximum prices to facilitate monitoring.

1.64 We are proposing that KCOM also be allowed to offer bespoke pricing as long as prices are not unduly discriminatory and do not exceed the prices set out in its published reference offer.

Consultation and next steps

1.65 We invite comments from interested parties on the proposals in this document. The consultation period runs for 10 weeks and the deadline for responses is 24 August 2012. We aim to publish our conclusions in the first quarter of calendar 2013.

1.66 We intend to publish our charge control proposals in the next few weeks. The consultation periods for these two consultations will overlap. This will give stakeholders the opportunity to review the complete package of remedies before responding to the consultations.

Section 2

Introduction

Scope and purpose of this review

2.1 This business connectivity market review (BCMR) considers the markets for:

- the retail provision of leased lines in the UK; and
- the wholesale provision of terminating segments and trunk segments in the UK.

2.2 When referring to these markets as a whole and in general terms we use the term 'the leased lines market' or 'the leased lines markets'.

2.3 The purpose of the BCMR is threefold:

i) to identify and define the relevant markets;

ii) to assess of whether any of the markets are effectively competitive. This involves assessing whether any operator has significant market power (SMP) in any of those relevant markets; and

iii) where there has been a finding of SMP, to assess the appropriate remedies which should be imposed, based on the nature of the competition problem identified in the relevant markets.

2.4 We set out the market review process in summary below, and we provide more detail in Annex 6. In the past the BCMR has been followed by the leased lines charge control (LLCC) consultation and statement. For the purpose of clarification, from a legal and procedural perspective, the LLCC is actually one part of the market review as a whole and falls under the third purpose, as set out above. As we explain in this consultation, we propose that charge controls form part of the appropriate remedies which should be imposed in some of the relevant markets to address the competition problems we have identified in those markets. We will be publishing a separate LLCC consultation shortly in which we set out in greater detail our reasons for this proposal, including the nature, form and duration of the proposed charge controls.

Background

2.5 Leased lines provide dedicated transmission capacity between fixed locations, and are essential components of information and communications technology (ICT) services used by businesses.

2.6 Many organisations, both in the private and public sectors, use leased lines to support a wide variety of ICT applications, such as access to the internet, private voice and data networks, backup and disaster recovery, remote monitoring and telemetry applications.

2.7 Leased lines are also used by communications providers (CPs) as components of consumer communication services, and hence play a significant role in determining the speed and cost of those services. For example, mobile network operators (MNOs) use large volumes of leased lines to carry mobile voice and data services between their radio base stations and switching centres; and providers of fixed

broadband services use substantial volumes of leased lines to carry their customers' traffic between BT's local exchanges and their networks.

Market structure

2.8 The leased lines market is part of a complex value chain, with business ICT services downstream and physical network components upstream. End-user organisations engage with leased lines in a wide variety of ways, depending largely on the level of involvement they require in the engineering of the ICT services that they consume.

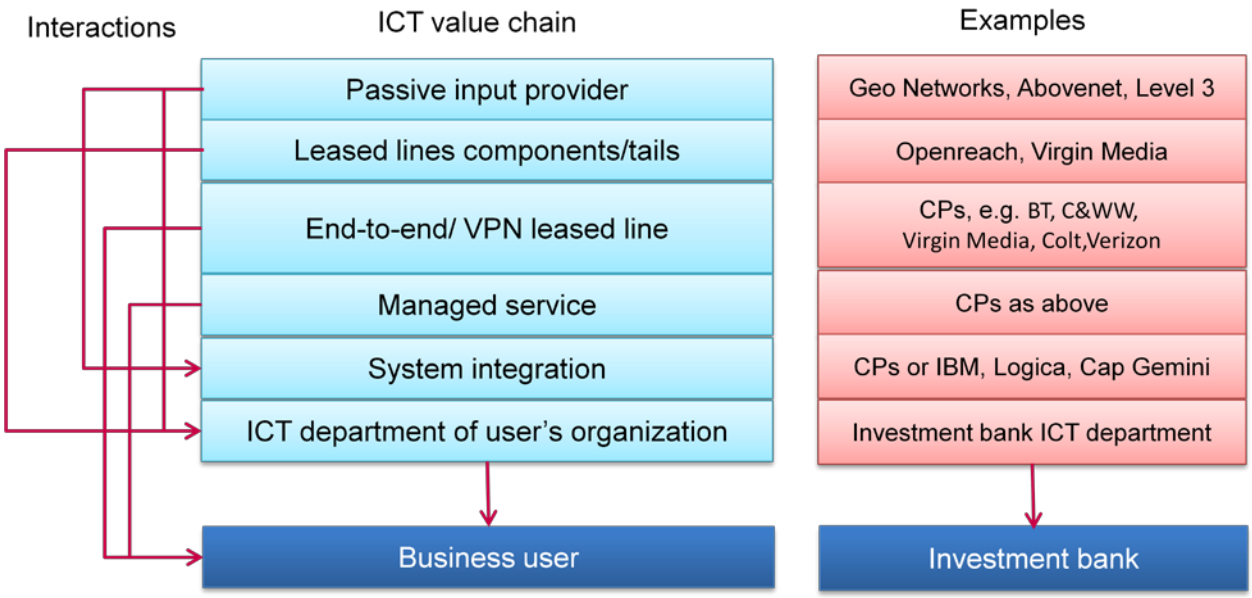
2.9 Many end-user organisations do not purchase leased lines as distinct services even though they might use them. For example, a public transport provider might have a turnkey contract with a systems integrator which provides and manages the closed-circuit television system it uses to monitor its railway stations. The systems integrator would, as part of the contract, purchase leased lines from a CP and use them to connect the cameras to a monitoring centre. The public transport provider would, in that case, not have a distinct contract in relation to those leased lines.

2.10 Other end-user organisations might purchase leased lines directly from CPs. For example, an operator of data centres, which house computer equipment hosting other companies' ICT applications, might purchase leased lines directly from a CP to connect its data centres together and/or to a carrier-neutral location to interconnect with the wider Internet.

2.11 We also understand that, in some cases, end-user organisations fulfil some of their connectivity services by procuring access to a network operator's unlit optical fibres and using it to connect equipment in their sites.

2.12 The range of participants in the value chain, and the interactions between them, is illustrated in the figure below.

Figure 1: The ICT value chain and examples



2.13 CPs that supply leased lines include BT, Virgin Media, Cable & Wireless Worldwide, Level 3, Colt, Verizon and Geo Networks, among others.

2.14 CPs usually carry leased line services in either copper wires or optical fibres, although fixed microwave links are also sometimes used. The inherent transmission capacity of optical fibre is far greater than that of either copper wire or microwave links. Construction of physical networks of copper wires or optical fibres requires a high initial investment in civil infrastructure, including trenches, ducts, poles and cables.

2.15 BT's physical network is ubiquitous in the UK and BT can deliver leased lines almost everywhere in the country except in Hull, where KCOM operates the only ubiquitous physical network. While other CPs including, for example, Virgin Media, C&WW and Level 3, own and operate sizeable physical networks in the UK, the coverage of each of those networks is significantly less extensive than BT's.

Market trends and recent developments

2.16 The capacity demanded of leased lines has been increasing in recent years and seems set to continue to increase. Businesses' needs for bandwidth is being driven by a number of factors, including increased adoption of remotely hosted ICT applications (often referred to as 'cloud computing'), greater consumption of bandwidth hungry applications and video content and increased reliance on the internet as a means of communicating and transacting with employees, customers and suppliers. As a result, more and more businesses are migrating from legacy based leased lines to modern Ethernet and WDM based services which are more cost effective in delivering higher data speeds. This has resulted in demand for legacy leased lines falling significantly (over 30%[11]) since the last market review and the take-up of Ethernet / WDM services growing by around 80%.[12] There nevertheless continues to be a significant number of customers who continue to consume legacy services.

2.17 Leased lines are also an important enabler of fixed and mobile broadband as they allow MNOs and fixed internet service providers (ISPs) to aggregate and transport data traffic from multiple end users to an internet aggregation point. The last two to three years have seen explosive growth in the take-up of mobile broadband – over the last year the proportion of UK adults using their mobile phones to access the internet has doubled to 36%[13]. As MNOs begin to deploy new 4G networks demand for mobile broadband capacity is likely to increase significantly.

2.18 Fixed broadband penetration has grown from 65% to 72% of households over a period of three years.[14] Average broadband speeds have also been increasing. Between November / December 2010 and November 2011 average speeds for residential use increased by 22% from 6.2Mbit/s to 7.6 2Mbit/s[15] as a result of ISPs either upgrading their broadband technologies or encouraging their customers to move to higher bandwidth packages. We expect this trend to continue particularly

[11] See section 7 Market Power Assessment Table 7.3. Note that this is the rate of decline for low bandwidth TISBO.which is the largest TISBO market by volume. Other TISBO markets have experienced a more significant rate of decline.

[12] See section 7 Market Power Assessment Tables 7.18, 7.21, 7.23 and 7.27

[13] Ofcom research Jan-Feb 2012 (unpublished)

[14] Ofcom technology tracker, Q1 2009 to Q1 2012

[15] http://stakeholders.ofcom.org.uk/market-data-research/other/telecoms-research/broadband-speeds/bb-speeds-nov-11

with the rollout of superfast broadband by BT and Virgin Media's intention to double the speeds available to its end users. [16]

2.19 Upgrades in fixed and mobile broadband capacity / technologies coupled with growing demand from end users for streamed video content will require fixed ISPs and MNOs to increase the capacity of their networks by consuming higher bandwidth leased lines.

2.20 Meanwhile, the costs of network equipment, particularly equipment using Ethernet and wave-division multiplex (WDM) technologies, have been falling. The number of leased lines services which use those technologies has been increasing. Legacy time-division multiplex (TDM) transmission technology now supports a declining but still large number of leased lines services. In addition, the transmission speeds that readily-available Ethernet and WDM equipment can support has also increased in recent years.

2.21 Until 2008 BT provided Ethernet leased line services by linking optical fibres to create a continuous optical path between the two end-user sites of each Ethernet leased line. This meant that each Ethernet service used a dedicated fibre link. Since then, BT has upgraded its national transmission network with modern Ethernet and WDM equipment. The new design allows BT to aggregate services efficiently, so that several leased lines and other services can share a single optical fibre where their respective routes coincide between BT's exchanges.

2.22 The last few years have also seen some significant mergers and acquisitions. Following its acquisition of Energis in 2006, Cable & Wireless acquired Thus Group in October 2008. In March 2010 Cable & Wireless Worldwide demerged from Cable & Wireless plc. Separately, Global Crossing acquired Fibrenet at the end of 2006 and merged in October 2011 with Level 3.

Services considered in this review

2.23 As set out above, our review considers the market for the retail provision of leased lines, and the wholesale markets for the provision of terminating segments and trunk segments of leased lines in the UK.

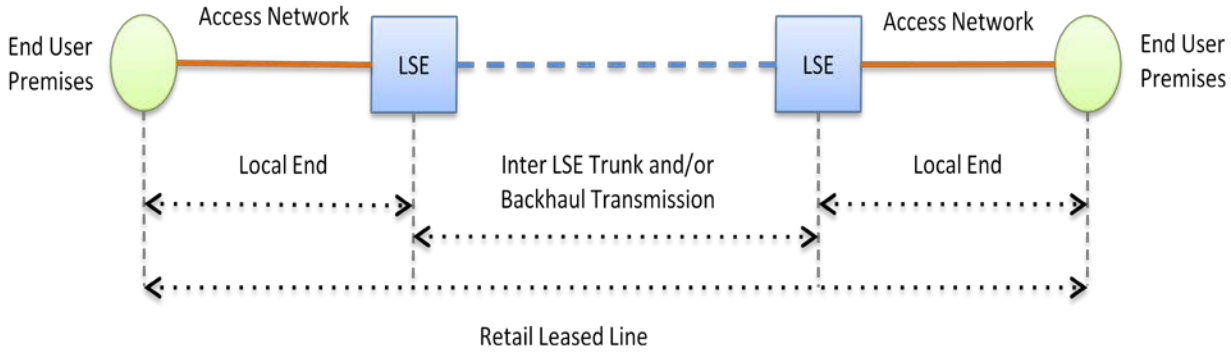
Retail services

Leased lines

2.24 Retail leased lines are fixed connections that provide end-user organisations with dedicated symmetric capacity between their sites. They can be used for a variety of communications including voice, video and data communications.

[16] Virgin Media announced in January 2012 that over the next 18 months it would be doubling the speeds available to its end-users. Upload speeds and traffic management fair usage amounts will be increased in proportion to the increase in downstream speed. See http://mediacentre.virginmedia.com/Stories/Virgin-Media-boosts-Britain-s-broadband-speeds-2322.aspx

Figure 2: Retail leased line

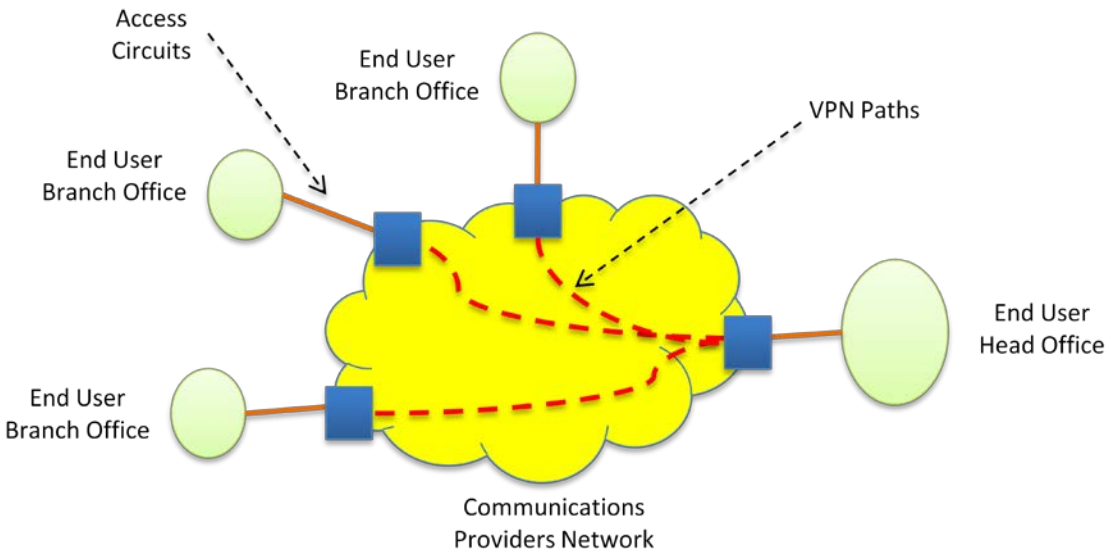


2.25 Figure 2 above shows a simplified configuration. The business sites at each end of the circuit are linked to the nearest nodes in the CP's network (the Local Serving Exchange (LSE) using an access network. The access network links are commonly known as 'local ends'. Connectivity between the LSEs may be provided by a direct fibre or copper connection or, more commonly for longer distance connections, using the CP's backhaul and core transmission network.

Virtual private networks

2.26 Organisations often use leased lines to build private networks linking their sites together so that offices can exchange data and access corporate applications. Virtual private networks (VPNs) provide an alternative to retail leased lines to achieve this functionality, using a public core network provided by a CP. The organisation's data is transmitted typically using virtual paths across a core infrastructure shared with other services. Specific protocols are used to ensure the privacy of each user organisation's transmissions through the shared infrastructure. The diagram below illustrates a simple example connecting several branch offices to a head office.

Figure 3: Virtual Private Network (VPN)



2.27 Each site needs an access circuit to connect it to the VPN. This may be provided with a leased line but other types of connection such as ADSL broadband are also used depending on the user's requirements.

Wholesale services

2.28 CPs provide wholesale leased lines services to each other, either on a commercial basis or on a regulated basis. A CP purchasing wholesale leased lines uses them either as components to construct retail leased lines services for end-user organisations, or to build its own network, for example to connect its network nodes together.

2.29 There are three broad types of wholesale leased lines service:

- end-to-end services: these link two end-user sites, typically over relatively short distances;
- terminating segments: most commonly these link an end-user's site to the purchasing CP's network node, enabling the purchasing CP to assemble an end-to-end service using a combination of wholesale inputs and its own network. Terminating segments can also be used to link together nodes in the purchasing CP's network; and
- trunk segments: these are segments of leased lines carried over aggregated links between major network nodes.

Technologies

2.30 In this review, we consider leased lines that employ technologies in common use in the UK. We classify those technologies into two main groups:

- **Traditional Interface (TI) leased lines**: This group includes services which use legacy analogue and digital interfaces. These have hitherto been the most common types of leased line in use in the UK, but their volume is now in sustained decline. In this category there are two broad types of circuit:
  - Analogue interface leased lines: These are commonly used for voice transmission e.g. external extension circuits between business sites. They are also used for low-bandwidth data transmission.
  - Digital interface leased lines based on legacy TDM technical transmission standards, including Plesiochronous Digital Hierarchy (PDH) and Synchronous Digital Hierarchy (SDH), and which use the ITU G.703 interface. As a result, they have stable and predictable transmission characteristics, low transmission delay (latency) and low jitter (variation in transmission delay). These characteristics are important in some user applications. PDH and SDH circuits are currently the most common type of leased line, and are used for enterprise voice and data services. They are available in bandwidths ranging from 64kbit/s up to 10Gbit/s. The most popular variants are n x 64kbit/s and 2Mbit/s.
- **Alternative Interface (AI) leased lines**: This group of digital leased lines services, uses modern interfaces that are generally more suitable for transmission of Internet protocol (IP) data, and are often more cost-effective in delivering high bandwidth services than legacy technologies. Interfaces used in AI leased lines include:
  - Ethernet is the most common AI leased lines technology. It was originally developed for office environments, where it is still used to transmit data

between computers in local area networks (LANs). In recent years it has been developed for use in telecommunications networks. Ethernet services are currently available in a range of bandwidths from 10Mbit/s to 10Gbit/s with the most common being 100Mbit/s.

- Fibre Channel (and related FICON and ESCON interfaces) is a high-bandwidth technology primarily used for data storage network applications. Originally developed for use with super-computers it has now become the standard connection type for enterprise storage area networks.

2.31 In addition, we also consider leased lines that use WDM technology. WDM is a transmission technology originally used by network operators to provide optical fibre links with very high capacity within their networks. It is increasingly being used by businesses that have very high bandwidth requirements, particularly for data centre and data storage network applications and in the media and broadcast industries. The distinguishing feature of WDM is its scalability. Each WDM system can support multiple circuits over one or two optical fibres (typically 16 or 32 circuits at capacities above 1Gbit/s). Additional circuits can be quickly added without disruption to the existing circuits and without adding additional fibres. WDM is most commonly used to provide circuits with AI interfaces such as Ethernet or Fibre Channel but it also supports the TI SDH interfaces.

Terminology

2.32 In the previous BCMRs we used an older term 'Symmetric Broadband Origination' to describe terminating segments. As the acronyms associated with this term are well known, in this document we have continued to use them to describe the markets for terminating segments. We therefore refer to the markets as follows:

- TI Terminating Segments = TI Symmetric Broadband Origination (TISBO); and
- AI Terminating Segments =AI Symmetric Broadband Origination (AISBO).

Passive remedies

2.33 In the context of our review of the Wholesale Access (WLA) market completed in October 2010, we imposed a new remedy on BT requiring it to offer access to its duct and pole infrastructure to provide superfast broadband services and telephony. We termed this remedy Physical Infrastructure Access (PIA). In our WLA statement we said that we expected *"PIA will be attractive to companies wishing to address market opportunities in advance of BT and may also be of particular interest to companies wishing to provide service in locations which may be in receipt of public funding support"*. Both in the course of our WLA consultation and also subsequently, (including in the context of responses to the BCMR CFI), a number of stakeholders have urged Ofcom to require PIA as a remedy in the BCMR market. A number of MNOs said that the saw PIA as an important means of stimulating competition for and reducing the cost of mobile backhaul in light of growing demand for mobile broadband as MNOs transition to 4G.

2.34 Other stakeholders argued that the current usage restrictions of PIA could place bidders for public funds available from Broadband Delivery UK (BDUK) to support investment in superfast broadband infrastructure in less populated parts of the UK at a disadvantage relative to BT who benefits from economies of scope.

2.35 Consequently, as part of this market review we consider whether there is a case for either changing our primary remedy focus in leased lines from actives to passive remedies, or whether specific issues raised by stakeholders may lead us to promote passive remedies in more restricted circumstances. Our consideration of passive remedies can be found in Section 8.

The regulatory framework

2.36 The regulatory framework has its basis in five EU Communications Directives, each of which have been implemented into national legislation.[17] It imposes a number of obligations on the relevant national regulatory authorities, such as ourselves. One of these obligations is to carry out a market review. We set out the market review process, and the regulatory framework, in more detail in Annex 6. In this chapter we have set out, in summary, what the market review process involves.

The market review process

2.37 The review is carried out in three stages:

i) we identify and define the relevant markets;

ii) we assess whether any of the markets are effectively competitive, which involves assessing whether any operator has significant market power (SMP) in any of the relevant markets; and

iii) we assess the appropriate remedies which should be imposed, where there has been a finding of SMP, based on the nature of the competition problem identified in the relevant markets.

2.38 In carrying out the review, we are obliged to define relevant markets "appropriate to national circumstances". [18] In so doing, we are also obliged to take "utmost account"[19] of the European Commission's (Commission) Recommendation[20] and SMP Guidelines.[21]

The Recommendation and its application to this review

2.39 The Recommendation sets out those product and service markets which, at a European level, the Commission has identified as being susceptible to ex ante regulation. These markets are identified on the basis of the cumulative application of three criteria:

- the presence of high and non-transitory barriers to entry;

[17] Recent amendments to the five EU Communications Directives were transposed into national legislation and came into effect from 26 May 2011. See Annex 7 for more detail.

[18] See Article 15(3) of the Framework Directive (Directive 2002/21/EC on a common regulatory framework for electronic communications networks and services, as amended).

[19] Ibid.

[20] Commission Recommendation on relevant product and service markets within the electronic communications sector susceptible to ex ante regulation in accordance with Directive 2002/21/EC of the European Parliament and of the Council on a common regulatory framework for electronic communications networks and services (Second Edition) (C(2007)5406 rev1).

[21] Commission guidelines on market analysis and the assessment of significant market power under the Community regulatory framework for electronic communications networks and services (2002/C 165/03).

- a market structure which does not tend towards effective competition within the relevant time horizon; and

- the insufficiency of competition law alone to adequately address the market failure(s) concerned.

2.40 The requirement to define relevant markets appropriate to national circumstances means we are free to identify relevant markets in the UK as susceptible to regulation other than those on the Recommendation. However, where we do so, the Recommendation requires that for each relevant market we must show that the cumulative criteria are satisfied.

2.41 All of the markets we identify in this review are listed in the Recommendation apart from four. These are:

- the retail market for the provision of low bandwidth Traditional Interface (TI) leased lines in the UK excluding the Hull area;

- the retail market for the provision of low bandwidth Traditional Interface (TI) leased lines in the Hull area;

- the retail market for the provision of low bandwidth Alternative Interface (AI) leased lines in the Hull area; and

- the wholesale market for the provision of regional trunk segments.

2.42 In the relevant chapters below in this consultation document we set out how the cumulative criteria are satisfied for each of these relevant markets we propose to define.

The SMP Guidelines and their application to this review

2.43 The SMP Guidelines include guidance on market definition, assessment of SMP and SMP designation. Oftel has produced additional guidelines on the criteria to assess effective competition based on the SMP Guidelines (Oftel Guidelines).[22] In the relevant chapters below in this consultation document we set out how we have taken both the SMP and Oftel Guidelines into account in reaching our proposals.

Forward look

2.44 Rather than just looking at the current position, market reviews look ahead to how competitive conditions may change in future. For this review we have taken a forward look of three years, reflecting the characteristics of the retail and wholesale markets and the factors likely to influence their competitive development. The forward look period also reflects the requirement in the Directives that ordinarily market reviews should be conducted within three years of the previous review.

2.45 This does not preclude us reviewing any of the markets earlier, but absent unforeseen developments we anticipate that we would time the next market review to conclude three years after completion of the current review. We therefore propose that the charge controls that we will set out in the forthcoming LLCC Consultation will apply for a period of three years following the completion of the BCMR and LLCC consultation process.

[22] See www.ofcom.org.uk/static/archive/oftel/publications/about_oftel/2002/smpg0802.htm.

The findings of the last BCMR

2.46 In January 2009, we completed the last BCMR[23] (the 2007/8 Review) as a result of which we imposed certain regulatory obligations on BT and KCOM in those markets where they were found to have SMP. Table 1 below summarises the market definitions and SMP findings of the last BCMR. A number of separate leased lines markets were defined based on the capabilities of different technologies: traditional interface services and alternative interface services. Table 2 provides an overview of the remedies imposed on BT and KCOM.

Table 1: Market definitions and SMP findings from the last BCMR

	Markets	UK except Kingston upon Hull	Kingston upon Hull
1	Retail market for analogue and digital low bandwidth TI leased lines at bandwidths up to and including 2Mbit/s and 8Mbit/s	BT	No SMP
2	Wholesale market for TI symmetric broadband origination (TISBO) at bandwidths up to and including 2Mbit/s and 8Mbit/s	BT	KCOM
3	Wholesale market for TISBO at bandwidths above 8Mbit/s and up to and including 45Mbit/s in the Central and East London Area (CELA)	No SMP	
4	Wholesale market for TISBO at bandwidths above 8Mbit/s and up to and including 45Mbit/s outside the CELA	BT	KCOM
5	Wholesale market for TISBO at bandwidths above 45Mbit/s and up to and including 155Mbit/s in the CELA	No SMP	
6	Wholesale market for TISBO at bandwidths above 45Mbit/s and up to and including 155Mbit/s outside the CELA	BT	KCOM
7	Wholesale market for TISBO at bandwidths above 155Mbit/s and up to and including 622Mbit/s	No SMP	No SMP
8	Wholesale market for low bandwidth AI symmetric broadband origination (AISBO) at bandwidths up to and including 1Gbit/s	BT	KCOM
9	Wholesale market for high bandwidth AISBO at bandwidths above 1Gbit/s	No SMP	No SMP
10	Wholesale trunk segments for TI leased lines[24]	BT	

[23] http://stakeholders.ofcom.org.uk/consultations/bcmr08/statement/

[24] The market for wholesale trunk segments of TI leased lines was defined as a national market. We did not assess the trunk market for the Hull area as no market then existed – or was thought likely to do so on a forward looking basis - for trunk circuits within the Hull area. See the January 2008 consultative document, (esp. para 6.89) at (http://stakeholders.ofcom.org.uk/binaries/consultations/bcmr/summary/bcmr_pt2.pdf.

Table 2: Obligations imposed on BT and KCOM as a result of SMP findings

SMP obligation	Applying to market(s)
BT	

- Obligation to provide existing and new 2 Mbit/s leased lines
- Requirement not to unduly discriminate
- Publish a reference offer
- Plus the following BT voluntary undertakings:
  - Supply new analogue circuits until 1st Jan 2011
  - Supply new sub 2Mbit/s circuits until 1st Jan 2011
  - Prices of analogue circuits capped to RPI-0% until 2010
  - Further 2 year price cap to be agreed with Ofcom
- Cost orientation and accounting separation would apply only if BT fails to comply with the agreed caps, or if Ofcom and BT fail to agree a new 2 year price cap for 2011-12[25]
	1

- Obligation to provide network access - Requirement to not unduly discriminate - Cost orientation - Publish a reference offer - 90 days notice of changes - 28 days notice of new services - Publish quality of service information - Notify technical information within 90 days of request - Obligations relating to requests for new network access - Cost accounting and accounting separation - Charge control - a direction under the quality of service information obligation (Only for TI services) - a direction under the network access obligation relating to SLGs (only for AI services) - Partial Private Circuit direction (only for TI services)	2, 4, 6, 8, 10

- Handover products offering comprising:
  - Customer Sited Handover
  - In Span Handover extensions
  - In Span Handover
- Make available accommodation products to support disaggregated AI and later TI products
- In Building Handover for low bandwidth AI services and later for disaggregated TI products
	2, 4, 6, 8, 10

KCOM	
- Obligation to supply wholesale products on request - Requirement to not unduly discriminate - Publish a reference offer - Publish technical information - Voluntary price increases limited to RPI+0% until 2012 included for low, high and very high TI services - Voluntary price increases limited to RPI-16% until 2012 included for low bandwidth AI services - Cost orientation and accounting separation would apply only if KCOM fails to comply with the agreed caps	2, 4, 6, 8

[25] Ofcom and BT did not agree a new 2 year price cap for 2011-12.

Call for inputs

2.47 Before starting our substantive analysis in this review, we published on 21 April 2011 a Call for Inputs (CFI) to gather stakeholders' views on the key issues.[26]

2.48 In the CFI we sought stakeholders' views about the range of products and services that we should cover and the analytical approach for the review, including our approach to considering appropriate remedies. In particular:

i) we asked stakeholders about the issues that we need to consider;

ii) we tested some hypotheses relating to the status of some of the market definition findings of the last BCMR which we thought might not have changed materially;

iii) we gathered stakeholders' views on their overall experience with regulated access products, market entry and competition in relation to business connectivity markets throughout the UK; and

iv) we sought stakeholders' views on whether and how, in their view, these markets had changed since the last BCMR was completed, both from their own perspective and the perspective of their end-users.

2.49 We discuss the responses to the CFI at appropriate points throughout this document.

Impact assessment

2.50 The analysis presented in this document constitutes an impact assessment as defined in section 7 of the Act.

2.51 Impact assessments provide a valuable way of assessing different options for regulation and showing why the preferred option was chosen. They form part of best practice policy-making. This is reflected in section 7 of the Act, which means that generally we have to carry out impact assessments where our proposals would be likely to have a significant effect on businesses or the general public, or when there is a major change in Ofcom's activities. However, as a matter of policy Ofcom is committed to carrying out impact assessments in relation to the great majority of our policy decisions. For further information about our approach to impact assessments, see the guidelines, Better policy-making: Ofcom's approach to impact assessment, which are on our website: http://stakeholders.ofcom.org.uk/binaries/consultations/ia_guidelines/summary/condoc.pdf

Equality impact assessment

2.52 Annex 9 details our Equality Impact Assessment for this market review. Ofcom is separately required by statute to assess the potential impact of all our functions, policies, projects and practices on race, disability and gender equality. Equality Impact Assessments (EIAs) also assist us in making sure that we are meeting our principal duty of furthering the interests of citizens and consumers regardless of their background or identity. Unless we otherwise state in this document, it is not apparent to us that the outcome of our review is likely to have any particular impact on race,

[26] http://stakeholders.ofcom.org.uk/consultations/bcmr-inputs/

disability and gender equality. Specifically, we do not envisage the impact of any outcome to be to the detriment of any group of society.

2.53 Nor are we envisaging any need to carry out separate EIAs in relation to race or gender equality or equality schemes under the Northern Ireland and Disability Equality Schemes. This is because we anticipate that our regulatory intervention will affect all industry stakeholders equally and will not have a differential impact in relation to people of different gender or ethnicity, on consumers in Northern Ireland or on disabled consumers compared to consumers in general. Similarly, we are not envisaging making a distinction between consumers in different parts of the UK or between consumers on low incomes. Again, we believe that our intervention will not have a particular effect on one group of consumers over another.

Consultation period

2.54 We intend to consult for a period of ten weeks.

2.55 As set out above, we propose that charge controls form part of the appropriate remedies which should be imposed in some of the relevant markets. We will be publishing a separate LLCC consultation shortly in which we set out in greater detail our reasons for this proposal, including the nature, form and duration of the proposed charge controls.

2.56 The BCMR and LLCC consultations will overlap. However, we consider this is appropriate given that, as set out above, from a legal and procedural perspective the LLCC is actually one part of the market review – i.e. it forms part of our assessment of the appropriate remedies which should be imposed, where there has been a finding of SMP, based on the nature of the competition problem identified in the relevant markets.

2.57 Importantly, the current charge controls applying to BT expire at the end of September. Since we propose that charge controls remain part of the appropriate remedies to address the competition problems we have identified, then, assuming our market review confirms our proposals in this respect, from a legal perspective it is necessary for us to have concluded the market review for any new charge controls to come into force.

2.58 In our view, the period of ten weeks, even though it will overlap with the LLCC consultation, is sufficient and consistent with our Consultation Guidelines.[27] We are aware that according to our Consultation Guidelines, the BCMR would be regarded as a 'Category 1' consultation for which we would normally allow a consultation period of ten weeks. However, the ten week period is not a minimum period required under national legislation. For the purpose of this market review, the minimum period required for consultation under the Communications Act 2003 is in fact one month.[28]

Structure of this document

2.59 The rest of this document is structured as follows:

27 http://stakeholders.ofcom.org.uk/consultations/how-will-ofcom-consult

[28] See sections 48A(4), 49A(4) and 80A(6). The minimum consultation period may even be shorter if we are satisfied there are exceptional circumstances justifying the use of a shorter period (see sections 48A(5), 49A(5) and 80A(7).)

- Sections 3-6 of this document describe our proposals with respect to market definition: Section 3 describes our proposed retail product market definition for the leased lines market in the UK; Section 4 outlines our proposed wholesale product market definition. Section 5 identifies the geographic boundaries for our proposed wholesale product markets in the UK and Section 6 sets out our proposed product and geographic market definition for wholesale trunk;

- Section 7 describes our assessment of SMP in the markets identified;

- Section 8 discusses our approach to setting remedies for the markets where we have identified SMP; and

- Sections 9 to 15 discuss our proposals for remedies in those retail and wholesale leased lines markets where we have found SMP. Section 9 covers the retail low bandwidth TI market, Section 10 covers the wholesale TI markets, Section 11 the wholesale AI market, Section 12 the wholesale MI market, Section 13 accommodation and interconnection services, Section 14 our proposed remedies for the Hull market and finally Section 15 discusses our proposals for cost accounting and accounting separation.

2.60 There are also a number of annexes, covering the following:

- Annex 1 – List of respondents to the Call for Inputs

- Annexes 2-5 concern the process for responding to this consultation, Ofcom's consultation principles and the consultation questions set out in this review;

- Annex 6 describes the regulatory framework for market reviews;

- Annex 7 covers our approach to defining markets;

- Annex 8 explains our approach to analysing the data we have collected for the purposes of this review;

- Annex 9 sets out the background and context to the analysis we have carried out in relation to the replicability of low bandwidth digital leased lines;

- Annex 10 provides a summary of an exemption from BT's Undertakings in relation to Wavestream National;

- Annex 11 sets out a mapping of Openreach's legacy to new Ethernet services;

- Annex 12 discusses whether there may be a case to apply differential remedies for data centres;

- Annex 13 lists the main sources of evidence we have relied on in undertaking this market review;

- Annexes 14 and 15 set out the draft SMP conditions and Directions we are proposing to apply;

- Annex 16 sets out the Equality Impact Assessment we have carried out;

- Annex 17 is a glossary of specialist terms used in this document; and finally

- Annex 18 lists out the questions we have sought answers to from stakeholders under formal information gathering powers.

Section 3

Retail product market definition

Introduction

3.1 This section sets out how we propose to define product markets at the retail level. Our proposals are set out in Table 3 below. This assessment enables us, firstly, to move on to define relevant upstream wholesale product and geographic markets, and then to determine whether any providers have SMP in those markets. Secondly, it enables as to consider whether it is appropriate, applying the three criteria test set out in the Commission's recommendation on relevant product and service markets, to identify any relevant retail product markets which are included in the Annex to that recommendation for the purposes of making market power determinations.

3.2 In summary, we have based our proposals on our analysis of retail services. We have structured the presentation of our analysis below so as to focus discussion on particular issues raised by stakeholders in response to the CFI.

Table 3: Summary of proposed retail product market definitions

Retail product markets	Bandwidth breaks			
TI retail leased lines	**Low bandwidth** - Up to and including 8Mbit/s (including analogue and SDSL services)	**Medium bandwidth -** Above 8Mbit/s up to and including 45Mbit/s	**High bandwidth** - Above 45Mbit/s and up to and including 155Mbit/s	**Very high bandwidth -** 622Mbit/s
AI leased lines	**Low** - Up to and including 1Gbit/s (including EFM services)			
MI leased lines	**Multiple Interface -** AI leased lines over 1Gbit/s and WDM services with all bandwidths and interfaces.			

Summary of Approach

3.3 The purpose of this section is to propose the scope of the retail product markets for leased lines.

3.4 We have followed our standard approach to market definition (as explained in more detail in Annex 7). The key steps are as follows:

- The first stage of the analysis is to consider the key characteristics of the services that might be classified as leased lines and to identify a set of focal services which form the starting point of our analysis;
- We then determine the market boundaries, meaning the range of services that fall within each market. These boundaries are determined by constraints on the price setting behaviour of firms. As discussed in Annex 7, we consider that two main types of constraint are relevant in this review:
  - Demand-side substitution - the extent to which end-users could substitute other services for those in question; and

- Homogeneity of competitive conditions - the extent to which levels of competition for the services in question are the same;

- We initially explore the constraints between the focal services and subsequently consider a wider set of services which do not exhibit all the characteristics of leased lines but may still impose a competitive constraint on leased line services.

3.5 In the CFI we set out our preliminary views about the key issues in relation to the product market definition, in particular focusing on areas where there may have been material change since the 2007/8 Review and noting where, in our view, material changes were unlikely to have occurred. We invited stakeholders to comment both on the issues we had identified and any other matters they considered particularly relevant.

3.6 In the responses to the CFI there was broad high level agreement on the key issues identified, in relation to retail market definition, and no stakeholder suggested that there were other issues that should be highlighted. The broad agreement on both points has allowed us to structure the discussion of our analysis in this section around the issues that we identified in the CFI as particularly salient. Table 4 sets out these issues and refers to the paragraphs in which each are discussed.[29]

Table 4: Structure of retail product market definition section

Issue	Summary of issue being considered	Reference
Issue 1: Technology and service requirements	Some types of leased lines might not be able to meet the service requirements of all end-users - how material is this to our assessment of market definition?	§ 3.13 - 3.74
Issue 2: Virtual Private Networks (VPNs)	Are business connectivity services provided over VPNs in the same market as leased lines?	§ 3.75 - 3.172
Issue 3: Broadband markets	Are symmetric or asymmetric broadband services a substitute for low bandwidth leased lines?	§ 3.87- 3.172
Issue 4: Bandwidth breaks	Can separate markets for leased lines at different bandwidths be identified?	§ 3.173 - 3.246
Issue 5: Wave Division Multiplex (WDM) services	Do WDM services fall within either or both of the TI or AI leased lines market?	§ 3.247 -3.299

3.7 For each of these issues we have taken the following into account where applicable:

- our assessment in the 2007/8 Review;

- stakeholders' responses to the CFI;

[29] We note that the standard approach to market definition is to start with the narrowest product market and then apply the SSNIP test to see if it can be broadened. However, given the complexity of the services considered and the number of possible permutations we would have to analyse, we consider that the approach set out above, which closely follows the approach set out in the 2007/8 Review, is the most appropriate.

- qualitative analysis of differences in the characteristics of the services;
- the results of a survey of end-users; and
- market developments since the 2007/8 Review, including an analysis of differences in relative prices and trends in usage.

Scope of our assessment

3.8 A leased line is a service that provides dedicated symmetric transmission capacity to carry voice and/or data traffic. Dedicated in this context mean uncontended, and symmetric means there are identical transmit and receive data rates. They are used to provide enterprise networks to carry inter-site and inter-company traffic. The terminology used in this section is further explained in the Glossary at Annex 17.

3.9 Our retail product market assessment is mainly concerned with services sold to end-user business consumers to support their business connectivity needs. Many of these consumers are willing to pay a premium for dedicated services that give them high quality connectivity. This reflects the connectivity requirements of their own businesses, for instance large financial institutions that require high quality connections to reliably transmit data. Quality requirements may differ for different consumer types, but in general, end-users that demand leased lines services need to ensure that they have reliable connectivity services that guarantee delivery of their voice, data and/or video services to a high standard.

Approach

3.10 We analyse each of the service types introduced in Section 2 and consider whether there are distinct leased lines markets based on the prices and the different characteristics of those services. Rather than starting from the view that there is an ‘intrinsic’ demand for particular service types we focus on the key underlying technical characteristics of each service. These are summarised in Table 5 below.

Table 5: Key technical characteristics of leased line services

Characteristic	Definition
Availability	The percentage of time a transmission path is in a functioning condition.
Bandwidth	In digital telecommunications systems the rate at which information can be transferred. Measured in bits per second (bit/s).
Contention	A measure of whether a service provides dedicated capacity to an end-user or whether that capacity is shared amongst a number of end-users. A dedicated connection has a contention of zero.
Jitter	A measure of the variation of delay in transmission over a transmission path.
Latency	A measure of delay in transmission over a transmission path.
Range	The distance over which transmission is supported.
Resilience	Provision of alternative resources (equipment or route) to protect against failure and enabling higher availability.
Security	A measure of the confidentiality and integrity of a communications service.
Symmetry	The ratio of transmitted to received bandwidth. If a service is symmetric the transmit and receive bandwidths are identical. If the service is asymmetric these bandwidths differ.
Synchronisation	The delivery of the accurate timing information needed for services such as mobile backhaul and telemetry.

Source: Ofcom 2012

3.11 The services vary in terms of these characteristics and prices. End-users' demand for these services is generally likely to be related to the trade-off between price and particular characteristics that each service delivers. The differences in these service characteristics may be important reasons why end-users require a particular type of leased line service over another. We use this analysis to specify market boundaries by determining which services are demand-side substitutes for each other. We also consider whether further separate markets may be identified in terms of other characteristics (e.g. based on bandwidth).

3.12 In addition, we need to consider whether a wider set of products and services, which were not included in the initial starting definition of leased lines, might act to constrain some or all of the starting leased line services. These alternative telecommunications services do not share all of the typical characteristics of a leased line, but they may be a realistic alternative for sufficient (current) users of leased lines to impose a competitive constraint. For example ADSL broadband and some VPNs do not provide dedicated capacity (and they may entail some compromises in service quality), but they may be able to deliver a sufficiently high service quality to act as a competitive constraint on certain leased line services. At the other end of the spectrum there are other 'high-end' business connectivity services - such as WDM

services - currently sold at a premium that may also be in a leased line market. Therefore, our retail market assessment considers both the narrow set of leased lines services and the wider products and services, which might act to constrain some or all of the starting leased line services.

Issue 1: Technology and service requirements

3.13 As discussed above, our starting point is to assess demand for dedicated leased lines services. Given end-users have specific service requirements; we consider whether the characteristics of particular leased lines services matter and whether the differences are significant enough to lead to separate markets for leased lines services with different technological characteristics.[30]

3.14 In the 2007/8 Review we defined two types of leased line services, 'Traditional Interface' (TI) services and 'Alternative Interface' (AI) services. As discussed in Section 2 TI services provide dedicated symmetric transmission at a range of bandwidths between two third party end-user premises using SDH or PDH transmission via copper or fibre. In the 2007/8 Review we also defined analogue circuits as a TI service.

3.15 Similarly, AI services also provide dedicated symmetric transmission at a range of bandwidths between two third party end-user premises, but this is supplied generally by means of Ethernet over fibre. It should be noted that Ethernet is not the only form of alternative interface (as discussed in Section 2 above) and that AI services can be supplied over copper. For example Ethernet First Mile (EFM) services are based on multiple copper access lines bonded together[31] and at the retail level are used to deliver Ethernet at low bandwidths to businesses. As EFM services offer similar functionality to low bandwidth Ethernet leased lines, in the 2007/8 Review we considered that EFM services could not be seen as a separate market from the current low bandwidth retail AI market, but rather that it was a different way of providing a retail AI service.

3.16 Below we review whether analogue and SDH/PDH leased lines are still in the same market, before considering whether technological differences and end-user service requirements are such that separate markets continue to exist for TI and AI services. Having done so, we propose that analogue and SDH/PDH leased lines are still in the same market and that there continues to be separate markets for TI and AI services.

(i) Analogue and SDH/PDH leased lines

Our assessment in the 2007/8 Review

3.17 In the 2007/8 Review we included analogue and low bandwidth SDH/PDH leased lines in the same market predominantly based on the following factors:

- analogue leased lines offer broadly equivalent functionality to low bandwidth digital SDH/PDH leased lines. It would be straightforward to adapt an analogue leased line to transmit digital information and to adapt a digital leased line to transmit analogue signals;

[30] Note here our assessment is focused on the different technologies associated with dedicated leased lines connections. Wider telecommunication services that may be a substitute to leased lines are discussed under Issue 2 (VPNs) and Issue 3 (Broadband) in this section.

[31] Copper access lines are available to all CPs due to the requirement on BT to provide unbundled local loops at a cost-oriented price which is a remedy arising from BT's SMP in the wholesale local access market.

- our analysis of the underlying costs of provision suggested that, for a given bandwidth, the prices in a competitive market were likely to be similar.[32] We noted that similar functionality and prices makes it likely that a SSNIP above the competitive price level of analogue circuits would be unprofitable due to switching to low bandwidth SDH/PDH circuits and vice versa; and

- in our end-user survey a relatively high number of consumers of each service claimed that they would be likely to switch to the other service in response to a SSNIP (in particular the stated amount of switching tended to significantly exceed the critical loss for each service).[33]

3.18 We therefore concluded that the low bandwidth retail TI market (at least) consisted of analogue and SDH/PDH services.[34]

Call for inputs

3.19 In the CFI we invited stakeholders to tell us about any issues they considered relevant, but we did not specifically ask about this issue, as we considered that the factors informing the analysis in the 2007/8 Review were unlikely to have changed materially.

Stakeholder views

3.20 We did not receive any comments from any respondent to the CFI on this issue.

Ofcom analysis

3.21 Given that, as set out in the CFI, we did not consider that material change could reasonably be expected to have occurred, we are not proposing to include a detailed discussion of our analysis of this issue. However, we note briefly that we consider the following factors, which were particularly relevant in the 2007/8 Review, remain relevant today:

- the services in question are based on legacy technologies which are no longer being developed and therefore the functional capabilities of the technologies are unlikely to have changed significantly;

- the relative costs of provision, and hence the level of prices in a competitive market, of the two services remains relevant. As we explained in detail in the 2007/8 Review, many analogue and low bandwidth digital leased lines run on the same network using the same technology; this suggests that any significant changes in costs are likely to affect both services and hence be reflected in the competitive price levels of both; and

- research in the 2007/8 Review found that end-users would be likely to switch between these services in response to SSNIP, which is the relevant

[32] We noted in the 2007/8 Review that analogue and 64kbit/s leased lines are provided on the same PDH platform and the only significant difference between the two services was the terminal equipment provided at each end of the service.

[33] The critical loss is the amount of switching just sufficient to render the SSNIP unprofitable.

[34] Note here our discussion sets out the rationale for analogue and sub-2Mbit/s services being in the same market. In the 2007/8 Review we considered that these services are also in the same market as TI services at 2Mbit/s and up to 8Mbit/s based on a chain of substitution between the bandwidths. This is reviewed under Issue 4.

consideration for market definition purposes. Since the services are based on legacy technologies, the profile of end-users is unlikely to have changed materially, and we consider the end-user research conducted for the 2007/8 Review remains robust.

Proposed market definition

3.22 On the basis of our analysis, we consider that analogue and low bandwidth SDH/PDH leased lines are in the same market (i.e. that the market is at least as wide as low bandwidth retail TI consisting of analogue and SDH/PDH services). We note that this is consistent with the conclusions of the 2007/8 Review.

(ii) Traditional interface versus alternative interface

3.23 Here we consider whether there continue to be distinct retail markets for AI and TI leased lines or whether or not these services might fall within the same market. We propose that there continues to be distinct markets.

Our assessment in the 2007/8 Review

3.24 In the 2007/8 Review we focused our analysis on TI leased lines and Ethernet leased lines. We concluded there were separate markets for Ethernet leased lines and TI leased lines. Our conclusion was supported by a qualitative assessment that found significant differences in their functional characteristics. On a forward looking basis[35], we expected the deployment of 'carrier class' Ethernet leased lines services by CPs would address most of these technological barriers. However, the market-wide adoption of carrier class Ethernet services by CPs appeared to be between two and five years away. Given this, and the length of investment cycles of CPs and enterprises, we expected that migration to carrier class Ethernet would not be completed during the timeframe of the review.

3.25 We also considered the pricing of the two types of services and migration trends. For high bandwidth circuits (above 10Mbit/s) the pricing analysis showed that TI circuits were markedly more expensive than AI circuits. This suggested that at higher bandwidths SDH/PDH circuits would not constrain the price of Ethernet circuits.[36] We also found evidence to suggest the result holds in the other direction and at higher bandwidths Ethernet did not constrain the price of SDH/PDH circuits. This was because our trend analysis suggested that switching between SDH/PDH and Ethernet had not been observed to an appreciable extent which, given the large price differentials and savings available, suggested that some important aspects of SDH/PDH-based services could not be replicated by an Ethernet-based service and that this was limiting the extent of demand-side substitution. At lower bandwidths (below 10Mbit/s) AI services only became economic to use for bandwidth requirements above 6Mbit/s. We also observed that volume trends showed that there continued to be a significant retail demand for low bandwidth TI leased lines.

Call for Inputs

3.26 In the CFI we noted that the migration trends from SDH/PDH to Ethernet observed in the 2007/8 Review and the growth in Ethernet services had continued strongly, but a

[35] As discussed in Section 2 the forward look covers the period of the review.

[36] In these circumstances, it is unlikely that existing users of Ethernet services would switch to SDH/PDH services in response to a SSNIP.

core of retail end-users continue to operate legacy services which rely on SDH and PDH services. On this basis we set out our preliminary view that, as we concluded in the 2007/8 Review, there are separate markets for TI and AI services. We invited stakeholders to comment on whether the characteristics of TI and AI services are such that separate markets continue to exist.

Stakeholder views

3.27 Eleven respondents commented on our question on AI and TI services [✂ ✂ ✂ ✂] and all bar one respondent agreed with our preliminary view that there remain separate markets for AI and TI services.

3.28 In support of this view, a number of points were made:

- one respondent [✂ ✂] noted that there are certain characteristics of AI and TI services that are not replicable by the other. This means that there are many instances in which, for example, a suitable AI based substitute to a TI service does not exist. The respondent thought this situation was unlikely to change during the period covered by the market review;

- supporting this Verizon noted that while some end-users regard AI and TI services as interchangeable for data applications, for some applications, notably legacy voice, TI services are still required;

- similarly MBNL and Three noted that although there is a degree of substitution from TI to AI services, there are still some significant barriers to switching, and these are likely to endure throughout the course of the next review period. In particular they highlighted issues posed by resilience requirements;

- Fujitsu noted that AI and TI are based on very different technologies;

- C&WW noted that from an end-user's perspective TI services continue to be regarded as offering superior functionality, service characteristics and service wrap, pointing to distinct service markets for AI and TI services; and

- BT agreed that TI and AI markets would remain separate at the retail level but said that they expected "step" reductions in TI demand as large end-users switch to AI, reducing the relative importance of the market for TI services.

3.29 A number of respondents also noted that TI leased lines services are now in long term decline as end-users migrate either to AI or to broadband services. BT thought that the decline in TI services was likely to accelerate as technical issues relating to Ethernet are resolved and businesses substitute TI leased lines with broadband and superfast broadband services. UKCTA however thought that TI services would continue to play an important role in the provision of business connectivity services throughout the review period and beyond. On this point they noted that there had been speculation about the future of TI services for many years and that the decline forecast in the 2007/8 Review and the 2009 LLCC had not materialised.

3.30 The respondent [✂ ✂] who disagreed with the distinction between AI and TI argued that such a classification was artificial and that the primary concern of end-users is the cost of bandwidth. This respondent argued that Ofcom should focus on access fibre remedies rather than on leased lines technologies.

Ofcom analysis

3.31 In our view, which reflects the approach in the 2007/8 Review and which was supported by the responses to the CFI, it is appropriate to assess the following factors in determining whether TI and AI are in separate markets:

- a qualitative assessment of the current capabilities of AI and TI services;
- a forward looking assessment of market developments;
- evidence from consumer surveys;
- relative price comparisons;
- a discussion of migration trends; and
- an assessment of barriers to switching.

Qualitative assessment

3.32 In the 2007/8 Review we noted there were similarities between TI SDH/PDH based leased lines and Ethernet leased lines in that they offer symmetric dedicated transmission capacity between two points. However, we also noted that there were significant differences between AI and TI services in relation to several key characteristics, namely:

- latency, jitter and synchronisation;
- resilience; and
- distance limitations.

3.33 Since the 2007/8 Review carrier class Ethernet equipment based on IEEE, ITU-T and MEF standards have become available and has been deployed by CPs, including BT.[37] Over the course of the next review period we expect carrier class Ethernet to gradually displace earlier Ethernet services. Carrier class Ethernet services have narrowed the differences between Ethernet and SDH/PDH services as illustrated in Table 6 below which compares the key features of SDH/PDH and carrier class point-to-point Ethernet leased lines services.

[37] The Institute of Electrical and Electronic Engineers (IEEE) modified the Ethernet standards to improve management and scalability. Further work by the IEEE and the International Telecommunications Union Telecommunications Standardisation Sector (ITU-T) added operations, administration and maintenance functionality. Alongside this, work by the Metro Ethernet Forum (MEF) defined the characteristics of Ethernet based services to facilitate interworking between equipment and networks.

Table 6: Comparison of key features of SDH/PDH and carrier class point-to-point Ethernet leased line services

	Point-to-point Ethernet (carrier class)	**SDH/PDH**
Contention	Dedicated	Dedicated
Distance limitations	Not limited	Not limited
Jitter	Low (load dependent[38])	Low
Latency	Low (load dependent)	Low
Resilience	High	High
Symmetry	Symmetrical	Symmetrical
Synchronisation	Networks supporting resilient synchronisation beginning to be deployed. Not supported by older carrier Ethernet services	Networks support resilient synchronisation of end-user equipment

Source: Ofcom 2012

Latency, jitter and synchronisation

3.34 In the 2007/8 Review we identified these characteristics as important differentiators between SDH/PDH and Ethernet services.

3.35 SDH/PDH leased lines are used for their ability to deliver Time Division Multiplexed (TDM) services which are deterministic in operation and therefore offer low and predictable latency and jitter and support for synchronisation. These features are important for certain applications including for example:

- electricity network protection applications - electricity networks use TI leased lines for telemetry applications that control their electricity distribution networks. These applications require low delay and jitter performance;
- mobile backhaul - mobile operators have to keep their mobile base stations synchronised to a reference clock source. TI leased lines are used to backhaul traffic from base stations to mobile switching centres and as a reference timing source to maintain synchronisation (see Section 2 for a more detailed discussion); and
- legacy voice services - TDM telephony services such as ISDN Primary Rate Interface (also known as ISDN30) are designed to use TDM leased lines as their bearer circuits.

3.36 In the 2007/8 Review we found that Ethernet services had a higher and more variable latency and jitter and were unable to support synchronisation.

[38] See paragraph 3.37 for explanation.

3.37 Ethernet services use packet transmission techniques and unlike SDH/PDH services are designed to handle bursts of traffic that exceed the service capacity. They do this by buffering traffic for later transmission. Therefore latency and jitter performance inevitably degrade at high traffic loads. However, provided that traffic loads are adequately managed, carrier class Ethernet services used in point-to-point solutions offer latency and jitter performance that is comparable with SDH/PDH services.[39]

3.38 To the extent that differences in latency and jitter performance remain, these differences are becoming less important as mainstream enterprise applications are increasingly migrating to Ethernet/IP technologies and are therefore designed to accommodate the performance characteristics of Ethernet services. For example IP based enterprise voice telephony applications such as SIP Trunking and IP Centrex can use Ethernet leased lines services unlike their predecessors that require SDH/PDH leased lines.

3.39 Another major development since the last market review is that CPs are beginning to deploy carrier class Ethernet services that support synchronisation protocols such as SyncE and IEEE 1588. The main application for these services is expected to be mobile backhaul (see Section 2 for a more detailed discussion).

Distance limitations

3.40 In the 2007/8 Review we reported that the majority of Ethernet services were being used for short haul services (such as local LAN interconnect) covering distances up to 5km, in part reflecting distance limitations for early Ethernet services. These distance limitations have now largely disappeared and CPs now offer long distance services across the UK.[40]

Resilience

3.41 In the 2007/8 Review we reported that Ethernet services were based predominantly on point-to-point fibre circuits and did not offer the same level of resiliency as SDH/PDH services. Since the 2007/8 Review, this issue has been largely addressed by CPs who have launched new carrier class point-to-point services with high resilience options (such as dual circuits with diversified routing and automatic switchover) that more closely match the capabilities of SDH/PDH services.

Forward looking assessment

3.42 As part of this qualitative assessment we have also considered market developments over the timeframe of this review. This is to assess whether expected market developments could impact our conclusions.

3.43 Ethernet leased lines services have developed considerably since we first examined them in our 2003/4 Review and with the widespread deployment of carrier class services Ethernet can now be considered a mature service. Thus from a technical perspective, we are not expecting major innovations over the timeframe of this review other than the deployment of services supporting synchronisation.

[39] See for example MEF service description provided here: http://metroethernetforum.org/metro-ethernet-services.pdf

[40] As noted in Table 6, the introduction of defined carrier class Ethernet standards have enabled long distance native Ethernet services to be carried.

3.44 Although Ethernet services cannot match all of the characteristics of SDH/PDH services, as discussed above, these differences are becoming progressively less important as mainstream enterprise applications migrate to Ethernet/IP technologies and are therefore able to use Ethernet leased lines. Thus whilst legacy applications and some specialist applications will continue to require SDH/PDH leased lines we expect that business will increasingly favour Ethernet services over TI services. However, migration of enterprise applications can be disruptive and typically requires investment in new or upgraded equipment. We therefore expect migration to proceed gradually and that there will be significant demand for TI leased lines during the timescale of this review and beyond.

Consumer survey analysis

3.45 To help establish the importance of service characteristics to end-users of leased lines we refer to an independent market research report commissioned by Ofcom, which was carried out by Jigsaw research. The market research involved interviews conducted in the summer of 2011 with 461 companies that purchase business connectivity services. The companies were selected to provide coverage of a range of business sizes, industry sectors and regions.[41]

3.46 Although these survey results have been used to inform our market definitions, the results should be seen as suggestive rather than definitive as they are subject to important caveats. Notably, they are based on claimed behaviour as opposed to observed consumer behaviour and, despite being based on robust sample sizes, can be subject to certain margins of error. In particular when interpreting the research results care is also needed for the following reasons:

- for some service groupings and questions there are small sample sizes which means that in some cases analysis of the results can only be indicative;[42]
- some technologies may be able to offer a greater range of services and hence it may be that end-users find it difficult to isolate the service that is of interest, e.g. the leased line service may also include value-added managed IT solutions as part of the contract;[43] and
- there may be other factors that influence consumer choice, such as whether they have an affinity to a particular service provider's brand, which means that the consumer would be willing to pay a premium to access that brand, even if it is only available on a sub-set of technologies.

[41] The research sample was structured to ensure an even split between small (10-100 employees), medium (101-500) and large (501+) companies. Sector and region were broadly represented but some of the low incidence sectors or regions were boosted to allow for analysis. In addition, we note that survey participants were a random sample; this means that (subject to sample size) the survey can provide us with robust inferences to the demands of the broader population of leased line end-users.

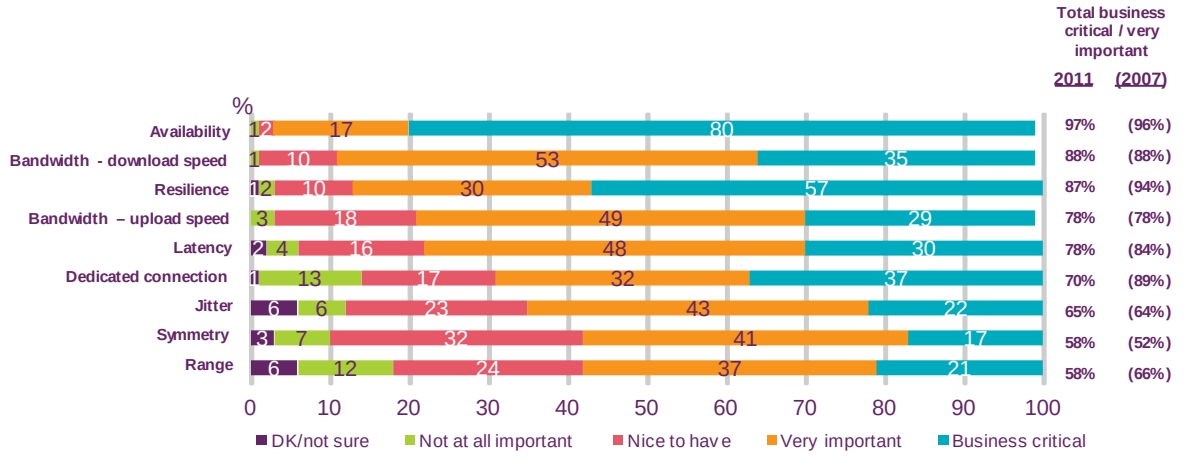
[42] In some cases this reflects the low overall population of respondents that used particular leased line services or in a particular sector or region. In addition, some questions were "nested" such that an initial question may yield multiple answers. Hence, even where initial sample sizes were quite high, because questions asked of a smaller sub-set of the original sample this sometimes resulted in insufficiently large samples for the follow-up questions.

[43] A possible way to overcome this is to use conjoint analysis which requires research participants to make a series of trade-offs to isolate the service that is of interest. This approach was used in the consumer survey in the 2007/8 Review, but we were unable to obtain robust results. Therefore we have not tried to replicate the results of the analysis for this review.

3.47 A full copy of the independent market research report is available on Ofcom's website.[44]

3.48 In order to inform our understanding of the importance of the different service characteristics of a leased line, we asked those interviewed to rate the importance of nine service characteristics to their business on a scale from business critical, to not at all important. Figure 4 below provides a summary of these results and provides a comparison with the results of the 2007/8 Review where the same question was also asked. As discussed above, jitter and latency are the two characteristics where TI and AI leased lines differ most markedly. The figure shows that the importance attached to these features by users of business connectivity services is broadly the same as in 2007, although the importance of latency appears to be lower than in 2007, with 78% of businesses now describing it as either "very important" or "business critical" (compared to 84% in 2007), although this change is not statistically significant.

Figure 4: The importance of service characteristics



Source: Ofcom end-user research, QC1 (2011 n=461; 2007 n=450)

3.49 Expanding on this question respondents were asked to think about how their business connectivity requirements might evolve over the next two years,[45] and to state whether each of the above service characteristics is likely to become more important, less important or to stay about the same in importance. For each of the characteristics listed above, over 95% of respondents stated that the characteristic would be more important or stay about the same in importance over the next two years. Only a small proportion (<5%) of respondents thought that latency and jitter would become less important, while 28% thought that latency would become more important and 23% thought jitter would become more important. If this is borne out in practice, it may act as a brake on migration from TI to AI service, tending to offset the reduction in the disparity between TI and AI latency and jitter performance.

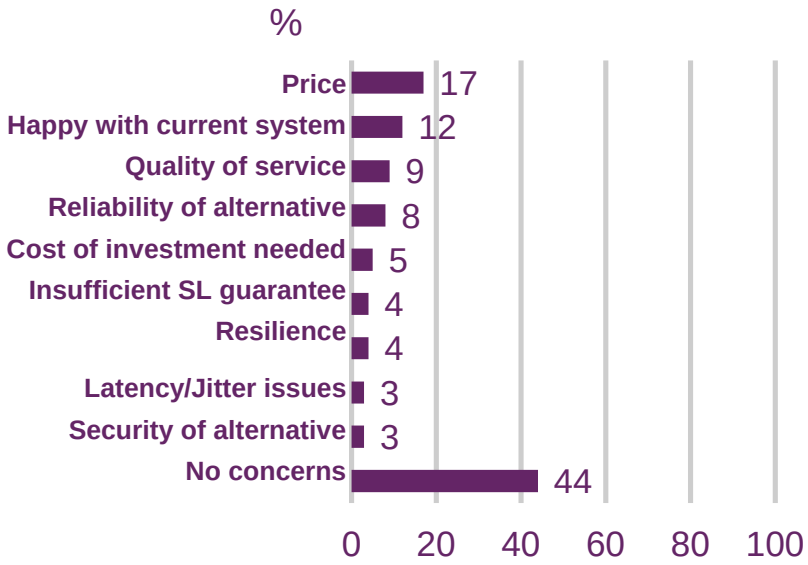
3.50 We also asked current users of TI services to consider the service characteristics of analogue or SDH/PDH leased lines compared to Ethernet leased lines and to identify the challenges or concerns they have about replacing analogue or SDH/PDH leased

[44] http://stakeholders.ofcom.org.uk/binaries/consultations/business-connectivity/annexes/business-review.pdf

[45] This question was based on a two year time horizon which was considered to be a reasonable planning period and comparable to our forward look, which covers the duration of this review.

lines with Ethernet lines. Respondents were able to identify more than one challenge or concern. The results across all respondents are summarised below in Figure 5.

Figure 5: Challenged or concerns about replacing TI services with Ethernet



Source: Ofcom end-user research, QE5 (n=177)

3.51 The responses to this question indicate that notwithstanding respondents' views about the increasing importance of latency and jitter over the next two years, only a small minority consider these characteristics to be a barrier to switching from TI to AI leased lines. Several of the other challenges and concerns identified by respondents may however relate to differences in the characteristics of TI and AI leased lines, or at least end-users perceptions of them (quality of service, reliability of alternative, insufficient service levels guarantees (SLGs), resilience, and security of alternative). Among those who do mention challenges or concerns around replacing TI services with Ethernet, price (17%) and 'being happy with current system' (12%) are the two most quoted challenges/concerns.

3.52 The above results from the end-user research suggests that there has not been a fundamental change in end-users' service requirements since the 2007/8 Review and that with the advances in AI some end-users perceive there to be fewer challenges to switching to Ethernet. However, at the same time, there are still many TI end-users who identify challenges and concerns about switching to Ethernet that relate to differences in the characteristics of TI and AI leased lines or at least a perception of them.

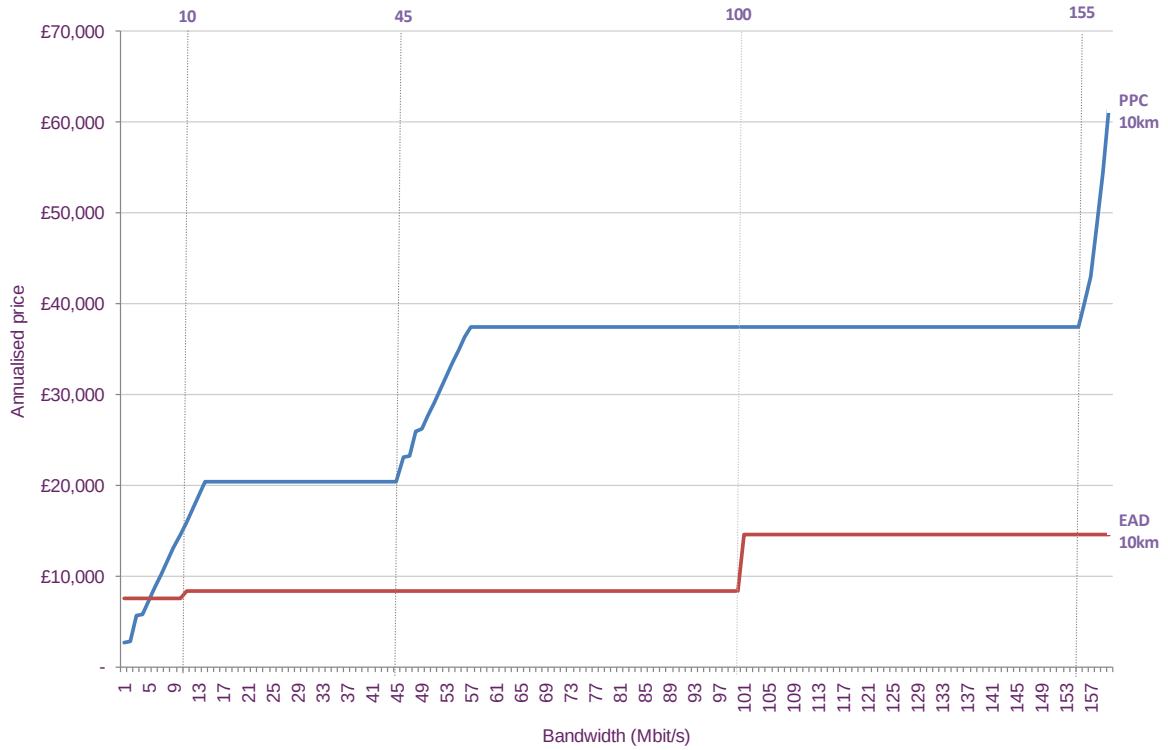
Relative price comparisons

3.53 In this section we compare the relative prices of AI and TI services. Figure 6 below provides an updated assessment of the relative prices of AI and SDH/PDH services across a range of bandwidths. In line with the 2007/8 Review, the modelling is based on the current underlying wholesale input services and prices, namely BT's EAD (AI) and PPC (TI) prices, with the assumption that these prices should provide a reasonable proxy for the relative differences in competitive retail price levels between services.[46] The analysis is based on circuits of 10km and outside of the Central

[46] The figure has been constructed on the basis that the prevailing wholesale prices are at competitive levels.This is in line with EC guidelines, which state that we should proceed on this basis unless there is evidence that this is not the case, and this applies both to unregulated prices, and also to regulated, cost-based prices (SMP

London Zone (CLZ).[47] As a sensitivity we have tested these relationships across a range of distances and our analysis shows that the general picture holds at both lower and higher distances.

Figure 6: PPC/EAD wholesale price comparison by bandwidth for a 10km service



Source: Ofcom analysis, based on BT wholesale pricelists for PPC and EAD services

3.54 The figure shows that at higher bandwidths, SDH/PDH circuits are still markedly more expensive than an Ethernet equivalent, which suggests that at higher bandwidths SDH/PDH circuits do not constrain the price of Ethernet circuits. At low bandwidths up to 6Mbit/s it would still be cheaper to buy a PPC, whereas at higher bandwidths, it would be more economic to use an Ethernet service if this met end-users requirements. Both of these results correspond broadly to the findings in the 2007/8 Review.

3.55 We have also considered the pricing of EFM services which provide Ethernet connectivity over multiple copper access lines. As EFM services use existing copper infrastructure they do not require the deployment of fibre. This means that EFM can be a lower cost alternative to dedicated fibre based leased lines. To compare the relative prices of EFM and other leased line services we have conducted research on the pricing of EFM packages offered by CPs. The research was carried out in February 2012 and is based on publicly available information on CPs' websites. In

Guidelines, paragraph 42). We note however that there is the possibility that actual retail prices may differ from the wholesale cost, for example because of the way relative prices are set to recover common costs or because, if competition is not yet effective at the retail level, there is some supernormal profit. Both of these factors may have affected actual patterns of usage at the retail level.

[47] CLZ refers to an area of London served by the 0207 dialling code. For the CLZ, BT applies different tariffs for some, but not all, of its leased lines services.

total we reviewed the packages offered by seven CPs, identifying 30 individual offerings.[48]

3.56 Across the packages surveyed there was a considerable variation in EFM prices reflecting the different available bandwidths and service wraps. The most commonly offered bandwidths were 2Mbit/s, 10Mbit/s and 20Mbit/s, though increments between these bandwidths were available up to 45Mbit/s. On average, across the packages surveyed a 2Mbit/s service cost £2,000 per year, a 10Mbit/s service cost £4,800 per year and a 20Mbit/s service cost £7,300 per year.[49] At each bandwidth there was also a range of prices which in part reflected different service wraps, where at a given bandwidth higher priced services can be seen as 'Premium' services offering enhanced features compared with 'Basic' EFM. Enhanced features vary by package but typically included higher level service guarantees and priority customer support. Differentials in service wraps are to some extent reflected in the highest and lowest prices at a given bandwidth and this is highlighted in Table 7 below.

Table 7: Annualised prices for EFM services by bandwidth

Bandwidth	Number of packages	Average price	Lowest price package	Highest price package
2Mbit/s	4	£2,000	£1,500	£2,900
10Mbit/s	7	£4,800	£2,000	£8,400
20Mbit/s	6	£7,300	£3,200	£13,200

Source: Publicly available prices on CPs' websites

3.57 We have also compared the prices of EFM, PPC and standard fibre-based Ethernet services. To provide 2Mbit/s using a PPC in the same exchange area would cost approximately £2,000, increasing to £10,000 for 10Mbit/s and £13,000 for 20Mbit/s.[50] For standard fibre-based Ethernet our estimates indicate that a 10Mbit/s service would cost approximately £3,000, increasing to just under £5,000 for a 100Mbit/s service.[51] A comparison with the EFM prices discussed above shows that EFM is priced at comparable levels to PPCs at 2Mbit/s. Packages are also available at 10Mbit/s and 20Mbit/s that undercut the charges for EADLA at 10Mbit/s and 100Mbit/s.[52] However, as bandwidth increases EFM becomes less economical (reflecting the cost of using additional copper access lines). This can be seen by looking at the most expensive EFM package covered by our research which was for 45Mbit/s. This cost approximately £22,200 per year.

[48] The research is based on the available prices for a three year contract; this is to allow easy comparison with our PPC and EAD prices which are also calculated over a three year term. If applicable the annual charges include the connection charge which has been annualised over the three years. Our sample of EFM prices was limited because the majority of CPs do not provide pricing information publicly and instead price on application. We note that this means that we have the risk of sample bias, as we only have a limited number of CPs in our data and there is the possibility that the unpublished prices could be significantly higher or lower than the ones collected in our research.

[49] Our research included four packages at 2Mbit/s, seven packages at 10Mbit/s and six packages at 20Mbit/s.

[50] This and the EADLA charges have been calculated using the wholesale input prices using the same methodology as Figure 6.

[51] This is based on EADLA which is only available in same exchange areas.

[52] If there is no existing fibre and excess construction charges have to be incurred to deploy fibre this would increase this effect.

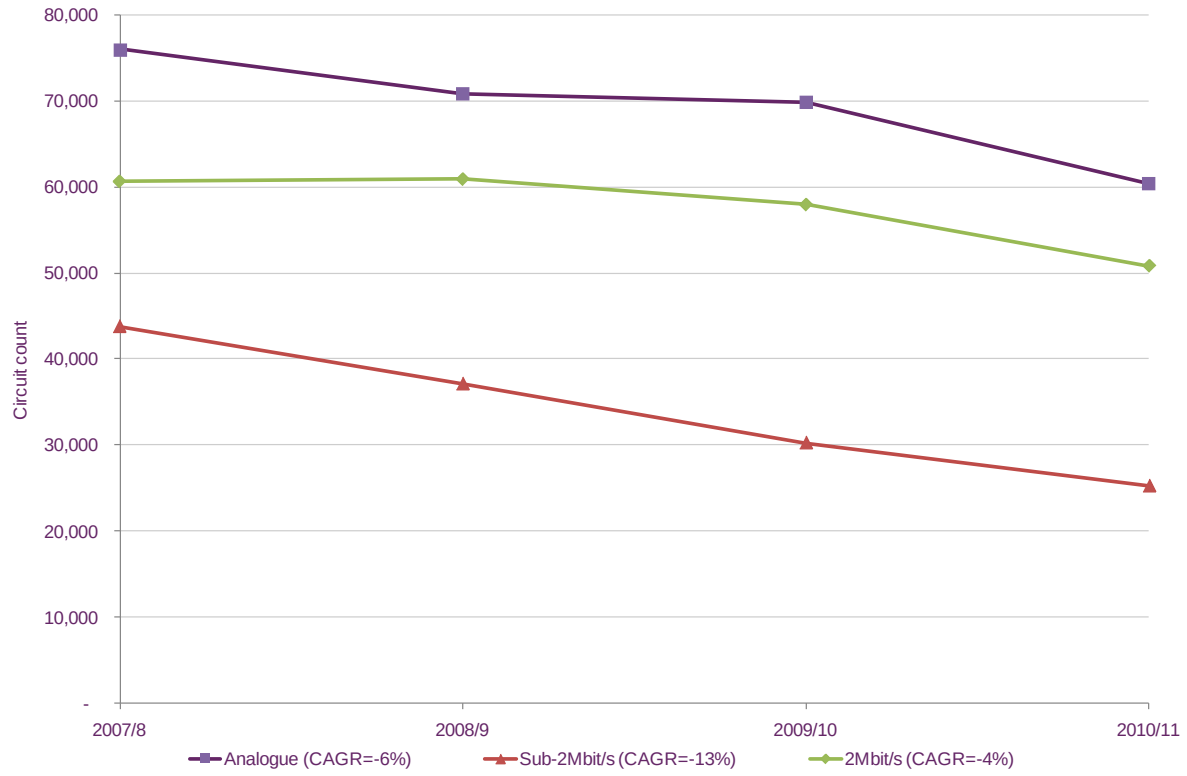
3.58 This analysis highlights that EFM services are most likely to be a substitute for fibre-based Ethernet and PPCs (for users who do not require TI functionality) at low bandwidths. To assess the extent of this and the implications of EFM, if any, for market definition, we discuss the available volume data below.

Migration trends

3.59 Since the 2007/8 Review there have been significant structural changes in demand for business connectivity services, with a shift away from analogue and SDH/PDH leased lines towards Ethernet. To illustrate this, below we show how the retail market has evolved by looking at the retail installed service volume data provided to us by CPs. This data is subject to some important caveats. In particular, some CPs were not able to collate full historic data for service volumes, while a number of CPs were not able to break out historic service volumes by bandwidth.[53] Nevertheless, we consider that the data should provide a reasonable guide to market developments over the last four years.

3.60 Trends in TI services are shown in Figure 7 (low bandwidth) and Figure 8 (high bandwidth) below where volumes by bandwidth for all CPs (including BT) as of Q4 in 2007/8, 2008/9, 2009/10 and 2010/11 are plotted.

Figure 7: Retail volume trends in low bandwidth TI services, 2007/8-2010/11



Source: CP's responses to s.135 information request, 2011

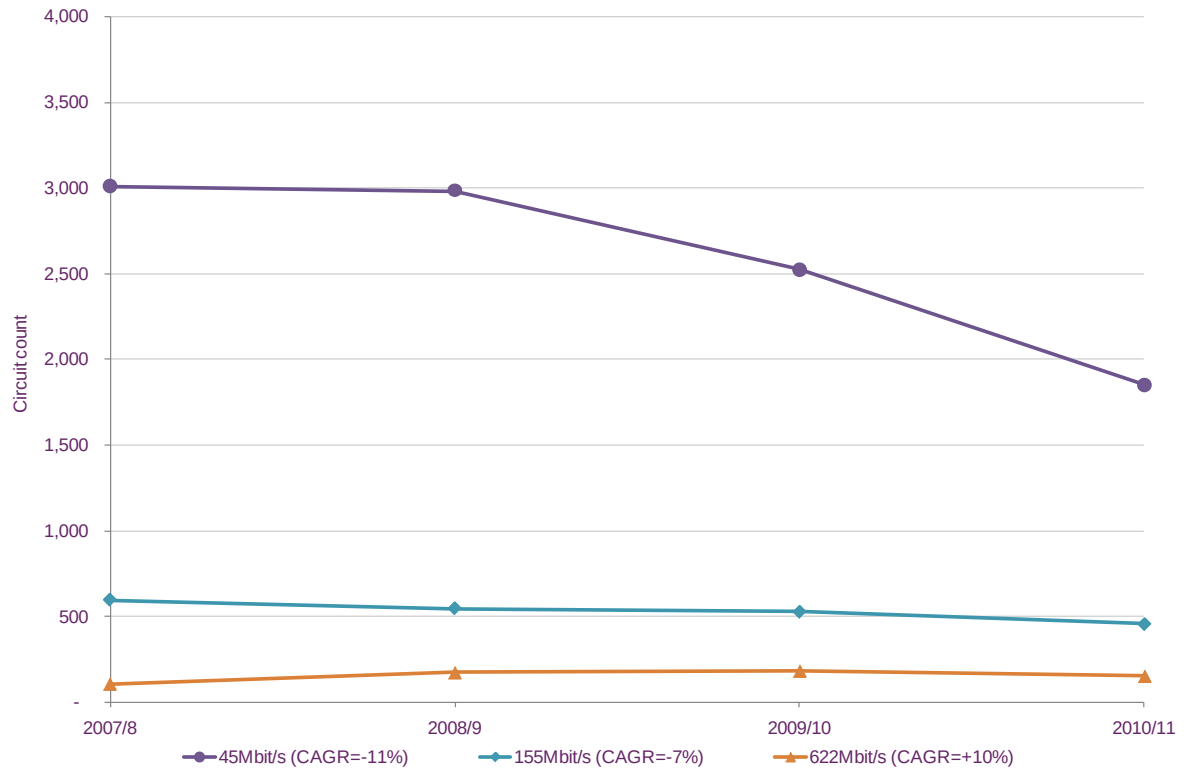
3.61 The figure shows that, at low bandwidths, TI services have been in steady decline since the 2007/8 Review. Sub-2Mbit/s services saw the steepest decline with our estimates indicating that volumes fell by 43% (19,000 circuits) between 2007/8 and

[53] This predominantly affected AI services, where approximately 15% of services were not broken down by bandwidth.

2010/11. Over the same time period, volumes of analogue and 2Mbit/s services also fell, by 21% (16,000 circuits) and 16% (10,000 circuits) respectively. Even with these falls in Q4 2010/11 our estimates indicate that there is still a substantial installed base of approximately 136,000 low bandwidth TI circuits.

3.62 The trends in low bandwidth TI services can be compared to the high bandwidth TI services shown in Figure 8 below.

Figure 8: Retail volume trends in high bandwidth TI services, 2007/8-2010/11

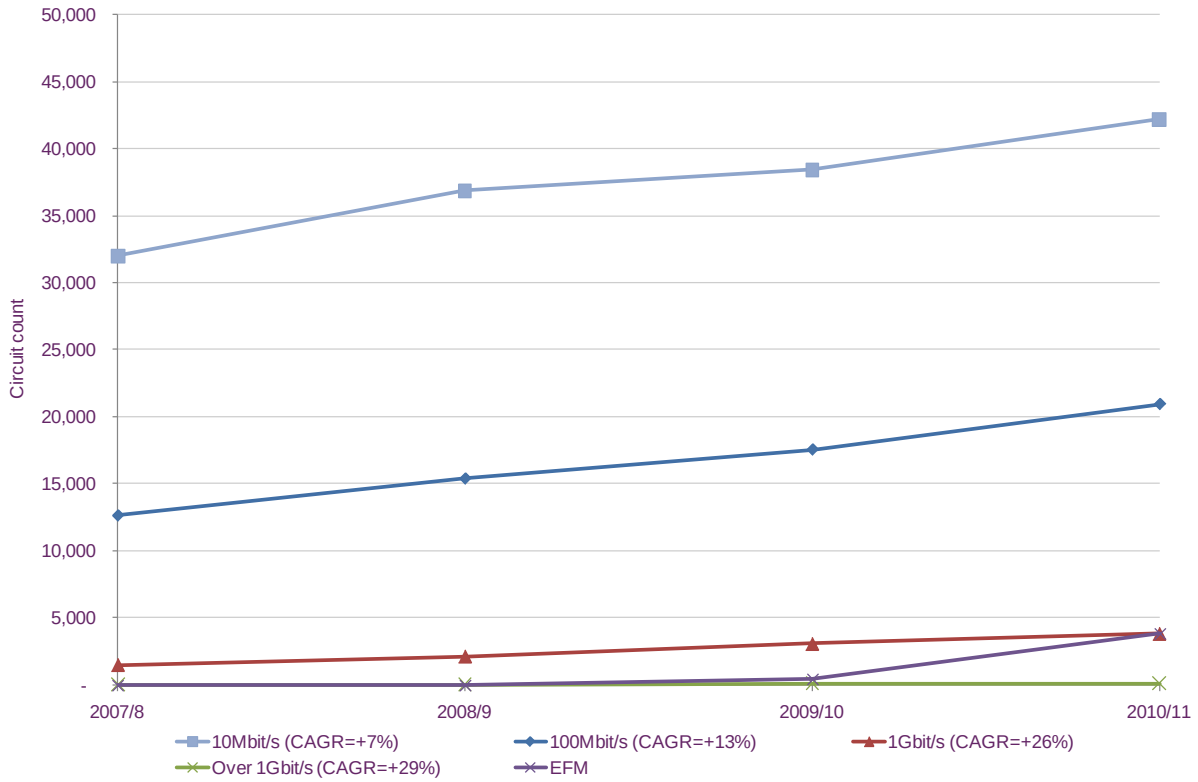


Source: CP's responses to s.135 information request, 2011

3.63 The figure shows that at high bandwidths there are only approximately 2,500 circuits. Of these, our estimates indicate that volumes at 45Mbit/s saw the steepest decline, with volumes falling by nearly 40% (1,200 circuits) between 2007/8 and 2010/11. Over the same time period volumes at 155Mbit/s also fell, but the fall was less marked at 24% (140 circuits). In contrast our estimates suggest that volumes of 622Mbit/s increased over this period, though we note that as 622Mbit/s volumes only account for approximately 200 circuits the trend here should be treated with caution as it is susceptible to reporting errors.

3.64 For AI services, Figure 9 below shows the volumes by bandwidth for all CPs (including BT) as of Q4 in 2007/8, 2008/9, 2009/10 and 2010/11. As discussed in paragraph 3.59 because of the issues with the AI data these estimates should be seen as indicative of the trends in the AI services and not a definitive view on the market as a whole.

Figure 9: Retail volume trends in AI services, 2007/8-2010/11[54]



Source: CP's responses to s.135 information request, 2011

3.65 The figure shows that AI volumes at all bandwidths have increased in every year since the 2007/8 Review. In terms of service count, while the largest increases have been at 10 and 100Mbit/s, there has also been significant growth at higher bandwidths. For example our estimates indicate that between 2007/8 and 2010/11, volumes at 1Gbit/s increased by 152% (2,300 circuits) while our corresponding estimate for services above 1Gbit/s is 173% (100 circuits).[55] While these estimates should be treated with caution, they point to a market that is seeing significant growth.

3.66 The figure also shows our estimates of the volumes of EFM services, which have to be treated with caution as we only have full historical data for one CP, with four other CPs only providing data for 2010/11 volumes. In addition, even our estimate of volumes in 2010/11 is likely to be an underestimate. This is because until recently the EFM market was dominated by smaller CPs whose volumes are not captured in our data request, which only captures the volumes from the largest CPs. Therefore to obtain a more complete overview of EFM services we have also considered available industry research. One source of evidence here is an Analysys-Mason viewpoint report published in October 2011 which discusses the prospects for EFM-based services and provides estimates for historical and forecast volumes.[56] The report

[54] Note we have not reported the CAGR for EFM as we only have full historical data for one CP, with four other CPs only providing data for 2010/11.

[55] Our analysis here excludes WDM-based services which are often used to provide bandwidths of above 1Gbit/s. The appropriate market definition for WDM services is discussed under Issue 5 in this section. We also note that while volumes of these services are low, in revenue terms they account for a larger percentage of the market.

[56] Bonded copper business broadband access services have good mileage yet to come, Viewpoint, Analysys-Mason, October 2011, available at:

notes that EFM services have seen strong growth, typically with a CAGR of around 100% (but from a low base) and estimates that the number of EFM services in 2012 is 15,000, forecast to increase to a peak of about 22,000 in 2014.[57]

3.67 However, when taken as a whole, while there has been significant growth in the AI market the pricing and migration trend data does not support placing Ethernet and SDH/PDH circuits in the same market. On pricing there is no evidence that the price differentials between the two services are closing, which we would expect to see if they were in the same market while, on migration, the decline in TI volumes has been relatively slow given the observed difference in prices. This is especially true at high bandwidths, where given such large price differentials and clear savings already enjoyed by users of Ethernet circuits; we would expect a larger proportion of SDH/PDH end-users to have switched. This suggests that for the end-users who are still using TI services other factors like functional differences and switching costs may still be important. All these factors when taken together suggest that, on balance, a SSNIP on SDH/PDH services is unlikely to accelerate migration to Ethernet to an extent which would make the SSNIP unprofitable. This suggests that AI and TI services continue to be separate markets.

3.68 We also note that with the introduction of EFM, a lower cost alternative to fibre-based Ethernet, there is an increased scope for substitution at lower bandwidths. However, our available evidence suggests that this is likely to be limited and that switching to EFM will not have a significant impact on the low bandwidth TI market. For example, the Analysys-Mason viewpoint report estimated that EFM take-up will peak at 22,000 in 2014 (an additional 7,000 services).

Barriers to switching

3.69 Barriers to switching from TI to AI can arise from the need to change Customer Premises Equipment (CPE) or from concerns about service disruption or could reflect end-users' perceptions of differences between the two services. If barriers to switching are significant this would be evidence in support of separate markets for AI and TI services.

3.70 Switching from a TI to AI-based service can be a complex process with the potential for service disruption. To avoid disruption typically a new service will be set up running alongside the current service for testing before any applications are migrated across. Before migration can happen, a change in the end-user equipment is also typically required. This means that currently end-users wishing to switch from SDH/PDH to Ethernet need to make various investments so that corporate applications can be carried on Ethernet networks. Moreover, the move from a TI-based enterprise network to one based on Ethernet circuits may also require investment in desktop CPE, such as IP PBXs, to allow convergence of voice and data traffic onto Ethernet circuits.

3.71 The investments required of the end-user are likely to constitute a barrier to rapid switching in response to a SSNIP, which is the relevant consideration for market definition purposes. This is compounded by the potential for disruption in changing over applications. Therefore, although the savings associated with the move from

http://www.analysysmason.com/Research/Content/Viewpoints/RDTW0_RDME0_Bonded_copper_Oct2011/

[57] This is because over the long-term, EFM use is expected to decline in favour of NGA, principally because the latter is likely to be substantially cheaper.

SDH/PDH to Ethernet are potentially quite high, we would therefore expect migration to proceed more gradually.

3.72 The above discussion highlights that there are barriers to switching from TI to AI. Equipment and application changes required to support equivalent services are likely to be a key source of this, though our consumer survey suggests this has become less of an issue over time. In addition, we noted that there was still a number of TI end-users who did identify challenges and concerns about switching to Ethernet, which either related to differences in the characteristics of TI and AI leased lines or at least a perception of them.

Proposed market definition

3.73 Based on the above analysis, we propose to define markets such that AI and TI remain in separate markets. This is because we do not expect a SSNIP to generate sufficient extra switching between AI and TI services for it to be unprofitable, for the following reasons:

- a comparison of relative prices and migration trends indicates that even with quite large price differentials there has only been a limited degree of switching between the two services, with SDH/PDH in gradual decline. We also observed that there is no consistent relationship between PPC and EAD prices at different bandwidths;
- a qualitative assessment shows that while carrier class Ethernet has closed the performance gap between AI and TI, there are still differences which mean that on a forward looking basis some legacy and specialist applications will continue to require TI services for the duration of this review period;
- consumer survey evidence shows that many TI end-users still identify challenges and concerns about switching to Ethernet which reflects differences in the characteristics of TI and AI leased lines, or at least end-users perceptions of them; and
- there are barriers to switching, including switching costs.

3.74 We note that this proposal is consistent with the conclusion of the 2007/8 Review, and that our preliminary view as set out in the CFI received eleven responses, with all bar one respondent supporting the retention of separate markets.

Issue 2: Virtual Private Networks (VPNs)

3.75 As discussed in Section 2, VPNs are an alternative and important means of delivering business services for many end-users. There are two types: (i) internet-based VPNs that use internet access connections as access connections (and sometimes also the internet for core connectivity) and (ii) higher specification leased line VPNs that use leased lines as access connections and dedicated core networks. VPNs therefore differ from leased lines that make use of dedicated point-to-point capacity over the entirety of the route. Given these differences, in this section we review whether VPNs are likely to provide a competitive constraint on the dedicated leased lines services (i.e. analogue, SDH/PDH and Ethernet). Based on this, we propose not to include VPNs as being part of either the retail TI or AI markets.

Our assessment in the 2007/8 Review

3.76 In the January 2008 consultation, having considered evidence on the relative prices of VPNs and leased lines, a survey of end-users, and an assessment of switching costs, we proposed that VPNs belonged in separate markets to leased line services. We considered this to be the case both with respect to VPNs accessed over Internet links and VPNs that utilised leased lines for the access links into the core network.

3.77 For VPNs accessed via Internet links we considered that they were unlikely to be substitutes for point-to-point leased line networks because they did not offer comparable levels of reliability, performance or security, all of which were of considerable importance to leased line users. We also noted that VPNs were considerably cheaper than an equivalent network constructed from leased lines. We argued that, with these price savings available, if internet-VPNs were able to address the same needs as a leased line service then the majority of users would have switched to such VPN services already. The fact that significant demand for leased lines remains despite the much higher prices suggested that these VPNs do not address the same end-user needs and were not close demand-side substitutes.

3.78 In contrast, we considered that VPNs accessed via leased lines did offer equivalent service features, but noted that they made heavy use of leased lines as an input and involve the additional provision of a network management function. For this reason these VPNs were best characterised as a downstream service rather than as a substitute to leased lines. The fact that leased lines were a significant input to such VPNs also limited the extent to which VPNs were able to constrain leased line prices. This was because if the price of leased lines increased then this would also affect the price of a VPN service that used leased lines as an input.

3.79 Our end-user survey also included a number of questions on VPNs and leased lines. Taking the responses to all relevant questions together, the results suggested that VPNs were not likely to be seen as a good substitute for leased lines. We concluded that end-users would only be willing to switch to VPN services as part of a wider decision to replace all of their connectivity services, rather than in response to a SSNIP on either an AI or TI leased line service over relatively short timeframes. Our end-user research also suggested that VPNs were often purchased alongside leased lines, rather than as a substitute for them.

3.80 We also identified switching costs which could inhibit substitution between VPNs and leased lines. In particular, it rarely made sense to switch to a VPN on a link-by-link basis and migrating to a VPN therefore required careful and costly management. VPNs are also usually managed by third parties, so any decision to move to a VPN was likely to involve a more wide-ranging decision to outsource functions such as IT support, which could also involve significant changes to staff and equipment. These costs made it unlikely that end-users would substitute to a VPN simply in response to a SSNIP on leased line prices. We also considered that supply-side substitution by VPN providers would not act as a constraint on leased line prices.

Call for inputs

3.81 In the CFI we noted the conclusion in the 2007/8 Review that these services were downstream of leased lines (i.e. that leased lines are an upstream input for VPNs). We put forward our preliminary view that the factors contributing to the conclusions in the 2007/8 Review had not altered materially. We noted that VPNs would continue to be relevant to our assessment to the extent that they were retail services that drove demand for leased lines (i.e. in our wholesale assessment we would consider any

demand for leased lines as inputs to VPNs). We asked whether VPNs continued to be outside the business connectivity markets.

Stakeholder views

3.82 Twelve respondents commented on our question on VPNs. Nine [✂ ✂ ✂ ✂] were in agreement that we should continue to identify VPNs as a separate market - with many agreeing that these services used leased lines as an input. Some respondents also highlighted that the quality characteristics of certain VPN services (such as IP-VPNs) did not make them a good substitute for dedicated services.

3.83 The three other respondents did not explicitly disagree with our proposals. One respondent [✂ ✂] noted that the distinction between leased lines and VPNs was being blurred as leased lines are now being included in the VPN offerings as opposed to being sold separately. Two other respondents highlighted the importance of VPNs and agreed that they were in a downstream market, although C&WW said that wholesale rather than retail leased lines were inputs into retail VPNs.

Proposed market definition

3.84 On the basis of our analysis, VPNs fall outside of the retail leased lines market. VPNs accessed via Internet links are unlikely to be close substitutes for point-to-point leased line networks as they are not able to offer the same service features, while leased-line based VPNs are excluded for the following reasons:

- such VPNs appear to be more appropriately regarded as a service downstream of leased line markets as they involve not just the provision of a network but also of a network management function; and

- as leased lines are an input to such VPNs services, the ability of a supplier of VPNs to constrain a hypothetical monopolist supplier of leased lines is limited.

3.85 We note that this is consistent with the conclusions of the 2007/8 Review and reflects both our preliminary view as set out in the CFI, which received broad support from respondents, that the factors informing the analysis were unlikely materially to have changed.

3.86 Hence, we do not propose to include VPNs as part of either the retail TI or AI markets. We note, however, the comments of some respondents that it is important to assess demand from retail VPNs in our market review, as these services make use of wholesale leased lines as inputs to the service. We agree with this view and have therefore made sure that any demand for wholesale TI and AI circuits arising from retail VPNs is taken into account when assessing wholesale market shares for our SMP assessment.

Issue 3: Broadband markets

3.87 Below we review the extent to which symmetric and asymmetric broadband provide a competitive constraint on retail leased lines. We first discuss current generation symmetric broadband services (SDSL) before considering asymmetric services, by first reviewing current generation ADSL and then next generation broadband services that have been introduced since the 2007/8 Review. Having done so we propose that SDSL services are within the retail TI leased lines market and that there continues to be separate markets for leased lines and asymmetric broadband services.

3.88 The following section does not consider whether a constraint exists in the opposite direction, namely whether retail leased lines offer a competitive constraint on broadband services. This has been considered (at the retail level) in the context of Ofcom's Wholesale Broadband Access (WBA) market review which concluded that broadband access services are not constrained by symmetric services like leased lines.

3.89 We also note that the Commission's recommendation on relevant product and service markets identifies separate markets for leased lines and asymmetric broadband at the wholesale level.[58] However, while we have taken this recommendation into account, we have conducted a full assessment of asymmetric broadband and leased lines.

(i) Symmetric broadband

Our assessment in the 2007/8 Review

3.90 In the 2007/8 Review we included SDSL, which is a Digital Subscriber Line (DSL) variant which provides the same upload and download data rate (and so is a symmetric service) in the low bandwidth TI market. Our assessment of SDSL against SDH/PDH leased lines was that, generally, the functionality of SDSL approximates that of leased lines (much more so than was the case with ADSL). This is because SDSL connections offer the ability to support dedicated, symmetric bandwidth at bandwidths and quality levels comparable to low bandwidth digital leased lines (i.e. up to 8Mbit/s). In addition, our pricing analysis showed that SDSL and low bandwidth leased lines were closely priced, which suggested that switching would be expected to occur between SDSL and low bandwidth leased lines in response to a SSNIP.

Call for inputs

3.91 In the CFI we invited stakeholders to tell us about any issues they considered relevant, but we did not specifically ask about SDSL, as we considered that the factors informing the analysis in the 2007/8 Review were unlikely to have changed materially.

Stakeholder views

3.92 We did not receive any comments from any respondent on SDSL.

Ofcom analysis

3.93 Given that, as set out in the CFI, we did not consider that material change could reasonably be expected to have occurred, we are not proposing to include a detailed discussion of our analysis of this issue, which concludes that SDSL services remain part of the low bandwidth TI market. However, we note briefly that we consider the following factors, which were particularly relevant in the 2007/8 Review, remain relevant today:

- the qualitative characteristics of SDSL and TI services;

[58] Commission Recommendation on relevant product and service markets within the electronic communications sector susceptible to ex ante regulation in accordance with Directive 2002/21/EC of the European Parliament and of the Council on a common regulatory framework for electronic communications networks and services (Second Edition) (C(2007)5406 rev1).

- SDSL service features and pricing; and
- migration trends.

Qualitative assessment

3.94 Table 8 provides an updated qualitative assessment of the key features of SDH/PDH and SDSL services.

Table 8: Key features of SDH/PDH and SDSL services

	SDH/PDH	SDSL
Geographic availability	Nationwide	Easynet provides services from 1200 exchanges, covering 70% of SME across the UK.[59] BT provides services from 809 exchanges, with an estimated national coverage of 20%.
Bandwidth	64kbit/s up to 2.5Gbit/s	Up to 2Mbit/s, bonded SDSL solutions are available offering bandwidths of up to 8Mbit/s[60]
Contention	Dedicated	Service dependent. Contention typically varies from 1:1 (i.e. uncontended) to 20:1
Latency/jitter	Low	High
Local Loop Distance (Note SDSL distance limits refer only to the loop length and not the end to end service length)	Not limited	Bandwidth decreases according to local loop length (practical limit of the order of 3km).
Resilience	High	Low
Symmetry	Symmetric	Symmetric

Source: Ofcom 2012

3.95 SDSL connections offer the ability to support dedicated symmetric bandwidth at bandwidths comparable to low bandwidth leased lines, i.e. up to 8Mbit/s. In contrast to ADSL, SDSL are generally targeted at business end-users and are offered with a business class quality of service. This includes higher traffic priority, lower contention ratios and business level service agreements and guarantees. These features mean that SDSL can be a viable alternative to low bandwidth leased lines for applications

[59] See: http://www.easynetconnect.net/products/sdsl.aspx

[60] Bonded SDSL allows multiple lines to be bonded together to increase bandwidth.

where the principal requirement is data transmission. Such applications represent a large proportion of the installed base of leased lines.

3.96 However, SDSL is not suitable for those applications where the requirement is for predictable latency. The opportunity to substitute is also limited by the smaller footprint of SDSL compared to SDH/PDH leased lines, though since the 2007/8 Review the availability of SDSL services has increased as it has been deployed by a number of LLU operators. A further limitation of SDSL services is that its capabilities are limited by the distance a premise is from the SDSL enabled exchange. BT has estimated that 1.6km is the practical limit for the provision of 2Mbit/s SDSL services and beyond this distance available bandwidths would be lower, with a practical limit of approximately 3km.[61] The distance limitations would also apply to the bonded solutions available.

3.97 We also note that BT has announced that it will be retiring its SDSL network by the end of 2014, and while SDSL will still be available from LLU operators after this date, the announcement suggests that SDSL is coming to the end of its life cycle and is being replaced by newer technologies.[62]

3.98 These factors suggest while TI services are a good substitute for SDSL services, it is unlikely that this constraint will be symmetric. This is because SDSL services cannot offer a fully equivalent service.

Service features and pricing

3.99 To help assess whether SDSL could impose a competitive constraint on low bandwidth leased lines we have also considered the marketing, service characteristics and pricing of SDSL packages offered by CPs and in particular publicly available information on CPs websites. In total we reviewed the packages offered by 11 CPs, identifying 38 individual offerings. In this section we first provide an overview of marketing and then discuss pricing.

3.100 A number of CPs provide online literature highlighting the potential to substitute leased lines with SDSL services with the selling point that business SDSL can provide a performance level that is comparable to TI leased line services.[63] It is also often marketed as being an ideal service for small businesses, as it can support sophisticated requirements like the centralisation of systems and servers, high volume email usage, and multi-site networking.[64] This suggests that SDSL is positioned as a substitute for low bandwidth TI services.

3.101 There is a considerable range of SDSL prices, reflecting the different available bandwidths and service wraps. Typical bandwidths offered include 512kbit/s, 1Mbit/s and 2Mbit/s, while services up to 8Mbit/s are offered using bonded SDSL. At each bandwidth there was also a range of service wraps, where at a given bandwidth higher priced services can be seen as 'Premium' services offering enhanced features in comparison to 'Basic' SDSL. Enhanced features vary by package but typically included higher level service level guarantees, priority customer support and lower

[61] See SIN405 available from: http://www.sinet.bt.com/.

[62] See: https://www.btwholesale.com/shared/document/21CN_Consult21/c21_MG_015_DSP_Jan12_Issue17.pdf

[63] For an example of this see: http://www.managedcomms.co.uk/products/business-sdsl

[64] For an example of this see: http://www.easynetconnect.net/products/sdsl.aspx

contention rates. Across all the packages surveyed, the cheapest package was just over £1,500 per year and the most expensive was almost £6,500 per year, with an average price of approximately £2,600 per year.

3.102 The prices of SDSL and PPCs are broadly comparable; 2Mbit/s SDSL services are generally available from approximately £2,000, while the estimated cost of using a 2Mbit/s PPC in the same exchange area is just over £2,000.[65] This closeness in price, combined with the similar functionality of the two services suggests that a SSNIP above the competitive price level of SDSL services would be unprofitable due to switching to low bandwidth SDH/PDH circuits.[66]

Migration trends

3.103 Since the last review SDSL volumes have continued to increase, albeit from a low base. Our estimate of the retail sales, based on volumes reported by CPs, suggests that volumes have more than tripled, increasing from just fewer than 3,000 services in 2007/8 to almost 14,000 services in Q4 2010/11.[67] The overall trend does however hide some disparities between CPs, with some CPs seeing a decline towards the later end of this period. This is broadly in line with the declines in the low bandwidth TI market discussed above.

Proposed market definition

3.104 On the basis of our analysis, we propose that SDSL services are within the retail TI leased lines market. We note that this is consistent with the conclusions of the 2007/8 Review and the preliminary view set out in the CFI that the factors informing that earlier assessment were unlikely materially to have changed.

(ii) Asymmetric broadband

Our assessment in the 2007/8 Review

3.105 In the 2007/8 Review we considered that, on balance, the evidence suggested that ADSL services and leased lines fell into separate markets. This was predominately based on an assessment of the functionality of the two services and comparison of relative prices and migration trends.

3.106 The qualitative assessment noted that an ADSL connection could be used to provide a symmetric service with a maximum data rate equal to the upload bandwidth of the ADSL service. At the time of the last review BT's highest bandwidth ADSL service had a download bandwidth of up to 8Mbit/s and an upload bandwidth of up to 832kbit/s (both dependent on line length).[68] Therefore a user with a 1Mbit/s leased line could consider this as broadly 'equivalent' in bandwidth terms to its current

[65] This has been calculated using the wholesale input prices using the same methodology as Figure 6.

[66] As we noted above the pricing constraint is unlikely to be symmetric, as SDSL services do not provide a fully equivalent service, which means that SDSL services are unlikely to constrain the price of leased line services. The "means to an end" argument is relevant here - it is unlikely to be possible to exploit market power in SDSL alone (unlike AI, where there are also significant price differences).

[67] As was noted above there are a number of CPs who sell SDSL at the retail level and our estimate of the market is based on a combination of retail and wholesale data.

[68] We also discussed the impact of bonded ADSL, this allows multiple lines to be bonded together to create higher bandwidth services. While bonding increases the physical upload and download capability of ADSL it does not change the characteristics of the service.

leased line service. However, we noted that ADSL was different in many respects including having:

- high contention rates;
- a lack of bandwidth guarantees; and
- poorer service quality in terms of latency and jitter and overall throughput.

3.107 These were factors that our end-user research had identified as very important to many business end-users and our research also highlighted, that most businesses were unwilling to compromise on the bandwidth of their connections.

3.108 On pricing, while the prices of ADSL were very low relative to low bandwidth leased lines we found no evidence of extensive switching. Indeed, our consumer research highlighted that while symmetry was one of the lowest rated service features in terms of importance, overall upload bandwidths were seen as more important. This suggested that a minimum upload level was valued, even if the overall requirement for download bandwidth to match upload bandwidth was less important. We also noted that end-users perceived issues with the levels of contention, security and quality of service offered by broadband, and that these may have been a barrier to switching. We concluded, therefore, that ADSL was a service which is complementary to leased lines rather than a replacement.

Call for inputs

3.109 In the CFI we noted that a key issue which might have changed since the 2007/8 Review was the extent of substitution between broadband services and leased lines. This was in light of developments, like the rollout of next generation broadband, which have increased the bandwidth capabilities of broadband since the 2007/8 Review. Our preliminary view was that it was possible there were market(s) for the provision of retail leased lines, and particularly the low bandwidth TI market, which should be broadened to include other business connectivity services, such as broadband services.

3.110 Consequently, we asked stakeholders for their views on the extent to which broadband services could be used effectively for the delivery of business connectivity, and how they thought this might change over the forward look of this review period.

Stakeholder views

3.111 11 respondents commented on our questions on broadband services and the leased lines market [✂ ✂ ✂ ✂]. There was a range of views expressed.

3.112 Many respondents noted that there had been substitution occurring as many business end-users now found that their business connectivity needs can be met effectively by broadband services, especially end-users with lower bandwidth and service quality requirements. BT noted that alongside small businesses many large businesses with distributed sites, such as national retail chains, had also switched from leased lines to broadband. Verizon identified business broadband as being a cost effective alternative to PPCs in many business to business applications for new business offerings. C&WW noted that the substitution had been one way, as businesses who had previously purchased retail leased lines as they were the only

business solution, have switched away to lower cost and lower service attribute ADSL services, as leased lines exceeded their requirements.

3.113 A number of respondents also noted that even though substitution had been occurring there were still a number of technical and service quality barriers that limited further switching. This is because services consumed by business end-users often differ in fundamental ways from those provided by current generation broadband to predominantly residential end-users. KCOM noted that while broadband can be a substitute for very small business end-users; its experience was that larger business users value certain characteristics of leased lines which ADSL services could not deliver. These characteristics include the provision of a symmetric service, uncontended bandwidth, resilience and higher level SLAs/SLGs. The distance limitations inherent in ADSL which impacted on attainable bandwidths were also noted as a significant limitation.

3.114 Other stakeholders also commented on differences. One respondent [✂ ✂] noted that the two services are not wholly substitutable when the requirement is for low latency and low jitter, which are key requirements for many applications. Another respondent [✂ ✂] identified the lack of a business level SLA, particularly in relation to line quality and repair, as a significant factor limiting substitution, while Verizon identified a gap in the current portfolio of CP service offerings due to the lack of an uncontended backhaul solution.

3.115 Barriers to switching were also discussed from a business end-user perspective in the Communication Management Association (CMA) response. This highlighted that many businesses would have embraced broadband but for a number of “obstacles”. These included concerns over LLU repair performance, the time taken to install new lines and the lack of an effective symmetric service. There were also concerns raised around the lack of business-grade service level guarantees on ADSL performance, and the focus of providers on consumer multiplay rather than on business.

3.116 The potential impact of next generation broadband on the business connectivity market was also widely discussed. There was a wide range of views on this, with most respondents fairly cautious about the potential impact.

3.117 For example, Verizon, while noting that next generation broadband has the potential to be transformative in the UK, argue that in order for this potential to be realised there needed to be the creation of business-grade FTTC and FTTP services. It also identified issues with the migration of end-users from traditional services to broadband which could limit the extent of substitution. Another respondent [✂ ✂] noted that while substitution could increase, it is difficult to be certain of the extent to which this would occur during this market review because it would be dependent on the relative capabilities of the technology deployed. This respondent also noted that substitution was likely to be most apparent where there was a lesser need for specific characteristics, like high quality service levels and low contention rates.

3.118 The role of specific characteristics was also noted in other responses. One respondent [✂ ✂] noted that requirements for low latency and jitter which could not currently be met by broadband would not change over the short to medium term, limiting potential substitution. Similarly KCOM noted that although substitution could increase, it did not believe that it would be a significant factor during the period covered by this market review because some of the requirements of business customers cannot be met with broadband. It further noted that substitution could increase if high bandwidth symmetrical solutions were developed, with little or no contention and acceptable latency characteristics.

3.119 In contrast, Fujitsu, in its response argued that the development of next generation access services had fundamentally changed the market for business connectivity. It noted that FTTP could be used for high bandwidth business services while FTTC can be deployed in lower bandwidth symmetric configurations, which although slow in terms of a fibre interface, would be sufficient for many business end-users. Fujitsu also noted that next generation access could create a synergy between business and residential rollouts that will see the mass migration away from leased lines onto open access networks for all bandwidths up to and including 10Gbit/s.

Ofcom's analysis

3.120 Given the extensive stakeholder comments we set out in detail below our analysis as to whether asymmetric broadband may act as a competitive constraint on retail AI or TI services. The analysis considers the impact of changes in broadband technology since the last review and expected future developments in this review period. Based on this analysis, we propose that asymmetric broadband services remain outside the leased lines markets. In particular our analysis covers:

- a qualitative assessment of different broadband technologies;
- evidence from consumer surveys;
- broadband service features and pricing;
- relative price comparisons and migration trends; and
- the barriers to switching.

Qualitative assessment

3.121 Our qualitative assessment sets out the technology, network architecture and service features of the dominant technologies used in the provision of fixed broadband access in the UK.[69] At a high level, broadband technologies can be categorised as:

- current generation;
- next generation; and
- cable modem[70]

Current generation broadband

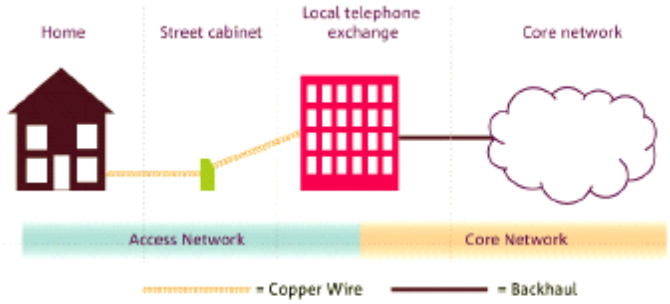
3.122 Current generation broadband uses ADSL or ADSL2+ technology over the copper access network from the local exchange to the end-user premises. ADSL technology allows the use of a standard copper telephone line to provide high bandwidth asymmetric data communications. It is asymmetric as it provides higher download than upload bandwidths. The bandwidths available to end-users are dependent both on the equipment at the local exchange (e.g. the type of ADSL technology deployed) and the distance the customer is from the local exchange. Available bandwidths can

[69] Alternative broadband technologies are discussed in the Review of the wholesale broadband access markets 2010 (Annex 7)

[70] We note here that cable modem services are capable of matching both current and next generation broadband bandwidths. We have included cable as a separate category because it is delivered over a different access network.

also be increased by using bonded ADSL, a process where multiple ADSL lines are bonded together to create larger internet pipes, increasing the physical upload and download capability of ADSL. The architecture required to deliver current generation broadband is shown below in Figure 10.

Figure 10: Current generation broadband[71]



3.123 Table 9 provides a qualitative assessment of the key features of current generation broadband and leased line services.[72]

[71] With current generation broadband no active equipment is deployed to the street cabinet.

[72] Here where we use the term leased line we are referring to both TI and AI services. We make this simplification because although some noteworthy performance differences between TI and AI services remain, the differences between an ADSL service on the one hand, and either an AI or a TI service on the other, are likely to be much more marked.

Table 9: Key features of current generation broadband and leased line services

	ADSL	ADSL2+	Leased line
Geographic availability	Nationwide	BT has deployed this to cover 80-85% of the UK. Talktalk covers 90% of the UK and has announced plans to cover up to 95% of the country	Nationwide
Bandwidth	Download bandwidth of up to 8Mbit/s, upload bandwidth of up 832kbit/s	Download bandwidth of up to 24Mbit/s, upload bandwidth of up 1.4Mbit/s	64kbit/s up to 100Gbit/s symmetric capacity available
Bandwidth limitations	Bandwidth decreases according to local loop length e.g. distance from the customer premise to the exchange (practical limit of the order of 3km (ADSL2+) - 5km (ADSL))		Not limited
Contention	The amount of contention can be varied by provision of backhaul capacity, depending on the demands of the end-user, contention typically varies between 20:1 to 50:1		Uncontended
Latency/ Jitter	Variable - dependent on the bandwidth capacity of the network and offered traffic at any given point in time, specified levels cannot be guaranteed		Low
Resilience	Not deployed to support resilience options		Resilience options available
Security	Perceived as less secure as carried over a shared infrastructure		Medium to High
Service level agreements/ guarantees (SLA/SLG)	Deployed to support residential end-user requirements[73]		Deployed to meet business level requirements
Synchronisation	Not supported		Supported

Source: Ofcom 2012

3.124 In terms of bandwidth, the introduction of ADSL2+ technologies offers much higher upload and download bandwidths compared to the ADSL services available at the time of the 2007/8 Review. An ADSL connection could be used to provide a symmetric service with a maximum data rate equal to the upload bandwidth of the ADSL service. A user with a 1.5Mbit/s leased line could compare this to an ADSL2+ service running (dependent on line) with a download bandwidth up to 24Mbit/s and an upload bandwidth of up to 1.4Mbit/s and consider this as broadly' 'equivalent' in bandwidth terms to its current leased line service. With bonded ADSL services higher

[73] Broadband networks are built to provide a specific quality of service. While this can be varied to provide business services, where business has lower contention and so on, it is still a shared network. Therefore in order to match the service levels provided on leased lines would require much more capacity and possibly increased resilience, which would add costs.

bandwidths could also be considered as equivalent, with the equivalent bandwidth dependent on the bandwidth of each bonded line.[74]

3.125 In contrast to leased lines, however, the highest current generation bandwidths are only available to end-users close to the exchange. Ofcom research on UK fixed broadband bandwidths carried out in 2011 highlighted that across end-users the typical download bandwidth range for ADSL up to 8Mbit/s packages was between 1-5Mbit/s.[75] The corresponding estimate for ADSL2+ packages was 3-10Mbit/s. Upload bandwidth is also distance dependent but, because upload bandwidths are lower they are not necessarily impacted to the same extent as download bandwidths as the distance from the exchange increases. These estimates highlight the variability in attainable bandwidths available to end-users. In addition, with associated high contention rates of ADSL connections, typically the bandwidth is not guaranteed and is also associated with poorer service quality compared to leased lines in terms of latency, jitter, and overall throughput. There are also differences in the level security, the available resilience options and synchronisation support. The level of SLA/SLG available is also lower than for leased line services.

3.126 The above analysis highlights that since the last review there has been a significant increase in download bandwidths available from 8Mbit/s to 24Mbit/s, with a relatively smaller increase in upload bandwidths from 832kbit/s to 1.4Mbit/s. We note that while the nature of inter-site traffic for a business is such that the same capacity requirement is often needed in both directions, for many users it is not 'symmetry' per se that is required, but simply the necessary upload and download bandwidths to meet their needs. Nevertheless, for end-users who may not need exact symmetry but do not have a marked asymmetry in their upload and download bandwidths current generation broadband could be seen as 'equivalent' in bandwidth terms to a wider set of leased lines. Even for these end-users, however, the above analysis highlighted that a range of service features of a leased line cannot be matched by current generation broadband.

3.127 Therefore, the analysis set out above suggests that where leased line features are required, current generation broadband is unlikely to be a direct substitute for a leased line.

Next generation broadband

3.128 Next generation broadband deployments focus on upgrading the access connection between the end-user and the network. The two main next generation architectures currently being rolled out are:

- Fibre To The Cabinet (FTTC) - the connection to the cabinet is replaced by fibre and active equipment is deployed in the cabinet. The current copper access network connection from the cabinet to the end-user remains in place; and

- Fibre To The Premise (FTTP) - fibre is used all the way from the exchange to the end-user.

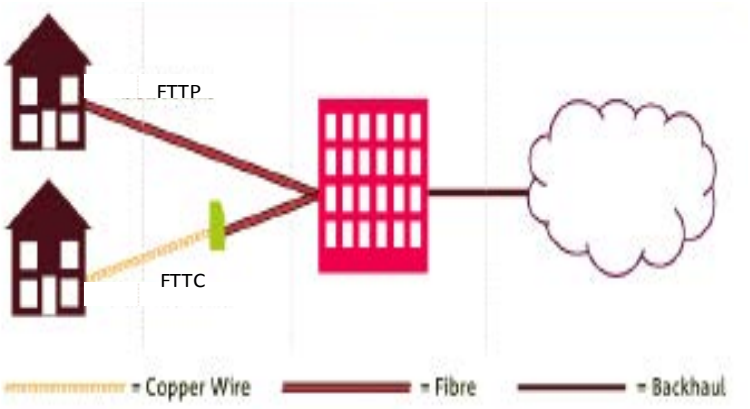
3.129 The architecture used to provide these two services is shown below in Figure 11 FTTC deployments use VDSL2 technology over the copper connection that remains

[74] Bonding copper loops increases the distance or bandwidth ADSL can achieve, typically a second copper loop will double the bandwidth available.

[75] See http://stakeholders.ofcom.org.uk/binaries/research/broadband-research/Fixed_bb_speeds_Nov_2011.pdf

between the cabinet and the end-user, while FTTP services can be provided using a range of different technologies. BT plans to deploy FTTP using a Gigabit Passive Optical Network (GPON) which shares a single fibre from the exchange between a number of end premises.

Figure 11: Next generation broadband



3.130 Table 10 provides a qualitative assessment of the key features of next generation broadband and leased line services.

Table 10: Key features of FTTC and FTTP and leased lines services

	FTTC	FTTP	Leased line
Geographic availability	As of 2012, BT has announced plans to deploy next generation broadband to 66% of the UK by the end of 2014. This will be made up of FTTC VDSL2 (75%) and GPON FTTP (25%) deployments.[76] There are also numerous smaller deployments by other companies. KCOM is planning trial deployments in the Hull area. Alongside this government funding has been announced to help cover the final third of the UK.		Nationwide
Bandwidth	Download bandwidth of up to 40Mbit/s, upload bandwidth of up to 10Mbit/s (Starting in Spring 2012 these bandwidths are expected to be doubled).	Download bandwidth of up to 110Mbit/s, upload bandwidth of up 30Mbit/s. (Starting in Spring 2012 this is expected to be increased to 300Mbit/s)	64kbit/s up to 100Gbit/s symmetric capacity available
Bandwidth limitations	Whilst bandwidth decreases according to loop length, the effect is much less than for ADSL technologies as the relevant local loop length is the distance from the end-user to the cabinet	Not distance limited	Not distance limited
Contention	The amount of contention can be varied by provision of backhaul capacity, depending on the demands of the end-user		Uncontended
Latency/ Jitter	Variable - dependent on the bandwidth capacity of the network and offered traffic at any given point in time, specified levels cannot be guaranteed[77]		Low
Resilience	Not deployed to support resilience options		Resilience options available
Security	Perceived as less secure as carried over a shared infrastructure		Medium to High
Service level agreements/ guarantees (SLA/SLG)	Deployed to support residential end-user requirements		Deployed to meet business level requirements

[76] BT have also announced that fibre on demand will be available in FTTC areas during this review period, this provides FTTP connectively, but requires an additional charge (not yet specified) for connection of fibre to the premises. For initial details see:

http://www.btplc.com/News/Articles/Showarticle.cfm?ArticleID=14863CF1-DD70-4D79-83F8-2CDA88B3E51B

[77] We note that while GPON is actually a TDM based system and has predictable latency and low jitter once at the exchange the core network can introduce variable latency and jitter.

Synchronisation	Not supported	Supported	Supported

Source: Ofcom 2012

3.131 With the introduction of next generation broadband available upload and download bandwidths have significantly increased. A leased line user with a 10Mbit/s leased line could compare this to a FTTC service running (dependent on line) with a download bandwidth up to 40Mbit/s and an upload bandwidth of up to 10Mbit/s and consider this as broadly 'equivalent' in bandwidth terms to their current symmetric service. Also in contrast to current generation broadband, because the copper section of the local loop is the distance from the cabinet to the end-user, rather than from the exchange to the end-user, a greater proportion of end-users are able to obtain the highest bandwidths. Highlighting this, Ofcom research on fixed broadband bandwidths found that average download bandwidths for FTTC were 36Mbit/s, 90 per cent of the advertised bandwidth of 40Mbit/s. Over the period of this review available bandwidths will further increase as BT has announced that, commencing in spring 2012, it plans to upgrade its network and double current bandwidths.[78]

3.132 FTTP services offer even higher bandwidths than FTTC services, with download bandwidths of up to 110Mbit/s and upload bandwidths of 30Mbit/s, which means FTTP could be seen in bandwidth terms as equivalent to a 30Mbit/s symmetric leased line. As FTTP is provided over fibre there is no significant decrease in attainable bandwidths with distance. Over the period of this review available bandwidths are expected to increase further as BT has announced that commencing from spring 2012 available download bandwidths will increase to 300Mbit/s. Trials of download bandwidths of up to 1Gbit/s are also taking place.[79]

3.133 However, while FTTC and FTTP services can provide higher download and upload bandwidths there are still a number of differences in service features compared to leased lines. These include differences in terms of contention, latency and jitter, the level of security, resilience options, SLAs/SLGs and synchronisation support (for FTTC). Also because next generation broadband services are currently being deployed they do not have the same coverage as leased line services, and there is some uncertainly on how widely they will be available at the end of this review, especially in the final third.[80]

3.134 The analysis above suggests that, next generation broadband services can be seen as equivalent to a wider set of leased lines than current generation broadband services in bandwidth terms. But, there are a range of leased line service features that cannot be matched by next generation broadband. Where these features are required, it is unlikely that next generation broadband will be a direct substitute to a leased line. For end-users whose bandwidth requirements can be met by next generation broadband, the level of switching will depend on their willingness to pay for the extra service features that leased lines offer over next generation broadband.

3.135 We have also considered the potential impact of virtual unbundled local access (VULA), a wholesale remedy available from our market review of the wholesale local access market. VULA allows competitors to deliver services over BT's next generation access network, using the FFTC/FTTP infrastructure, with a degree of control that is similar to that achieved when taking over the physical line to the end-

[78] See http://www.btplc.com/News/Articles/Showarticle.cfm?ArticleID=7E309437-6929-442F-8F25-CDD388518C64

[79] Ibid

[80] The final third captures the areas for which BT has not announced NGA rollout plans.

user. As VULA offers a service agnostic and uncontended Ethernet connection to the end-user, it could be used to provide a leased line service (i.e. dedicated symmetric transmission capacity to carry voice and/or data traffic), which would be carried over the broadband infrastructure. For market definition, although these services would be carried over the broadband infrastructure, the services would offer similar functionality to low bandwidth Ethernet leased lines. As such, we consider that VULA based leased lines cannot be seen as a separate market from the current low bandwidth retail AI market, but rather they are a different way of providing a retail AI service.[81]

3.136 On a forward looking basis, over the duration of this review, we consider that there will only be limited take-up of leased line VULA-based solutions. The availability of VULA is limited to the areas where BT has deployed infrastructure (about 66% of the UK by the end of 2014) and the bandwidth available and the ability to support additional service features is limited by the technology deployed by BT, as highlighted in Table 10. Further, VULA is predominantly focused on the residential market, and it is likely that VULA services would require additional investment to support enterprise customers with more stringent quality of service requirements.

Cable modem

3.137 Virgin Media's access network is different to the current and next generation broadband architecture discussed above. In respect of the broadband service, the connection between the end-user and the network is not provided over copper and DSL technology is not used in the access network. Instead, the end-user connects via a hybrid coaxial/fibre network utilising Data Over Cable Service Interface Specification (DOCSIS) technology to the head-end equipment in the Virgin Media serving exchange. The use of DOCSIS technology means that the cable network is not subject to the same bandwidth limitations that are evident with DSL technology. Having upgraded the DOCSIS technology in its network, Virgin Media is able to run services at higher bandwidths than current generation broadband and as such it can be considered to be a next generation access network.

3.138 Table 11 provides a qualitative assessment of the key features of cable modem broadband and leased line services.

[81] By the same reasoning EFM services, which offer Ethernet over the copper access network, are also part of the low bandwidth retail AI market.

Table 11: Key features of cable modem broadband and leased line services

	Cable	Leased line
Geographic availability	48% of UK premises are covered by Virgin Media	Nationwide
Bandwidth	Download bandwidth of up to 100Mbit/s, upload bandwidth of up 10Mbit/s[82] Bandwidth not dependent on distance.	64kbit/s up to 100Gbit/s symmetric capacity available
Contention	The amount of contention can be varied by provision of backhaul capacity, depending on the demands of the end-user	Uncontended
Latency/ Jitter	Variable - dependent on the bandwidth capacity of the network and offered traffic at any given point in time, specified levels cannot be guaranteed	Low
Bandwidth limitations	Cable networks have been deployed to ensure there is no significant decrease with distance	Not limited
Resilience	Not deployed to support resilience options	High
Security	Perceived as less secure as carried over a shared infrastructure	Medium to High
Service level agreements/ guarantees (SLA/SLG)	Deployed to support residential end-user requirements	Deployed to meet business level requirements
Synchronisation	Not supported	Supported

Source: Ofcom 2012

3.139 Cable modem services are able to offer bandwidths similar to next generation broadband, and trials are taking place to further increase the headline download bandwidth to 200Mbit/s.[83] There have also been limited trials of cable services offering download bandwidths of 1.5Gbit/s with 150Mbit/s upload.[84] Unlike DSL services, with cable services bandwidth does not vary with distance. The Ofcom fixed broadband speed report found that on average cable modem services delivered between 94 and 100 per cent of the advertised download bandwidth. However, as with FTTC and FTTP, although cable modem can offer the same download and upload bandwidths as many leased lines there are still a number of differences in the service features. This includes differences in terms of contention, latency, jitter, the level of security, resilience options, SLAs/SLGs and synchronisation support. Furthermore cable services are only available in 48% of the UK.

[82] Virgin Media announced in January 2012 that over the next 18 months it would be doubling the bandwidths available to most end-users (I.e. Below 100Mbit/s bandwidth would double, end-users currently at 100Mbit/s will see their bandwidth increase to 120Mbit/s). Upload bandwidths and traffic management fair usage amounts will be increased in proportion to the increase in downstream bandwidth. See http://mediacentre.virginmedia.com/Stories/Virgin-Media-boosts-Britain-s-broadband-speeds-2322.aspx

[83] See http://mediacentre.virginmedia.com/Stories/Virgin-Media-rolls-out-UK-s-fastest-broadband-with-100Mb-1c6.aspx

[84] See: http://mediacentre.virginmedia.com/Stories/Virgin-Media-delivers-world-s-fastest-cable-broadband-2131.aspx

3.140 Therefore as with next generation broadband, although cable modem services can match many leased lines in terms of bandwidth, there are key differences in service features. Where these features are required, we consider cable modem broadband is unlikely to be a direct substitute for a leased line.

Consumer survey analysis

3.141 The assessment of broadband technology highlighted a number of differences to the characteristics offered by leased lines. However, these differences alone do not necessarily mean that these services are in separate markets, as users may be willing to compromise or upgrade their services in response to a SSNIP. To help establish whether this is the case, below we refer to an independent market research report commissioned by Ofcom, which was carried out by Jigsaw research.[85] We also refer to relevant stakeholder evidence; including the Internet Opportunity Survey (IOS) which focused on business users and was commissioned by the Communications Management Association (CMA) and the Federation of Small Businesses (FSB).[86] This survey included 300 organisations in total, covering both the public and private sectors and large and small organisations.

3.142 To understand the characteristics that end-users may be prepared to compromise on it is useful to reconsider the results on leased line characteristics and their relative importance, summarised below in Figure 12.[87] Symmetry was identified as either business critical or very important by 58% of respondents and was (along with range) the lowest rated service features in terms of being rated either business critical or very important, suggesting that some end-users may be prepared to compromise on this. However, set against this the level of available upload bandwidths was seen as either business critical or very important by 78% of respondents. This suggests that a minimum level of upload bandwidths is still valued, even if the overall requirement for symmetry (58%) is less important in relative terms. In the same context, download bandwidths were identified as either business critical or very important by 88% of respondents. These demands mean that at higher bandwidths, broadband is unlikely to provide a constraint on leased lines as it is not able to offer the same levels of upload and download performance which end-users value. In contrast, at lower bandwidths there is greater scope for substitution.[88]

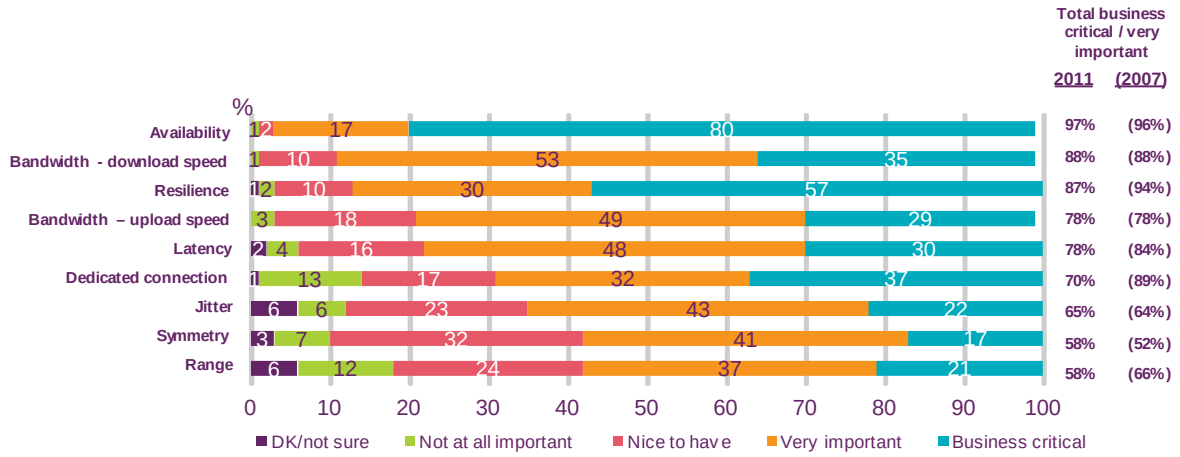
[85] http://stakeholders.ofcom.org.uk/binaries/consultations/business-connectivity/annexes/business-review.pdf

[86] An executive summary of the results is available at: http://www.thecma.com/content_pdf/press/Internet_Opportunity_Survey_2011.pdf

[87] These results were also discussed under Issue 1, paragraph 3.48.

[88] The qualitative analysis above highlighted that in terms of download bandwidth next generation broadband will by the end of this review period offer bandwidths of 80Mbit/s on FTTC, 300Mbit/s on FTTP and 200Mbit/s on cable modem. While the effective symmetric bandwidth available will be much lower because of lower upload bandwidths it is clear that there will be wide scope for substitution for bandwidth requirements lower than 100Mbit/s.

Figure 12: The importance of service characteristics



Source: Ofcom end-user research, QC1 (2011 n=461; 2007 n=450)

3.143 However, substitution may be limited due to end-users demand for other characteristics. Our qualitative assessment noted that broadband is not able to offer the same level of performance in terms of contention, latency/jitter and resilience. We noted further that due to different levels of SLAs/SLGs broadband does not currently offer the same level of guarantees of availability as a typical leased line.[89] These were all features that were identified as business critical or very important by over 65% of all respondents, with availability being cited by 97% of respondents, resilience by 87% and latency by 77%. Having a dedicated connection (no contention) and jitter were seen as relatively less important but were still cited by 70% and 65% of respondents respectively. These results suggest that end-users typically place higher value on one or more characteristics of leased lines which cannot be matched by broadband. Therefore end-users may be unwilling or unable to switch to broadband because it cannot meet the requirements that end-users see as vital to their organisations.

3.144 For all characteristics respondents were also asked whether their relative importance to them would increase or decrease over the next two years.[90] For all the above characteristics 95% of respondents stated that it would either be more important or stay about the same level of importance. This suggests that the above findings are likely to be robust over the duration of this review.

3.145 We also asked respondents specific questions on ADSL services. All respondents were asked whether their company/organisation had ever replaced leased lines with ADSL services. Across all respondents 20% had replaced leased lines with ADSL, with switching being more prevalent among larger organisations. Alongside this respondents were also asked whether they were likely to replace leased lines with ADSL, with answers ranging from very likely to very unlikely. In total only 14% of respondents answered that they were either very or quite likely to replace leased lines with ADSL, while 74% of respondents stated they were either very or quite

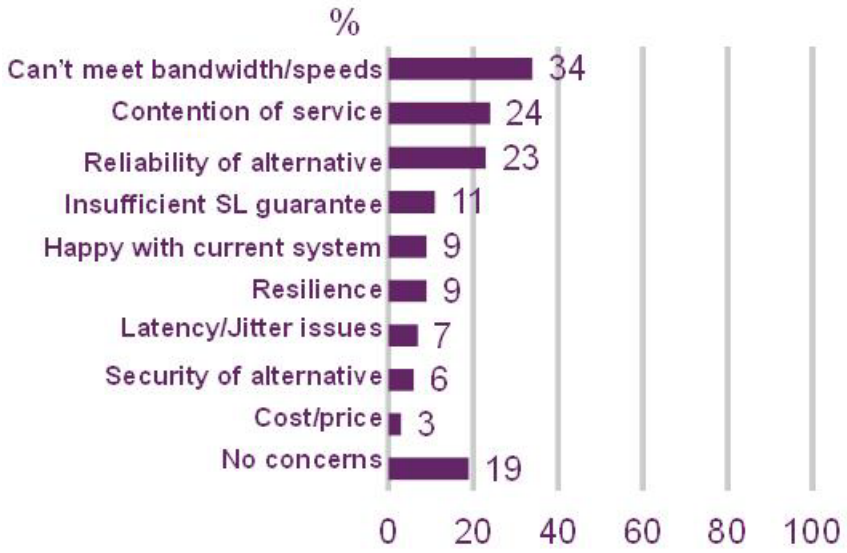
[89] As we noted above broadband networks are shared among businesses and consumer end-users and are built to provide a specific quality of service and while this can be increased this would come at a cost. Given that currently there are no broadband products on the market that offer equivalent SLA/SLG as leased lines this suggests that there is insufficient demand from end-users, especially consumer end-users, to pay for higher level SLA/SLG.

[90] http://stakeholders.ofcom.org.uk/binaries/consultations/business-connectivity/annexes/business-review.pdf

unlikely to replace leased lines with ADSL. In contrast to the previous question smaller organisations were more likely to switch to ADSL than larger organisations.[91]

3.146 As a follow up question respondents were asked to consider the service characteristics of ADSL and leased lines and to identify the challenges or concerns they had about replacing leased lines with ADSL.[92] Respondents were able to identify more than one challenge or concern as summarised below in Figure 13.

Figure 13: Challenges or concerns about switching to ADSL



Source: Ofcom end-user research, QE3 (n=308)

3.147 Among those interviewed it is important to note that 19% of current leased line users identified no challenges or concerns in switching to ADSL. The most commonly cited concern was bandwidth limitations, identified by 34% of respondents, followed by concerns about the contention of service (24% of respondents) and the reliability of ADSL (22%). Several of the other challenges or concerns also relate to the differences in characteristics of leased lines and ADSL (level of SLGs, resilience, latency/jitter and security). These results suggest that a significant percentage of leased line users have concerns about switching to ADSL services.

3.148 In addition to questions on ADSL, we also asked about the impact of next generation broadband. All respondents were told that in the next few years superfast broadband will offer much higher upload and download bandwidths than are currently available with existing ADSL technology. They were then asked how likely this is to prompt them to switch from their current services, with possible responses ranging from very likely to very unlikely. Here 53% of respondents answered that they were very or quite likely to switch to superfast broadband, while 32% answered that they were very or quite unlikely to switch. The remaining 16% of respondents either did not know or were either unlikely or likely to switch. This result suggests that superfast broadband could potentially be highly significant with over 50% of users saying they were likely to switch.

[91] Note, for this question small businesses have a low base size so any results should not be overstated as they are subject to a larger statistical margin of error.

[92] This question was asked to all respondents with leased line access links irrespective of whether they said they were likely to consider switching.

3.149 However, caution must be applied to this estimate because this is a stated rather than revealed preference. One issue is stated preference bias; this is the tendency of respondents to overstate their willingness to undertake an action, like switching to superfast broadband, which means that the levels of switching may be over-estimated. As discussed above, upload and download bandwidths are not the only features end-users value from a leased line. The demand for other characteristics like resilience may limit substitution because as even if the upload and download bandwidth requirements are met; superfast broadband is not able to match leased lines in terms of other characteristics. Also as no time limit was set on this question, it is likely that respondents stated their general interest in the service, rather than a concrete confirmation of switching in the short to medium term.

3.150 Nevertheless, it is clear that with the rollout of superfast broadband there will be a greater opportunity for end-users who value bandwidth but have a lesser need for specific characteristics to switch. This is because higher levels of bandwidth, which previously were only available with leased lines, will be available with NGA, and this may lead some end-users in this group to switch away to lower cost NGA services. As shown in Figure 13, the most commonly cited concern about switching to ADSL was that it would not be able to meet the bandwidth required; this would be less of issue with superfast broadband.

3.151 The impact of superfast broadband was also a focus of the IOS commissioned by the CMA and the FSB.[93] All respondents were asked whether their organisation used superfast broadband. Across all respondents 16% were already using or implementing superfast broadband, 19% were planning to use it in the next 12 months, while 65% had no plans to use it. This shows that most businesses have no plans to adopt superfast broadband. Moreover, for those with plans to use, or who are already using NGA, we cannot tell from the data if it is a substitute or a complement to leased line use, or if end-users are upgrading from current generation broadband.

3.152 As a follow-up question, respondents who had no plans to use superfast broadband were asked to identify the main factor preventing their organisation from using it. Here the most commonly cited reason was geographic availability. These users were then also asked to assess the likelihood of using superfast broadband once available. Similar to the above result, 60% of respondents said they were either very likely or likely to switch, while 40% of respondents were either unlikely or very unlikely to switch. Again this points to the potentially significant impact of superfast broadband.

3.153 The end-user research discussed above suggests that differences in service characteristics mean there are a number of barriers to switching from leased lines to broadband. This was highlighted by the discussion of ADSL and end-users concerns/challenges about replacing leased lines with ADSL. The potential impact of superfast broadband was also discussed, and the results are suggestive that a large proportion of users could migrate from leased lines to broadband. With the rollout of superfast broadband it is clear that there will be a greater opportunity for end-users who value bandwidth but have a lesser need for specific characteristics to switch, although the full competitive impact of superfast broadband cannot be known with certainty at this stage.

[93] http://stakeholders.ofcom.org.uk/binaries/consultations/business-connectivity/annexes/business-review.pdf

Broadband service features and pricing

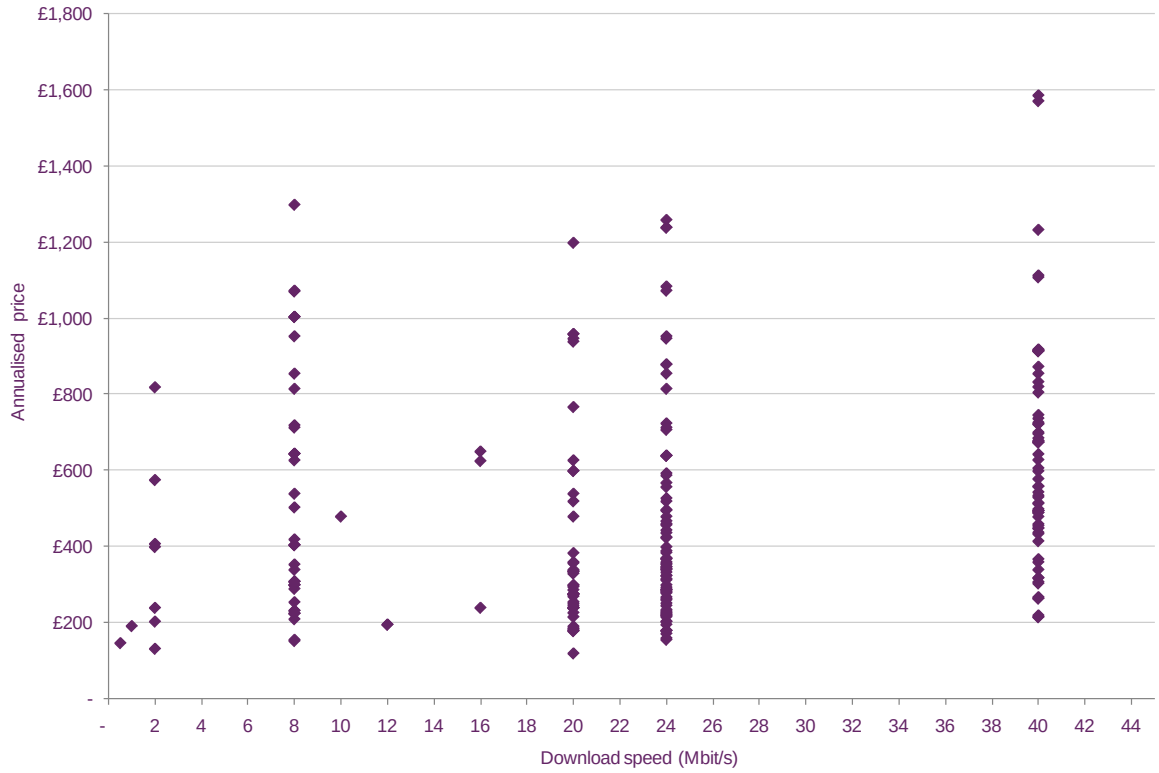
3.154 In order to help inform our assessment of whether business broadband could impose a competitive constraint on leased lines we have also considered the marketing, service characteristics and pricing of broadband packages offered by CPs and in particular, publicly available information on CPs' websites. In this section we first provide an overview of marketing and then discuss the relationship between price and download/upload bandwidth, usage allowances and contention ratios.

3.155 The marketing of business broadband packages helps provide an understanding of how providers position broadband services relative to leased lines. The review of marketing covered the websites for each of the packages included in our research. A common feature in the marketing was to set out the sort of business the service might apply to, this was often designated by the number of end-users it was designed to support, or whether the service was suitable for heavy or low business usage. Across providers, business broadband was not usually positioned directly against leased lines. CPs who provide both broadband and leased lines typically positioned leased lines as a premium service. Overall the marketing suggests that broadband services are not simply characterised as a cheap substitute for leased lines but are aimed at end-users who demand different service characteristics.

3.156 On service features and pricing we first consider the relationship between download bandwidth and price. Our research covered 249 individual broadband packages offered by 40 providers covering downloads bandwidths of 512kbit/s up to 40Mbit/s.[94] Figure 14 plots the relationship between the annualised price including connection fees and the headline download bandwidths in Mbit/s across these packages.

[94] Note the analysis is based on headline bandwidths and that where no contract length was given we have assumed it to be 12 months.

Figure 14: Broadband price comparison by download bandwidth



Source: Ofcom analysis, based on publically available prices on CPs' websites

3.157 The figure shows that there is a considerable range in broadband prices and businesses can expect to pay from as little as £120 per year to up to £1600 per year.[95] Across the packages and bandwidths the (unweighted) average price for broadband is approximately £500 per year. At each bandwidth the range of prices reflects the variety of different service wraps available, where higher priced services can be seen as 'Premium' services offering enhanced features over 'Basic' broadband. These enhanced features are typically a mix of improved upload bandwidths, lower contention rates, higher usage allowances or other features like static IP addresses. At the package level there is no clear relationship between price and bandwidth because of the variety of different 'Premium' services available at each bandwidth. But on average, prices increase with bandwidth, with the research suggesting that a business can expect to pay approximately £400 per year for a broadband service offering a 2Mbit/s download bandwidth, increasing to £620 per year for a 40Mbit/s service.

3.158 The upload bandwidth available is another key service feature; across all the packages available upload bandwidths varied from 256kbit/s to 10Mbit/s with a ratio of download to upload bandwidths of roughly 15:1. This varies across broadband technologies and for ADSL and ADSL2+ the ratio of download to upload bandwidths is roughly 17:1, while the corresponding estimate for FTTC packages is roughly 10:1. Across bandwidths, packages offering higher upload bandwidths were typically 'Premium' services, however, because improved upload bandwidths were normally just one of the improved service features it is difficult to draw a definitive conclusion on the additional cost of improved upload bandwidths, though our research did find

[95] Note this figure excludes estimates for uncontended broadband solutions which were the most expensive broadband solutions available and were only offered by a small subset of providers. These are discussed further in paragraph 3.160.

one CP offering a straight upload upgrade from 448kbit/s to 832kbit/s on all of its ADSL packages for an additional £84 per year.[96]

3.159 Business broadband packages also offer a range of usage allowances; these define the total amount of download and upload capacity available to an end-user. Across all the packages usage allowances range from 1Gbit per month up to unlimited usage (subject to a 'fair use' restriction) with prices typically increasing with higher usage allowances. On average (unweighted) across all bandwidths, a business broadband end-user would expect to pay £280 per year for a service with a 20Gbit monthly allowance, £640 per year for a service with a 100Gbit monthly allowance, and £675 per year for a service providing unlimited usage.

3.160 Alongside usage allowances there were also different contention ratios available, ranging from 50-1 to uncontended. As we noted in footnote 95 we excluded uncontended services from Figure 14 because they were some of the most expensive broadband packages available. Highlighting this, our research found an uncontended 2Mbit/s package costing approximately £5,000 per year; this can be compared to an average price of £400 for a 2Mbit/s package.[97] While there is a clear price mark-up for an uncontended service, as with upload bandwidths it is difficult to assess the relationship between price and improved contention ratios because they were normally part of a 'Premium' packages offering other improved service features as well.

3.161 Our analysis above of broadband pricing and service features highlights the range and variety of business broadband packages available. Across packages there are clear price differences with 'Premium' services offering higher upload bandwidths, usage allowances and lower contention ratios being significantly more expensive than 'Basic' packages at the same download bandwidth. We also considered marketing, noting that broadband is not typically characterised simply as a cheap substitute for leased lines but rather is positioned as appealing to end-users with different requirements.

Relative price comparisons and migration trends

3.162 While broadband and leased lines have different pricing structures, it is possible to compare the relative price of delivering a given bandwidth. To deliver 2Mbit/s using a PPC in the same exchange area would incur an annual charge of approximately £2,000.[98] In contrast our broadband pricing research suggested that on average a business can expect to pay approximately £400 per year for a broadband service offering 2Mbit/s download bandwidth, increasing to £620 per year for a 40Mbit/s service. This highlights that in general, broadband, even at higher bandwidths, is significantly cheaper than SDH/PDH circuits.[99] Also, as discussed in Issue 1 in this section, as Ethernet circuits are more expensive than SDH/PDH at low bandwidths this result will also hold for Ethernet circuits (i.e. broadband is significantly cheaper).

[96] See http://www.timico.co.uk/soho/ip_connectivity/adsl

[97] This was the most expensive broadband solutions covered. We note that these solutions are typically marketed as being particularly suited to businesses sited near busy exchanges, for example see: http://www.idnet.net/solutions/uncontendedadsl.jsp

[98] This has been calculated using the wholesale input prices using the same methodology as Figure 6 in Issue 1 of this section.

[99] Note that we compare the wholesale price of a PPC or Ethernet circuit with retail asymmetric broadband package prices. We consider that wholesale prices represent the minimum price of a PPC, as they do not include the costs of the retail service wrap. Thus the finding that PPC prices are significantly above asymmetric broadband prices would be stronger if we had used retail leased line prices.

3.163 The above price comparisons show that significant savings are available by switching to broadband, but that these appear to be insufficient to act as a constraint on pricing of low bandwidth circuits. If there was a sufficient constraint between low bandwidth leased lines and broadband services we might expect the pricing of the two services to be closer, or for there to be much less demand for the higher priced service. The presence of significant demand for leased lines at the same time as significant price differentials suggests that they are in separate markets.

3.164 We believe that a finding of separate markets is also consistent with the market trend data discussed under the heading of Issue 1 and summarised in Table 12 below. This shows that sub-2Mbit/s volumes saw the steepest decline, falling by 43% by the end of 2010/11 compared to 2007/8; the corresponding estimate for analogue and 2Mbit/s volumes is 21% and 16% respectively. In contrast our estimates indicate that business broadband has been growing strongly, with an increase of 16% (111,000 extra services).[100] As our data is at the aggregate level, and not at the level of the individual end-user, we cannot accurately measure or track the extent of switching between services. Nevertheless, it is likely that some of the growth in broadband use will have been due to low bandwidth leased line users switching to broadband. Some of the reduction in low bandwidth leased line volumes may also be due to other factors, such as switching to higher bandwidth leased lines.

Table 12: Market trends for low bandwidth services, 2007/8-2010/11

Service	2007/8 Volumes	2010/11 Volumes	Volume (%) change
Analogue	76,000	60,000	-16,000 (-21%)
Sub-2Mbit/s	44,000	25,000	-19,000 (-43%)
2Mbit/s	61,000	51,000	-10,000 (-16%)
Business broadband[101]	674,000	785,000	111,000 (16%)

Source: CP's responses to s.135 information request, 2011

3.165 However, we do not think these trends mean that low bandwidth leased lines and asymmetric broadband services should be regarded as part of a single market. One reason is that the price differentials to which users may be responding are far larger than a 10% SSNIP. So even if these differentials are inducing some switching to broadband and contributing to the fall in demand for TI services, we do not think this means that a SSNIP would be unprofitable. In addition, as noted above, a substantial number of leased line users have still not switched, despite the savings available. It seems likely that the remaining leased line customers are the ones most likely to need the additional functionality of leased lines and therefore to be relatively unlikely to switch in future. Finally, there does not seem to have been any real price convergence to suggest that there is a common pricing constraint covering broadband and leased line services.

3.166 We also note that even though low bandwidth leased lines have been in decline, there is still a relatively large installed base of 136,000 circuits. The majority of these are likely to be concentrated across a narrow set of end-users who either have a

[100] To provide some context to this increase we note that in the 2011 Ofcom Communications Market Review it was reported that the number of residential broadband connections increased from 15.6m in 2007 to 19.6m in 2010. See: Communications Market Report, Ofcom, August 2011, Figure 5.32, available at: http://stakeholders.ofcom.org.uk/binaries/research/cmr/cmr11/UK_CMR_2011_FINAL.pdf

[101] Note this captures business broadband volumes submitted to us by CPs and as above while we recognise that it may not accurately capture all volumes, it should provide a robust view of the trends in the market.

legacy network for site interconnection or require specific characteristics of a leased line.[102] Given the significant price premium of leased lines over broadband it is unlikely that end-users would continue to purchase leased lines if broadband was a good substitute. Here we note that while there have been advances in broadband technology and applications that allow it to be used where previously leased lines would be required,[103] we consider that, during this review period, broadband is unlikely to be a sufficiently close substitute to a leased line to define a broad market.

Barriers to switching

3.167 End-users wanting to switch from leased lines to broadband face some of the same considerations as end-users considering moving from TI to AI leased lines, this includes:

- the potential for service disruption;
- parallel operation whilst the new broadband service is tested; and
- for TI end-users, change of CPE such that data is mapped to Ethernet rather than TDM interfaces and investment in new CPE to convert existing TDM services, such as voice, to a data interface.

3.168 Alongside these, there are additional factors that end-users need to consider:

- the end-user must consider the security considerations of using a shared medium rather than the dedicated medium of leased lines;
- the service level agreement for broadband is different to that for a leased line and the end-user needs to determine that it is sufficiently robust for their needs; and
- there needs to be an analysis of the upstream and downstream bandwidth available over the course of a typical week - broadband services exhibit varying transmission rates depending on network loading, the service quality set and whether data is being downloaded or uploaded.

3.169 In situations where broadband is a good substitute for a leased line the impact of switching costs will vary by type of end-user. For end-users with large legacy networks or who use specialised applications, there are likely to be significant switching costs involved. This is because of the need to upgrade all the customer premises equipment and applications to support broadband and before migrating applications across, the broadband systems would have to be set up and tested. These factors are likely to delay switching, and mean that switching might only take place when the end-user equipment or applications come to the end of their product life cycle. In contrast, for end-users who do not require specific characteristics and/or use a small number of leased lines, the costs of switching are likely to be less significant. This is because broadband can be delivered with relatively inexpensive customer premises equipment (relative to leased lines).

[102] Significant end-users include utility companies, local government and high street banks. BT's view is that in the future there may be step changes in volumes as large end-users migrate and/or upgrade their applications to run on higher bandwidth leased lines and/or broadband.

[103] This includes applications like CCTV and road traffic management applications, for example see:

http://www.easynet.com/gb/en/about/pressRelease.aspx?SecondaryNavID=52&pressreleaseid=1461

Proposed market definition

3.170 On the basis of our analysis, we consider that broadband and leased lines continue to fall into separate markets for the following reasons:

- our qualitative differences between broadband services and leased lines highlighted that, while broadband bandwidths have increased significantly there are still a number of key differences in service features;
- evidence from consumer surveys highlighted that the service features of leased lines are highly valued by end-users and that end-users have significant concerns about switching to ADSL-based services. We also discussed the impact of next generation broadband and we noted that it had a potential to increase switching in the future, but that this would be limited in the short run and that it could be limited by end-users demands for characteristics only offered by leased lines;
- relative price comparisons and migration trends highlighted that although significant savings are available from switching to broadband, switching does not appear to have resulted in convergence between the prices of asymmetric broadband and low bandwidth leased lines. At the same time there is still significant demand for low bandwidth leased lines; and
- consideration of barriers to switching highlighted that for end-users with large legacy networks and/or who use specialised applications are likely to face significant switching costs.

3.171 Our analysis summarised above suggests that broadband is likely to have some impact on the demand for leased lines and that this impact may increase with the deployment of next generation broadband. However, demand for leased lines will remain significant for the market review period. This is because there are a number of end-users for which dedicated low bandwidth leased lines are essential to meet their business needs. As the strength of substitution is not sufficient to make a SSNIP in the price of retail leased lines unprofitable, we propose that asymmetric broadband services remain outside the leased line markets.

3.172 Supporting this we note that respondents to the CFI noted that even though substitution had been occurring there were still a number of barriers, based both on technological and service quality that limit switching. The impact of next generation broadband was also widely commented upon, with most respondents fairly cautious about the potential impact.

Issue 4: Bandwidth

3.173 Business end-users have a diverse range of bandwidth requirements. Some business end-users only require very low bandwidths reflecting requirements to transmit relatively small amounts of data reliably and quickly (e.g. for bank cash points), while at the top-end, business end-users such as those operating data centres may require many Gbit/s of capacity. As part of the retail market definition we need to consider whether AI and TI services fall into one or more service markets by bandwidth. This depends on whether there are breaks in the chain in substitution. For the reasons set out below, we propose to define four retail TI markets based on the same bandwidth breaks as in the 2007/8 Review, and two AI markets, again reflecting the conclusions of the 2007/8 Review.

3.174 Table 13 below sets out the typical bandwidths available for TI and AI services.

Table 13: Typical bandwidth increments of leased line services

	TI services	AI services
Typical bandwidth increments	64kbit/s	2 - 20Mbit/s (Ethernet First Mile)
	n * 64kbit/s (up to n=31)	10Mbit/s
	2Mbit/s	100Mbit/s
	n * 2Mbit/s	1Gbit/s
	45Mbit/s	2.5Gbit/s
	155Mbit/s	10Gbit/s
	622Mbit/s	

Source: Ofcom 2012

3.175 In terms of pure functionality, multiples of low bandwidth circuits are in the majority of cases substitutes for circuits of higher bandwidth and vice versa.[104] This means there is the potential for substitution between services of different bandwidths and we observe that this does happen in the market. For example, in the TI market an end-user requirement for 10Mbit/s of capacity could be met by using a 45Mbit/s service or by buying five 2Mbit/s circuits. The choice between these two options will depend on their relative prices, with the assumption that end-users want their total bandwidth to be met at the lowest possible price, given the other service characteristics which they also value (such as latency, jitter etc).

3.176 If there are enough end-users who can, and are willing to switch between services of two different (but adjacent) bandwidths in response to small price changes, then this demand-side substitution may be sufficient to mean that there is a single market including circuits of both bandwidths. If there are enough such end-users throughout the available range of bandwidths then circuits of all capacities might be linked by a chain of substitution. For example if in response to a small price change, enough end-users would switch between 2Mbit/s TI services and 45Mbit/s TI services for them to be regarded as close substitutes, and 45Mbit/s circuits in turn were substitutes for 155Mbit/s TI services, then this would create a chain of substitution, and a single market, consisting of all three bandwidths.

3.177 In some markets we have found that chains of substitution of this kind do exist. When we reviewed markets for asymmetric broadband access we did not distinguish separate markets according to the bandwidth of the package.[105] We took the view that a chain of substitution means that there is a single market for packages of all currently available bandwidths. However, the existence of a chain of substitution is an empirical question specific to the circumstances of the markets under review. In leased line markets the number of end-users is smaller and the 'gaps' in the chain, in bandwidth and price, are larger, reducing the likelihood that a chain of substitution exists. Indeed, in the 2003/4 and 2007/8 Review we found that a chain of substitution did not exist and that there were separate markets based on bandwidth.

3.178 Therefore on this basis, below we review the bandwidth breaks for the TI and AI markets.

[104] However there may be some costs associated from moving from a single circuit to multiple bonded circuits which are likely to require the use of more complex and expensive CPE to implement the bonding.
[105] For a full discussion of this see the Review of the wholesale broadband access markets 2010 (Section 3).

(i) Bandwidth breaks in the TI market

Our assessment in the 2007/8 Review

3.179 In the 2007/8 Review we identified a number of bandwidth breaks in the TI market:

- low - up to and including 8Mbit/s (including analogue and SDSL services);
- high - above 8Mbit/s up to and including 45Mbit/s;
- very High 155 - above 45Mbit/s and up to and including 155Mbit/s; and
- very High 622 - above 155Mbit/s, including 622Mbit/s.

3.180 The bandwidth breaks were based on a number of considerations. Firstly, the results of our consumer survey suggested that retail end-users are rarely willing to compromise on bandwidth. However, as noted above, there is more than one way of meeting a requirement for a given total bandwidth and this means that services of different bandwidths can be substitutes. We assessed whether switching between them would be sufficiently strong to constrain a SSNIP above the competitive price imposed by a hypothetical monopolist across a range of bandwidths. To do this we used the market definition methodology developed for the 2003/4 Review:

- First, for a particular end-user's bandwidth requirement we identified the lowest cost theoretical combination of circuits needed to deliver that bandwidth requirement. This was on the assumption that, in a competitive market, prices would be driven to a level just sufficient to recover costs and allow a reasonable return on capital. We used BT's cost orientated wholesale service based PPC charges[106] on the basis that they were a reasonable proxy for the structure of retail prices.[107]
- Having calculated the least cost combination of services over the likely range of end-user bandwidth requirements, we then considered what would be the impact of imposing a SSNIP on the price of the circuits of each bandwidth (as identified in Table 13 above).
- We then assessed, given the likely distribution of demand for different levels of bandwidth, whether a SSNIP would be profitable for a circuit of a particular bandwidth.

3.181 Our analysis suggested that for TI services, breaks in the chain of substitution existed at around 8Mbit/s, 45Mbit/s and 155Mbit/s. This was because there were significant price jumps at these levels, indicating that a SSNIP applied to the price of circuits at these bandwidths would not prompt switching to higher bandwidth services. These results continued to apply under a range of different sensitivity scenarios.

3.182 For 155Mbit/s and 622Mbit/s, while the pricing analysis suggested there could be a chain of substitution, we noted that its existence was dependent on the distribution of end-users according to demand for bandwidth. Specifically, 155Mbit/s lines would only be constrained by 622Mbit/s lines if an end-user was acquiring four or five

[106] Note before 2009 TI products were not charge controlled and were only subject to cost orientation.

[107] See footnote 46.

155Mbit/s lines along the same route as part of a higher bandwidth requirement. This was because 622Mbit/s lines were significantly more expensive than 155Mbit/s lines and where 155Mbit/s lines were acquired as single lines across a particular route (i.e. where end-users only wished to acquire 155Mbit/s of bandwidth) they were unlikely to be constrained by the price of 622Mbit/s services. This remained the case even after a SSNIP was imposed on the 155Mbit/s line. Our analysis indicated that only 30% of 155Mbit/s lines connected to the same two points as another 155Mbit/s line, implying that most 155Mbit/s lines were acquired as single circuits rather than as multiple lines across the same route. This suggested that the two services were in separate retail markets.

3.183 Even if there was a break in the chain of substitution, we also noted that 155 and 622Mbit/s services could still be regarded as being part of the same market if the competitive conditions of the supply of the two services were sufficiently homogenous. However, our analysis of competitive conditions suggested that competitive conditions differed significantly, as while BT had around 49% of retail 155Mbit/s lines in the UK excluding Hull; the corresponding estimate for 622Mbit/s lines was only 11%.

Call for inputs

3.184 In the CFI we put forward our preliminary view that the factors leading to our conclusions in relation to the main bandwidth breaks for TI services in the 2007/8 Review were unlikely to have changed materially for the following reasons:

- Since the 2007/8 Review, new investments have been directed mainly towards Ethernet (including R&D in network equipment) and therefore it is unlikely that the demand and cost conditions which underlie the bandwidth breaks found in TI markets in the 2007/8 Review would have materially changed.

- Also, as the current markets are narrowly defined to include only services at specified bandwidths, if we retain the bandwidth breaks from the 2007/8 Review we are unlikely to err by inadvertently including competitive services in the same market as less competitively-supplied services, even if there have been some changes in competitive conditions since the 2007/8 Review.

3.185 However, we did note that we could streamline our analysis by combining the up to 45Mbit/s and the up to 155Mbit/s markets. In the 2007/8 Review we found that the competitive conditions for these services were broadly similar and, providing this continues to be the case, we proposed that we would conduct our SMP assessment based on a combined high bandwidth market for TI services above 8Mbit/s up to 155Mbit/s.[108]

3.186 We asked stakeholders for their views on main bandwidth breaks for TI services and the possibility of combining the up to 45Mbit/s and the up to 155Mbit/s markets.

Stakeholder views

3.187 Nine respondents [✂ ✂ ✂ ✂] commented on our proposals for TI bandwidth breaks in the CFI. There was a broad consensus on retaining the main bandwidth breaks but a more mixed

[108] In the 2007/8 Review we identified a separate competitive geographic market for the Central and East London Area (CELA) both for services up to 45Mbit/s and 155Mbit/s. For both bandwidths, BT was found to have SMP in the rest of the UK outside of the CELA (excluding Hull).

response to our proposal to combine the up to 45Mbit/s and up to 155Mbit/s markets. Of the nine respondents, six supported this proposal; two expressed no particular preference, while one respondent disagreed.

3.188 A number of points were made in support of the proposal:

- KCOM and Verizon both noted that market conditions are such that these services should be combined. KCOM highlighted that for circuits above 8Mbit/s and up to 155Mbit/s they have seen static demand and said that they do not believe that combining the services in the market analysis will have a great impact on the outcome of the market review. This view was echoed by another respondent [✂ ✂] who added that any change would not be of great significance to their business.

- 3UK and MBNL noted that they have only a few remaining 45Mbit/s services and that over time they have replaced many of these with better value 155Mbit/s services.

- the Communication Management Association (CMA) response gave the proposal a qualified "yes", with the caveat that combining the two markets must not be allowed to result in a single service offering (or price) which could have implications for the equipment costs for the different interfaces.

3.189 Of the two respondents who expressed no particular preference, one respondent [✂ ✂ ✂] stated that while Ofcom should revalidate its analysis, it did not see combining the up to 45Mbit/s and up to 155Mbit/s markets as an important issue. The other respondent [✂ ✂] cautioned that while they had no preference they consider it vital that any review of competitive conditions is sufficiently accurate and that any variation in competitive conditions (for example any geographic distinctions) is not masked by such consolidation.

3.190 The respondent who did not support the proposal to combine the two markets was C&WW. C&WW's view was that, unless Ofcom is able to prove that the break in substitution between these bandwidths no longer exists, we should define separate markets at 45 and 155Mbit/s. C&WW emphasised that market definition and SMP designation must be based on robust and sound market analysis.

3.191 BT's response also raised the issue of the appropriate market definition for sub-2Mbit/s services. It argued that we should take into account significant differences in the characteristics of TI services at 2Mbit/s and those below 2Mbit/s which it suggests point to a separate market for sub-2Mbit/s services. BT also noted that over the last three years volumes of sub-2Mbit/s services have declined by 42% as users have switched to broadband, a greater decline than that experienced in 2Mbit/s services. No other respondent raised this point in the CFI.

Ofcom analysis

3.192 In the responses to the CFI, there was a broad consensus that there had been no material change in the main bandwidth breaks in the TI market, but a more mixed response to our proposal to combine the up to 45Mbit/s and the up to 155Mbit/s markets. The issue of the appropriate market definition for sub-2Mbit/s services was also raised. In light of these responses we have structured our discussion of our analysis of bandwidth breaks in the TI market as follows:

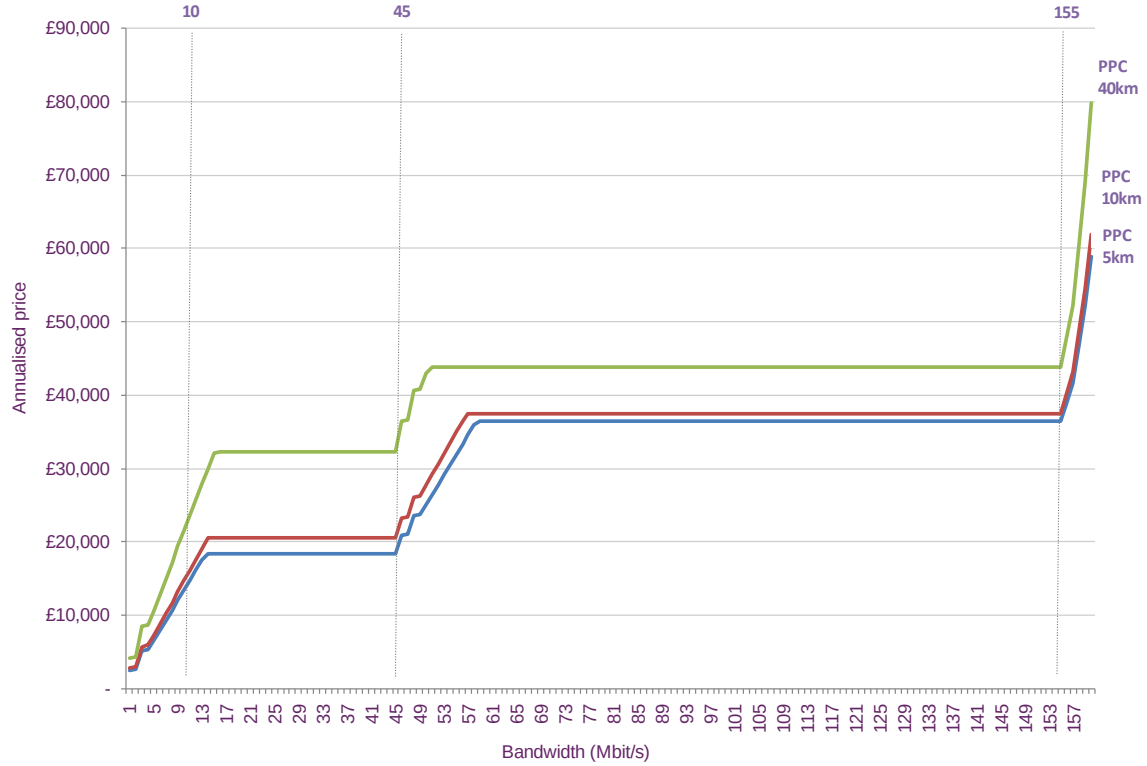
- an updated analysis of the main TI bandwidth breaks;

- an assessment of whether it is appropriate to combine the up to 45Mbit/s and the up to 155Mbit/s markets; and
- an assessment of the appropriate market definition for sub-2Mbit/s services.

Revalidating the main TI bandwidth breaks

3.193 Our analysis supports the continuation of main TI bandwidth breaks as set out in the 2007/8 Review, noting that this is in line with the preliminary view set out in the CFI which received broad support. Therefore, following the approach used in the 2007/8 Review, set out in paragraph 3.180, Figure 15 below shows the cheapest theoretical combination of circuits that can be used to provide a particular bandwidth requirement at different distances. For example, a user requiring 100Mbit/s would be likely to purchase a 155Mbit/s service. At low bandwidths up to around 10Mbit/s, a user could use multiples of 2Mbit/s circuits to deliver their bandwidth requirements (rather than using the next bandwidth increment of 45Mbit/s).

Figure 15: Wholesale price estimates for TI services (non-CLZ)



Source: Ofcom analysis, based on BT wholesale pricelist for PPC services

3.194 The analysis points to the continued existence of bandwidth breaks at around 8Mbit/s, 45Mbit/s and 155Mbit/s as shown by the 'steps' in the figure above and this result is consistent across a range of distances shown. The smoother the increase in the (total) price as total bandwidth increases, the more likely it is that circuits of different bandwidths fall in the same market. In the above analysis there appear to be clear steps which indicate there are significant price increments at certain points which we refer to as "bandwidth breaks". This suggests that a SSNIP applied on a bandwidth just below these levels would not prompt switching to higher bandwidth services, which suggests that there will be a break in the chain of substitution between bandwidths. For example in response to a SSNIP, an end-user with a bandwidth requirement of 45Mbit/s would not switch to a 155Mbit/s service, because

the jump in price (indicated by the step in the figure) is greater than the effect of the SSNIP (which is typically taken to be a price increase of 5 or 10%). These results continue to apply under the range of different sensitivity scenarios which were first tested in the 2007/8 Review. We have carried out sensitivities on a range of assumptions relating to the mix of trunk and terminating segments, the utilisation of the point of handover and the circuit length.[109]

3.195 For 155Mbit/s and 622Mbit/s, as was discussed above, substitution is only likely to occur where an end-user is acquiring four or five 155Mbit/s along the same route (i.e. if an end-user is acquiring multiple 155Mbit/s services as part of a higher bandwidth requirement). However, our updated analysis suggests that the majority of 155Mbit/s lines are still acquired as single circuits, as only 10% of 155Mbit/s lines linked the same two points as another 155Mbit/s line.[110] This suggests that the two services still operate in separate retail markets. We also note that our analysis suggests that the competitive conditions in the two markets still differ significantly, as our wholesale service share estimates show that BT appears to have only 5% of 622Mbit/s lines, compared to 50% of 155Mbit/s lines in the UK excluding Hull.

3.196 Under Issue 5 below, we identify a multiple interface market serving customers with very high bandwidth requirements, which includes leased lines services above 1Gbit/s. The analysis of very high bandwidth services focuses on Ethernet and WDM services. But we note that retail WDM services allow equipment installed at customer premises to support multiple wavelengths and different client interfaces including SDH. SDH carried on such WDM equipment would retain all of the characteristics of a native SDH service. Given the significant declines in the cost of WDM-equipment, TI services above 155Mbit/s may face an additional competitive constraint from WDM retail services such that we could, in principle, include some or all of the very high bandwidth TI services (e.g. TI services at 622Mbit/s, 2.5Gbit/s or 10Gbit/s) in the MI market. In our SMP assessment we therefore take into account the potential for an additional competitive constraint arising from WDM services.[111]

3.197 On the basis of the analysis set out above, we consider that the main bandwidth breaks from the 2007/8 Review have not materially changed.

Should the up to 45Mbit/s and the up to 155Mbit/s markets be combined?

3.198 Even though there is a break in the chain of substitution, 45Mbit/s and 155Mbit/s services could still be regarded as being part of the same market if the competitive conditions of the supply of the two services are sufficiently homogeneous, bearing in mind that market definition is a means to an end (i.e. to assist in the assessment of SMP).[112] If competitive conditions are sufficiently similar the SMP analysis can be simplified without affecting the outcome by combining two services in a single market. In the CFI we noted that the results of the 2007/8 Review suggested that competitive conditions for these services were broadly similar, as for both markets we identified a separate competitive geographic market for the Central and East

[109] For a full explanation of the sensitivities applied to this model see paragraph 3.328 of the January 2008 Consultation.

[110] This estimate is based on an analysis of per circuit data of 5 CPs (BT, Colt, C&WW, Verizon and Virgin Media) who together account for over 90% of 155Mbit/s volumes.

[111] Due to issues over data quality and on practicality grounds, we include all leased lines services above 1Gbit/s (including where specified any SDH circuits for example at 2.5Gbit/s or 10Gbit/s) in the MI market.

[112] As discussed in Annex 7, although homogeneity of competitive conditions is usually used in the context of geographic market definition as a reason for aggregating different areas not linked by demand or supply side substitution, it might also be used in the product market context.

London Area (CELA) and found BT to have SMP in the rest of the UK outside of the CELA (excluding Hull).

3.199 Nevertheless, our analysis suggests that the competitive conditions in the two markets are not sufficiently similar to support combining them. In the wholesale market for the UK excluding Hull, BT appears to have a market share of around 60% in the up to 45Mbit/s market, compared to a market share of 50% in the up to 155Mbit/s market. These differences call for separate examination, although ultimately we conclude that BT has SMP in both markets (at the wholesale level). We also note that this result does not seem to be explained by 'small number' issues because significant quantities of both lines are still supplied.[113]

Should there be a separate market for sub-2Mbit/s services?

3.200 In the CFI BT argued that we should take into account significant differences in the characteristics of TI services at 2Mbit/s and those below 2Mbit/s which it suggests point to a separate market for sub-2Mbit/s services. BT noted that over the last three years volumes of sub-2Mbit/s circuits have declined by 42% as end-users have switched to broadband and Ethernet, a greater decline than that experienced in 2Mbit/s circuits. In this section we review the appropriate market definition for sub-2Mbit/s services. We consider in turn:

- the qualitative characteristics of sub-2Mbit/s and 2Mbit/s services;
- relative price comparisons; and
- migration trends.

Qualitative assessment

3.201 Sub-2Mbit/s and 2Mbit/s services are both TDM services and are deterministic, in that they offer low and predictable latency and jitter. As highlighted in Figure 4 these are features that end-users value. The fact that sub-2Mbit/s and 2Mbit/s services share these characteristics suggests that there is the potential for substitution between them for end-users whose demand can be met either by multiple 64kbit/s circuits or a single 2Mbit/s circuit.

3.202 One difference between the two services is that sub-2Mbit/s services are typically delivered over copper, while 2Mbit/s services are typically delivered over fibre. In the 2007/8 Review we considered whether there should be separate markets for copper-based and fibre-based services but concluded that there should not. We considered that retail end-users will in general be indifferent between a service provided over copper and an equivalent service provided over fibre, as the underlying technology only matters to end-users to the extent that it affects prices or quality of service. At low bandwidths there are no significant qualitative differences between copper and fibre based services and 2Mbit/s circuits can be provided over copper, at the same prices as equivalent services provided over fibre.[114] These factors do not point towards the identification of separate markets for fibre-based or copper-based services.

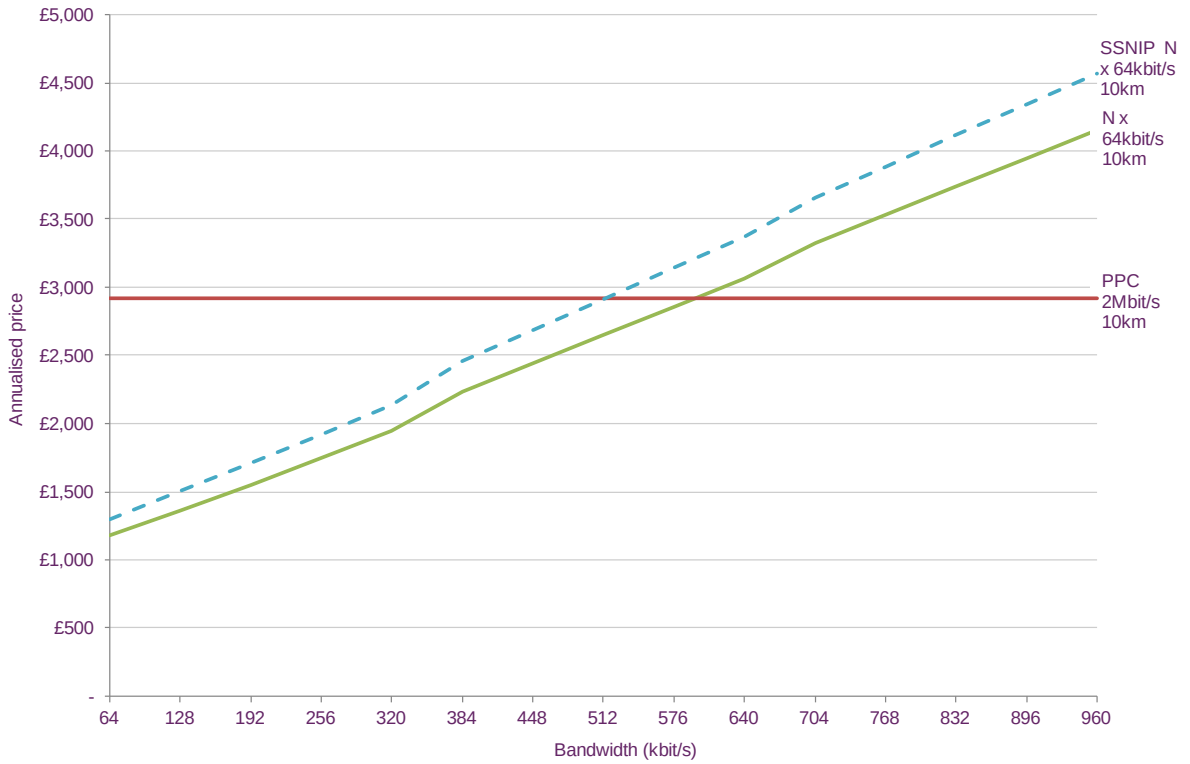
[113] Around 10,000 ends are provided in the up to 45Mbit/s market, against around 6,000 in the up to 155Mbit/s market.

[114] In 2007/8 Review our analysis indicated that approximately 20% of BT's 2Mbit/s services were provided over copper.

Relative price comparisons

3.203 Figure 16 below provides comparative price information for 2Mbit/s and sub-2Mbit/s PPCs based on BT's wholesale input prices, with the assumption that these prices should provide a reasonable proxy for the relative differences in competitive retail prices between services. The SSNIP adjusted price of sub-2Mbit/s circuits is also plotted alongside this data.

Figure 16: Wholesale price estimates for low bandwidth TI services (non-CLZ)



Source: Ofcom analysis, based on BT wholesale pricelist for PPC services

3.204 The figure suggests that, at current prices, for bandwidth requirements of above 576kbit/s it is cheaper to buy a 2Mbit/s service rather than sub-2Mbit/s services. After a SSNIP on sub-2Mbit/s services our analysis suggests that for bandwidths of 512kbit/s and above it would be cheaper to buy a 2Mbit/s service. These results continue to apply under a range of different sensitivity scenarios including changing the distances modelled.

3.205 If a hypothetical monopoly supplier of sub-2Mbit/s services could impose a SSNIP above the competitive level modelled above without losing sales to such a degree as to make this unprofitable, sub-2Mbit/s services could be considered to constitute a separate market. This is assessed by critical loss analysis. The critical loss is the percentage reduction in demand required as a result of the price increase in order for a SSNIP to be unprofitable. A SSNIP will have a number of offsetting effects, which the critical loss calculation attempts to capture. On the one hand, the end-users switching away will result in a loss of revenue. On the other, a hypothetical monopolist would no longer incur costs of serving the end-users that switched away. In addition, the monopolist on whose network end-users stay would receive additional revenue in proportion to the size of the SSNIP.

3.206 In order to assess the level of switching that would yield a SSNIP unprofitable, it may be relevant to consider the critical loss factor. The critical loss can be interpreted as

follows: if the reduction in demand in response to a SSNIP were above this level, the SSNIP would be unprofitable, with the implication that the market should be defined more widely than the focal service being considered. In contrast if the reduction in demand in response to a SSNIP were below this range, the SSNIP would be profitable and the focal service being considered may constitute a separate market. In the 2007/8 Review we estimated that for the main leased line services the critical loss factor was around 16 to 21 per cent.[115] Given that sub-2Mbit and 2Mbit/s services are based on mature technologies, we would not expect there to have been significant changes in the cost of provision such that this estimate will have materially changed.[116] Therefore, we apply a range of 16 to 21 per cent in our analysis below.

3.207 In the scenario above the change in demand will depend on the distribution of end-users by bandwidth and the willingness of end-users to switch services in response to a SSNIP. The distribution of end-users by bandwidth is important because Figure 16 clearly shows that for lower bandwidth requirements (64-448kbit/s) even after a SSNIP it would not be economic to switch to 2Mbit/s services. Therefore if the majority of end-user demand was concentrated at these bandwidths then it is likely that a SSNIP would be profitable. To gain an understanding of the distribution of end-users we have investigated the distribution of retail end-users for BT's 64kbit/s Kilostream services by bandwidth in 2010/11 and the results of this analysis are summarised in Table 14.

Table 14: Distribution of BT's Kilostream servcies by bandwidth 2010/11

Bandwidth	Percentage of Kilostream end-users
64kbit/s or under[117]	38%
128-192kbit/s	7%
256-320kbit/s	10%
384-448kbit/s	1%
512kbit/s	44%
Above 512kbit/s	1%

Source: BT response to s.135 information request, 2011

[115] The critical loss is calculated as a function of the SSNIP (which we take to be 10 per cent) and the ratio of the marginal cost to the current price (i.e. the price before the SSNIP). Our estimate in the 2007/8 Review was based on available data on price/cost relationships for the main leased line services. For a full discussion of the critical loss see Annex 9 of the January 2008 Consultation.

[116] To derive an estimate of the ratio of marginal cost / price, we base this on measures we have on how BT's costs of TI services are likely to react to a decline in BT's volumes. These measures are known as asset volume and cost volume elasticities ('AVEs' and 'CVEs'). These AVEs and CVEs can be used to provide a reasonable estimate of the likely costs that a hypothetical monopolist would avoid if it lost a particular level of sales (although they will not be identical). BT has provided updated information on the relationship of its costs of TI services to a decline in volumes for the forthcoming LLCC. Relative to estimates available at the time of the 2007/8 Review, BT estimates of its cost volume relationships may have changed for some operating costs (CVEs), but it does not estimate any significant changes for its AVEs.

If we were to use BT's updated AVEs and CVEs to estimate the likely costs that a hypothetical monopolist would avoid if it lost a particular level of sales, we do not consider that the changes BT proposed would be material enough to significantly change the level of critical loss very much. In support of this we note that our critical loss estimates derived in the January 2008 Consultation (Figure 95a) shows that a ratio of marginal cost to the initial competitive price of up to 60% would yield a critical loss of just over 20%. It is only at very high ratios of marginal costs relative to initial competitive prices there is a steep increase in the level of switching required to make a SSNIP unprofitable. We consider that BT's latest AVEs and CVEs do not suggest a ratio of marginal cost to the competitive price level above this 60% mark. Therefore, we propose to retain our estimate of the critical loss in 2007/8 Review of 16-21%.

[117] Some services are supplied over 64kbit/s bearers but have their bandwidth throttled.

3.208 The table highlights that the distribution of end-users is concentrated at two bandwidths with 44% of end-users at 512kbit/s and 38% at 64kbit/s. Of the remaining end-users 18% are at bandwidths between 128-448kbit/s while only 1% of end-users are at bandwidths above 512kbit/s. This is in line with Figure 16 which showed that at current prices for bandwidth requirements above 576kbit/s, it is cheaper to buy a 2Mbit/s service. This distribution turns out to be key to our analysis as, when combined with the SSNIP analysis above, this suggests that the 44% of end-users at 512kbit/s would have an incentive to switch to 2Mbit/s services in response to a SSNIP.

3.209 Of this group the level of switching will depend on the willingness of end-users to switch services in response to the SSNIP. In the 2007/8 Review our consumer survey evidence suggested that for SDH services up to and including 2Mbit/s there was likely to be significant levels of switching in response to a SSNIP.[118] This was further supported by our assessment of switching costs which found that they would not be material enough to prevent existing users switching following a SSNIP.[119]

3.210 Given these findings our available evidence suggests that in response to a SSNIP a significant percentage of end-users at 512kbit/s would be likely to switch to 2Mbit/s services. The resulting reduction in demand for 64kbit/s circuits would be considerably greater than the critical loss which indicates that a SSNIP on sub-2Mbit/s services would be unprofitable.[120] This suggests that sub-2Mbit/s and 2Mbit/s are linked by a chain of substitution and are in the same market. We also note that BT plans to cease new supply of some Kilostream services, though it plans to continue to supply 512Kbit/s. A full discussion of the future withdrawal of sub-2Mbit/s services is provided in Section 10.

Migration trends

3.211 Migration trends in the TI market are shown in Figure 7 and summarised in Table 12. These highlight that volumes of sub-2Mbit/s and 2Mbit/s leased lines have both fallen steadily since 2007/8. As noted by BT the steepest decline in both percentage and service (number of circuits) terms was for sub-2Mbit/s circuits, which fell by 43% (19,000 circuits) by the end of 2010/11 compared to 2007/8. The corresponding estimate for 2Mbit/s volumes was 16% (10,000 circuits). Even with these declines in Q4 2010/11 there is still a substantial installed base of circuits (25,000 sub-2Mbit/s and 51,000 2Mbit/s circuits respectively).

3.212 BT suggests that the steeper fall in volumes of sub-2Mbit/s services is because of higher levels of switching to broadband than for 2Mbit/s services. Certainly in terms of bandwidth, broadband, even during the 2007/8 Review could have been a viable alternative to many sub-2Mbit/s leased lines, while it is only with the recent advances in broadband technology that symmetric-equivalent bandwidths of 2Mbit/s and above have become available. This suggests end-users who value bandwidth but have a

[118] Indeed in the 2007/8 Review we considered that this would be well above the upper bound of the critical loss range, indicating that a SSNIP would be unprofitable.

[119] This excludes any connection fees the communications provider would be likely to levy. For example, if an end-user wanted to migrate its analogue leased lines to digital leased lines, a supplier would need to carry out engineering work (the most expensive part of the migration) and to install new network terminating equipment (NTE). However, these equipment costs should already be reflected in the relative price comparisons (for example as annualised connection fees) set out previously under this discussion. On this basis, these costs are not viewed as additional switching costs.

[120] For example if we assume that 40% of end-users at 512Kbit/s switch this would result in a 32% fall in demand for 64kbit/s services (weighted by circuit numbers), this is far higher than our critical loss estimate of 16-21%.

lesser need for specific characteristics at sub-2Mbit/s will have had greater opportunity to switch to broadband than similar users of 2Mbit/s services. This is likely to be reflected in the volumes.

3.213 However, our consumer survey provides no evidence that sub-2Mbit/s end-users are more likely to switch to broadband than 2Mbit/s end-users. In addition, there is no evidence that demand for the service characteristics of a leased line (i.e. latency, jitter, resilience, etc.) are lower at sub-2Mbit/s than at 2Mbit/s. For example important uses of sub-2Mbit/s circuits include Airwave (the Police/Fire radio system), high street banks ATM networks and network monitoring and protection applications for power and water utilities. All of these services use the characteristics of a leased line to perform their role. In the 2007/8 consumer survey when sub-2Mbit/s users were asked to identify the service that they saw as the closest substitute to their current service, Ethernet was the most commonly cited substitute candidate, suggesting that end-users at these bandwidths value the characteristics of a leased line.

3.214 Indeed another possible explanation of the divergence in trends between sub-2Mbit/s and 2Mbit/s services is that 2Mbit/s services are used as inputs to a wider array of services than sub-2Mbit/s circuits. For example 2Mbit/s circuits are often used as the bearer circuits for legacy voice services such as ISDN Primary Rate Interface (also known as ISDN30). Continued demand for these applications that require 2Mbit/s circuits could provide an explanation for the slower decline in 2Mbit/s services than seen at sub-2Mbit/s.

3.215 In all, given the factors discussed above we do not consider that there is strong evidence to suggest that there are separate markets for sub-2Mbit/s and 2Mbit/s services. The difference in volume trends does not, in our view, indicate a significant difference in competitive conditions, which would point to separate markets.

Proposed market definition for sub-2Mbit/s services

3.216 Given the above analysis of the qualitative characteristics, comparative prices and migration trends of sub-2Mbit/s and 2Mbit/s services, we do not consider that the evidence points to a separate market for sub-2Mbit/s services. However, in Section 7 we consider whether there are some differences in competitive conditions and therefore whether different remedies may be required (see Section 10).

Proposed market definition

3.217 Based on the results our analysis we propose that the bandwidth breaks in the TI market are unchanged from the 2007/8 Review and are as follows:

- Low - up to and including 8Mbit/s (including analogue and SDSL services);
- Medium - above 8Mbit/s up to and including 45Mbit/s;
- High - above 45Mbit/s and up to and including 155Mbit/s; and
- Very High - 622Mbit/s.

(ii) Bandwidth breaks in the AI market

Our assessment in the 2007/8 Review

3.218 In the 2007/8 Review we identified the following bandwidth breaks in the AI market:

- Low - up to and including 1Gbit/s; and
- High - over 1Gbit/s.

3.219 The bandwidth breaks were based on a number of considerations. First we looked at whether it would be appropriate to use the chain of substitution approach based on pricing analysis as used in the TI market. However, before the 2007/8 Review AI charges were not controlled and we noted that BT's financial statements suggested that AI prices varied with bandwidth to a greater extent than BT's reported costs. This was because for AI services the cost of duct and fibre formed a high proportion of the total cost, and given the point-to-point dedicated service architecture used the costs of AI services were generally invariant with bandwidth.[121] This suggested that AI price differentials were primarily the result of commercial pricing decisions, rather than a reflection of cost differences between the different bandwidth services (i.e. value-based pricing).[122]

3.220 Given the limitations of pricing analysis we also considered BT's underlying costs of providing AI services across different bandwidths. The analysis found that the cost of the equipment to provision a service at bandwidths above 1Gbit/s (i.e. at 2.5Gbit/s and 10Gbit/s) was significantly greater than the cost of the equipment for services at bandwidths up to and including 1Gbit/s. This led to the total costs per service of the high bandwidth services above 1Gbit/s being significantly greater than the total costs per service of 1Gbit/s and below, which would be reflected in the competitive prices. We concluded that demand-side substitution to high bandwidth AI services in response to a SSNIP in the price of low bandwidth services would be unlikely to be sufficient to render such a SSNIP unprofitable, this suggested that there was a break in the chain of substitution for AI services for services above 1Gbit/s.

3.221 Further, our review of competitive conditions across different bandwidths suggested that competitive conditions were different. This is because absent regulation we noted that operators faced high sunk costs for self-provision. At higher bandwidths, much higher revenues were likely to be associated with the high bandwidth services, which suggested that CPs would be able to offset the associated investment risks. A CP would face relatively higher certainty that investments sunk in the provision of a single retail contract could be recovered over the duration of the contract. This analysis was supported by our service share analysis which found that BT's share in the retail low bandwidth AI market was 73% whilst its share of the retail high bandwidth market was 49%, highlighting the stronger levels of competition at higher bandwidths.

[121] This was because AI services were supplied on the basis of one fibre (or pair of fibres) per service with no opportunity for infrastructure sharing (other than duct) at any point over the length of the service. In contrast TI services employ multiplexers to allow different segments of the service to share fibre and electronics with other services in an optimal fashion.

[122] While in theory efficient prices should be equal to marginal costs, with AI based services there are significant economies of scale and average costs are above marginal costs, this means that setting prices at marginal cost would result in losses. This would be unsustainable in a competitive market. Identifying the most efficient way of setting prices to recover total costs in these circumstances is a complex issue but it will generally be efficient for prices to be related to (peak) capacity used. One possibility is that multi-part tariffs combining fixed and capacity-related elements could be used. While further discussion is out of the scope of this review the key point is that the competitive price of shared backhaul is likely to exhibit a significant bandwidth related component. Such pricing can be consistent with competitive market outcomes.

Call for inputs

3.222 In the CFI we noted that with continued growth in demand for bandwidth there has been an increase in demand for high bandwidth AI services capable of delivering bandwidths above 1Gbit/s since the 2007/8 Review. We highlighted that this, together with price and technical changes to the network capabilities used to support these services, represented a possible change in the market which meant particular consideration should be given to whether there was still a break in the market for Ethernet services provided at bandwidths above 1Gbit/s. Consequently, we asked stakeholders for their views on the existence of a break in the market for Ethernet services provided at bandwidths above 1Gbit/s.

Stakeholder views

3.223 Ten respondents [✂ ✂ ✂ ✂] provided their views on the existence of a break in the market for Ethernet services provided at bandwidths above 1Gbit/s. Five respondents supported the continuation of a bandwidth break at 1Gbit/s, two respondents called for the bandwidth break to be moved upwards, while three respondents proposed alternative market definitions.

3.224 In support of the continuation of a bandwidth break at 1Gbit/s a number of points were made. BT's response noted that the cost of equipment required to provide services over 1Gbit/s is significantly higher than that used to deliver lower bandwidth services and that there is a stark difference in the volumes of services, with the numbers of services above 1Gbit/s still comparatively low. They also noted that competitive conditions at the wholesale level vary dramatically; with Openreach having far lower market shares above 1Gbit/s. Moreover, BT argued that competition at above 1Gbit/s is likely to become even stronger reflecting the incentives for CPs to enter this growth market.

3.225 In contrast, while supporting the continuation of a bandwidth break at 1Gbit/s 3UK and MBNL argued that competitive conditions have changed and that BT will have significant market power in both markets. They noted that the deployment of LTE will increase BT's market power above 1Gbit/s because demand for these services will increase considerably outside of major urban areas, in areas where BT is often the only supplier with network coverage.

3.226 Another respondent [✂ ✂] argued that there is a break in the chain of substitution and a separate market for higher bandwidth services. This is because with increases in bandwidth demand, CPs increasingly need higher capacity backhaul and to support this it is likely to be impracticable and/or inefficient to purchase multiple sub-1Gbit/s services instead of a single higher capacity service. While Verizon noted that although there is an increasing demand for high bandwidth services the major requirement in the immediate future will continue to be for services up to 1Gbit/s.

3.227 A different view was expressed by some respondents who called for the bandwidth break, if retained, to be moved upwards. The respondents noted that since the 2007/8 Review there has been a huge growth in the consumption of higher bandwidth Ethernet services for both access and backhaul and that the current break of 1Gbit/s will not adequately address the bandwidth demands for the next four years. In addition, one respondent noted that take-up of services above 1Gbit/s is currently being inhibited, not by the cost of the services, but by the cost of hardware interfaces, which are falling, and this will enable cost effective consumption of higher

bandwidth services, in particular for use in backhaul solutions. Given this context, the respondent [✂ ✂] suggested that 10Gbit/s would be a logical break to cover increasing bandwidth requirements over the next four years.

3.228 Alongside these views, three respondents also suggested alternative market definitions. Sky's response noted that there may be a combined AI market covering all bandwidths without an upper limit. This is because in the 2007/8 Review Ofcom argued there was a break in the chain of substitution at 1Gbit/s, because a hypothetical monopolist in the low bandwidth AI market could profitably impose a SSNIP as there would be little or no scope for supply-side substitution to occur from the high bandwidth AI market. However, not only are optical services now widely used to deliver services above and below 1Gbit/s, but the cost of the WDM equipment used has fallen markedly - by more than 90% over recent years. Therefore the cost differential between this equipment and standard Ethernet cards and chassis has narrowed significantly. These changes suggest the SSNIP test described above may now prove unprofitable because of the increased scope for supply-side substitution, which it argued points to a combined market, irrespective of bandwidth and without an upper limit.

3.229 Similarly C&WW's response noted that it regards above 1Gbit/s services as an extension of the AI market, suggesting that there is a combined market covering all AI bandwidths. This is because above 1Gbit/s services are increasingly being requested for end-user access, which means that above 1Gbit/s will soon become the norm for backhaul to keep pace with access growth. Another respondent [✂ ✂] suggested that Ethernet services above 1Gbit/s and WDM services should be a separate market within the business connectivity market but outside of TI and AI, as in the respondent's view, both of these services will become more widely used over the short term.

Ofcom's analysis

3.230 Given the extensive stakeholder comments, we structure the discussion of our analysis below to focus on whether there continues to be a break in the market for standard Ethernet services provided at bandwidths above 1Gbit/s, in particular by considering the following:[123]

- relative price comparisons;
- equipment and other costs of providing services; and
- variations in competitive conditions.

Relative price comparisons

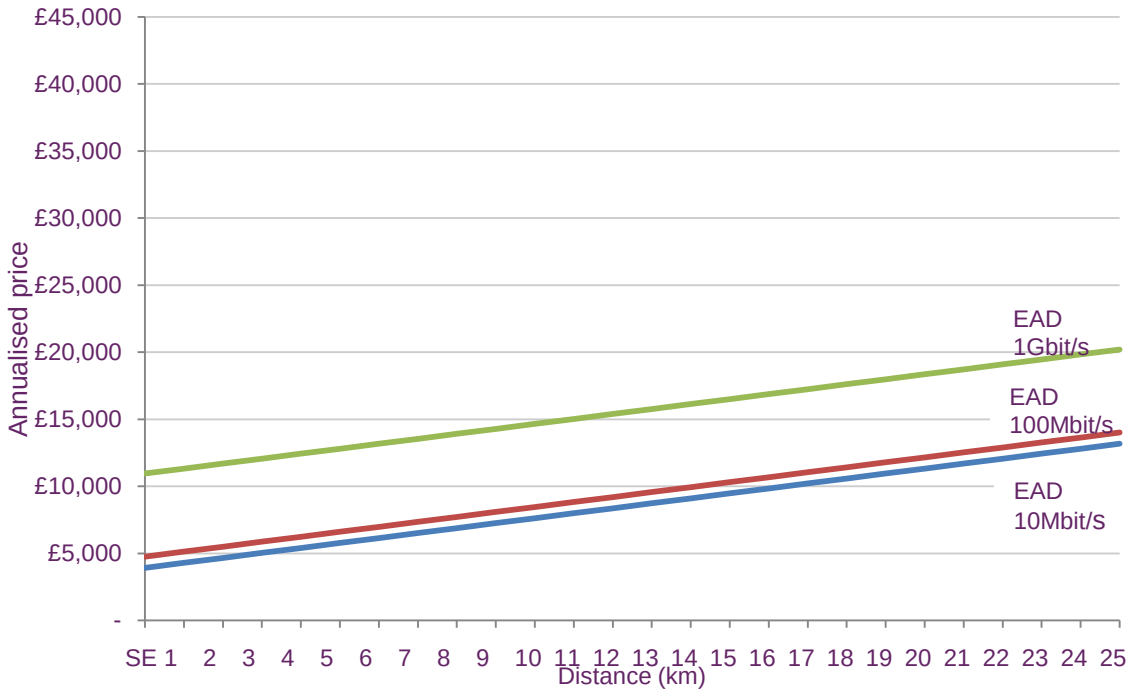
3.231 As a first step we consider whether relative prices suggest that different Ethernet services at different bandwidths are in the same market. In the 2007/8 Review we also conducted this analysis; however, we noted that the evidence suggested that AI prices were not cost-reflective and therefore we could not rely on them for market definition purposes. Nevertheless, since the 2007/8 Review, wholesale AI charges up to and including 1Gbit/s have been charge controlled which suggests that they should now be more cost-reflective. Our price comparisons are based on Openreach's wholesale input prices for EAD and WES services which apply

[123] Note this does not include a discussion of Ethernet supplied over WDM; the implications of WDM-based services are discussed under Issue 5.

throughout the UK.[124] In the analysis, each service consists of one local end and a main link and the price includes: (i) a connection fee which has been amortised over three years (ii) the annual rental cost and (iii) the main link charge if applicable.[125] As WES services have a maximum distance of 25km the comparison has been made over distances up to 25km.

Table 15: Comparison of wholesale Ethernet prices by bandwidth

[✂ WES prices redacted✂]



Source: Ofcom analysis, based on BT wholesale prices for EAD and WES services

3.232 The results show that 10 and 100Mbit/s services are closely priced, while a 1Gbit/s service is approximately double the price of these services. Above 1Gbit/s, there is a step change in the price of services of approximately [✂£ ✂] and this increase is higher than the step-ups in price for services of 1Gbit/s and below. Given the significant price gap the figure suggests that it would be unlikely that many end-users would upgrade from low to high bandwidth services if a hypothetical monopolist sought to impose a SSNIP on the low bandwidth services.

3.233 By itself, the pricing comparison suggests that there could be separate markets at every bandwidth increment. This is because for any intermediate bandwidths between two bandwidth increments, it will always be cheaper to buy the higher bandwidth service rather than multiples of low bandwidth services. For example, for a user with demand for capacity between 10 and 100Mbit/s, a 100Mbit/s service will always be cheaper than multiple 10Mbit/s services; this would not be affected by a SSNIP. Defining a market for circuits at each bandwidth would be a change from the conclusions of the 2007/8 Review.

[124] EAD services are available for new supply at 10Mbit/s, 100Mbit/s and 1Gbit/s; WES services are available for new supply at 2.5Gbit/s and 10Gbit/s.

[125] There is no trunk/terminating distinction for AI products, therefore no trunk/terminating ratio assumptions or sensitivity analysis were needed in relation to this analysis.

3.234 However, an issue to note is that we do not know what prices would look like in a competitive market. It may be that even though prices have been regulated, there is still some supernormal profit and that the pricing structure is distorted by market power. In a competitive market, the increases in price with bandwidth could be smaller than the ones we currently observe. Hence, as in the 2007/8 Review we have investigated the underlying costs of provision. This may provide some additional insight into the likely competitive level of prices although we also note that, whilst competitive markets would bring prices into line with costs on average, some prices could be lower than BT's FAC whilst others could be above FAC. The structure of prices in a competitive market could still feature prices which increase with bandwidth more steeply than BT's fully allocated cost.

Equipment and other costs of providing services

3.235 In the 2007/8 Review, we noted that the way that the cost of provision varies with bandwidth is largely driven by the higher cost of equipment at higher bandwidths. We said that these costs can form a large proportion of the total cost of provision and that other common costs such as digging and ducting are typically constant across bandwidths.[126] For this Review we have updated our analysis of the cost of equipment across bandwidths. Alongside this we have also considered how indirect costs like planning, design and installation vary across bandwidths.

3.236 The results of our analysis of equipment costs are shown below in Figure 17; this is based on data supplied by BT in January 2012 which we have used to derive estimates of the equipment costs incurred to provide Ethernet services across a range of bandwidths. The costs modelled are for the provision of a new leased line (i.e. there is no existing equipment) between an end-user premises and a CP POP located in a BT exchange collocation space. As WES services are only available on a single service point-to-point basis the comparison has been made on this basis. The equipment costs include the cost of the chassis, the required optics and the management router; they do not capture any installation costs or estimates of ongoing costs like space and power.

[126] Common costs here refer only to costs that do not vary by bandwidth, this includes the cost of digging and duct etc which can be used to support services of all bandwidths and are common to all the services contained in the duct. This is in contrast to other general overheads which would be common to a wider range of services.

Figure 17: Cost of Ethernet equipment by bandwidth

[✂Figure redacted✂]

Source: BT response to s.135 information request, 2012

3.237 The results show that up to and including 1Gbit/s, the variations in cost per service are not significant. On the other hand there appears to be a step change in the costs of provisioning 2.5 and 10Gbit/s. Our estimates indicate that the equipment costs at 2.5Gbit/s are seven times higher than at 1Gbit/s while at 10Gbit/s equipment costs are nine times higher than at 1Gbit/s.

3.238 However, caution should be applied to these estimates as they may be overstating the equipment cost gap for services up to 1Gbit/s and above 1Gbit/s. This is because our analysis is based on the cost of equipment for EAD for services up to 1Gbit/s while for 2.5Gbit/s and 10Gbit/s our analysis is based on WES, an earlier generation Ethernet service.[127] In the 2007/8 Review our analysis of WES equipment costs by bandwidth found that while the cost gap was significant, it was smaller than our estimates above.[128] A comparison with the previous results shows that while costs of equipment above 1Gbit/s have fallen, the main driver of the higher multiples seen above has been the significant decline in equipment costs for services at 1Gbit/s and below.[129]

[127] We have made this comparison because while WES services at 1Gbit/s and below have been withdrawn from new supply and replaced by EAD, WES services at 2.5Gbit/s and 10Gbit/s are still available and there is no equivalent EAD product available at these bandwidths.

[128] In the February 2009 Statement we estimated that equipment costs at 2.5Gbit/s were 3 times higher than at 1Gbit/s while at 10Gbit/s equipment costs were 7 times higher than at 1Gbit/s.

[129] The mass IT market now includes 1Gbit/s Ethernet interface bandwidths resulting in significant price reductions. Bandwidths above 1Gbit/s are generally only seen in large networks with correspondingly low volumes and higher prices.

3.239 While our estimate above may overstate the extent to which equipment costs increase above 1Gbit/s, we consider that there still is a step change in the costs of provisioning services above 1Gbit/s. Further, we note that it is possible to increase the bandwidth of AI services at up to 1Gbit/s by changing the port card in the network terminating equipment (NTE). However, for services above 1Gbit/s dedicated NTE are employed. Therefore migration within the <2.5Gbit/s portfolios can be accomplished via card change whereas migration from <2.5Gbit/s to 2.5Gbit/s or 10Gbit/s, or from 2.5Gbit/s to 10Gbit/s, requires NTE change. The cost of moving from a low bandwidth (up to 1Gbit/s) service to a high bandwidth (over 1Gbit/s) service is therefore likely to be significantly higher than the cost of substituting one low bandwidth service (e.g. 100Mbit/s) for another low bandwidth service of different bandwidth (e.g. upgrading to 1Gbit/s).

3.240 In addition, users of Ethernet interfaces at 1Gbit/s and below are able to benefit from scale economies arising from the higher volumes of Ethernet components used in carrier and enterprise markets at these bandwidths.[130] Indeed our analysis above suggests this has already happened, because the cost of equipment at 1Gbit/s and below has fallen significantly and at a faster rate than the fall in equipment costs for services above 1Gbit/s. Nevertheless, with the expected higher take-up of services above 1Gbit/s over this Review we would expect to see a greater downward pressure on equipment costs at higher bandwidths than seen since the 2007/8 Review.

3.241 There are also other indirect costs which distinguish higher bandwidth Ethernet services from lower bandwidth services. These include higher levels of planning and design and the provision of additional fibre for dual-fibre 2.5Gbit/s and 10Gbit/s Ethernet services. Installation costs are also typically higher, as higher levels of training are required to install and configure the equipment and often additional tests are required such as Polarisation Mode Dispersion (PMD).[131] Also due to the higher SLAs associated with these services, there are additional costs associated with the equipment used to conduct these tests. With higher level SLAs and lower volumes, equipment spares need to be stored on a geographically-dispersed basis to enable BT to respond to its SLAs. This, and the generally higher cost of servicing higher levels of SLAs, means that there are higher costs associated with higher bandwidth services.

3.242 Therefore the above analysis suggests that there is a break between services at 1Gbit/s and below and services above 1Gbit/s. This is because the differences in equipment and other indirect costs are sufficiently significant that prices in a competitive market would reflect them, and the scale of these differences would then make it unlikely that users of the lower bandwidth service would switch to the higher bandwidth service in response to a SSNIP. A SSNIP would be unlikely to prompt switching from 1Gbit/s to a higher bandwidth service. It would also not be economic for users requiring 2.5Gbit/s and above to use multiple 1Gbit/s services if a SSNIP were imposed on the higher bandwidth service.

[130] Our retail market volumes summarised in Figure 9 suggests that as of Q4 2010/11 there are approximately 68,000 services at 1Gbit/s and below, our corresponding estimate for services above 1Gbit/s is approximately 150.

[131] PMD causes pulse distortion through the differential interaction of the polarisation states of the light, comprising the pulse, interacting with the non-circular perturbations of the optical fibre. Pulse distortion becomes progressively damaging at higher transmission bandwidths where the pulses are shorter.

Variations in competitive conditions

3.243 Competitive conditions are likely to vary between low and high bandwidth AI services because of the presence of significant sunk costs and economies of scale which are likely to act as a barrier to competitive entry, especially at lower bandwidths. In the absence of regulation, it is likely that retail competitors to BT would be reliant on self-supply or interconnection with OCPs in order to compete. Given that a significant proportion of the costs of entry would need to be sunk, the question is whether these barriers are more or less likely to be overcome at different bandwidths such that variations in competitive conditions might be observed.

3.244 In the case of higher bandwidth AI services, we consider that the much higher revenues likely to be associated with these suggest that CPs would be able to offset any investment risks associated with high sunk costs. For example, for high value retail services, the CP would be more confident that any investments sunk in the provision of a single retail contract could be recovered over the duration of the contract. In contrast, at lower bandwidths, costs are likely to be a higher proportion of end-users' willingness to pay and hence of the price which may be charged. Therefore in order to recover costs the CP would need to ensure a larger volume of sales over a particular timeframe, which may limit the scope of competition as it makes the prospect of entry riskier (i.e. the CP would need to secure multiple contracts in order to compete).

3.245 We consider, therefore, that CPs may be able to compete more intensively for higher bandwidth services. This is supported by our estimates of BT's wholesale market shares. Our estimates indicate that BT's wholesale national market share for low bandwidth AI (up to and including 1Gbit/s) services is 62% compared to 50% for high bandwidth (above 1Gbit/s) AI services.

Proposed market definition

3.246 Based on the analysis set out above, we consider that two separate AI markets should be defined: one for services up to and including 1Gbit/s and the other for services over 1Gbit/s. In summary, the key reasons for this are:

- evidence that demand-side substitution is limited:
  - a comparison of relative prices, which suggested that there was a step change in price of services above 1Gbit/s; and
  - an analysis of equipment and other costs of providing services, which suggested that differences in these costs are sufficiently significant that a competitive provider would be expected to price to reflect these differences.
- evidence that the competitive conditions in the two markets appear to differ significant:
  - an assessment of CP's incentives, which suggested that they will be able to compete more intensively for high bandwidth services: and
  - BT's market share is significantly lower in the high bandwidth market.

Issue 5: Wave Division Multiplex (WDM) services

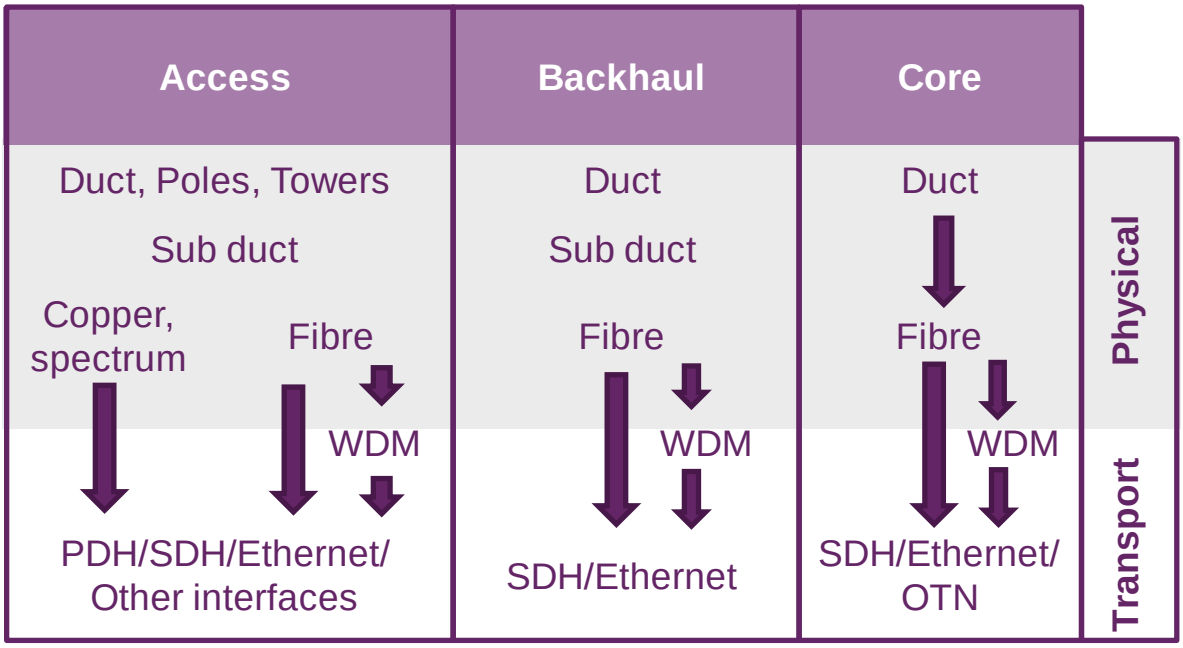
3.247 Wave Division Multiplexing (WDM) is a technology that can be deployed to significantly increase the data carrying capacity of a single optical fibre as it allows multiple wavelengths of light (operating at different frequencies) to be sent down a single optical fibre simultaneously. This allows WDM-based services to support multiple circuits (typically 16 or 32) at capacities above 1Gbit/s; further, once a system is installed, additional circuits can be quickly added without disruption to the existing circuits.[132] These characteristics mean that WDM is often deployed for backhaul and core networks where CPs need to transport multiple traffic streams efficiently over high capacity links.

3.248 In the 2003/4 and 2007/8 Reviews, we noted that WDM-based retail services were beginning to be offered by CPs. For example BT Global Services first introduced Wavestream, which is the service name of their retail WDM services at the time of the 2003/4 Review. Retail WDM services extend the use of WDM to the access part of the network and allow end-users to buy an end-to-end solution with WDM equipment installed at each end-user site. As a retail service, it is typically presented to the end-user using a specified AI interface such as Ethernet, but it can also support TI SDH interfaces and other interfaces like Fibre Channel. These services have historically been used by data intensive end-users such as data-centres. However, since the 2007/8 Review the use of retail WDM services has expanded and a wide range of CPs have begun to offer WDM-based retail services.

3.249 Figure 18 shows the different uses of WDM and highlights its use as a high capacity wholesale input to leased lines services (TDM and Ethernet based services) and as an input into an optical-based retail service in its own right.

[132] See Section 2 for a further explanation.

Figure 18: WDM services as upstream inputs and retail services



Source: Ofcom 2012

3.250 The figure highlights that there are a number of upstream wholesale inputs to retail leased lines and other retail services. These wholesale inputs include duct, fibre and, in the core/backhaul parts of the network, WDM as a transmission medium. For TDM and Ethernet retail leased lines, these inputs are combined with access fibre and necessary TDM or Ethernet equipment to deliver dedicated point-to-point services via SDH or Ethernet interfaces to the end-user. WDM-based retail services are provided on an end-to-end basis and require dedicated WDM equipment to be installed at the retail end-user premises. For the retail WDM service to be able to transport traffic between sites it must be presented to the end-user with the relevant interface. As discussed above and shown in the figure above, this includes a range of interfaces such as Ethernet or SDH or other interfaces like Fibre Channel.

3.251 Our assessment below focuses on the demand from retail end-users for WDM services. We assess whether it is appropriate to identify retail WDM services in a separate retail market to other high bandwidth retail leased lines. We note that while it is possible for retail end-users to make use of SDH/PDH interfaces over WDM, we consider that it is only relevant to assess WDM services against retail AI services that offer high bandwidth services (at 1Gbit/s and above) because of the small number of TI SDH interfaces being sold.[133] The role of WDM as both an upstream input to leased lines and as a retail service also has implications for our wholesale market definition which is considered in Section 4.

3.252 As a result of our assessment, we propose to define a very high bandwidth retail market (the Multiple Interface market) consisting of WDM services and high bandwidth AI services, and encompassing Ethernet at above 1Gbit/s and WDM

[133] At higher bandwidths a key driver of demand is data transfer, this does not require the specific characteristics of TI services. Illustrating this, our analysis of a sample of BT's Wavestream Regional and National services orders from 2005-2010,[✂ ✂] indicates that SDH interfaces account for approximately 18% of orders.

services including AI interfaces. This reflects significant developments in the market since the 2007/8 Review.

Our assessment in the 2007/8 Review

3.253 In the 2007/8 Review we considered whether retail WDM services were in the same market(s) as other leased line services. We concluded that WDM-based retail services were not part of either the very high bandwidth AI or the TI markets. We based this conclusion on evidence that demand-side substitution would be limited:

- First, neither TI nor AI circuits can provide all the functionality of a WDM circuit. A particular feature of the latter is that it is possible to increase the capacity of an existing WDM circuit quickly and at low incremental cost.

- Second, there is an additional cost associated with WDM equipment. The evidence suggested that end-users who need the enhanced functionality of WDM services would be willing to pay the necessary premium but that WDM-based services will be used largely by this group of end-users.

3.254 In addition, as now, our view was that the scope for supply-side substitution was limited and would not constrain the price of WDM services. Therefore we excluded WDM from the leased line markets which were the subject of the market review.

Call for inputs

3.255 In the CFI we noted that since the 2007/8 Review there has been a continued growth in the demand for bandwidth, with a significant increase in demand for high bandwidth circuits capable of delivering bandwidths at or in excess of 1Gbit/s. We noted that this trend, together with potential price and technical changes to the network capabilities used to support these services, suggested that there may have been relevant changes in relation to WDM since the 2007/8 Review and the conclusions at that time may not be the appropriate starting point for our analysis.

3.256 Therefore we asked stakeholders for their views on the extent to which WDM-based services are part of the leased line markets subject to market review. We asked whether they thought that WDM-based services should be seen as part of the TI market, the AI market, or whether it should be a separate market within the set of leased line markets. We also asked for stakeholders' views on how this position could change over the forward look of the review period, given the rate of growth in bandwidth demand.

Stakeholder views

3.257 Eight respondents [✂ ✂] provided their views on the appropriate market definition for WDM-based services. A key theme of many responses was that with developments in the market since the 2007/8 Review, the distinction between WDM and high bandwidth Ethernet services is difficult to maintain. Only BT argued that WDM-based services are still outside the business connectivity market.

3.258 BT noted that its WDM based Wavestream services are used by a small number of end-users with a particular need for high-bandwidths and low latency. As such the WDM market is still emerging and small in terms of volume relative to more established forms of business connectivity. BT also noted that there is considerable competition in the WDM market, with the public websites of other CPs confirming

their offerings of high bandwidth WDM solutions. When taken together BT noted that these factors suggest that WDM represents a separate specialised market which is intensely competitive.

3.259 In contrast, UKCTA noted that the same basic WDM equipment can now be used to provide non-Ethernet services, higher bandwidth Ethernet services and WDM services, in a more cost effective manner. Supporting this they noted that the AI WES 2.5Gbit/s and WES 10Gbit/s service price reductions made by Openreach during the current review period were due to reductions in the cost of the WDM boxes and that Openreach's wholesale EBD service used to provide Ethernet backhaul circuits is WDM-based. Similarly, Sky's response argued that with reductions in the cost of WDM equipment the cost differential between WDM and standard Ethernet has narrowed significantly. This suggests that there is increased scope for supply-side substitution between Ethernet and WDM which they argued points to a combined market, irrespective of bandwidth and without an upper limit.

3.260 Verizon's response noted that since the 2007/8 Review, the differences we highlighted between WDM services and other TI/AI services no longer generally apply. As such, with the increasing importance of WDM services it would be appropriate for them to be included in this review. This view was also shared by C&WW, who noted that with the growth in demand for multiple Ethernet services between end points, CPs need the ability to increase capacity quickly (without building new fibre infrastructure) and to provide non-Ethernet protocols, such as Fibre channel. In these respects, point-to-point WDM services are the natural successor to current AI services.

3.261 Similarly, a number of respondents noted that the importance of WDM-based services will increase over the duration of this review. Fujitsu noted that 10Gbit/s services (and above) are likely to be used by retail end-users and as transport for carrier networks and that with this demand for high capacity links and the UK tax regime for fibre networks, it is likely that WDM will have an increasing role in the market. A different respondent [✂ ✂] considered that while demand for Openreach's WDM-based Optical Spectrum Access services were in their infancy, they anticipated growth in the adoption of these services particularly in providing lower cost backhaul solutions.

3.262 On a slightly different point, MBNL and Everything Everywhere thought that it is important for Ofcom to consider whether underlying WDM-based wholesale input services form part of the business connectivity market. They noted that competing providers of point to point Ethernet services struggle to replicate the efficiencies that BT can generate by providing business connectivity services over a national 21CN core network (based on WDM). On this basis, they thought it was necessary to consider whether BT should provide wholesale WDM-based services to competitive providers of AISBO and TISBO services (not just to providers of retail WDM services).

Ofcom's analysis

3.263 In light of extensive stakeholder comments we structure the discussion of our analysis below around the appropriate market definition for retail WDM-based services. Our analysis is based on two broad areas:

- a qualitative assessment, which starts with a comparison of the functionality of retail WDM and AI leased lines; and

- demand-side substitution analysis based on the relative costs of provision, relative prices and SSNIP analysis for WDM and leased lines services; evidence on market trends and usage of high bandwidth services; and an assessment of possible switching costs.[134]

Qualitative assessment

3.264 In the 2007/8 Review we identified the scalability of WDM as one of the key features of retail WDM services. The time required to change the configuration of the service is a function of the commissioning and installation of cards in the equipment at each end. In principle, where the relevant WDM equipment is available, bandwidth upgrades to WDM services can be applied in a few days. This is because any increase in capacity will use the existing fibre circuit and would simply entail an additional card being installed on existing equipment chassis. In contrast, for both SDH/PDH and Ethernet circuits, where existing capacity is fully utilised, new fibre circuits must be added which is costly and will have a far longer lead time. The ability to add additional high bandwidth connectivity (with guaranteed delivery times) quickly and in a cost-effective manner once the end-user has purchased an initial service is a key feature of WDM-based services.

3.265 A retail WDM service also needs a service layer (interface) to be added in order to be used to transfer data. The modularity of WDM equipment allows line cards to be installed so that traffic can be transported using various interfaces such as Ethernet, SDH or other interfaces such as Fibre Channel. In contrast, a standard Ethernet service while also relying on a pair of lit wavelengths over fibre, does not offer this modularity. For example if an end-user using Ethernet wanted to change the transmission to SDH, then new customer premises equipment would be required.

3.266 The above qualitative assessment does not suggest there have been significant changes in the feature set of WDM since the 2007/8 Review; it is still a scalable service, able to support very high bandwidths over multiple interfaces and distances. However, a key change since the 2007/8 Review is that there has been a marked decline in the cost of WDM equipment. This was a key theme of a number of CFI responses and is confirmed by our analysis of current Ethernet and WDM equipment costs discussed in paragraphs 3.269 - 3.273 below.

3.267 The fall in WDM equipment costs has implications for market definition. In the 2007/8 Review we considered WDM-based services to be relatively “niche”, reflecting the premium associated with WDM and the small class of end-users such as data centres willing to face this initially higher upfront cost of equipment to deliver scalable bandwidth and more configurable solutions. Given the increasing demand for higher bandwidths from end-users, highlighted by the fast-growing market above 1Gbit/s, and the fall in the premium associated with WDM services, due to falling equipment costs, WDM-based services are potentially no longer only restricted to a small number of specialist application end-users. Therefore, below we consider the available cost, pricing and demand evidence.

[134] Following the reasoning set out in Annex 7, we do not consider in detail whether supply-side substitution would provide a competitive constraint. Further discussion of supply-side constraints between WDM and AI and TI leased lines is set out in the January 2008 Consultation, paragraphs 3.391 to 3.393. However, we note that the fact that some CPs appear to supply all high bandwidth services in the form of WDM circuits suggests that supply-side substitution into the provision of high bandwidth AISBO circuits might be a relevant possibility; this would of course provide further support for the definition of a single high bandwidth market.

Demand-side substitution analysis

3.268 In this section, we assess whether at very high bandwidths end-users consider WDM-based retail services to be a substitute for AI high bandwidth services and vice versa. We focus on WDM versus AI services because as noted in paragraph 3.250 the majority of demand for high bandwidth services is for services presented with Ethernet interfaces. Our analysis includes a consideration of:

- the relative costs of equipment;
- relative price comparisons;
- an assessment of the hypothetical monopolist test;
- demand for high bandwidth Ethernet and WDM services; and
- the barriers to switching.

Relative differences in the cost of equipment

3.269 A key theme in the CFI responses was that there has been a marked decline in the cost of WDM equipment since the 2007/8 Review and because of this the price premium previously associated with WDM-based services has been eroded. Therefore we have investigated the relative costs of provisioning different bandwidths using Ethernet and WDM equipment.

3.270 Our analysis presented in Figure 19 is based on information supplied by BT in January 2012. We used this to derive estimates of the lowest cost combination of equipment that can be used to provide a range of bandwidths. The costs modelled are for the provision of a new (i.e. there is no existing equipment) point-to-point leased line and include the cost of the chassis, the required optics and an estimate for the cost of fibre.[135] The results do not capture any installation costs or ongoing costs like space and power.

[135] The analysis includes an estimate of the cost of fibre as while a WDM system can support multiple bandwidths on a single optical fibre, multiple Ethernet services will require multiple fibres. In the analysis our estimate of fibre costs is based on the average of the main link charge for EAD, WES and OSA services which we assume is a proxy for fibre costs.

Figure 19: Relative costs of Ethernet and WDM equipment by bandwidth - for a 10km service

[✂Figure redacted✂]

Source: Ofcom analysis, based on BT response to s.135 information request, 2012

3.271 The figure above shows that for the provision of services at 1Gbit/s, there is still a significant cost gap between WDM and Ethernet. As total bandwidth increases, this gap narrows and our estimates indicate that the equipment required to provide 10Gbit/s using WDM only costs approximately [✂ ✂] more than the equivalent Ethernet solution. If we were to take into account other costs like installation and ongoing costs such as management, it is likely that the gap between WDM and the cost of provisioning bandwidth above 10Gbit/s using multiple Ethernet services would be more pronounced as additional Ethernet bandwidth requires the installation of entirely new circuits with their associated costs, while in contrast, WDM only requires the adding of additional wavelengths. Below 10Gbit/s the gap would be smaller.

3.272 As noted above, the fall in WDM equipment costs has implications for market definition. This is because in the 2007/8 Review we argued that only a small number of end-users would be prepared to pay the premium required (due to higher equipment costs) for WDM-based services that offer scalable and configurable bandwidth. However, our estimates now indicate that WDM-based services no longer incur a significant premium over Ethernet solutions. As WDM provides a more enhanced feature set than dedicated Ethernet, providing increased flexibility for CPs and end-users, this suggests that WDM may now be the technology of choice for delivering higher bandwidth services.

3.273 In addition, our analysis of CP provisioning of services has highlighted that for services above 1Gbit/s many major CPs such as [✂ ✂] and [✂ ✂] predominately provide new retail leased lines above 1Gbit/s using WDM. This is further support for the view that WDM is now the technology of choice for supplying

end-users with bandwidth requirements above 1Gbit/s and that WDM would be a relevant constraint on a service otherwise provided using high bandwidth AI circuits.

Relative price comparisons

3.274 We have based our pricing analysis on Openreach's wholesale price lists because, given the bespoke nature of pricing to end-users, we have not been able to obtain representative data on retail service pricing.[136] In practice, the prices of retail services will include not only the wholesale inputs but will also include relevant retail costs and service wrap that might accompany business connectivity services. Nevertheless, in the absence of this retail data, we assume that these prices should provide a reasonable proxy for the relative differences in competitive prices between retail services.[137]

3.275 Figure 20 below compares the service-based price per annum of a 1Gbit/s EAD circuit and that of a similar capacity circuit provided over a WDM service (based on Openreach's OSA service). The annualised price includes the connection fee which has been amortised over a typical contract length of three years, plus annual rental and the distance related fees.[138]

[136] We also note that because of the bespoke nature of contracts it is likely that any pricing information gathered would be likely to exhibit significant variation across end-users.

[137] See footnote 46.

[138] We note that this result is not dependent on the contract length chosen and holds for one year and five year contracts.

Figure 20: Comparison of wholesale input prices of a 1Gbit/s point-to-point Ethernet and a WDM circuit

[✂Figure redacted✂]

Source: Ofcom analysis, based on BT wholesale pricelists for EAD and OSA services

3.276 The figure shows that for the distances considered WDM-based services are sold at a significant premium to Ethernet circuits at 1Gbit/s. This suggests that the majority of end-users requiring bandwidth less than or equal to 1Gbit/s would prefer to purchase point-to-point Ethernet circuits.[139]

3.277 However, as noted in the qualitative assessment, a key differentiator of WDM-based services is the ability to support multiple circuits at high bandwidths. Therefore Figure 21 below compares the cost of meeting increasing bandwidth demands (from 1-20Gbit/s) using point-to-point Ethernet and WDM-based services. An illustrative circuit length of 10kms has been used for the comparison.[140]

[139] This is confirmed by an analysis of a sample of the sales of WDM by BTGS, [✂ ✂], where we found that no end-users in the sample were using WDM to supply only 1Gbit/s.

[140] There are a number of configurations of WDM services, which would add significant complexity to any comparison of an Ethernet service with WDM. To overcome this complexity, we have selected OSA as the basis for our comparison of WDM with high bandwidth Ethernet services because it represents the least cost method of delivering a retail WDM circuit. To the extent that there is still a significant price premium for the least cost WDM service, then the fact that there are more complex and expensive solutions available would not overturn this observation.

Figure 21: Comparison of the price of bandwidth for wholesale point-to-point Ethernet services (EAD 1Gbit/s, WES 2.5Gbit/s and 10Gbit/s) and WDM services (OSA 2.5Gbit/s and 10Gbit/s) inputs - 10km distance [✂ Figure redacted ✂]

Source: Ofcom analysis, based on BT wholesale prices for EAD, OSA and WES services

3.278 As shown in the previous figure at 1Gbit/s WDM still attracts a significant premium. Above 1Gbit/s, for bandwidth requirements that can be supported using a 2.5Gbit/s service (1.5-2.5Gbit/s), Ethernet and WDM-based services are closely priced. At 2.5Gbit/s our estimates indicate that dedicated Ethernet costs only [✂✂]% less than a WDM-based solution. For bandwidth requirements above 2.5Gbit/s WDM-based services are the most efficient solution and the gap between Ethernet and WDM increases with bandwidth given that, as discussed above, additional Ethernet bandwidth requires the installation of entirely new circuits while WDM only requires the adding of additional wavelengths.

3.279 This analysis suggests that WDM is the most economic way to deliver capacity to end-users with total bandwidth requirements above 2.5Gbit/s. For these end-users it is likely that WDM is no longer seen as a premium service as irrespective of whether their requirement is to scale capacity quickly or a 'generic' requirement for high capacity Ethernet services, WDM is currently the most economic way for a retail end-user to purchase a bandwidth requirement above 2.5Gbit/s. In contrast dedicated Ethernet is the cheaper solution for end-users with bandwidth requirements of 2.5Gbit/s and below.

3.280 However, the available market evidence discussed in paragraphs 3.284 - 3.287 below suggests that there may be some retail end-users using WDM with total bandwidth requirements between 1 and 2.5Gbit/s. Given the premium associated with WDM services at these bandwidths, this suggests that there are end-users that value the service features of WDM, such as the ability to quickly increase bandwidth, even though they could in theory meet their current bandwidth requirements at a lower price with dedicated Ethernet. The observation of demand for WDM circuits at

bandwidths where dedicated Ethernet could in theory be cheaper also suggests that it is important not only to consider an end-user's current bandwidth requirements, but also their need to increase capacity in the near future. The implications of this observation are discussed in paragraph 3.289.

Assessment of the hypothetical monopolist test

3.281 We have considered whether in response to a SSNIP on high bandwidth Ethernet services, sufficient numbers of end-users with dedicated Ethernet services are likely to switch to retail-WDM services (or vice versa) to make the price increase unprofitable. If the SSNIP was unprofitable then it would suggest that high bandwidth Ethernet services and WDM-based services can be considered to constitute a single market (and vice versa).

3.282 The figure below shows the cost of providing a range of specific bandwidth requirements using dedicated Ethernet (after a SSNIP) and WDM-based services.

Figure 22: Comparison of the price of bandwidth for SSNIP adjusted wholesale point-to-point Ethernet services (EAD 1Gbit/s, WES 2.5Gbit/s and 10Gbit/s) and WDM services (OSA 2.5Gbit/s and 10Gbit/s) inputs - 10km distance [✂Figure redacted✂]

Source: Ofcom analysis, based on BT wholesale prices for EAD, OSA and WES services

3.283 The figure suggests that after a SSNIP on Ethernet services, end-users currently using a 2.5Gbit/s service would have the incentive to switch to WDM - especially as there are service benefits associated with WDM-based services. For end-users who were using Ethernet services above 2.5Gbit/s, even before the SSNIP, WDM should be a more efficient solution. At 1Gbit/s our analysis shows that even after the SSNIP, WDM-based services are priced at a premium to Ethernet. Therefore, for current Ethernet demand at 2.5Gbit/s there could be switching, as we consider that any

barriers to switching from standard Ethernet to a WDM-based service are unlikely to be significant[141], while at 1Gbit/s - a SSNIP is unlikely to prompt switching. At higher bandwidths, where remaining Ethernet users could already apparently make savings by switching to WDM, we do not consider that the failure to switch so far means that they would not respond to a SSNIP. We explain why below, and the reasons include the fact that there do not appear to be any significant barriers to switching.

Analysis of volume and demand trends

3.284 In this section we consider the available evidence on volumes and the distribution of demand for high-bandwidth Ethernet and WDM-based services from service volume data provided to us by CPs. There are a number of data limitations around this analysis. We note that, for high bandwidth services, some CPs did not distinguish between high bandwidth services that were delivered using WDM and those that were delivered using dedicated Ethernet.[142] Additionally some CPs were unable to collate full historic data for service volumes and some volumes were not separated by bandwidth. Nevertheless, we consider that the data should provide a reasonable guide to market developments and the distribution of demand at high bandwidths over the last four years.

3.285 Table 16 shows the demand trends and the distribution of demand for WDM services based on the number of retail wavelengths sold between 2007/8 and 2010/11. The distribution of wavelengths through time is also shown in indexed form in Figure 23.

Table 16: Demand trends and distribution of WDM services, 2007/8-2010/11[✂Figures redacted✂]

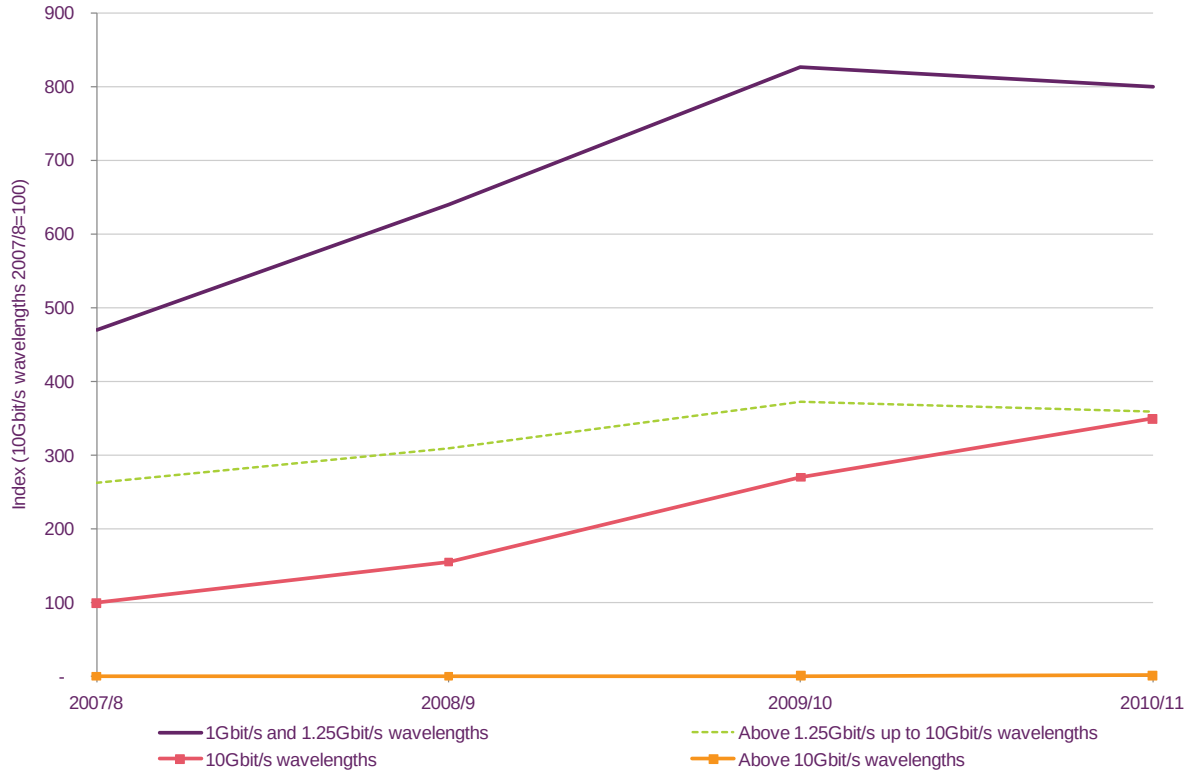
	Unit	Installed base			
		2007/8	2008/9	2009/10	2010/11
1Gbit/s and 1.25Gbit/s	Wavelengths	✂	✂	✂	✂
Above 1.25Gbit/s up to 10Gbit/s	Wavelengths	✂	✂	✂	✂
10Gbit/s	Wavelengths	✂	✂	✂	✂
Above 10Gbit/s	Wavelengths	✂	✂	✂	✂
Total	Wavelengths	✂	✂	✂	✂
Total bandwidth	Gbit/s	✂	✂	✂	✂
Average bandwidth per wavelength	Gbit/s	✂	✂	✂	✂

Source: CP's responses to s.135 information request, 2011

[141] See the discussion in paragraphs 3.291 - 3.295 below.

[142] For the affected CPs we estimated the split between Ethernet and WDM-based retail volumes on the basis of the CPs reported split between dedicated Ethernet and WDM above 1Gbit/s at the wholesale level.

Figure 23: Distribution of WDM wavelengths, 2007/8-2010/11



Source: CP's responses to s.135 information request, 2011

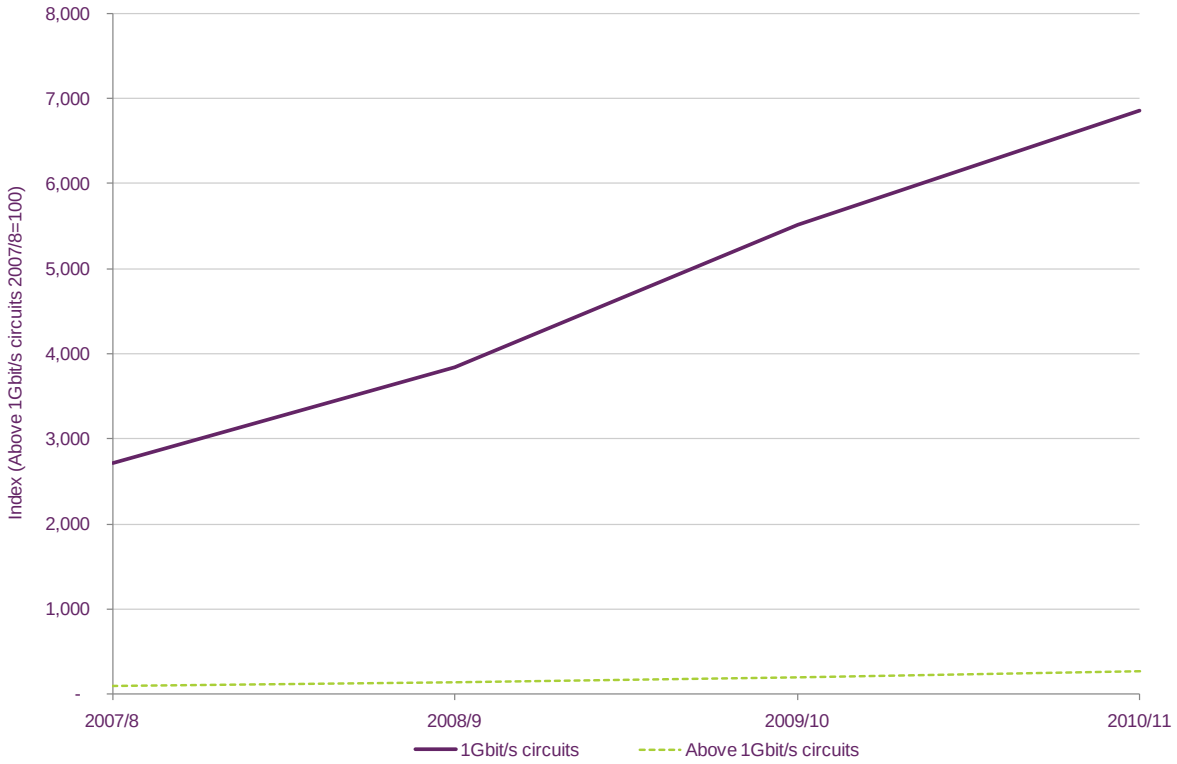
3.286 The table and figure show that there has been significant growth in the total wavelengths sold over the last four years. More recently at the lower bandwidths there has been a slight decline in the number of installed wavelengths, although the increase in wavelengths at 10Gbit/s has more than off-set this slight reduction in demand at lower bandwidths. Highlighting this, between 2007/8 and 2010/11 our estimates indicate that the total bandwidth supplied more than doubled and the average bandwidth per wavelength increased from 2.6 to 3.6Gbit/s. The trends in WDM volumes can be compared with the trends in higher bandwidth Ethernet services over the same period summarised in Table 17 and Figure 24.

Table 17: Demand trends and distribution of high bandwidth Ethernet services, 2008/8-2010/11 [✂Figures redacted✂]

	Unit	Installed base			
		2007/8	2008/9	2009/10	2010/11
1Gbit/s	Circuits	✂	✂	✂	✂
2.5Gbit/s	Circuits	✂	✂	✂	✂
10Gbit/s	Circuits	✂	✂	✂	✂
Above 10Gbit/s	Circuits	✂	✂	✂	✂
Total	Circuits	✂	✂	✂	✂
Total bandwidth	Gbit/s	✂	✂	✂	✂
Average bandwidth	Gbit/s	✂	✂	✂	✂

Source: CP's responses to s.135 information request, 2011

Figure 24: Distribution of high bandwidth Ethernet services, 2007/8-2010/11[143]



Source: CP's responses to s.135 information request, 2011

3.287 The table and figure show that demand for dedicated Ethernet services is concentrated at bandwidths of 1Gbit/s and below and in volume terms our estimates indicate that volumes above 1Gbit/s account for less than 1% of all Ethernet volumes. However, volumes above 1Gbit/s have seen strong growth, albeit from a low base, but we note that above 1Gbit/s significantly more bandwidth is delivered over WDM rather than over dedicated Ethernet.

Addressing data imperfections

3.288 As stated, in paragraph 3.274, there are a number of limitations associated with basing our market definition on Openreach's current wholesale prices. Furthermore, even if these prices were reflective of current cost differences, on a forward-looking basis such analysis could become invalid if - as a number of stakeholders have pointed out - the gap between the cost of WDM and Ethernet equipment continues to narrow significantly.

3.289 The analysis of the relative price of bandwidths based on a defined bandwidth requirement is also not forward-looking. As discussed in paragraph 3.280 above, any assessment of price and bandwidth should take into account not only an end-user's current bandwidth requirements but also their future requirements. In the context of the hypothetical monopolist test, end-users' expectations about their future bandwidth demand might influence their propensity to switch to WDM today, since doing so will reduce the cost of future expansion. Take for example a group of end-users with a bandwidth requirement of 2.5Gbit/s today, which they expect to double in the space of two to three years. These end-users know that they will need to

[143] In light of the small number of high bandwidth Ethernet volumes above 1Gbit/s, in the figure we have aggregated volumes at 2.5 and 10Gbit/s in order to show the overall trend in volumes.

upgrade their capacity sometime in future. In these circumstances WDM would offer a stronger competitive constraint over the prices of Ethernet services above 1Gbit/s than in the static scenario analysed above. This is because if a hypothetical monopolist were to impose a SSNIP on high bandwidth Ethernet circuits then these end-users may simply bring forward their purchasing decision (which our analysis indicates would be met using a WDM-based solution) which makes it more likely that sufficient end-users would switch such that a SSNIP on dedicated Ethernet circuits would be unprofitable.

3.290 The views of a number of stakeholders in the CFI clearly suggest that end-users' bandwidth demands are continuing to grow. The SSNIP analysis combined with a forward looking consideration of bandwidth demand over the duration of this review suggests that WDM is the natural successor service to address growing high bandwidth requirements (including the current Ethernet end-user base). However, at lower bandwidths, standard Ethernet is much cheaper, and this is where demand for Ethernet is strongest. We consider that this shows that there are distinct markets for low (Ethernet only) and high (including multiple interfaces over WDM) bandwidth circuits.

Barriers to switching

3.291 Barriers to switching from high bandwidth Ethernet services to WDM could weaken substitution possibilities between the services. This could reflect the commercial costs and risks of moving from an existing service, or barriers that could arise if end-users perceive that there are differences between the two services. If barriers to switching are significant then this would be a factor that might suggest that the two services are in separate retail markets.

3.292 The change in the price of equipment discussed above suggests that WDM is the efficient way to deliver very high bandwidth services particularly for end-users. If an end-user were to switch from an Ethernet or SDH-based leased line service, this would require a CP to make some changes in the equipment it provisions at the end-user's site. However, as WDM offers delivery over multiple interfaces (Ethernet, SDH and Fibre Channel) this would not require a user currently on an individual Ethernet circuit to invest in additional customer premises equipment or systems to deal with new interfaces. This means for end-users the perceived risks of switching to retail WDM may be quite low.

3.293 As with all other leased lines markets, there would remain a degree of market inertia associated with possible disruption of service and installation of new equipment. However, we consider that this is unlikely to be that significant a factor relative to the significant costs associated with high bandwidth circuits.

3.294 There may be a number of reasons why a small number of users remain on high bandwidth AI circuits. For example, this may indicate that they benefit from prices below the level assumed in our analysis. Alternatively, they may be waiting for further declines in the price of WDM equipment before switching, or they may be in a long term contract.

3.295 We also note that demand for high bandwidth services is growing strongly, and this means that providers are competing not just for existing end-users, who might face barriers to switching, but also for new end-users, who will not. Even with switching costs/barriers, competition for new end-users should benefit all end-users (unless firms can price discriminate between new and existing end-users) and would tend to suggest that different end-users bases are not in separate markets.

Proposed market definition

3.296 On the basis of the analysis set out above, we propose to identify a very high bandwidth retail market consisting of WDM services and high bandwidth AI services encompassing:

- AI services such as Ethernet at bandwidths above 1Gbit/s; and
- WDM services including AI interfaces such as Ethernet (typically at bandwidths above 1Gbit/s) and other interfaces including TI SDH interfaces, some of which have bandwidths below 1Gibit/s.

3.297 As WDM services support multiple interfaces including TI interfaces we call this market the Multiple Interface market.

3.298 In summary, our proposal is based on the following considerations:

- an analysis of equipment costs which suggested that the cost premium associated with WDM equipment has eroded. We also noted that many major CPs now use WDM to provide services above 1Gbit/s;
- relative price comparisons, which showed that at 1Gbit/s WDM is priced at a premium but for bandwidth requirements that can be met using a 2.5Gbit/s service WDM and Ethernet are closely priced, with Ethernet being marginally cheaper. Above 2.5Gbit/s our analysis suggested that WDM is the most economic way of delivering the service;
- an assessment of the hypothetical monopolist test suggested that, after a SSNIP, end-users using a 2.5Gbit/s Ethernet service would have an incentive to switch to WDM. We noted that while there is some uncertainty on the level of switching, there are a number of factors that suggest it could be significant and this was reinforced by a discussion of the implications of increasing bandwidth demand; and
- an assessment of the barriers to switching, which suggested that because of the flexibility of WDM services, these will not be significant relative to the cost savings available with WDM circuits.

3.299 In this context, we also note that the responses to the CFI from a number respondents highlighted that, with developments in the market since the 2007/8 Review, such as the fall in equipment costs and the increasing use of WDM-based services, the distinction between WDM and high bandwidth Ethernet services is difficult to maintain.

Retail market definition conclusions (in the absence of wholesale regulation)

3.300 We have concluded from the above analysis that the following relevant product markets exist in the UK (in the absence of wholesale regulation) for retail leased lines:

- Low bandwidth traditional interface retail leased lines - Up to and including 8Mbit/s (including analogue and SDSL services);

- Medium bandwidth traditional interface retail leased lines - Above 8Mbit/s up to and including 45Mbit/s;
- High bandwidth traditional interface retail leased lines - Above 45Mbit/s and up to and including 155Mbit/s;
- Very high bandwidth traditional interface retail leased lines - 622Mbit/s;
- Low bandwidth alternative interface retail leased lines - Up to and including 1Gbit/s (including EFM services); and
- Multiple Interface retail leased lines - AI leased lines over 1Gbit/s and WDM services with all bandwidths and interfaces.

3.301 These conclusions are used to inform our wholesale market definition in Section 4, which is defined still assuming the absence of regulation. For the wholesale markets defined, we then assess whether there is SMP in Section 7 and if so propose appropriate remedies in Sections 10-12.

3.302 Since we consider it necessary to assess whether any CP has SMP at the retail level, there is a further step in the retail definition. Once the relevant analysis of SMP and remedies is considered at the wholesale level, it then follows that the retail market should be defined (taking appropriate account of remedies that have been proposed at the wholesale level). In particular, if the presence of upstream wholesale regulation can assist entry and/or impact on competition downstream, then it is appropriate to take this into account when considering SMP and possible remedies in retail markets. Therefore, any assessment of retail markets needs to be based on retail market definitions that reflect the presence of upstream wholesale regulation. This assessment is carried out below.

Retail market definition (in the presence of upstream wholesale SMP regulation)

3.303 The purpose of this section is to assess whether the retail market definitions derived above change if wholesale remedies based on a finding of SMP in those wholesale markets are taken into account.[144] This is necessary only for the retail markets which we have reviewed in this section, to assess whether any additional regulatory remedies are required for the relevant retail market (i.e. in the retail low bandwidth TI market).

3.304 For the purpose of this section it is assumed that cost based TI and AI wholesale services are available on regulated terms and conditions. These wholesale remedies do not affect our proposed retail market definitions based on our demand-side substitution analysis, because our analysis is conducted under the framework of the hypothetical monopolist test. On this basis, we assume that, for example, a leased lines service is priced at a competitive (cost based) level. Hence, any demand-side analysis of consumer responses should be unaffected by the available of regulated wholesale inputs set at a similar cost based level.

3.305 However, the availability of regulated wholesale inputs could impact our conclusions about supply-side substitution. As set out in Annex 7, we considered that, absent wholesale regulation, supply-side substitution would in general not be a strong

[144] This is stage 4 of the market definition process as set out in Annex 7.

constraint in response to a SSNIP on the price of a particular leased lines service. This was because it would involve CPs incurring significant sunk-costs associated with entering the market to self supply and/or obtaining commercially agreed access. In principle, the availability of regulated wholesale inputs could increase the strength of any constraint arising from supply-side substitution and could therefore change our proposed retail market definitions.

3.306 Our assessment is focused on whether we need to define wider markets, as we would not anticipate the availability of regulated wholesale inputs will result in a narrower definition for retail markets. As where we have identified wider retail markets already, this is typically based on demand-side constraints, and as set out in paragraph 3.204 above, we consider that upstream regulation should not affect the results of demand-side substitution analysis.

3.307 Therefore, we reconsider below the five main issues for the retail market definition, to assess whether, in the presence of wholesale regulation, supply-side substitution is likely to support wider markets.

Issue 1: Technology and service requirements

3.308 We consider that the introduction of wholesale remedies will not modify the results of our analysis of technology and service requirements. For analogue and low bandwidth SDH/PDH services we have defined a relatively broad market, this could not be narrowed any further by the presence of PPC regulation at the wholesale level.

3.309 Similarly, our finding of separate markets for TI and AI services will still hold. On the demand side, our analysis would be unaffected because the availability of cost based wholesale inputs will not affect consumer preferences. On the supply-side, the presence of wholesale regulation could make it easier for suppliers of one symmetric data service (TI or AI-based) to enter the supply of the other. This is because existing suppliers of one service (e.g. Ethernet-based AI retail leased lines) might use wholesale inputs (such as PPCs), in order to offer the other service (e.g. TI retail leased lines). However, all the major suppliers of AI retail leased lines are also suppliers of TI retail leased lines and cannot therefore be considered a new and additional competitive constraint on the hypothetical monopolist.[145]

3.310 Therefore, the markets defined in the absence of regulation are not changed by considering the impact of upstream regulation.

Issue 2: Virtual Private Networks (VPNs)

3.311 The presence of wholesale regulation could make it easier for suppliers of other symmetric data services to enter the supply of retail leased lines. This is because existing suppliers of other symmetric data services might then purchase leased line wholesale services, such as PPCs, in order to offer retail leased line services. However, almost all existing suppliers of other symmetric data services are also suppliers of retail leased lines and cannot therefore be considered a new and additional competitive constraint on the hypothetical monopolist.

[145] We note that there are a number smaller CPs who focus exclusively on Ethernet services, however, in general these CPs would not be able to easily offer PPC services as entry would still entail additional investment in network infrastructure to support TI services.

3.312 We therefore consider that the other existing suppliers of other symmetric data services, if any, are not in a position to impose a competitive constraint on the hypothetical monopolist. This is why in the presence of the proposed wholesale remedies, supply-side substitution between retail leased lines and other symmetric data services is not present.

3.313 The above considerations show that in the presence of the proposed wholesale remedies, retail leased line services and other symmetric data services are in separate markets.

Issue 3: Broadband markets

3.314 The introduction of wholesale remedies is not expected to modify the conclusion of the demand-side substitution analysis. This is because the demand-side substitution analysis is not influenced by the presence or absence of regulation at the wholesale level.

3.315 On the supply-side, the presence of wholesale regulation could make it easier for suppliers of asymmetric broadband services to enter the supply of symmetric broadband services and of leased lines in particular. This is because existing suppliers of asymmetric broadband services might then purchase leased line wholesale inputs, such as PPCs, in order to offer leased lines.

3.316 In the case of broadband service providers, in our market review of Wholesale Broadband Access we identified a number of 'Principal Operators' that were the main LLU operators in the provision of broadband access.[146] In general most of these providers are already present in leased line markets. Further, those LLU operators that are not present in leased lines markets typically have a strong residential focus - so they would require additional investment to support enterprise customers with more stringent quality of service requirements.[147] This suggests that any supply-side substitution from broadband would be on a limited scale such that it is unlikely to impose a sufficient additional constraint.

3.317 In support of this we have identified factors that are likely to limit the speed at which these asymmetric broadband services suppliers (who are not present in leased lines markets) can enter the supply of leased lines and win end-users from the existing suppliers. These factors are of two types:

i) Factors affecting the time needed to acquire and organise leased lines in a network capable of delivering retail leased lines: This captures the lead time needed to acquire wholesale leased line services and equipment. In addition it captures that time needed for a new entrant to set up a fully functional network, this includes installation and testing.

ii) Factors influencing the time needed to attract a sufficiently large number of end-users: This relates to the various barriers to switching (e.g. contract lengths, end-users averse to forgoing volume discounts, end-user inertia) and barriers to expansion identified as part of the market power assessment in Section 7.

3.318 For a class of new entrants to constitute supply-side substitutes, it is necessary that they would be able to enter sufficiently quickly and at sufficiently low cost to make a

[146] The principal operators are defined as BT, C&WW, O2, Talktalk, Sky and Virgin Media.

[147] For example Sky broadband services are targeted at residential end-users and are often bundled with Pay TV services.

SSNIP by the hypothetical monopolist in leased lines unprofitable. The above considerations show that this requirement is not fulfilled by potential entrants into leased lines from asymmetric broadband services. The possibility of entry into retail leased lines by such suppliers is, however, included as part of the assessment of market power (under criteria such as potential competition and entry barriers).

3.319 Therefore, in the presence of the wholesale remedies, retail leased lines and asymmetric broadband services are in separate markets.

Issue 4: Bandwidth breaks

3.320 Our analysis of demand-side substitution identified a number of breaks in the chain of substitution for both TI and AI services. As above, we need to consider whether the availability of symmetric broadband origination at cost-based prices is likely to modify our market definition. Again, the focus in on supply-side substitution as the existence of wholesale regulation will not modify our conclusions derived from demand-side analysis.

3.321 For TI services, a hypothetical monopolist supplier of low bandwidth TI leased lines is not constrained by supply-side substitution from a higher bandwidth supplier because there is no supplier that only sells high bandwidth leased lines. In other words, all high bandwidth suppliers are also likely to be low bandwidth suppliers and vice versa. The same principle also applies to suppliers of low bandwidth AI and MI leased lines, all low bandwidth AI suppliers are also likely to be MI bandwidth suppliers and vice versa. Therefore, we consider that supply-side substitution is not relevant.

3.322 The above considerations show that, in the presence of the proposed wholesale remedies, our proposed bandwidth breaks will not change.

Issue 5: Wave Division Multiplex (WDM) services

3.323 As described previously, the introduction of wholesale remedies is not expected to modify the conclusion of the demand-side substitution analysis. On the supply-side, we consider that the relatively broad market we define would not be narrowed any further by the presence of regulated inputs at the wholesale level. In addition, as all high bandwidth Ethernet suppliers are also likely to supply bandwidth over WDM and vice versa, any supply-side substitution is unlikely to be material.

3.324 Therefore, we consider that the presence of wholesale regulation will not modify the conclusion of the analysis carried out in the absence of any regulation.

Retail product market conclusions (in the presence of regulation)

3.325 We have concluded that the following product markets exist in the UK (in the presence of wholesale regulation) for retail leased lines:

- Low bandwidth traditional interface retail leased lines, at bandwidths up to and including 8Mbit/s (including analogue and SDSL services);
- Medium bandwidth traditional interface retail leased lines, at bandwidths above 8Mbit/s and up to and including 45Mbit/s;
- High bandwidth traditional interface retail leased lines, at bandwidths above 45Mbit/s and up to and including 155Mbit/s;

- Very high bandwidth traditional interface retail leased lines, at a bandwidth of 622Mbit/s;

- Low bandwidth alternative interface retail leased lines, at bandwidths up to and including 1Gbit/s (including EFM services); and

- Multiple Interface retail leased lines - AI leased lines over 1Gbit/s and WDM services with all bandwidths and interfaces.

Question 1: Do you agree with our approach to retail market definition and our proposed retail product market definition?

Section 4

Wholesale product market definition

Introduction

4.1 This section sets out how we propose to define relevant product markets at the wholesale level. Our proposals are set out in Table 18 below.[148]

4.2 In summary, we have based our proposals on our analysis of wholesale markets in the light of the proposed retail markets identified in the previous Section. We have structured the presentation of our analysis below so as to focus discussion on particular issues raised by stakeholders in response to the CFI.

Table 18: Summary of proposed relevant wholesale product market definitions

	Product Markets			
TISBO	**Low Bandwidth TISBO:** Wholesale market for low bandwidth traditional interface symmetric broadband origination at bandwidths up to and including 8Mbit/s.	**Medium Bandwidth TISBO:** Wholesale market for medium bandwidth traditional interface symmetric broadband origination at bandwidths above 8Mbit/s and up to and including 45Mbit/s	**High Bandwidth TISBO:** Wholesale market for high bandwidth traditional interface symmetric broadband origination at bandwidths above 45Mbit/s and up to and including 155Mbit/s	**Very High Bandwidth TISBO:** Wholesale market for very high bandwidth traditional interface symmetric broadband origination at a bandwidth of 622Mbit/s.
AISBO	**Low Bandwidth AISBO:** Wholesale market for low bandwidth alternative interface symmetric broadband origination at bandwidths up to and including 1Gbit/s.			
MISBO	**Very High Bandwidth MISBO:** Wholesale market for multiple interface symmetric broadband origination at all bandwidths for services delivered using WDM equipment at			

Summary of Approach

4.3 CPs use wholesale leased lines extensively, not only to provide leased lines services to business end-users, but also to link facilities in their own networks. For example, mobile network operators (MNOs) use them to link radio base stations to switching centres to provide consumers with mobile voice and data services; and several providers of residential broadband and voice services use them to link equipment in BT's local exchanges to their networks.

4.4 In arriving at our market definition proposals for wholesale leased lines product markets, we have followed our approach to market definition which we describe in Annex 7.

4.5 Demand for wholesale products derives from demand for retail services, and we therefore identify wholesale product markets by drawing on the market definitions proposed in the previous Section on retail leased lines markets. Accordingly, we examine whether there are separate product markets for wholesale circuits which are of different bandwidths or types of interface, in a similar manner to our assessment in the previous Section in relation to the retail markets.

4.6 We do not, however, rely solely on our retail market definitions to inform the boundaries of wholesale markets. In order to define market boundaries, we also examine the ability of CPs to switch to alternative wholesale products and whether this would be sufficient to act as a constraint on the price-setting behaviour of firms for each of the wholesale products (demand-side substitution). Where relevant we also consider whether potential providers not currently active in supplying that

[148] For a glossary of terms used in this section refer to Annex 16.

wholesale product could quickly enter the market and provide an additional competitive constraint (supply-side substitution). In addition to looking at demand and supply-side substitution, we also consider other relevant factors, such as any differences in competitive conditions between different products and whether this supports our proposed findings informed by our retail market definitions and based on demand and supply-side substitution analysis.

4.7 We also recognise that characteristics specific to wholesale products may support identification of markets which may not be apparent from examination of retail services. We therefore consider whether we should distinguish between markets for access, backhaul and trunk services, which correspond to different levels of traffic aggregation in networks. Opportunities for aggregation on networks can be very location specific, and there is therefore a need to consider product and geographic market definition in parallel to some degree. Our approach to analysing these different parts of the network takes this into account when considering how to capture any distinctions between these network elements.

4.8 Our analysis in this Section is structured around issues which we identified in the CFI as particularly important to wholesale leased lines product market definition, and which were further developed in stakeholders' responses to the CFI. Table 19 sets these issues out and refers to the paragraphs in which each issue is discussed.

Table 19: Structure of Section on wholesale product market definition

Issue	Summary of issue being considered	Reference
Issue 1: Alternative and traditional interfaces	Should we identify separate product markets for the wholesale inputs used to deliver retail AI and TI leased lines services?	§§ 4.21 –4.51
Issue 2: Very high bandwidth leased lines	In light of our identification of a retail Multiple Interface (MI) market, is there a single wholesale product market for all leased lines services supporting very high bandwidths?	§§ 4.52 –4.101
Issue 3: Access and backhaul	Are there a separate markets for access and backhaul (or is there a combined market for terminating segments)?	§§ 4.102 –4.188
Issue 4: Wholesale leased lines as an input to other retail services	Should we identify separate market(s) for leased lines services used to support: mobile backhaul; LLU backhaul and CCTV or include them in either the AI or TI wholesale markets?	§§ 4.189 –4.332
Issue 5: Bandwidth breaks	Do our findings on retail bandwidth breaks result in similar bandwidth breaks for terminating segments or is there a case for wider markets?	§§ 4.333–4.346

4.9 Under Issues 1-2, we consider whether to identify separate wholesale markets depending on the interface type (i.e. AI, TI or MI). In our retail product market definition, we identified three broad categories of retail leased lines services defined by their interface type (AI, TI and very high bandwidth MI services). Given this retail market definition, under Issue 1 (paragraphs 4.21 to 4.51) we first consider whether to identify separate wholesale leased lines market for wholesale terminating segments used to support retail AI and TI services. As a result of this analysis, we propose to retain separate AI and TI wholesale markets. We then discuss under Issue 2 (paragraphs 4.52 to 4.101), whether there is a single wholesale multiple interface product market for wavelength division multiplexed services (WDM) and other leased lines services above 1Gbit/s. We propose that there is such a combined wholesale market, which we refer to as the Multiple-Interface Symmetric Broadband Origination (MISBO) market.

4.10 Under Issue 3 (paragraphs 4.102 to 4.188), we consider whether we should identify a separate market for different parts of the network used to deliver the terminating segments of leased lines services. Many retail leased lines services rely both on access and backhaul wholesale inputs. But there may be greater scope for competition in backhaul parts of the network (relative to access) such that these services are not always purchased together. However, our analysis overall does not support defining separate access and backhaul markets, and we propose symmetric broadband origination markets (i.e. combined access and backhaul markets).

4.11 Under Issue 4 (paragraphs 4.189 to 4.332), we consider the impact of demand for leased lines coming from other retail services on our market definition findings. In particular, we consider whether wholesale leased lines used to provide backhaul services to LLU providers and mobile operators are in the wholesale leased lines markets we propose to identify following our assessment of Issues 1-3. As a result of this analysis, we propose that RBS backhaul is part of the same market as TISBO, and that mobile Ethernet backhaul and LLU backhaul are each part of the same market as AISBO. We propose not to include CCTV Broadcast Access and Street Access in either the AISBO or TISBO markets.

4.12 Finally, under Issue 5 (paragraphs 4.333 to 4.346), having established the key wholesale terminating segment products (AISBO, TISBO and MISBO) we then consider whether to identify any breaks in the chain of substitution in the market for each service by bandwidth. In particular, we consider whether our findings on retail bandwidth breaks map onto our identified terminating segment markets. As a result of this analysis, we propose four wholesale TISBO markets (at low, medium, high and very high bandwidths respectively), a low bandwidth wholesale AISBO market at speeds up to and including 1Gbit/s, and a combined wholesale MISBO at speeds exceeding 1Gbit/s.

4.13 We consider issues associated with trunk and core networks in Section 6. As discussed in paragraph 4.7 above, different levels of traffic aggregation in access, backhaul and trunk networks affect the potential for competition. Since these aggregation opportunities are often very location specific, there is a need to consider product and geographic market definition in parallel to some degree and particularly for trunk services. We therefore analyse product and geographic market definition for these services together (after we have introduced the main concepts associated with geographic market definition (for terminating segments) in Section 5).

The scope of our wholesale assessment

4.14 Before discussing each of the above issues we explain below three issues that we consider are important in terms of the scope of our wholesale assessment. First, we explain that the focus of our wholesale product market definition is primarily on 'active' wholesale leased line services. Second, we also discuss the relevance of existing ex-ante regulation to our wholesale market definition. Third, we highlight that when we analyse relevant competitive constraints at the wholesale level, we have focussed on wholesale network providers rather than intermediary firms.

We focus on 'active' wholesale leased lines services

4.15 In Section 2, we showed the various levels in the leased lines value chain. In summary, we set out that CPs need active wholesale products to deliver a fully managed retail service. 'Passive' inputs[149] such as duct access or dark-fibre are upstream in the value chain. Hence, if a CP were to purchase a commercially available 'passive' input such as dark fibre, it would still need to invest in additional equipment to make that service capable of supporting a fully managed retail service.

4.16 A passive product gives the user greater ability to determine the characteristics of the service provided over it, compared to an active product, but also requires more investment by the user. Hence the distinction between 'passive' and 'active' products is important: if a passive product rather than an active product is used, it may affect the way the operator competes in downstream markets.

4.17 We do not include passive inputs within the scope of this wholesale product market definition section as they are upstream of the markets we first need to assess. However, our analysis of active services will take into account relevant upstream inputs passive used in the delivery of those active products. For example, when we assess circuit volumes, we include in our circuit count any leased line services which may be provided by one operator using a passive input (such as dark fibre) provided by another. Thus a dark fibre input used to supply a leased line will be counted once only, as a leased line provided by the using operator. Dark fibre which remains unlit is not included in the market but could be relevant to the SMP assessment, as its presence may indicate an absence of barriers to expansion. We are also not precluded from considering whether there is a case for a requirement to provide passive products as a remedy for SMP. For example, we could require duct access or dark fibre to be made available as a remedy for SMP in TISBO markets, and the case for doing so is considered later in this document at Section 8.

We conduct our assessment under the modified Greenfield approach

4.18 It is also important to note the role that existing regulation has in our wholesale product market definition. We conduct our market definition assessment in the absence of any other wholesale SMP regulation in the relevant leased lines markets under review (referred to as the modified Greenfield approach (as discussed in Annex 7).[150] To the extent that any wholesale leased lines remedies associated with market power determination in leased lines markets exist, then, following the

[149] They are a 'passive' service as they only provide access to physical network elements (access to duct or dark-fibre) and they are not supplied with any active equipment. 'Active' products by contrast would provide access to the electronic equipment that is connected to the physical infrastructure.

[150] See Section 6 for an explanation.

modified Greenfield approach, it is first appropriate to conduct market definition and SMP analysis in the absence of these remedies. For example, in our product market definition, we must assume that BT would not face an ex-ante regulatory obligation to provide network access for leased lines products. BT's leased lines services would also not be subject to any controls on its charges. However, we take into account any ex-ante wholesale regulation upstream of leased lines markets that exists independently of a finding of SMP in the markets being reviewed (e.g. local loop unbundling).

4.19 We note that the application of the modified Greenfield approach has relevance to our consideration of the role of 'passive' services should have in our wholesale markets assessment. As set out in paragraphs 4.16 to 4.17 above, we focus our wholesale assessment on active remedies. But even if we were to require BT to make available dark fibre or duct access as a remedy in this market review, we would need to exclude it from any assessment of wholesale markets focused on active remedies. This is because any passive remedy would be excluded from our analysis due to the modified Greenfield approach (i.e. as a passive remedy for SMP in the market being analysed it must be assumed not to be in place for the purposes of market definition and assessing SMP).

We focus on wholesale providers rather than intermediary firms

4.20 We also focus on wholesale providers with their own network[151] (rather than intermediary firms such as aggregators or resellers).[152] Resellers operate downstream of the markets under review and purchase services which are sold by CPs in wholesale markets and so could not impose a competitive constraint on wholesale providers. Therefore, as we include all relevant constraints from providers with their own network (CPs), we do not include intermediary firms in our wholesale assessment as they would not add any further competitive constraint at the wholesale level over and above operators with their own networks.[153]

Issue 1: Alternative interface and traditional interface services

4.21 In Section 3, we proposed separate retail product markets based on the interface type presented to the end-user. We identified alternative interface (AI) services (at speeds up to and including 1Gbit/s) in a separate market to traditional interface (TI)

[151] This is likely to include (but is not necessarily limited to):

- BT and major CPs that might purchase Partial Private Circuits from BT and wholesale Ethernet services from Openreach (or alternative wholesale services from OCPs) to combine with their own networks to deliver retail leased lines or services to other retail markets (e.g. using wholesale leased lines to support broadband backhaul); and

- Mobile network operators: where they are purchasing leased lines for the purpose of delivering mobile network connectivity (where mobile network connectivity includes circuits between their radio base stations (RBSs) and for the backhaul of traffic from RBSs to core nodes and between core network nodes).

[152] These resellers essentially buy or aggregate together services from wholesale providers to deliver end-to-end solutions. This includes firms providing reselling or valued-added functions (e.g. IBM or CSC). As such, when considering market power at the wholesale level, these resellers would not impose an additional competitive constraint unless they were to enter by owning or operating their own infrastructure.

[153] We also include mobile operators' purchases of leased lines to build mobile networks in our wholesale assessment. However, our wholesale definition excludes mobile operators' purchases of retail business connectivity circuits (i.e. circuits purchased to connect together their own retail stores to their headquarters).

services.[154] Under Issue 1, we consider whether separate markets exist for AI and TI wholesale services used to deliver those specific alternative interface and traditional interface retail services. We focus this assessment initially on terminating segments.[155] We consider markets for AI and TI trunk segments in Section 6.

4.22 Our assessment begins by looking at the findings of the 2007/8 Review and stakeholders' responses to the CFI. We then analyse the case for separate wholesale markets based on AI and TI services in light of:

- *Derived-demand and indirect constraint arguments*: we consider whether the retail market definitions for AI and TI are closely reflected in demand for separate AI and TI wholesale inputs for those services;
- *Direct demand-side substitution:* we consider whether any competitive constraints arising from demand-side substitution at the wholesale level might undermine the view that there are separate wholesale markets for AI and TI services (we do not consider supply-side substitution to be relevant for the reasons set out in Annex 7)[156]; and
- *Analysis of competitive conditions*: we assess whether any apparent differences in competitive conditions of providing wholesale AI and TI services support our proposed finding of separate markets.

4.23 Having considered all of the above factors, we propose to find separate markets for AI and TI wholesale services. Our analysis of the derived demand arguments reflects that which supported our findings of separate markets in the 2007/8 Review. Our assessment of the other factors mentioned above (i.e. the scope for demand or supply-side substitution) as well as wider evidence on competitive conditions are consistent with this proposal.

2007/8 Review

4.24 In the 2007/8 Review, we concluded that separate wholesale AI and TI markets existed. We found AI and TI services to be in separate markets at the retail level, so this did not suggest putting AI and TI wholesale inputs in a single wholesale market (based either on derived demand or indirect constraint arguments).[157] However, we also considered it necessary to analyse whether a direct constraint might arise from CPs switching between AI and TI wholesale inputs.

4.25 We noted that some CPs had said that they were intending to deliver leased lines services presented to customers as SDH/PDH (TI) circuits using Ethernet (AI) inputs

[154] The retail AI market for services up to and including 1Gbit/s. We identified a number of sub-markets for TI services market on the basis of the particular speed of that service, which we discuss under Issue 5 (paragraphs 4.333 to 4.346) of this Section.

[155] In general terms, terminating segments are the middle and last mile connectivity that operators use to build out from their core networks to a customer's premises.

[156]For supply-side substitution to be relevant, it would require that CPs are not already 'present' in the supply of the focal product or services and those providers could enter and begin supplying 'equivalent' Ethernet services relatively easily within a short-space of time (i.e. they have existing network capacity and capability to supply Ethernet interfaces). The first condition is unlikely to hold as most wholesale suppliers of TI services are also active in the supply of AI.

[157] For an explanation of derived demand and indirect constraints see paragraphs 4.34 to 4.38 below.

in the near future. In addition, one CP noted that wholesale services would become available on BT's 21CN platform and that these were likely to include services provided over the underlying Ethernet-based infrastructure presented to an end-user as a TI service, as well as more standard Ethernet (AI) services. We noted that this raised the possibility of direct substitution at the wholesale level between TI and AI services at some point in the future.

4.26 We noted, however, that BT was continuing to offer access to "native" TDM services (i.e. services that still rely on SDH/PDH technologies) until at least 2014. We considered that BT's decision to continue to support these services was supportive of the view that Ethernet was still not a good substitute for "native" TDM products (i.e. using SDH/PDH) that were, at the time, the predominant method of delivering retail TI services.

4.27 No CP was able to provide firm evidence that they were supplying TI customers currently supplied with leased lines using SDH/PDH technologies with alternatives, such as using technologies that seek to "emulate" the main characteristics of TDM services but over an Ethernet leased lines. We considered it premature to conclude that wholesale Ethernet services would be an effective substitute. Therefore, we did not consider that a single wholesale market for AI and TI services existed.

Call for Inputs

4.28 In our CFI, we noted the findings of the 2007/8 Review, that the market boundaries identified for retail product markets such as AI and TI markets were reflected in the wholesale product definition. We set out our preliminary view that the factors informing the analysis in the 2007/8 Review were unlikely to have changed materially and we would expect this to be reflected in an unchanged definition for the associated AI and TI wholesale markets.

Stakeholder views

4.29 In general, stakeholders did not provide detailed comments on our wholesale definition with respect to AI and TI. However, as noted in Section 3, the majority of stakeholders agreed with our proposals to retain separate retail markets for AI and TI services. In addition, the majority of stakeholders did not object to using this retail product market definition to inform the wholesale market definition.

4.30 One stakeholder [✂ ✂] considered that the split in the market for AI and TI services was artificial. It argued that these distinctions make little sense to users who, in the data transport market are only interested in cost for bandwidth (with customers having varying additional technical requirements).

4.31 Most other respondents suggested that there remain differences in services at the wholesale level. For example, H3G, MBNL and Everything Everywhere noted that there was a significant move from TI to AI products reflecting the ever growing need for high capacity backhaul links. Nevertheless, they noted that there are still significant barriers to switching from TI to AI products.

Ofcom's analysis

4.32 As set out in paragraph 4.22 above, our assessment focuses on three main pieces of analysis: a re-assessment of the derived-demand and indirect constraint reasoning set out in the 2007/8 Review; an analysis of any constraints that might arise from

demand and supply-side substitution at the wholesale level; and an analysis of competitive conditions.

Derived demand and indirect constraints

4.33 As discussed in Section 3, similar to the reasoning set out in the 2007/8 Review, in this consultation we propose to find separate retail markets for AI and TI services.

4.34 A direct constraint at the retail level can give rise to an "indirect" constraint on the prices of the wholesale inputs whose demand is derived from demand for the retail services, in the following way. If there is an increase in the price of a wholesale service which is used to provide one of the retail services (but not the other), and this increase is passed through in the retail price, then the wholesale price increase may also be made unprofitable by switching by retail customers to the other product whose price has not increased. This is an indirect constraint on the wholesale price.

4.35 Indirect constraints arising from retail level substitution may be sufficiently strong for wholesale products to be placed in a single market, even if there is no possibility of directly substituting one wholesale input for another in the production of a given retail service. For this to be the case, it is necessary for the following conditions to be satisfied: the relevant retail products are sufficiently good substitutes for there to be a single retail market; wholesale prices are largely or wholly passed on to retail customers; and the price of the wholesale service forms a high proportion of the retail price.

4.36 As discussed in Section 3, at the retail level, there remains underlying demand from some end-users for TDM-based technologies based on the characteristics these services deliver. In our retail market definition assessment we propose separate AI and TI markets. This being so, we consider that it is unlikely that indirect constraints at the wholesale level will be sufficiently strong to point to a single wholesale market. We now turn to the question whether any direct demand-side constraints could be relevant.

Demand-side constraints

4.37 In this part we assess whether direct demand-side constraints could be a reason to identify a combined AI and TI market. That is, we consider whether a hypothetical monopoly supplier of wholesale TI services would be constrained from raising prices by the prospect of CPs responding to such a price increase by switching to wholesale AI services (or vice versa).

4.38 The analysis of direct demand-side substitution is distinct from our retail market analysis of substitution between AI and TI retail services. At the retail level, we identified specific markets based on end-user demand for low latency, synchronous and resilient services that have tended to be supplied using TI services. Our assessment was that there are sufficient number of these customers in the TI market unwilling to switch to alternative technologies such as AI services (or vice versa). By contrast, direct demand-side substitution at the wholesale level would entail CPs currently supplying retail customers using wholesale TI inputs instead switching to supplying those customers with a wholesale input based on AI technologies. The nature of any direct constraint would therefore arise from the behaviour of wholesale providers switching from wholesale TI to AI services rather than from the switching behaviour of downstream end-users.

4.39 At one level the question of direct demand-side substitution relates to the technical capabilities of AI and TI services to deliver particular services. In particular, whether it is possible that retail demand (for low latency, synchronous and resilient services of the type demanded by TI customers) could instead be delivered using AI-based wholesale inputs. If it were possible to "emulate" the main characteristics of TI services that end-users value but over an Ethernet leased line then this would indicate there are not separate wholesale markets. This is because a CP could in principle substitute directly a wholesale TI circuit with an AI circuit. A further relevant question is whether it is possible that a TI-based wholesale input could be used to deliver an AI service.

4.40 In the 2007/8 Review, we noted that it remained the case that an AI service cannot generally be used to provide an equivalent retail TI circuit or vice versa. In other words, a monopoly supplier of TI circuits would not be constrained from raising prices by the prospect that wholesale customers would respond to such a price increase by switching to AI circuits, or vice versa. This was because the technical capabilities of AI and TI services did not make them effective demand-side substitutes for one another.

4.41 Since the last review, Ethernet technologies have continued to evolve such that a number of differences between Ethernet and TDM-based services have reduced. One major development has been the emergence of 'carrier-class' Ethernet. The availability of carrier-class Ethernet means that AI services are now closer to TDM services in that they can now fulfil many of the functions needed to support the efficient provision of leased lines services across national and international networks (rather than Ethernet having more limited functionality and being confined to metro or local area networks).[158]

4.42 Ethernet technologies have also evolved to support synchronisation functions (which for some customers is one of the drivers for the demand for TDM circuits).[159] Therefore, the convergence of Ethernet and TDM may have eroded many of the technical differences that would matter to most end-users. [✂ ✂]'s response to the CFI, provided some support to this view as it did not see a difference in markets between TI, AI and WDM.

4.43 However, we note that BT continues to support TI services using "native" SDH/PDH technologies (rather than a solution that relies on Ethernet). This is likely to reflect the fact that there continues to be a number of retail customers still requiring the strictest performance characteristics of TDM-based technologies. In addition, at lower bandwidths (2Mbit/s), in particular, TDM services remain competitively priced relative to lower bandwidth Ethernet services (e.g. at 10Mbit/s).[160] In the context of our market definition, this means that insufficient numbers of wholesale users would be

[158] This includes a traffic management and hierarchical QoS (quality of service) mechanisms, standard end-to-end OAM (operations, administration and maintenance) and performance monitoring, extensive fault management and diagnostics.

[159] MNOs have for example relied on SDH-based circuits to their mobile base stations. Because SDH uses a common synchronised timing source to deliver SDH circuits using time division multiplexing, MNOs can use this synchronised timing to manage mobile end-users moving between different cell sites. We discuss synchronous Ethernet solutions in more detail in relation to mobile backhaul under issue 4a below.

[160] Under Issue 3 below, we also highlight that there are barriers to CPs providing Ethernet and TDM backhaul on a converged basis. In some cases the geographic location of networks and circuits used to deliver Ethernet services and TDM-based services can be different. Therefore, even if a CP had invested in support for TDM-emulation over Ethernet circuits, it would not necessarily be straight-forward to re-assign a retail TI circuit to an Ethernet services where the CP's network (used to support each service type) is not always located in the same areas.

willing to switch to Ethernet in response to a SSNIP on TI services to make it unprofitable, because this would mean that their retail customers would experience an unacceptable loss of key service characteristics.

4.44 We consider that the points that [✂ ✂] raised in the response to the CFI (see paragraph 4.30 above) are likely to be more relevant at higher speed (Gigabit speeds) used for data transport. However, given the cost premium associated with such technologies, we consider that for lower speed circuits (e.g. TI circuits below 1Gbit/s), it is unlikely that CPs would install (on a forward looking basis) equipment capable of supporting multiple interfaces for these lower value circuits.

4.45 Given that the TI market is in decline overall, it is likely to be more economic to continue to support the synchronisation, resilience and low-latency features of the TI services currently supplied (which in the main includes services at 2Mbit/s and below) using "native SDH" products. Therefore, for TI terminating segments (at lower speeds) these services are likely to continue to be provided over dedicated TDM-based equipment.

4.46 Therefore, while technical differences have reduced, the evidence points to a base of customers (at least at lower bandwidths) that have a positive preference for TDM-based services. We note that most other respondents suggested that despite migration occurring between AI and TI there remain differences in services at the wholesale level and barriers to switching that suggest that separate markets continue to exist.

Competitive conditions

4.47 In the preceding paragraphs 4.32 to 4.46 above, we explained why we propose separate wholesale AI and TI markets. For the purposes of market definition assessment, we have also considered whether wider market evidence appears to support this finding (based on an assessment of any differences we might observe in relation to the competitive conditions). If competitive conditions were homogeneous across AI and TI services, we could combine them in a single market to enable us to simplify the SMP analysis without affecting the conclusions.

4.48 The competitive conditions for different AI and TI markets is assessed in detail in our SMP assessment in Section 7. It is noted, however, that the differences in competitive conditions for AI and TI services tends to support our proposals to define separate markets.

4.49 In that Section, we observe that one reason for differences in competitive conditions is that many of the TI markets are largely in decline. One implication of this would be that there could be limited incentives for BT's competitors to enter or to invest further in this market. The majority of TI users likely to remain are on lower bandwidths (2Mbit/s and below). BT's share of this market has remained stable through time and it has faced limited competition for the lower bandwidth services that constitute the largest part of the market.

4.50 By contrast to TI services there is emerging competition for AI services in some geographic areas. Indeed, for the most commonly purchased TI bandwidths (2Mbit/s and below), we observe BT with a significant national share (86%) and we do not observe significant differences in competition in the London area. This contrasts with the AI services where our market evidence suggests greater variation in competitive conditions by geography (BT's national share is around 62% for the UK overall and –

on a comparable basis – about 41% in the London area).[161] Given that competitive conditions appear to vary it is not appropriate to use a combined market to simplify the analysis.

Ofcom's proposals

4.51 On the basis of the above analysis, Ofcom proposes to retain separate wholesale markets for alternative interface and traditional interface services respectively (at least for services below 1Gbit/s). We note in particular the derived demand analysis and a lack of demand side and supply side substitution opportunities between the two services at the wholesale level. The wider market evidence on variations in competitive conditions calls for separate examination of each.

Issue 2: Very high bandwidth leased lines services:

4.52 In our retail assessment in Section 3, we propose to identify a single leased lines market addressing needs of retail customers requiring very high bandwidths (above 1Gbit/s). In that Section, we explain that a particular technology: wavelength division multiplexing (WDM) can be used to deliver multiple interface types (including AI and TI) and this would be an effective substitute for standard AI services used to provide very high bandwidth services. In light of this retail market assessment, we propose to define a "multiple interface" (MI) market. This MI market covers all very high bandwidth leased lines services (including WDM services and all other retail leased lines services above 1Gbit/s irrespective of interface presented to the end-user).[162]

4.53 We consider under Issue 2, the implications of our retail proposals for wholesale product definition. In particular, we consider whether there is a combined market for very high bandwidth wholesale services (i.e. including WDM services and other interfaces (AI and TI)). Our assessment begins by looking at the findings in the 2007/8 Review and stakeholder's responses to the CFI. We then analyse the case for the identification of a separate wholesale market in light of:

- *Technical assessment:* we look at the particular wholesale service requirements needed to meet demand from very high bandwidth retail customers;
- *Demand and supply-side substitution:* given our finding of a combined retail market, we consider any derived demand arguments for a combined wholesale product market based on 'indirect' demand constraints or more direct demand or supply-side constraints at the wholesale level;
- *Analysis of competitive conditions*: we consider whether wider evidence on the competitive conditions of providing WDM services relative to other wholesale leased lines services is consistent with our proposals for a combined market; and

[161] In the section of this document where we consider whether BT has SMP in this market, we describe refinements which we make to our market share estimates. After these refinements, we estimate BT's share to be between 45% and 50%, see Section 7.

[162] In Section 3, we consider that for this part of the retail market, where users require higher speeds, and given the relative costs of the technologies which can be used to deliver those requirements, many CPs will choose to provide customers with WDM-based retail services. As these WDM-based retail services are capable of supporting high speed and multiple interface services we consider that they would be an effective substitute for AI and TI services provided using dedicated Ethernet or SDH equipment capable of supporting very high bandwidths.

- *Barriers to interconnection:* we consider whether any technical and economic issues associated with interconnecting WDM-circuits create any barriers to end-to-end competition that could affect our market definition.[163]

4.54 In our assessment below, we focus our substitution analysis on the wholesale inputs most commonly used to deliver very high bandwidth services, namely WDM-based services and standard Ethernet services (e.g. BT's WES services at 2.5Gbit/s and 10Gbit/s). This is because Ethernet (delivered either over point to point or networked Ethernet links) is one of the main interface types that has typically been used in the delivery of very high speed data services. Hence, we focus on these two services because we would expect *a priori* that Ethernet would be the next closest substitute to a WDM service (and vice versa). In light of our proposed findings in the retail market assessment (where we identified a separate market for low bandwidth AI services at 1Gbti/s and below), we also focus our analysis of very high bandwidth services on Ethernet services above 1Gbit/s and WDM.

4.55 As a result of our assessment, we propose to identify a combined market for terminating segments with any interface and delivering any service faster than 1Gbit/s, and for terminating segments delivered with WDM equipment at the customer's premises (providing services at any bandwidth). We call this market the wholesale Multiple-Interface Symmetric Broadband Origination ("MISBO").

2007/8 Review

4.56 In the 2007/8 Review, we found that retail WDM was not part of either the retail AI or TI markets. Given the still relatively nascent nature of WDM-services, we did not go on to review wholesale WDM services as part of the wholesale product market definition.

Call for inputs and stakeholder views

4.57 In our CFI, we did not ask a specific question on wholesale WDM services. Instead, we asked stakeholders for their views in relation to retail demand. We highlighted that, in general, we would inform our analysis of wholesale markets based on derived demand (i.e. based on the findings in retail markets). For a full summary of specific stakeholder views on retail WDM, see Section 3.

4.58 In general, there was support from stakeholders for further analysis of wholesale WDM products and services. For example, Verizon submitted that the importance of WDM products was increasing and it was therefore appropriate for wholesale WDM to be part of this review.

4.59 There was also support from most stakeholders, a number of whom argued for a "service agnostic" definition in particular for higher speed services. (i.e. a market definition for higher speed services that did not identify breaks in the market based on interface type). For example, one stakeholder [✂ ✂] stated that at gigabit speeds, most of the equipment it uses is either agnostic to interface type used or it can transport wavelengths *"irrespective of the underlying format."* UKCTA highlighted

[163]This issue arises because any interconnection of a WDM circuit needs to meet the necessary standards to ensure that:

- inter-operability of WDM equipment available from different vendors; and
- the interconnection of wavelengths between equipment also supports the end-to-end service requirements (such as circuit monitoring).

that the same basic WDM equipment can now be used cost-effectively for non-Ethernet services, higher speed services, and WDM services. It submitted that any difference that previously might have existed has now collapsed.

4.60 C&WW argued that demand is now growing for multiple Ethernet services between end-users' sites. The nature of this demand requires the ability to grow capacity quickly (without new infrastructure fibre build) and it also requires the use of non-Ethernet protocols. It submitted that WDM services (that offers the flexibility to meet demand for increasing bandwidth and different interface types) were now the natural successor to current Ethernet products.

4.61 Sky supported a single market that included WDM services and not just point-to-point Ethernet. It noted that the cost of the WDM equipment used has fallen markedly – by more than 90% - over recent years. As a result, the cost differential that existed between WDM and standard Ethernet has narrowed significantly. It submitted that WDM was now widely used to deliver services above and below 1Gbit/s. It considered that there would not be a break in the market at a particular bandwidth or interface type.

4.62 Only BT stated that it supported a separate WDM market on the basis it considered that these services perform a very specialised role (e.g. relative to standard Ethernet leased lines). It submitted that the market is an emerging one and small in terms of volume relative to more established forms of business connectivity.

Ofcom's analysis

4.63 We have set out below what we see as the technical scope of wholesale WDM services. We then assess - in light of our retail product market definition and this technical assessment of wholesale products- the implications for wholesale product market definition.

Technical assessment

4.64 In this technical assessment, we consider the underlying technologies and services that would be used by CPs to support very high bandwidth services above 1Gbit/s.

4.65 Historically, WDM was first used by CPs to enable efficient transport of traffic in their core networks). The benefit of WDM is that it uses individual wavelengths of light to deliver very high capacity, with each wavelength supporting speeds ranging from 1Gbit/s and now up to 100Gbit/s (and multiples thereof) over a single fibre.[164] The deployment of WDM was initially a solution to make core networks more efficient. But the use of WDM evolved through time as an efficient way to meet the needs of retail customers with very high bandwidth requirements.

4.66 As noted in Section 3, there are a range of end-users requiring very high speed services including data centres; companies offering cloud computing hosting or financial firms that need to transfer data on their financial transactions with low latency. If a retail customer has requirements for a very high bandwidth leased lines service (say, 10Gbit/s), this demand can be served using the following wholesale inputs:

[164] Recently vendors have introduced equipment capable of supporting speeds of 40Gbit/s and 100Gbit/s per wavelength.

- *Ethernet services:* CPs can install 'dedicated' Ethernet equipment at the customer's premises pre-configured only to provide the relevant required speed.[165] For example, leading equipment vendors such as ADVA and CISCO sell Ethernet-based equipment that are available at specific speeds of 10 and 100Mbit/s and 1, 2.5, 10, 40 and 100Gbit/s. This equipment sends data on a single pair of lit wavelengths over optical fibre.

- *WDM services:* CPs can deploy WDM equipment that enables single or multiple wavelengths of light to be sent down the same optical fibre. Because the end-user has additional WDM equipment at its premises, additional wavelengths can be added ranging from 1Gbit/s through to 100Gbit/s very easily (i.e. without further change in equipment). The modularity of WDM equipment also allows line cards to be installed that deliver retail services with all major interface types (Ethernet, traditional interface (SDH) or other 'niche' interfaces such as Fibre Channel).

4.67 There is an important distinction to highlight between 'WDM equipment' and a wholesale WDM service. Installing WDM equipment at either end of a piece of fibre would merely set-up the capability to deliver multiple wavelengths of light down a piece of fibre. But this is not *sufficient* to deliver a fully functioning retail service. A wholesale WDM service would require relevant client interfaces such as Ethernet to actually transport data across those wavelengths (and to support any operations, administration and management of that service on an end-to-end basis). Therefore, to enable WDM equipment to provide an active very high bandwidth wholesale service requires relevant line cards at either end of the circuit. Hence, when we refer to wholesale WDM service in this Section, we are referring to a wholesale service delivered:

- over a WDM-based transmission medium, including WDM-based equipment at a customer's premise; and

- delivered to a customer with a specified client interface(s).

4.68 As identified in the 2007/8 Review and discussed in Section 3, one of the key features of WDM service is the flexibility/scalability of the service. The time frame required to change the configuration of the service is a function of the commissioning and installation of cards in the equipment at each end. In principle where the relevant equipment is available, upgrades to the bandwidth of the WDM service could be achieved in a few working days. This is because any increase in capacity will use the existing fibre circuit and would simply entail an additional "line card" being installed on existing equipment housing.

4.69 WDM also has benefits as it is possible to deliver services over multiple interfaces such as Ethernet, SDH and some 'specialist' interfaces required by companies storing and archiving data (e.g. fibre channel). A dedicated Ethernet box whilst also relying on a pair of lit wavelengths over fibre, does not offer the same modularity as WDM equipment. If a customer has a 1Gbit/s Ethernet service and wants to upgrade for 1Gbit/s to 2Gbit/s, say, then a new piece of equipment is required.

[165] When we refer to 'dedicated' Ethernet equipment, we are referring to equipment designed primarily to deliver Ethernet interfaces installed at the customer's premise. Within a CPs core or backhaul network, a CP could provision this Ethernet service over shared fibre and network equipment. The key point with respect to 'dedicated' Ethernet equipment (as compared to WDM-based services) is that the Ethernet service cannot be easily switched to alternative interface types without first changing the customer premises equipment.

Demand-side substitution

4.70 In our retail market definition, we propose a combined MI retail product market consisting of a number of retail services. This retail market includes WDM-based services (at all bandwidth) and all other leased lines services (above 1Gbit/s) irrespective of the interface used. Hence, we include in our MI retail product market, WDM services (at all bandwidths) and AI and TI services (above 1Gbit/s).

4.71 Given that we find these services in the same retail MI market, then it is possible that the wholesale inputs used to deliver those retail services could be in a combined wholesale market. Such a product market definition would be justified if there was a sufficiently strong indirect constraint on the prices of the wholesale services arising from substitution at the retail level. We explained how indirect constraints might arise at paragraphs 4.33 – 4.36 above.

4.72 For indirect constraints to be relevant to these markets would require that a hypothetical monopolist of relevant focal product (i.e. a very high bandwidth wholesale Ethernet service) would find a SSNIP unprofitable due to a response from downstream customers. In particular this indirect constraint would arise due to retail customers switching away from dedicated retail Ethernet services (that rely on the focal AI wholesale product as an input) in response to wholesale price increases passed through to retail products. If there is sufficient switching at the retail level from Ethernet services to WDM-based services, then this would suggest that we should widen our wholesale product market to include both Ethernet services and WDM-based wholesale services.

4.73 In assessing possible indirect constraints it is important to consider how retail prices would change in response to price increases at the wholesale level. There are two main factors to consider:

- *the extent of pass-through:* whether the absolute increase in the wholesale input price would be reflected in full in retail prices and not 'absorbed' to any material extent by retail providers; and

- *the significance of those wholesale input prices to retailers' costs:* the extent of any percentage price increase at the wholesale level may be 'diluted' in terms of the percentage increase seen in retail prices.

4.74 If the retail market were fully competitive then we would expect any increase in the price of the Ethernet input to be passed on to retail customers in full. This is because the product in question would already be supplied at the competitive price prior to the hypothetical price increase. Hence, there would be limited scope for a competitive provider of a retail service to absorb any increase in input prices via a reduction in its retail margins. If the market were less competitive then there would be greater scope for retailers to absorb some of the increase in the price of a wholesale input. Nevertheless, our assumption, for market definition purposes is that wholesale price increases are passed through in full.

4.75 However, any wholesale price increase is still likely to be 'diluted' because the cost of a wholesale input may only be one element (albeit a significant one) in the cost stack associated with providing a retail service. While in absolute terms a price increase would be the same (e.g. a £10 wholesale price increase passed on in full would become a £10 increase at the retail level), the increase would not be the same in relative terms. The result is that we consider a SSNIP (e.g. 10%) in the wholesale

price would be expected to result in a less than 10% increase in retail prices due to this 'dilution' effect.

4.76 For the retail services (very high bandwidth Ethernet), however, we would expect that in a competitive market the costs of wholesale inputs form a significant component of any retail price. This is because the cost of equipment and digging and ducting are significant relative to other retailing costs. On this basis, a SSNIP is likely to translate into a significant increase in prices at the retail level. This means that wholesale elasticity will be relatively close to retail market elasticity as dilution is low.

4.77 As such, we consider switching from very high bandwidth Ethernet services to WDM services at the retail level would impose a sufficient indirect constraint on a wholesale provider of wholesale dedicated Ethernet services.[166] On this basis a derived demand assessment (based on indirect constraints) would suggest including WDM and very high bandwidth Ethernet services in the same wholesale market.

Direct demand side constraints

4.78 If wholesale price increases (i.e. a SSNIP) were significantly diluted at the retail level then this could undermine the above *indirect* constraint argument. We consider that this is unlikely to be the case for the reasons set out above. But even if there were not sufficiently strong case for indirect constraints, it is still possible to find a combined very high bandwidth wholesale market (i.e. WDM and Ethernet services) based on a *direct* demand side constraint.

4.79 Direct demand side constraints would arise if a CP using a wholesale Ethernet service to deliver a very high bandwidth retail leased line could instead switch to delivering this service over WDM (or vice versa). If sufficient CPs were willing to do so in response to a SSNIP applied to a wholesale Ethernet service then this direct demand-side substitution would suggest identifying a combined very high bandwidth wholesale market. We explain below that, in addition to the indirect constraints arguments in paragraphs 4.70 to 4.77 above, direct demand-side substitution would provide a further reason to include Ethernet and WDM in the same market.

4.80 Under the technical assessment above, we noted that a CP could fulfil the requirements for high bandwidth service using either a wholesale WDM service (such as BT's OSA or OSEA services) or using Ethernet leased lines services. In both cases, the end-user would be presented with identical Ethernet interfaces and the service delivered to the end-user would be indistinguishable.

4.81 The extent to which a CP chooses standard Ethernet or WDM equipment with an Ethernet client interface comes down to the trade-off between costs and the likely bandwidth requirements of the customer. If there are not large cost differences between the two provisioning options then WDM equipment may always be preferred. If there are larger cost differences, then a CP may consider more carefully its customer's present and future bandwidth requirements and opt for a dedicated Ethernet circuit at 1Gbit/s and above in some cases and WDM circuits in others.[167]

[167] Such considerations were highlighted in our retail definition, but are only likely to apply where the costs differences between services are significant. Where cost differences are significant then it might suggest that:

- for many retail customers that know that their bandwidth will not grow significantly then standard Ethernet services using equipment dedicated to a particular bandwidth may be sufficient.

4.82 In Section 3 we assessed the costs of WDM relative to Ethernet. This analysis suggested that there is not a significant cost premium for WDM services above 1Gbit/s relative to Ethernet services.[168] In our analysis in Section 3, we concluded from our analysis that a WDM service could impose a competitive constraint on Ethernet services above 1Gbit/s. By contrast, when comparing WDM services to standalone Ethernet equipment at 1Gbit/s, we observed that there is a more significant premium. Consequently, even if a SSNIP were applied to AI service (for services at 1Gbit/s and below), a WDM-based solution would not be a viable solution (i.e. WDM would still remain at a premium to those AI services).

4.83 On a similar basis to our retail definition, for services above 1Gbit/s, our analysis of direct demand-side substitution suggests that a wholesale WDM service (such as BT's OSA) would be in the same market as an Ethernet service. For AI services at or below 1Gbit/s, there is a sufficient step-up in the cost of deploying WDM equipment that we do not consider it provides a sufficient constraint on Ethernet services at these lower speeds.

Supply-side substitution

4.84 Our assessment of demand-side substitution suggests a combined market for WDM and AI services above 1Gbit/s. However, we have also looked at supply-side substitution (paragraphs 4.85 to 4.88) and a wider market assessment (in paragraphs 4.89 to 4.91 below), which provides further support to a combined market.

4.85 In general, for supply-side substitution to be relevant to our assessment we would require that CPs:

- are not currently providing a very high bandwidth service using dedicated Ethernet equipment; and
- could enter and begin supplying 'equivalent' Ethernet services relatively easily within a short-space of time (i.e. they have existing network capacity and capability to supply very high bandwidth services over Ethernet interfaces).

4.86 With these criteria in mind, we consider that a possible constraint could also exist from supply-side substitution. This is because some major OCPs such as [✂ ✂ ✂ ✂] appear to supply all their customers (at least above 1Gbit/s) using WDM services. Therefore, on the basis of the data available to us, these major CPs would not appear to be active in a narrowly defined market for very high bandwidth Ethernet services (i.e. delivered using dedicated Ethernet equipment above 1Gbit/s).

4.87 In those geographic locations where such CPs have network presence but are not currently active in the provision of high speed Ethernet, we consider that they could offer a competitive constraint on a hypothetical monopolist of wholesale Ethernet services. Where CPs have sufficient network presence, the value of the customers at

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- if bandwidth requirements are likely to grow more quickly than a dedicated Ethernet service would not be very suitable as each time the customer exceeds the capacity a new fibre circuits must be added, which is potentially more costly and will have longer lead times.

[168] As noted in Section 3, we have compared the cost of dedicated Ethernet equipment to a simple WDM-configuration using a single chassis with the relevant Ethernet interface. This is because such a comparison is most relevant to any assessment of substitution between a dedicated point to point Ethernet service and a WDM-based equivalent.

very high bandwidths makes provision commercially attractive. We also observe that it is technically feasible to enter the market for the provision of Ethernet services using WDM presented with Ethernet interfaces.

4.88 However, if an operator does not have significant network presence, then the high sunk cost associated with digging and ducting is likely to create a barrier to supply-side substitution. On this basis, we consider that supply-side substitution may only offer a relevant further constraint in limited geographic locations.

Competition conditions

4.89 In this Section, we consider whether the available evidence on the competitive conditions associated with the supply of WDM and AI services is supportive of a high bandwidth market above 1Gbit/s. In the following paragraphs, we compare service share data both on a national basis and by geography to see if there are similar patterns of competition for AI and WDM services above 1Gbit/s.

4.90 If we consider the market for AI services above 1Gbit/s[169] our prior expectation would be that competition is more intensive for higher value customers using higher bandwidths. Similarly, reflecting a similar pattern, we would expect competition is more intensive for higher value customers using WDM services. Indeed, when we consider BT's share of supply it is the same for both AI High and WDM irrespective of geography. BT's service share for AI High and WDM services is around 50% of the market nationally for AI High and around 46% for WDM compared to a 67% service share for AI Low services at 1Gbit/s and below. [170]

4.91 For AI High and WDM, we also observe a similar pattern in the overall variations in competitive conditions by different geographic locations. For example, BT has similar service share in the London area for AI High and WDM services, which is likely to reflect OCPs' fibre presence and willingness to build out to higher value customers. We therefore consider that the available evidence of the variations in competitive conditions for WDM services relative to AI services is consistent with a combined market for very high bandwidth services as suggested by our analysis of demand and supply-side substitution.

Barriers to interconnection for wholesale WDM services

4.92 In this part we consider whether interconnection for WDM-based services is in principle possible. This question is significant for our market definition because if interconnection is not possible it will fundamentally impact on the nature of competition in this market (as explained in more detail in paragraphs 4.93 to 4.95 below). In this section, we therefore assess barriers to interconnection for WDM-based services.

Why barriers to interconnection are important to our wholesale definition

4.93 In leased lines markets, competition is often based around CPs supplying terminating segments (either self-provided or purchased from third parties) which they combine with their own core networks to deliver retail end-to-end services. In most cases, OCPs have existing core networks, but they need connectivity from their existing networks to customers to deliver a retail service. In many situations, however, the

[169] However, we are not proposing to define a separate "AI High" market. Instead, these are part of our proposed MISBO market.

[170] Based on analysis of CPs' S135 submissions.

distances involved in building to a customer will be too far (as most CPs do not have ubiquitous network). In those situations a CP might rely (to some extent) on third-party supply for wholesale leased lines. Clearly, where a CP buys a circuit from another supplier, there need to be effective interconnection arrangements in place so that CPs can connect wholesale circuits supplied by a third-party to their own networks without there being any degradation in the service that the CP can provide to its downstream customer.

4.94 If interconnection is not in principle possible then the CP would have to supply the entirety of the retail circuit. Even if a CP has its own core network (capable of supporting WDM services), if it cannot interconnect third-party terminating segments to that core network then it could not rely on being able to use terminating segments from other providers. Hence, in order to deliver retail WDM service between an end-user's sites, the OCP must self-supply the connectivity from its core network to each of the retail customer's sites. If interconnection is not possible, then competition for WDM-based services would be restricted only to those CPs able to self-provide WDM-based services on an end-to-end basis. Therefore, our market definition would be limited to wholesale end-to-end services.

4.95 On the other hand, if interconnection to a competitive core is in principle technically possible then a definition based around separate WDM-based terminating segments and a separate core market would be more appropriate. That is not to say that there may not still be other barriers to overcome to enable a CP to compete effectively downstream using its own core network combined with third-party provided terminating segments. For example, there may be an additional cost of interconnecting WDM circuits that would not be faced by a CP that can self-supply a WDM circuit on an end-to-end basis. But as interconnection is in principle possible, any remaining market power issues would then be more about leverage of market power which could be addressed by making available an effective interconnection product at appropriate prices.[171]

Assessment of barriers to interconnection

4.96 In the case of WDM, there are some technical issues associated with interconnecting wholesale circuits, which may create barriers to end-to-end competition. In particular, some specific issues arise in relation to the interconnection of a WDM circuit, which needs to meet the necessary standards (for example recognised standards such as Optical Transport Network ("OTN"))172 to ensure that there is:

- inter-operability of WDM equipment available from different vendors; and
- the interconnection of wavelengths between equipment that supports the end-to-end service requirements (such as operation, network management and administration and circuit monitoring).

4.97 By contrast, for Ethernet leased lines services, the necessary interworking and interconnection standards are well established and (for the most part) allow CPs to maintain necessary operation, network management and administration and

[171] In particular, a firm with market power in the provision of terminating segments (where there may be significant barriers to competition) could be able to leverage that market power into core networks (even where the barriers to competition are much lower). This could result in the firm with market power in terminating segments not facing as strong a constraint on the price it could charge for WDM services that make use of a core network thereby making competition in core networks weaker.

[172] For a further discussion of OTN standards see Section 11.

monitoring functions on an end-to-end basis even where they rely on wholesale third-party supply for some parts of their end-to-end requirements.

4.98 For WDM services, without the implementation of relevant standardised interconnection (as has been achieved for standard Ethernet services), it would be very difficult for a CP to make use of a third party wholesale WDM-service. In principle, it is technically possible to provide 'work-arounds' to link different equipment together. But the cost of deploying such 'work-arounds' may make them commercially prohibitive.[173]

4.99 Our assessment of the development of interconnect products based on discussion with major equipment vendors is that the technical standards for OTN are now sufficiently well defined. For example, we have been told by ADVA that interworking between vendors is common. We therefore consider interconnection is technically possible such that a retail service could, in principle, be delivered using a CPs own network and third-party links. Therefore, there seems to be no 'inherent' technical requirement for WDM technologies to be restricted only to provision on an end-to-end basis. We consider it appropriate to identify a separate MISBO market (i.e. for WDM terminating segments).

4.100 Nevertheless, as noted in paragraphs 4.93 to 4.95, even if interconnection standards (such as OTN) were fully supported on an ongoing basis, there may still be an additional cost of interconnecting WDM circuits that is not faced by CPs able to provide WDM circuits entirely on their own networks. If these interconnection costs are material then this could then create a situation whereby competition is less effective for WDM markets. On this basis, we propose to take into account any competition issues that arise from a lack of effective or commercially attractive interconnection products in our SMP and regulatory remedies.

Ofcom's proposals

4.101 In light of our analysis as set out above, we propose to identify a combined market for terminating segments with any interface and delivering any service faster than 1Gbit/s, and for terminating segments delivered with WDM equipment at the customer's premises (providing services at any bandwidth). We call this market the wholesale Multiple-Interface Symmetric Broadband Origination ("MISBO"). Our proposed identification of a MISBO market is made, in summary, for the following reasons:

- Derived demand arguments based on indirect constraints suggest that a hypothetical monopolist would be constrained in raising the price of wholesale Ethernet services due to switching downstream to alternative WDM-based solutions.[174]

- Supply-side substitution might also be relevant in these markets, as there are current providers of WDM-based services not currently supplying a standard wholesale Ethernet service but that could potentially enter and begin supplying WDM-based services (where they have network presence).

[173] This entails installing transponders capable of taking an optical signal (where one WDM circuit ends) turning it into an electrical signal which is then converted back to an optical signal that would interwork with the WDM equipment of another CP.

[174] Direct-demand side substitution would in any case suggest identification of a combined MISBO market.

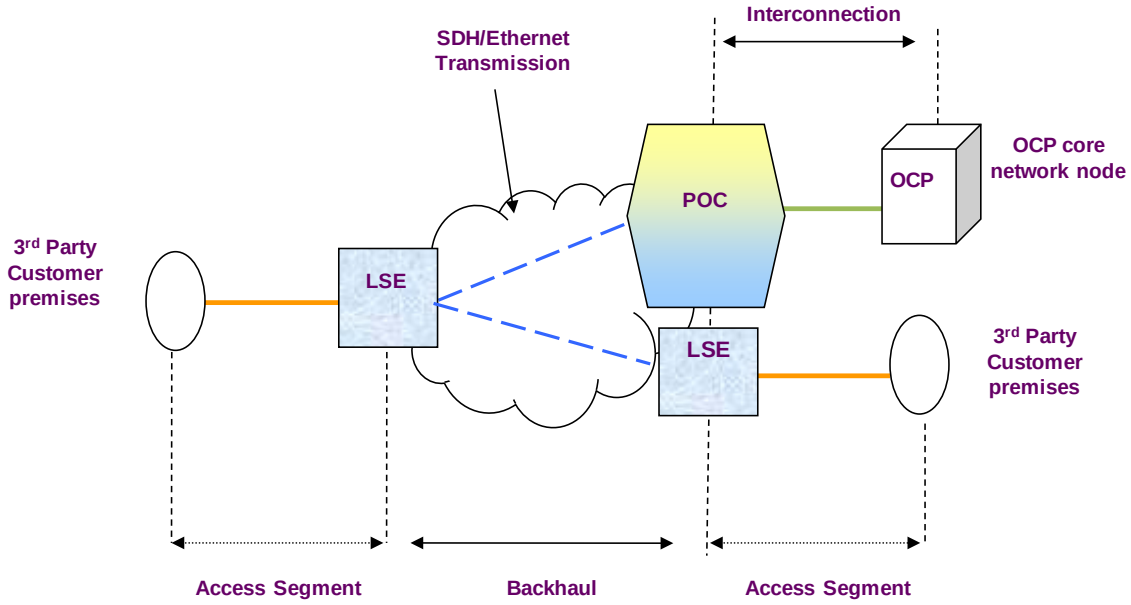
- The empirical evidence points to similar competitive conditions for WDM and Ethernet services and a more competitive situation for higher bandwidth services (for Ethernet services above 1Gbit/s and WDM) relative to low bandwidth AI services.

Issue 3: Wholesale access and backhaul markets:

4.102 Under this issue, we consider whether a separate market exists for access and backhaul for leased lines services or whether there is a combined "symmetric broadband origination" market.

4.103 Figure 25 shows a stylised depiction of the access and backhaul parts of the network as explained in the 2007/8 Review.

Figure 25: Access and backhaul



Source: Ofcom 2012

4.104 In the 2007/8 Review, we identified the following distinctions between access and backhaul segments:

- *Access segments*: these are typically the final network leg running from an end-user's premise (at the network termination equipment) to a local access node (typically this might be in a local serving exchange ("LSE")).[175] We noted that CPs can provide access segments over radio access links, or copper and fibre-based links dedicated to that end-user.

- *Wholesale backhaul services:* these are circuits running from a local access node to:

  - another local access node (on the same CP's network) (so it would include inter-exchange connectivity circuits); or

[175] We note that a backhaul network could in theory start from a point closer to the end-user, for example where a CP has installed equipment in a street cabinet. However, in most circumstances a local serving exchange is the first point at which different traffic streams from individual end-users come together.

- a trunk node (on the same CP's network); or
- another Communications Provider's point of connection (POC).

4.105 In our assessment below we first discuss the findings of the 2007/8 Review, which previously identified a combined access and backhaul product market. We then consider responses to our CFI. In light of those stakeholder comments we then consider whether there is a case for separate access and backhaul markets in light of:

- *Technical assessment:* we look at some of the general features of access and backhaul that would distinguish both services;
- *Demand and supply-side substitution:* we discuss why we consider that demand and/or supply-side substitution does not support a combined access and backhaul market; and
- *Analysis of competitive conditions*: we consider whether the competitive conditions associated with providing access services are sufficiently similar to backhaul services to support a combined market.

4.106 In addition to the above analysis, we also respond to points raised by stakeholders in particular with respect to their views on inter-exchange connectivity.

4.107 On the basis of our assessment, we propose to identify a combined market for access and backhaul. We term these combined access and backhaul services as symmetric broadband origination. Consequently, we propose to identify (relevant) symmetric broadband origination market(s) for the AISBO, TISBO and MISBO markets respectively.

2007/8 Review

4.108 In the 2007/8 Review, we noted the complementary nature of access and backhaul segments. This was because we observed that CPs tended to purchase these services predominantly together. We concluded that we should identify a combined access and backhaul market.

4.109 We noted that the take-up of disaggregated wholesale access and backhaul (such as BT's Ethernet services (WES A and WES B) and disaggregated TI products (TILLAPs and TILLBPs)[176] was not happening on a significant scale. In the vast majority of cases, CPs purchased circuits with access and backhaul as a bundle. We noted that when CPs were able to self-supply they tended to provide both elements (rather than self-supplying either the access or the backhaul elements only).

4.110 We noted however that key to a finding of a separate backhaul market would be the emergence of a converged backhaul market.[177] A converged backhaul market would mean that operators could pick-up traffic from different downstream services (e.g. demand from fixed narrowband voice, and leased lines including AI and TI) and

[176] Traditional interface leased lines access and backhaul products.

[177] *Converged backhaul* would entail a communications provider (CP) using a single wholesale product to carry a number of different types (or even all) of its traffic between two end points, irrespective of the retail service from which that traffic is derived. The greater the opportunity to converge this traffic the greater might be the opportunity to generate sufficient economies of scale and scope to enable CPs to competitively supply their own backhaul.

provide this traffic over a common backhaul link. We concluded that the conditions for the emergence of a converged backhaul market were not currently present. We noted that we only observed a few CPs picking up traffic at local exchanges and self-supplying backhaul.[178]

Call for inputs

4.111 In the CFI, we noted the findings of the 2007/8 Review (i.e. a combined access and backhaul market). We noted that since the last review, there have been various developments both in BT's Ethernet network deployment and in the networks of BT's competitors that may have altered the purchasing behaviour of CPs with respect to access and backhaul. We asked respondents whether and, if so, why they thought that separate markets might or might not now exist for access and backhaul products.

Stakeholder views

4.112 Thirteen respondents made specific comments on access and backhaul markets. Two of these respondents (Geo and INCA) suggested we revisit the question of access and backhaul markets based around the emergence of passive remedies in NGA. Of the remaining respondents, five favoured a combined market and the remainder generally supported separate access and backhaul markets.

4.113 BT did not provide comments on access and backhaul in its response to the CFI. However, in a subsequent presentation to us, BT identified three competitive scenarios:

- Major urban areas and other geographic locations where CPs had fibre presence and were willing to build out to end-users (in which case access and backhaul were competitive);
- Geographic areas where CPs did not have fibre presence and it would not be commercially viable for them to build out (in which case neither access nor backhaul would be competitive); and
- Geographic locations that BT termed a 'competitive hinterland', where competitive backhaul was likely in some cases where CPs had presence at local exchanges, but where CPs are still reliant on BT for access.

4.114 BT suggested that a separate access and backhaul definition was most relevant in the last of these three general scenarios.

4.115 For those stakeholders supporting combined access and backhaul markets, Three, MBNL and Everything Everywhere did not believe that a distinction could be drawn between access and backhaul components that they purchase. Another stakeholder [✂ ✂] considered that separate markets did not exist for access and backhaul. It considered a circuit to be a circuit irrespective of the purpose it is used for.

4.116 [✂ ✂] submitted that it was possible that separate access and backhaul markets existed. However, in general it considered that access and backhaul have similar economic characteristics:

[178] Even for LLU backhaul, we found that there was not significant self-supply. This was despite the fact that CPs were willing to invest in co-located equipment at the local exchanges.

- For access, C&WW submitted that its ability to supply services relies upon wholesale inputs from Openreach, unless historically C&WW had its own fibre installed or suitably near to the customer. Even at very high bandwidths, C&WW believed that large proportions of the UK would not have a competitive alternative to BT.

- For backhaul, C&WW noted that backhaul is generally required at higher bandwidths than access and for circuits between a defined number of locations (e.g. BT exchange buildings to a CP's PoP). C&WW noted that CPs may have their own backhaul fibre in some cases but often they do not. Even where an OCP has fibre presence, this may not be enough for it to self-provide backhaul in its entirety as diverse routing is required to ensure backhaul is provided on a resilient basis.

4.117 One stakeholder [✂ ✂] considered that a single combined market for access and backhaul continued to exist. Its view was that, while BT had started to offer separate access and backhaul, it considered these offers to be relatively nascent. It submitted that it will take time for CPs to take advantage of converged backhaul by aggregating different traffic streams (that were traditionally conveyed over separate service specific platforms). [✂ ✂] therefore considered that in the next three years or so, CPs will continue to procure access and backhaul together.

4.118 Another stakeholder [✂ ✂] saw no functional difference between backhaul from a cabinet (for competitive FTTC) and access to a house or business near to that cabinet. Where it would draw a distinction is for the "middle mile" backhaul from local exchanges. It noted however that even here there is not a strong distinction for this type of backhaul to access segments as most CP connections are at the trunk level (suggesting that they are not self-supplying backhaul).

4.119 KCOM considered that backhaul was more contestable than access. The costs of providing a combined access and backhaul service are driven by the access element with the costs of provision for different providers being closely aligned. Backhaul however is more contestable with alternative solutions providing a means of reducing costs and encouraging self-provision.

4.120 UKCTA, Talk Talk and Verizon made a number of points related to access and backhaul markets, but it was not clear whether they were suggesting separate access and backhaul market definitions:

- UKCTA noted that CPs' networks are evolving from broadband backhaul style "hub and spoke" configurations towards partially meshed networks. UKCTA claimed that this reflects changes in local access pricing (EAD LA).

- UKCTA urged Ofcom to consider identifying "inter-exchange connectivity" as an important market in its own right, which if not managed appropriately, may exclude CPs from making use of the lowest cost local access products. Talk Talk also noted that the withdrawal of WES and BES services has resulted in CPs having to adopt one product to cover both access and backhaul (EAD) and there is no longer a product enabling inter-exchange connectivity.

4.121 Verizon considered that changes in BT access points which determine which elements (trunk or terminating segments) are purchased, along with CPs' network reach, means there could be separate markets. Verizon also saw merit in greater disaggregation of markets as it would provide greater visibility of the actual cost of provision of access and backhaul.

Ofcom's analysis

4.122 We note that there were differing stakeholder views on whether or not there are separate access and backhaul markets. Some stakeholders have argued for a combined market because they consider that:

- there are similar competitive conditions between access and backhaul; and/or
- these network elements are predominantly purchased together.

4.123 By contrast, others considered backhaul to be prospectively more competitive (at least in some geographic areas) relative to access markets (although some prospective future users of passive infrastructure access (such as Fujitsu) considered that backhaul is less competitive than access in the absence of a passive remedy).

4.124 We analyse below the arguments for and against separate markets. We first begin with a technical assessment and discussion of demand- and supply-side substitution. We then discuss evidence of any differences in the competitive conditions between access and backhaul. We conclude by proposing a combined access and backhaul market.

Technical assessment

4.125 In this part, we briefly describe the general differences in access and backhaul. We also set out some of the developments in CPs' networks that are important to our subsequent assessment.

4.126 As set out in paragraph 4.104 above, wholesale access services represent the 'local end' of a circuit and generally use dedicated fibre circuits from an end-user premise back to a local network node (often a local serving exchange or a CP's POP). Due to an access segment typically only serving a single customer premise there is generally not the same economies of scale or scope. As such, access segments will typically not make use of common CPs backhaul transmission systems (i.e. there is no benefit in aggregating traffic for individual traffic streams in an access segment). The scope for use of common duct and fibre may also be more limited.

4.127 Wholesale backhaul services are used to provide high capacity backhaul links between operators' network nodes. For backhaul circuits there is generally greater scope for CPs to make use of transmission systems. Therefore, for backhaul circuits, CPs often multiplexor aggregate circuits onto higher capacity links along with other traffic to be backhauled efficiently to a CPs' core network. Backhaul circuits are typically between network nodes where CPs have installed necessary transmission equipment to enable switching/multiplexing of their services.

4.128 Access and backhaul typically have a complementary relationship in that a retail circuit from A to B will typically require both an access and backhaul segment at both ends of the retail circuit. However, CPs will not always purchase (or self-supply) access and backhaul services in fixed proportions:

- retail customers may only require a short distance leased lines service starting and ending in the same local area (therefore a CP would potentially only need to self-supply or purchase an access segment without making use of its main transmission network); or

- even if a retail circuit would need to include a wholesale access and backhaul segment, CPs may not purchase access and backhaul circuits as a bundle. In theory they may decide to self-supply either an access segment only or backhaul segment only or they may decide to self-supply both.

4.129 In this section we look at some of the key changes to BT's and OCPs' networks since the last review in order to provide greater context to our discussion of access and backhaul.

Developments in TISBO markets

4.130 In relation to TI markets, there have not been major changes in BT's or OCPs' deployments of SDH/PDH-based services. For BT, its major network SDH-nodes (Tier 1 nodes) and technologies employed in its SDH/PDH network have not changed since the last review.

4.131 Similarly for OCPs, there has not been very much change other than greater consolidation in the market place. C&WW, for example, has acquired Thus and some other smaller OCPs such as Your Communications. It has also taken on responsibility for managing wholesale circuits for OCPs or providing retail circuits that were previously provided by other CPs.

4.132 These changes have not significantly impacted on SDH/PDH network deployments. For example, the available evidence on OCPs' Point of Handover purchases suggests that there has been an overall decline in the installed base of POHs and BT has not received significant new orders of PPC POHs in recent years.[179] Since the 2007/8 Review, we have also not seen evidence of OCPs relying on alternative technologies to "emulate" TDM services on their backhaul networks. Where CPs have migrated, in general, it appears to have been in response to retail customers migrating to new technologies (supported by Ethernet or ADSL technologies).

Developments in AISBO markets

4.133 With respect to AI services, the main change since the 2007/8 Review is BT's deployment of Ethernet services provided over newer network technologies. As part of this roll-out, BT sells three main services, EBD, EAD and EAD Local Access. We discussed the details of these products in Annex 11. In summary, EAD is in many respects a direct replacement for Openreach's existing point to point Ethernet services such as WES and BES services (albeit using more modern equipment). On the other hand, BT's networked Ethernet services such as EBD represent a more fundamental change to its network topology as they introduce greater aggregation in backhaul and a new hierarchy of nodes in BT's Ethernet network.[180]

4.134 BT's investment in its networked Ethernet services has required significant upfront investment in a new fibre network. BT has deployed fibre configured in local chains, which are always linked back to BT's main network nodes known as Openreach

[179] The data on BT's sales of POHs shows a significant decline in the volume. In terms of new orders, the data also shows that in 2010/11 BT had received three new orders and in the half-year (2011/12) only two new orders. None of these POH orders are for new Customer Sited Handovers. Therefore, this is supportive of the discussions we have had with OCPs that they have made limited changes to their networks since the 2007/8 Review to support the TI market.

[180] Networked Ethernet was available as a technology at the time of the last review, but no CP had yet deployed such a network on a large scale for backhaul links.

Handover Points (OHPs). The deployment of these chains allows BT to provide resilient networked Ethernet backhaul services at a sub-set of BT's local exchanges (called access serving nodes (ASNs), which are parented to BT's OHPs.

4.135 This new network Ethernet service offers the potential for greater efficiencies in backhaul, by offering multiple high bandwidth (1Gbit/s and 10Gbit/s) Ethernet backhaul circuits over the same capacity, which can help drive down the cost of each unit of bandwidth delivered. On each (1Gibt/s or 10Gbit/s) backhaul circuit, CPs can also aggregate traffic from different access segments (e.g. LLU traffic and Ethernet) – although currently a CP would need to deploy their own switches and co-locate at BT's ASN to allow aggregation of circuits from BT's ASNs back to their own core networks.

4.136 BT's investment in networked Ethernet services may have implications for the scope of competitive backhaul. As stated above BT's investment in networked Ethernet requires significant upfront and sunk costs. This means that OCPs considering whether to invest in their own backhaul will need to achieve a sufficient level of traffic and utilisation of that capacity in order to justify that investment (relative to buying backhaul from another scale player such as BT).

4.137 If the potential for CPs to achieve economies of scale and scope in backhaul is limited (i.e. CPs could be in a position of a relatively low retail share) then this could make the competitive conditions for access and backhaul more alike (i.e. it would be more likely that CPs rely on BT both for their access and backhaul requirements). On the other hand, if OCPs are able to replicate these economies (i.e. where they are able to achieve sufficient scale) using their own networks then this could increase the scope for competitive supply in backhaul.

Demand and supply-side substitution

4.138 As noted in the technical assessment above, access and backhaul typically have a complementary relationship. The complementary nature of products is not a reason for putting two services in a single market, but it suggests that an access segment would not be an efficient substitute for a backhaul segment or vice versa. On this basis, we do not rely on demand-side substitution as a basis for identifying combined access and backhaul markets.[181]

4.139 The lack of demand-side substitution reflects the differences in aggregation opportunities at different levels in the network. The general distinction between access and backhaul products relates to the greater aggregation opportunities for backhaul. Where sufficient aggregation opportunities exist, then backhaul circuit (taking advantage of economies of scale and scope) would be preferred. By definition, it is unlikely that an access link dedicated to an individual customer would be efficient alternative and would therefore not provide an effective competitive constraint on a backhaul link.[182]

[181] We also do not consider supply-side substitution is likely to be relevant. An analysis of a market defined on the basis of demand-side substitution (between access and backhaul) will typically include any operators with the technical capability for supply-side substitution.

[182] In the context of a HMT, a SSNIP on backhaul segments would not prompt sufficient levels switching to access segments to make that price increase unprofitable. Similarly, it would not be efficient for a CP to rely on a backhaul link where there are limited aggregation opportunities (as is the case for most access segments used to provide a local-end to the end-user).

4.140 Therefore, we are not relying on demand or supply-side substitution as a reason for a combined market. We have identified, however, two other reasons why in theory a combined market may be appropriate:

- *If access and backhaul segments form a 'cluster' market*: One reason for a combined access and backhaul market definition is the existence of certain efficiencies (sometimes referred to in academic literature as 'transactional complementarities') such that CPs will often prefer to purchase access and backhaul together. Such complementarities might include, for example, the cost of co-locating at an access node and connecting together separately purchased access and backhaul circuits. If the costs of doing this are high, such that purchasing access and backhaul together is generally more efficient, then access and backhaul could form what is termed a 'cluster market'.[183] If a 'cluster market' exists because of these strong complementarities then any competitive constraint would only come from rivals selling terminating segments combining both access and backhaul components (or from firms willing to self-supply terminating segments entirely themselves).

- *If there are similar competitive conditions between access and backhaul:* It may be that empirically the competitive conditions between access and backhaul are sufficiently homogenous that we treat them as part of a combined market (i.e. we would not come to a different view on market power if they were treated as separate markets). On the other hand, if CPs provide one service (e.g. backhaul) competitively, but not the other then the competitive conditions will be different.

4.141 In principle, we think that CPs could find it economic to purchase access and backhaul separately, or to self-provide one and purchase the other, meaning that the strict conditions for them to constitute a cluster market are not satisfied. Therefore, we focus on this latter question of whether competitive conditions are similar between access and backhaul, which is primarily motivated by practicality concerns. If we find the competitive conditions between access and backhaul are sufficiently similar then our market power findings would be the same irrespective of whether we identified a break in the market between access and backhaul or combined markets. Moreover, to the extent that CPs generally purchase terminating segments then it is justified to think about these as the focal product for any market definition and subsequent market power assessment.

4.142 In the following section we set out our analysis of the competitive conditions for access and backhaul services and why we consider that a combined market definition is appropriate.

Analysis of competitive conditions

4.143 It is likely that in a number of geographic locations the competitive conditions for access and backhaul are similar. On this basis, there would be no need to analyse market power in the supply of access and backhaul separately – as each CP would either self-supply terminating segments to compete in downstream retail markets or

[183] See for example Ergas (2007) who defines these complementarities that lead to consumers to purchase goods together as 'cluster markets'. If good A and good B form a cluster market, then this implies *"that a firm selling only A or only B would not be able to compete with one selling both A and B -- either because the supply cost of producing A and B jointly is substantially below that of producing them separately, and/or because consumers incur additional costs when they purchase A and B separately as against purchasing them jointly."*

otherwise it would purchase combined access and backhaul products from another operator.

4.144 To see why this will be the case, we can think about a CPs' decision either to self-provide or rely on third-party supply of a wholesale circuit in order to deliver a service to an end-user. In leased lines markets, self-provision will typically be based on a CP having network sufficiently near to the prospective retail customer. If it is sufficiently close to a customer to efficiently build out to that retail customer then a CP would be in a position to supply any access and backhaul together. Therefore, it would be in a position in some competitive areas to self-supply a combined access and backhaul circuit (i.e. a terminating segment).

4.145 In other scenarios (such as in rural locations) if a CP does not have fibre presence sufficiently near to the customer then it would be reliant on wholesale inputs from a third-party. In non-competitive areas, it would need a terminating segment product from another operator in order to offer retail services.

4.146 In both the urban area (where the CP self-provides the access link and has backhaul presence) and the rural area (where the CP is entirely reliant on a third party for access and backhaul) the competitive conditions for access compared to backhaul in each respective area would be similar.

4.147 This leaves us with a single competitive scenario where access and backhaul may be supplied separately. This is where CPs have network presence and can self-supply backhaul, but where they cannot self-supply access segments.

4.148 To answer the question whether there are separate access and backhaul markets, we have focussed our analysis on the situations where competitive backhaul is possible. To inform this assessment, we have focussed on CPs' interconnections at BT's network nodes (such as BT's local serving exchanges), as these are common points in UK where CPs can co-locate and interconnect (both with BT and with each other). Therefore, our analysis below focuses on:

- *OCPs' fibre presence at local serving exchanges:* we consider OCPs' fibre presence at local exchanges as an indicator of the *potential* for an OCP to self-supply or offer competitive wholesale backhaul services (discussed in paragraphs 4.151 to 4.158 below);

- *OCPs' purchases of separate access and backhaul:* we consider evidence on CPs purchases of access and backhaul products (including disaggregated products) from BT and OCPs; and

- *Converged backhaul assessment:* we also assess whether any changes likely in the timeframe of this review might increase (or reduce) the scope for competitive backhaul to emerge. We consider in particular the scope for the emergence of converged backhaul markets and the implications of this for our market definition.

4.149 Our analysis therefore looks at whether there are *sufficient* numbers of wholesale providers able and willing to purchase access and/or backhaul separately and whether there is a sufficient number of providers able to offer competitive backhaul.

4.150 As there have been limited developments in TI networks reflecting the maturity of the technology and limited incentives for further investment (in light of the continued declines in the customer base), we have mainly focused our analysis of competitive backhaul on AI markets. In general, for AI markets, our preliminary findings are that

there is not strong evidence of significant purchases of access and backhaul on a separate basis (they continue to be purchased together). We consider also that there remain barriers to competitive backhaul including on a forward looking basis. We believe that competitive conditions are sufficiently similar, in general, for us to continue to combine access and backhaul in AISBO markets and TISBO markets respectively.

OCPs' fibre presence at local serving exchanges

4.151 In the following paragraphs, we assess whether OCPs have their own fibre network nearby or at BT's local exchanges access nodes in order to pick up access circuits from BT. The greater the extent of alternative networks (e.g. at local exchanges) the greater the scope for self-provision of backhaul circuits. We assess whether in fact CPs have network presence at access nodes close to end-users. If there is strong evidence of network presence and an ability for CPs to self-supply then this would point to separate access and backhaul markets.

4.152 In Table 20, we present available evidence on operator interconnection by the main levels in the BT network hierarchy and in particular for its metronodes (part of its "core" network) and the lower tier Access Serving Nodes (ASNs) and local exchanges.[184]

4.153 For our assessment of connectivity at nodes and local exchanges we have relied on information obtained from BT on its sales of 'external cable-link' circuits. According to BT, these circuits are used to connect services delivered to BT's exchanges to external fibre not owned by BT. The extent of cable link sales is a potential indicator that either:

- an OCP is either able to self-supply fibre at that location (i.e. the external cable link circuit is interconnected into an OCPs' own network); or
- it is purchasing backhaul from a third party provider.

4.154 For each level in BT's network, we show: (i) the total number of BT nodes (ii) the number of those nodes where CPs buy cable link; and (iii) the average number of CPs at those locations where at least one CP is interconnected. If there were a high proportion of local exchanges where CPs are buying backhaul and a large average number of CPs at each location then this would *potentially* suggest that competitive supply of backhaul is widespread.

[184] We note that in analysing this interconnection evidence that we have looked primarily at interconnection at local exchanges and other BT network nodes. We recognise there are other forms of interconnection, but we note that a CP's ability to purchase access separately and to self-supply backhaul is largely governed by where it has decided to interconnect with other CPs. By definition this is likely to be centred around key network hubs that emerged through time, which in the main are BT's core nodes and its local exchanges. Therefore, we think that it is important to focus on these key networks points.

Table 20: Implied operator co-location at different BT network nodes

Network level	Number of nodes	Number of nodes where CPs interconnect with BT (based on Cable Link External purchases)	Average number of CPs buying Cable Link External
Metro node	107	102	4
Openreach handover points	56	56	3
Tier 1 nodes	67	67	4
Local exchanges	5,600	1,228	2

Source: Ofcom 2012, BT S135 data

4.155 Looking first at BT's main network nodes (for Ethernet these include: Metronodes and Openreach Handover Points and for SDH/PDH: Tier 1 nodes) there is extensive presence at the majority of these major nodes. All Openreach Handover Points and Tier 1 nodes are covered on average by more the two CPs. In general, we would expect fairly extensive CP presence as many CPs will have core or trunk networks linked to BT's major nodes (potentially indicating that CPs will be reliant on BT or other CPs for terminating segments from these network points.

4.156 We have also looked at evidence of any BT network nodes and local exchanges where there is apparently OCP fibre presence used to self-supply backhaul. Based on the above evidence, at just over 20% of BT's local exchanges (1,228 out of 5,600) there is at least one operator purchasing an external cable link. This in principle suggests that the extent of OCPs' self-supply of backhaul (or purchase backhaul from another provider) may be material. Across the 1,228 exchanges where external cables link are purchased, however, on average fewer than two OCPs are present (this is because in some cases a OCP might purchase more than one cable link connection at a particular exchange). There are in fact a smaller number of exchanges (517) where there are two or more unique OCPs apparently present. This represents less than 10% of all of BT's local exchanges.

4.157 In many cases, it appears that OCP presence (where they could provide competitive backhaul or are purchasing from OCPs) is concentrated in a handful of local exchanges. This evidence suggests that backhaul will generally face similar competitive conditions to access. Moreover, while CP presence is one of the *necessary* conditions for infrastructure-based competition in backhaul, we think that we need to be cautious in concluding that the apparent presence of two or more OCPs is *sufficient* on its own to justify defining a separate backhaul market. For example, the OCP in question may have limited capacity at that location or the OCP may still rely on BT for resilient links from that local exchange (i.e. even if the OCP were self-supplying a circuit from that location, it may also have to purchase a second diverse route from a third-party).

4.158 We have nevertheless considered below wider evidence of OCPs' actual purchasing behaviour. This analysis focuses on whether CPs presence at exchanges is having an impact on the access and backhaul products purchased from BT.

OCPs' purchases of separate access and backhaul

4.159 In the above analysis, the evidence suggested that some OCPs were interconnected with BT at local exchanges. In principle, this suggests that there could be some scope for competitive backhaul provision. If this were the case, we might observe at those locations that OCPs were purchasing access services from BT (such as EAD LA) and providing their own backhaul rather than combining that access service with an EBD service or purchasing EAD services to their point of presence.

4.160 In this section, we assess the extent to which 'access only' products are sold to OCPs and whether the evidence suggests that OCPs are able to combine these access products with their own self-supplied backhaul (or purchases from third party suppliers). We consider in particular the take-up of 'access only' products relative to the take-up relative to 'combined' access and backhaul services.

4.161 We start by looking at a high-level at the overall sales of different products. We then look in more detail at the purchasing behaviour of OCPs at the sub-set of local exchanges where there is apparently one or more CPs (as was suggested by the analysis of 'external cable link' in Table 20 above).

Figure 26: BT's sales of Ethernet access and backhaul products [✂Redacted✂]

Source: Ofcom 2012, BT S135 data valid as at 31 March 2011

4.162 Figure 26 above shows that [✂ ✂] of BT's installed base of circuits sold to CPs are either WES, WEES or EAD type circuits. This is important as EAD and WES circuits are the circuits sold typically with access and backhaul components. Indeed, if circuits sold to providers for LLU backhaul (for which BT has already provided the copper access) are excluded, then nearly [✂ ✂] of all circuits sold are either WES, WEES or EAD type circuits.

4.163 WES and EAD type services will often include access and backhaul components to an OCP's PoP. However, not all WES and EAD services must contain both an access and backhaul component. Therefore, if the majority of Ethernet service purchases are WES and EAD type services, it does not automatically follow that we have a combined access and backhaul market. It is possible for an EAD, WES or WEES circuit in some cases not to include any backhaul. There are two reasons why a circuit would not require backhaul.

- *Access only circuits:* in some cases the circuit may not require any backhaul (if the circuit is linking customer end points close to each other). But as these circuits types would not require a backhaul segment then they would not be relevant to our assessment of variations in competitive conditions between access and backhaul; or

- *Backhaul is provided competitively from a CPs' PoP:* it may be that a WES or EAD circuit is provided to a CP's own PoP located close-by to the customer end-point. In the latter case, it may be that a CP only requires an access segment from BT (with backhaul self-supplied by the OCP).

4.164 We have therefore conducted a more detailed analysis of the actual sales of WES, WESS and EAD type services and whether this is indicative of a combined access and backhaul market. In particular, we have considered BT's per circuit information on sales to major OCPs to estimate the proportion of circuits sold with access and backhaul components. We relied on geographic data associated with each circuit to estimate whether it contains both an access and backhaul segment. In particular, if both ends of a circuit start and end in an area served by the same local exchange, we assumed the circuit is an "access-only" service. Likewise, if the end points of a circuit are in areas served by different local exchanges, we assumed that the circuit contains both access and backhaul elements.[185]

4.165 This analysis suggests that the majority of WES and EAD circuits (excluding LA variants) contain both an access and backhaul element. We estimate that 79% and 84% of EAD and WES circuits apparently contain a backhaul element.

4.166 In the analysis above, there were still a number of other circuits where providers were purchasing either separate access products (such as WES LA or EADLA) or backhaul only products. We estimate that around 12% of BT's external circuit sales are WESLA or EADLA variants. But even where BT is selling access tails such as EADLA our analysis does not suggest that significant numbers of CPs are self-supplying their own backhaul from local exchanges. Therefore, the true extent to which an OCP only purchases an EAD LA circuit with no backhaul purchased from BT is likely to be lower than 12%.

4.167 The information on overall purchases by CPs of separate access and backhaul products and information co-location suggests that the majority of CPs are reliant on combined access and backhaul services. Our analysis of overall purchases of access and backhaul circuits is therefore indicative of limited differences in competitive conditions for access and backhaul. This is supportive of a combined market definition.[186]

Competitive backhaul in specific geographic areas

4.168 We have so far focused on a top-down assessment of the scope for separate access and backhaul markets. The national picture suggests that there is fairly limited potential for competitive backhaul overall. Nevertheless, in our analysis above we identified a sub-set of local exchanges where there is apparently quite concentrated OCP presence. In principle the scope for different competitive conditions by different geographic locations might be a reason to identify a separate geographic market.

[185] As a further cross-check, we also looked at the distances of the circuits sold as a proxy for whether they might contain access and backhaul. Based on the S135 data, we calculated the average length of a circuit from a customer-end to the local exchange is approximately 1.5 km. This analysis suggested that the vast majority of wholesale circuits sold had circuit lengths beyond 1.5km and is consistent with the findings based on geographic data.

[186] We consider the implications of LLU backhaul for our market definition in more detail under Isssue 4b below where we discuss whether LLU backhaul is part of this market.

4.169 We have summarised here the results of a number of key indicators of any geographic variations in competitive backhaul. In our analysis, we have focused on [✂ ✂] as these operators are LLU providers in a position to purchase separate backhaul products. We consider that if these providers do not rely to a significant extent on third party supply, then it is unlikely that other CPs providing services to enterprise customers (i.e. that need end-to-end services with access and backhaul) would purchase significant volumes of backhaul separately to access circuits.

Table 21: Analysis of main purchasers and sellers of separate backhaul products[187]

[✂Redacted✂]

Source: Ofcom 2012, BT and OCP s.135 data

4.170 For these two LLU providers alone, BT accounts for [✂ ✂] of their backhaul circuit requirements. This evidence seems to be consistent with our view that overall backhaul is not competitive in the vast majority of cases – with only a few local exchanges (fewer than [✂ ✂] of all local exchanges) where there could be competitive supply.

4.171 However, as noted above, our analysis has centred on LLU providers that have already invested in co-location. It is less clear that OCP presence at those exchanges would provide a material competitive constraint on BT's pricing of access and backhaul more generally. We observe, for example, that BT does not offer any specific geographic discounts that vary in these locations (either aimed at LLU providers or purchasers of leased lines more generally). Furthermore, one of the LLU providers that purchases from OCPs at particular locations often also continues to purchase backhaul from BT at the same locations for resilience purposes.

Converged backhaul assessment

4.172 Another potential (and related) change that may alter the way in which access and backhaul are used on a forward-looking basis is the emergence of a converged backhaul market. A converged backhaul market would arise if aggregated backhaul links were able to support demand from different traffic streams (i.e. supporting voice, leased lines and asymmetric broadband). This would allow an operator to achieve greater economies of scope and scale in backhaul segments and, in principle, this could alter the economics of provision of backhaul.[188] Since access segments are

[187] Data as at Q4 2010/11 (based on OCP's135 aggregate data on wholesale purchases).

[188] In relation to backhaul provision there is a higher upfront cost of investing in high capacity backhaul links on a prospective basis. This higher upfront investment is more likely to be commercially viable if a CP is able to leverage its traffic from a number of retail markets. For example, it might be possible for a CP that has unbundled a number of local exchanges to provide broadband services to residential customers and it can combine backhaul traffic from those customers with leased lines services.

dedicated connections to each customer the same opportunities to converge traffic streams do not apply in the same way.

4.173 The conditions identified for the emergence of a converged backhaul market would include:

- the possibility of a single backhaul product for all of its retail services e.g. leased lines, broadband, PSTN voice, mobile voice and mobile data;
- single links between access and end points for all types of traffic; and
- access and end points capable of handling different types of traffic simultaneously.[189]

4.174 But even if all the supply-side conditions for the provision of a converged backhaul product, including co-location of nodes were met, it may still be that different services with different functional characteristics would be provided at different prices over the single converged backhaul links, and these would correspond to demand arising from different downstream services.

4.175 CP's responses to our formal S135 information request set out details of how they have configured their networks, the technologies used and the services supported over those technologies. Our assessment of this information suggest that there continues to be a split between the networks used to deliver TI and AI services. There is no reported use of circuit emulation or pseudo-wire solutions that would entail TI services being run over Ethernet.

4.176 However, there seems to be stronger convergence of services onto the Ethernet platform in general. More retail business connectivity users are now served using Ethernet leased lines or VPNs (although there remains a substantial installed base of TI services). In the past, a number of other retail markets (i.e. other than leased lines markets considered in Section 3) did not necessary use Ethernet to backhaul traffic but they now do. For example, retail asymmetric broadband often used ATM technologies for backhaul/core networks, whereas Ethernet is now largely the technology of choice for backhauling asymmetric broadband technologies. Mobile operators are also in the process of moving their services to Ethernet.

4.177 The implication of converged Ethernet backhaul is that only the largest players (including BT) may be able to fully exploit these economies of scope and scale. But, if anything, this is likely to weaken rather than strengthen the scope for competitive backhaul and hence it would undermine the case for separate access and backhaul markets. For example, due to its large retail base BT would be best placed to aggregating large amounts of traffic using converged backhaul, driving down its average backhaul costs. Therefore, potential competitors considering investment in infrastructure would have to overcome barriers associated with the ubiquity of BT's backhaul network, but increasingly also its lower backhaul costs. So this could potentially mean that CPs would only be able to reach the scale of traffic needed to achieve cost-competitiveness with BT in dense population centres and in only some of the routes between them.

4.178 Therefore, the current purchasing behaviour of CPs is against a background where convergence of different traffic streams over Ethernet can occur (e.g. LLU and leased

[189] Where the converged backhaul product carries a number of different types of traffic, converged backhaul would require these three bullet points to apply for all of those multiple products.

lines backhaul). The available evidence suggests that this is not driving significant demand for disaggregated products or greater scope for CPs to self-supply. As noted in paragraph 4.177 above, it may be forcing some CPs to reduce the amount of self-supplied backhaul as they cannot generate the same scale and scope as the largest players.

Assessment of other stakeholder comments

4.179 In response to our CFI, a number of stakeholders commented on what they considered to be the need to identify a separate 'inter-exchange' connectivity market (i.e. backhaul circuits between local serving exchanges). CPs typically use 'inter-exchange' connectivity to route traffic back to a 'consolidation' hub or network node (perhaps using lower capacity backhaul links). From this location they might route traffic over a very high capacity link back to their core network. In other cases, CPs may demand inter-exchange connectivity to link together local exchanges for resilience purposes and to provide a more meshed network, in particular in areas where demand is concentrated.

4.180 We explain below why we do not consider that there is scope for a separate and distinct inter-exchange connectivity market. In particular:

- we see inter-exchange connectivity as a 'backhaul type' service;
- we note that the competitive conditions associated with the provision of 'inter-exchange' connectivity are unlikely to differ significantly from other forms of backhaul.

4.181 However, we note that in light of our trunk market definition (discussed in Section 7), some longer distance inter-exchange circuits between exchanges in different major urban areas would fall within our national trunk definition).

We consider inter-exchange connectivity as a type of backhaul

4.182 By definition, the main distinction between access and backhaul is that access links are typically dedicated to the end-user they serve reflecting limited aggregation opportunities. By contrast, backhaul is a product that might bring together a number of traffic streams (as the starting point for a backhaul circuit is often where the CPs can co-locate active equipment). It reflects the fundamentals of network design whereby CPs can combine individual circuits or traffic together and deliver them over more aggregated links where possible (and efficient) to do so.

4.183 As noted in paragraph 4.104 above, and consistent with the 2007/8 Review, in general terms this results in backhaul being defined as a circuit either between a local exchange[190] to a trunk network node or between local exchanges. Therefore, inter-exchange connectivity is by definition likely to support multiple traffic between exchanges. On this basis, we consider inter-exchange connectivity to be more like a backhaul service (as the scope for aggregation for access segments is far more limited).[191]

[190] In practice the distinction between access and backhaul is more fluid and complex and will vary depending on the distribution of customer, topographical and commercial considerations.

[191] There might be some exceptions to this distinction such as for WDM access services may contain significant aggregation and different traffic streams for instance where that connectivity is supplied into a data centre. However, we do not consider that this difference matters to our market definition, as MISBO services are in a separate market to services at 1Gbit/s and below.

Competitive conditions are likely to be similar

4.184 We do not consider that the competition conditions associated with the supply of these different types of backhaul will vary significantly. The ability of CPs to provision backhaul between local exchanges and main network nodes is likely to coincide strongly with their network footprints, which in turn reflect aggregation opportunities. Therefore, we consider 'inter-exchange' connectivity to be a type of backhaul service and one for which the competitive conditions are likely to be similar to other forms of backhaul. On this basis, we propose to include inter-exchange connectivity as part of the AISBO (or TISBO) market.

Inter-exchange connectivity may include a trunk or core network segment

4.185 It is likely in most circumstances that inter-exchange connectivity would qualify as backhaul. However, it does not seem appropriate to regard *any* circuit linking *any* two exchanges across the UK as backhaul – as CPs are likely to aggregate traffic between major urban areas over their core networks. On this basis, it is clearly not consistent with basic network design principles to consider longer distance inter-exchange circuits linking major centres of demand as a backhaul circuit. It will be efficient in these circumstances for any circuit to be transported across a core or trunk network. Therefore, for inter-exchange connectivity we distinguish between:

- *'Local' and 'regional' connectivity:* a CP is using circuits to link together a number of local exchanges in close proximity to each other. This situation looks more like backhaul. For example, some CPs can 'daisy-chain' a number of local exchanges to a single larger collection hub where they can then aggregate traffic to backhaul more efficiently to their own core networks; and

- *'National' connectivity*: a CP connecting traffic between exchanges in different urban centres. In this example, it is likely that the circuit would include elements of both trunk and terminating segments.

4.186 We discuss our proposed break-point between trunk and terminating segments (for market definition purposes) in more detail in Section 7.

Ofcom's proposals

4.187 Our analysis indicates that:

- Demand and supply-side substitution analysis does not point to combined access and backhaul markets.

- However, we consider that there are grounds for a combined market on the basis of sufficiently similar competitive conditions for access and backhaul:

  - there is some evidence of CP presence at some local exchanges (but it is not extensive);

  - there limited evidence of CPs on sales of separate access and backhaul products, demand remains relatively nascent; and

  - we do not see strong evidence of major purchasers of backhaul services making use of alternatives to BT.

4.188 We consider that it would be premature to define separate access and backhaul. Therefore, on the basis of the above analysis, we propose a combined market for access and backhaul. We term these combined access and backhaul services as symmetric broadband origination. Consequently, and in light of our proposals under Issues 1 and 2, we propose to identify (relevant) symmetric broadband origination market(s) for AISBO, TISBO and MISBO markets respectively.

Issue 4: Symmetric broadband origination as an input to other retail services

4.189 Leased lines are also vital to competition in downstream communications services. The same (or similar) leased line inputs used to deliver business connectivity can be used to deliver services to other retail services that fall outside of the retail leased lines markets we considered in Section 3. For example, mobile network operators connect most of their radio base stations to their switching centres using leased lines from other CPs. Similarly, most operators of broadband services rely on leased lines to backhaul broadband traffic from BT's exchanges (where they have co-location equipment to aggregate unbundled local loops) to their core networks.

4.190 We note that, in general, many markets have different customer bases within them, and the fact that there are identifiable customer types, is not in itself a reason to define separate markets for each customer group within a market. In this part, we instead consider whether there are particular features of the demand for mobile or LLU backhaul that rely on leased lines that justifies identifying separate wholesale markets.

4.191 Given the scope of each of these issues, we have structured our analysis of Issue 4 as follows:

i) Issue 4a: Leased line backhaul services to mobile operators and microwave links (in paragraphs 4.194 to 4.265);

ii) Issue 4b: Backhaul services to LLU providers (in paragraphs 4.266 to 4.297); and

iii) Issue 4c: Leased lines used as inputs to other services such as CCTV, broadcast and other niche applications (in paragraphs 4.298 to 4.332).

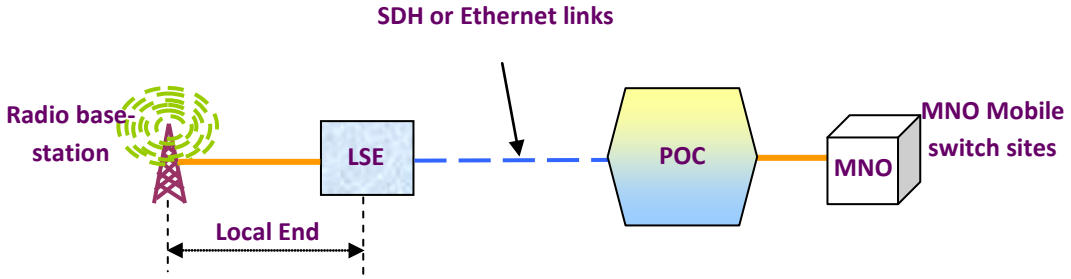
4.192 As per the framework we have used to assess other aspects of our wholesale product market definition, for each of these sub-topics, we summarise our approach to market definition in the 2007/8 Review and stakeholder views to our CFI. We then analyse whether leased lines used to serve these other retail markets fall within either or both of the AISBO and TISBO markets. Our proposal is to include mobile backhaul in the relevant AISBO and TISBO markets and LLU backhaul in the relevant AISBO market. We consider that the inputs to other services such as CCTV, broadcast and other niche applications fall outside of our market definition.

4.193 In considering each of the above issues we do not rely on derived demand/indirect constraints arguments as wholesale leased lines such as RBS and LLU backhaul serve separate retail demand. Therefore, any proposals for the inclusion of LLU or mobile backhaul services in AISBO or TISBO markets must rely on other market definition criteria such as: competitive constraints arising from direct substitution at the wholesale level or on homogeneity of competitive conditions.

Issue 4a: Mobile backhaul

4.194 In this market definition exercise, we refer to mobile backhaul as the network connectivity between mobile network operators' (MNOs) 2G and 3G radio base stations and their core network.[192]

Figure 27: Mobile backhaul



Source: Ofcom 2012

4.195 The radio base stations (RBS) and the controllers such as MNO mobile switching centres are typically located at different physical sites and mobile backhaul provides transmission capacity between these two sites. This mobile backhaul may include a local end from the RBS site back to a local exchange and additional connectivity from a local exchange to a point of connection (POC) with the MNOs mobile switch site. In some cases, the traffic from multiple RBS sites is aggregated at one RBS site (a hub) before being transported to the controller site ("switch site"). These links joining RBS sites are also included within the definition of mobile backhaul.[193] The core mobile network connectivity between switch sites (for example MSC-MSC connectivity) is not included within the scope of mobile backhaul for market definition purposes (as this is more like a trunk or core network).

4.196 When discussing mobile backhaul in this section, we use the term 'RBS backhaul' specifically to refer to mobile backhaul provided over SDH links. This is consistent with the use of 'RBS backhaul' term historically (for example BT uses this as a product term for SDH-based leased lines sold to MNOs). When we refer to mobile backhaul over Ethernet links, we use the term mobile Ethernet backhaul.

2007/8 Review

4.197 In the 2007/8 Review, we considered RBS backhaul to be within the same market as TISBO services as they used the same wholesale inputs (PPCs). We saw no evidence that there were differences in network provision of RBS backhaul circuits apart from the end point being a radio base station rather than the end-user. We noted that to the extent that MNOs might begin to demand Ethernet links then mobile operator's demand for mobile Ethernet backhaul would be part of the AISBO market.

4.198 We also examined microwave connectivity (which MNOs either purchase from third parties or self-supply). We noted that some MNOs were using this connectivity as an alternative to TISBO services. Hence, we noted, in principle, that microwave could be

[192] In future this will also include 4G-enabled base stations, although the precise timing of LTE deployment is currently uncertain.

[193] In some cases, the radio base station controllers are located at a remote site, i.e. a site which does not have other switches such as MSC/MGWs and SGSNs/GGSNs. The network connectivity between such remote sites and switches are also included within the mobile backhaul definition used in this document.

a potential substitute in some circumstances. But we concluded that the evidence on the inclusion of microwave connectivity in the TISBO market was not clear-cut as there were barriers to switching and significant technical issues that limited microwave usage (in a commercially viable manner) for RBS backhaul.[194] Nevertheless, we decided to include high-bandwidth radio links in the High bandwidth TISBO market (primarily as a sensitivity for our SMP assessment) so that we took into account all *potential* competitive constraints in our SMP assessment. In doing so, we noted that a degree of caution was required in our SMP assessment as it was not clear how strong any competitive constraint from these services might be.

Call for inputs

4.199 In the CFI, we explained that there was growing demand for mobile backhaul services using Ethernet technologies. We asked stakeholders whether or not they thought that separate markets now existed for mobile backhaul products.

Stakeholder views

4.200 Telefónica, H3G, EE and MBNL all noted the significant growth in mobile capacity backhaul demand particularly in the context of next generation deployments of mobile technology known as Long Term Evolution (LTE). Telefónica referred to backhaul both as connecting radio base stations in the access layer and as backhaul in the core network.

4.201 H3G, EE and MBNL noted that mobile backhaul requires specific performance parameters with respect to delay and latency for guaranteed throughput. They submitted that it is also difficult for mobile backhaul to offer the scale efficiencies associated for example with broadband backhaul due to the large geographic spread of MNO requirements for backhaul.

4.202 Fujitsu noted that the only differentiator between standard access services and mobile backhaul is the requirement for synchronous Ethernet.

4.203 BT considered that as long as mobile backhaul consumed the same inputs, there was not a justification for defining different markets according to how CPs use them. Another stakeholder [✂ ✂] also did not agree that there was a separate market for mobile backhaul.

4.204 KCOM noted that separate markets may now well exist for mobile and LLU backhaul. It had seen increased deployment of radio backhaul solutions for both broadband and mobile. It highlighted for instance, backhaul for mobile services is provided completely independently of the KCOM network suggesting competition in the provision of backhaul.

4.205 As noted in paragraphs 4.116 above, [✂ ✂] considered that it was possible that there were now separate access and backhaul markets. In relation to mobile backhaul, C&WW argued that the competitive conditions associated with mobile backhaul probably look more similar to access than they do to backhaul used to deliver leased lines to enterprise customers. C&WW noted that mobile backhaul is backhaul in the sense that it connects one network site (the base station) to another network location (the mobile switching centre). However, it submitted that the nature

[194] We considered the inclusion of microwave connectivity relative to TISBO markets reflecting the fact that all demand was from mobile operators was likely to be for TI services. Microwave links support various protocols, however, including SDH and Ethernet.

of demand and supply are different to backhaul provided for leased lines. In particular:

- Until recently, demand at mobile sites has been for relatively low bandwidths and has tended to be served by 2Mbit/s connections (although this is changing with the growth in demand for data). Nevertheless, even with cell site sharing there has not been enough demand in a particular location to drive WDM equipment deployment (unlike other wholesale leased lines);

- The economics look more like access in the sense that the operator with infrastructure closest to mobile cell sites will be best placed to supply mobile backhaul. In this respect, prior to regulation, BT was able to build up a dominant position in the supply of mobile backhaul and create a first-mover advantage because of its ubiquitous copper network and far greater fibre coverage; and

- It is very difficult for any other operator to win mobile backhaul contracts because BT has designed its existing contracts in a way that makes switching supplier both costly and difficult.

4.206 C&WW considered that at the very least Ofcom should seek to understand why competition for mobile backhaul appeared to be less intensive and whether this was a reason mobile backhaul is in a market of its own.

Ofcom's analysis

4.207 We assess below whether mobile backhaul services provided using different technologies (i.e. RBS backhaul and mobile Ethernet backhaul) fall within the respective AISBO or TISBO market or in separate mobile backhaul market(s). We propose mobile backhaul be included in AISBO and TISBO markets respectively.

4.208 We structure our analysis in particular around the implications for our market definition of developments in the market since the 2007/8 Review. From our discussions with MNOs (and their responses to the CFI) a key issue is their interest in purchasing higher capacity Ethernet backhaul links. Given these developments, we have considered the implications of the growth in demand for Ethernet mobile backhaul in addition to the continued use of more traditional technologies such as SDH/PDH using RBS backhaul circuits. We discuss microwave links in paragraphs 4.251 to 4.263 below.[195]

4.209 For each of the technologies, we consider the following:

- *Technical assessment:* we consider whether any technical requirements exist for mobile backhaul using SDH/PDH or Ethernet equipment (in particular synchronisation requirements) that may differ from demand for typical leased lines users;

[195]The use of WDM in mobile networks is limited to core network connectivity in most instances. However, in a minority of cases WDM is used for backhauling traffic from radio base station controllers to core network nodes. In these instances, MNOs purchase dark fibre from other providers and manage the network connectivity using their WDM infrastructure. WDM based backhaul is unlikely to be used to a significant extent for mobile backhaul purposes because of the relatively low bandwidth requirements across most backhaul links. There is some uncertainty about future bandwidth requirements over backhaul with growing usage of data services on user devices and future roll-out of advanced 4G mobile technologies. We have nevertheless confined our analysis of mobile backhaul demand relative to AISBO and TISBO circuits at 1Gbit/s and below.

- *Demand and supply-side substitution:* in the light of specific technical requirements for MNO backhaul, we consider whether any demand or supply-side substitution opportunities exist between, on the one hand AISBO and TISBO services, and on the other, mobile backhaul services; and

- *Analysis of competitive conditions:* Reflecting in part the comments from C&WW, we assess whether there are differences in mobile network connectivity requirements that suggest differences in the competitive conditions for mobile backhaul.

Technical assessment

4.210 In this part we consider the specific technical requirements for mobile backhaul using either SDH/PDH or Ethernet equipment. Before presenting our technical assessment below, we set out some of the underlying trends in mobile backhaul demand likely in the next three years or so, based on discussions we have had with MNOs.

4.211 One of the key trends is the significant growth in mobile data demand. In Ofcom's Communications Market Report 2011,[196] we noted the increasing take-up of powerful mobile devices, the availability of fast mobile networks and the ever-growing availability of internet applications and services (many of which are mobile-specific). These factors are driving consumers to download and upload an increasing quantity of data on handsets, datacards and dongles. We noted for example that monthly data traffic per mobile connection in the UK increased by 108% between December 2009 and December 2010 alone. The expectation is that this growth trend is set to continue (or even to accelerate).

4.212 MNOs are planning to respond to this data growth by upgrading their networks to the next generation of mobile technologies (4G/LTE) and installing higher capacity fibre-based links.

4.213 4G mobile technologies support much faster download (and upload) speeds. Unlike previous generation networks such as 2G (or 3G), 4G networks are packet switched *only.* This is important to MNOs' choice of leased lines technology, as Ethernet is seen by mobile operators as particularly suitable for 4G applications. The roll-out of 4G technologies is expected to occur in the timeframe of this review.

4.214 In addition, the growth in mobile data and expected 4G deployments are driving MNOs to deploy much higher capacity Ethernet backhaul links to a large number of their RBS sites. From our discussions with MNOs, we are not aware of any firm plans for mobile backhaul capacity at the densest locations in excess of 1Gbit/s (within the timeframe of this review). And, in some cases, in more rural locations, MNOs would expect that there could be a number of sites where they continue to meet forecast data requirements over existing capacity in the near term.

Mobile backhaul using SDH/PDH

4.215 Currently, mobile backhaul connectivity in the vast majority of cases is provided over SDH links. This transmission is provided over various media: microwave, copper or fibre. Self-provided microwave links are also sometimes used for RBS to RBS connectivity (typically at the edge of the network) and mobile operators typically

[196] http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr11/international/6.11

purchase wholesale links (over fibre or copper) for RBS site to switch site connectivity. However, as demand for data grows, MNOs have begun to deploy Ethernet transmission links to their RBS sites to carry the increasing traffic generated at those sites.

4.216 Reflecting past availability and bandwidth and synchronisation requirements, mobile operators have tended to use digital PDH/SDH symmetric transmission over fibre and copper for their mobile backhaul. These links typically carry backhaul traffic as E1 (2Mbit/s) or STM-1 (155Mbit/s) frames. The lower bandwidth 2Mbit/s links are predominantly used for connectivity between RBS sites back to BSC/RNC and the higher bandwidth 155Mbit/s links are typically used in MNOs' core networks and in some cases as high capacity links to backhaul traffic from a "hub" site that serves a number of base stations.

4.217 We noted in the 2007/8 Review that the characteristics (from both demand and supply side) of RBS backhaul links are not different from the SDH/PDH links used for other types of applications (e.g. in fixed networks). Both PDH and SDH are internationally agreed standards that are supported by network equipment vendors. We are not aware of any recent technical developments indicating that the technology requirements of RBS backhaul using TI circuits are now different. Therefore, we do not consider that there is a basis (on technology grounds) to distinguish between demand for RBS backhaul and other forms of TISBO services.

Ethernet mobile backhaul

4.218 MNOs have said to us that they are beginning (or planning) to deploy Ethernet mobile backhaul. As set out above, the main drivers of this Ethernet deployment are: the cost effectiveness in meeting the significant growth in data requirements of mobile networks; and its suitability for future 4G mobile networks.[197]

4.219 One of the challenges faced by MNOs in introducing Ethernet backhaul is the need to provide synchronisation information at RBS sites. These synchronisation requirements arise from the need to manage customer mobility between cells.[198] generic carrier Ethernet products would generally not meet the needs of mobile backhaul in all circumstances given the strict latency and jitter performance requirements. In principle, this suggests that Ethernet demanded for mobile backhaul would be a different type of product compared to either generic Ethernet (e.g. Ethernet used by business leased lines customers) [199] due to the specific demand-side characteristics of mobile backhaul with strict synchronisation requirements. By contrast, synchronisation is inherent in RBS backhaul services as these services are based on TDM, which provides a common clock-source[200] to each cell site. To date,

[197]For example, in Section 3, we show that BT's charges for 155Mbit/s PPCs are around three times that of 1Gbit/s Ethernet links.

[198]Accurate synchronisation of base stations to nanosecond accuracy is critical to minimise service disruptions and eliminate dropped connections as calls move between adjacent cells. Highly accurate frequency synchronisation also ensures that the radio spectrum is not spread into the adjacent channels. Without accurate synchronisation, the mobile technologies will not work to specifications, resulting in failed call setups, releases, handovers, and other network issues. For further discussion see:

http://www.ixiacom.com/pdfs/library/white_papers/MEF-MBH_Synch_HaughHirdRam-Draft_101208_1725_1.pdf

[199]Although synchronisation over Ethernet may also be required for non-mobile applications, mobile backhaul is currently the market driver for products that provide synchronisation over Ethernet.

[200]Telecoms networks rely on a hierarchical structure to deliver accurate timings. The hierarchy comprises a master or Primary Reference Clock ('PRC') and the timing information from the PRC is distributed to Slave Clocks that reside at relevant points in the network. These master and slave clocks provide timing outputs for the

a number of MNOs that have deployed Ethernet have (as a transitional arrangement) retained 2Mbit/s TDM circuits for synchronisation.

4.220 Therefore, the Ethernet standards currently deployed in most carriers' networks do not support the particular requirements for synchronisation at base stations. Providers of mobile Ethernet backhaul are in the process of bringing synchronised Ethernet backhaul to the market to address the specific synchronisation requirements of mobile backhaul. Some stakeholders have told us that they have already deployed in the UK a particular type of synchronisation over Ethernet backhaul known as IEEE1588.[201] The main alternative synchronisation method is known as Synchronous Ethernet (SyncE).[202,203]

4.221 SyncE is based on a well established SONET/SDH synchronisation model and therefore there are no standardisation constraints that prevent its adoption. But, to allow synchronisation between the base station and a reference clock-source, SyncE requires all intermediate network nodes to be SyncE compliant. We understand that Openreach is engaged with industry in developing a SyncE configuration that it would expect to meet all its customer needs. [204]

4.222 In the absence of fully deployed Ethernet solutions that support synchronisation, many MNOs that already have Ethernet backhaul to their RBS sites predominantly use the Managed Ethernet Access Solution (MEAS) supplied by BT Wholesale. BT has deployed an interim solution in its Ethernet product MEAS which uses 'Pseudowire' technology. This enables 2Mbit/s TDM circuits to be emulated over Ethernet connections in order to deliver synchronisation. However, this is seen as a short term solution pending the deployment of the more efficient synchronisation standards described above.

4.223 In summary, the general technical requirements for mobile backhaul (in particular synchronisation requirements) can be met by existing TI circuits. As demand for mobile backhaul bandwidth increases, MNOs are looking to move to more cost effective Ethernet solutions to support their next generation networks (4G/LTE). But the technical requirements of operating mobile networks means that MNOs need to retain the capability for synchronous backhaul solutions that are inherent in TI technologies. Two different Ethernet standards known as Synch-E and IEEE 1588 have developed aimed at meeting synchronisation requirements. In principle, these technical requirements for mobile Ethernet are potentially different to enterprise customers (using existing Ethernet solutions).

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rest of the network equipment to use. TDM and SDH-based systems, such as the RBS backhaul product, are designed in such way to natively propagate the clock signal from the PRC to the all the network nodes..

[201] C&WW mentioned at the 31st October 2011 meeting with Ofcom that it provides an IEEE1588-based synchronisation solution for the mobile Ethernet backhaul solutions it supplies to Vodafone.

[202] Virgin Media recently announced that it would supply a SyncE solution to MBNL. BT has indicated to us that it was also planning to bring Synchronous Ethernet backhaul to the market from 2012.

[203] BT has told us that it plans to deploy both SyncE and IEEE 1588. ADVA (one of BT's equipment suppliers) told us that it will support both interfaces as MNOs are likely to use both for synchronisation and timing purposes.

[204] Openreach recently announced that it expects to support Synchronous EAD as part of R1900. Press release available at: http://www.openreach.co.uk/orpg/home/updates/briefings/generalbriefings/generalbriefingsarticles/gen10911.do The latest information available from Openreach suggests that these services are due for delivery in mid to late 2012.

4.224 In our demand and supply-side substitution analysis below, we consider whether these differences in technical requirements for mobile backhaul would be significant enough to identify Ethernet mobile backhaul as a separate market to standard Ethernet services. Our proposed conclusion is that mobile backhaul be included in AISBO and TISBO markets respectively.

Demand and supply-side substitution

4.225 In the above analysis we considered any differences in the technical requirements for mobile backhaul of circuits and how this compared to typical AISBO and TISBO circuits. In this part we consider any evidence on potential demand and supply-side opportunities between TISBO and RBS backhaul and AISBO and Ethernet mobile backhaul. In particular, we consider whether a hypothetical monopolist would find a SSNIP on RBS backhaul services unprofitable either due to demand or supply-side substitution to TISBO (or vice versa). We then consider a similar question with respect to AISBO and mobile Ethernet backhaul. Finally, we consider substitution between RBS backhaul and mobile Ethernet backhaul.

TISBO versus RBS backhaul

4.226 RBS backhaul and TISBO rely on the same underlying inputs and therefore the cost of providing these services should be the same. As stated in paragraphs 4.215 to 4.217, there would not be any basis on technology grounds to distinguish between SDH/PDH mobile backhaul and other forms of TISBO services. On this basis it should be possible, technically, to use a TISBO service to deliver RBS backhaul (or vice versa). Therefore, a SSNIP imposed on RBS should be constrained by switching to TISBO services (or vice versa).

AISBO versus Ethernet mobile backhaul

4.227 On the demand-side, the nature of mobile backhaul provision suggests a strong requirement for synchronised Ethernet. BT's current provision of mobile backhaul essentially relies on the same wholesale inputs (e.g. EAD services) used to provide Ethernet leased lines and LLU backhaul. However, technically, a standard AISBO service would not be a direct substitute for a synchronous Ethernet service as it would not be provided with the necessary clock source. As such a 'standard' AISBO service (that is typically made available today) would not be a sufficiently good substitute for synchronous Ethernet such that it would make a SSNIP on mobile Ethernet unprofitable.

4.228 However, we have talked to equipment vendors (such as ADVA and Cisco) about Ethernet equipment available today. Based on these discussions, there are not significant technical barriers to CPs accessing the equipment to support synchronous Ethernet (based on the 'state of the art' equipment). For example, in terms of the currently available equipment, we understand that the current generation of Ethernet products used by BT (supplied by ADVA) and available to other CPs are ready to support synchronous Ethernet "out of the box". This is an important point, as it suggests that it seems likely that the synchronisation methods explained in paragraphs 4.218 to 4.223 above (SyncE and 1588) will become essentially standard features of carrier Ethernet services over the next few years.

4.229 That being the case, as new Ethernet equipment is deployed these synchronisation methods will be part of the Ethernet base product. So in future it will, in principle, be difficult to draw a distinction between synchronised Ethernet and ordinary carrier Ethernet (i.e. a similar situation to TI where there is essentially no difference between

PPCs and RBS circuits). This would tend to undermine some of the arguments for a distinction between mobile Ethernet and AISBO services.

Supply-side substitution

4.230 If CPs supplying AISBO services could easily enter the market for mobile Ethernet backhaul, then it could suggest that supply-side substitution could be relevant to our market definition (i.e. it could justify the inclusion of mobile Ethernet backhaul in the AISBO market).

4.231 However, one of the key remaining issues related to supply of synchronous mobile Ethernet backhaul (for a supplier with Ethernet equipment capable of supporting synchronous Ethernet) would be that CPs would still require access to the necessary clock-source. In principle, a CP currently providing TDM-based circuits (including to mobile operators) would have their own access to a clock source therefore there would be no specific technological barrier to providing synchronised Ethernet circuits. Indeed, the fact that providers of AISBO services such as Virgin Media will shortly enter the market with the provision of synchronous Ethernet may suggest that there are not major technical hurdles to providing synchronous services.

4.232 The above analysis suggests that the requirements for synchronous Ethernet can be achieved by currently available Ethernet equipment. While this is likely to add an additional cost to Ethernet equipment (so that the equipment supports synchronous capability), it is unlikely to be a significant proportion of any cost of deployment (relative to the costs of installing fibre and Ethernet equipment). [205] A remaining issue is that CPs operating Ethernet networks would need access to their own clock source. This could be a reason preventing a CP currently providing a generic Ethernet service entering the market and providing a constraint on a hypothetical monopolist of Ethernet mobile backhaul. We do not see this as a major barrier however, as operators with TDM-networks such as Virgin have entered and begun providing SyncE solutions.

4.233 In summary, we consider that there continues to be a strong case based on demand-side substitution to include RBS backhaul services in the TISBO market. For mobile Ethernet backhaul and AISBO the case for a combined market is less clear based on demand-side substitution and the technologies available today. However, we observe CPs currently supplying AISBO services have entered the mobile Ethernet market and are starting to provide mobile Ethernet backhaul solutions. This suggests that supply-side substitution provides a relevant constraint.

Synchronous Ethernet versus RBS backhaul

4.234 As well as considering the arguments for including RBS backhaul in the TISBO market, and mobile Ethernet backhaul in the AISBO market, we have also considered whether technical similarities might point to a combined mobile backhaul market (i.e. the inclusion of RBS backhaul and mobile Ethernet backhaul in a separate mobile backhaul market). MNOs' requirements for synchronisation are quite similar for RBS backhaul and mobile Ethernet backhaul. However, we do not consider that this alone justifies a combined "mobile backhaul" definition. Future

[205] If the cost of synchronous Ethernet were significantly higher than 'standard' Ethernet then this could undermine this view. In other words, if there were a significant premium associated with synchronous Ethernet then it may be that CPs would seek to avoid the equipment costs of this feature for end-users that do not generally need it. We do not have detailed information on the likely costs, but from informal discussions with vendors, we do not consider that the costs of SyncE would be sufficiently large that a hypothetical monopolist would be able profitably sustain a price increase of 10% on 'standard' Ethernet.

demand for mobile backhaul is likely to be focused on Ethernet solutions and this is being driven by the exponential growth in mobile data demand. In this context, if MNOs were migrating services to Ethernet we need to think about the competitive constraint that RBS backhaul / TISBO would offer on mobile Ethernet backhaul (or vice versa).

4.235 With respect to the competitive constraint that RBS/TISBO would place on mobile Ethernet backhaul, we consider that this is unlikely to be very strong. From our discussions with MNOs, we understand that their migration to Ethernet is motivated primarily by their planned future 4G network deployments and increasing bandwidth requirements for network capacity. In this respect, as set out in Section 3, there is a significant price premium for TI circuits above 2Mbit/s relative to Ethernet technologies. Therefore, it is unlikely that a SSNIP on Ethernet services (where demand is for higher bandwidths) would be constrained by the existing TISBO/RBS backhaul services.

4.236 With respect to substitution from RBS backhaul to mobile Ethernet backhaul, we note that Ethernet is now likely to be the technology of choice for new mobile backhaul demand. [206] Migration is occurring to meet higher capacity requirements. But there may remain a 'rump' of cell sites for which synchronous Ethernet is unlikely to be needed (or an efficient solution) over the next three years or so. This suggests that mobile operators will retain RBS backhaul at certain cell sites particularly if the capacity on existing RBS backhaul links can handle the forecast data requirements. Given that 2Mbit/s SDH links are less expensive than Ethernet counterparts (i.e. Ethernet circuits at 10Mbit/s) then it is unlikely that synchronous Ethernet would provide an effective constraint for those backhaul sites where high capacity links are not needed. In these circumstances, mobile operators are unlikely to find mobile Ethernet backhaul an effective substitute for RBS links.

4.237 Therefore, we do not consider that a separate mobile backhaul market definition is appropriate owing to the cost advantages of Ethernet at higher bandwidths and SDH at lower bandwidths.

Differences in competitive conditions

4.238 Some stakeholders have argued that there are differences in the nature of competition for the provision of mobile backhaul circuits (relative to AISBO or TISBO services). Both leased lines and mobile backhaul services make use of essentially the same wholesale inputs, but stakeholders have argued that differences in the ability of CPs to compete for mobile and business customers could justify a separate wholesale market. In light of our discussions with stakeholders, we have identified that, in principle, there could be four possible reasons for differences in competitive conditions in the provision of mobile backhaul (compared to leased lines):

- technical barriers to interconnecting with multiple providers;
- the scale of first-mover advantages in the supply of mobile networks;
- the nature of mobile network demand and the location of base stations (and hence demand for mobile backhaul) extends to more remote and difficult to serve areas; and

[206] This is in light of 4G/LTE deployments and the cost of Ethernet on a per Mbit/s basis for higher speed backhaul services. For example in Section 3 we show that for a 100 Mbit/s Ethernet circuit the 'equivalent' PPC would be around four times as expensive.

- the ability of MNOs to self-supply.

Technical barriers to interconnecting with multiple providers

4.239 Some mobile operators have suggested that there are technical difficulties in procuring backhaul links from multiple providers in different locations, purchased on a site by site basis. In particular, it has been put to us that one of the benefits of purchasing mobile backhaul services from a single operator is that it can facilitate end-to-end monitoring of the mobile network.

4.240 In principle, with better end-to-end monitoring functions, this would provide a benefit in terms of service availability as any system faults can be rectified more quickly and network management functions can be more integrated. However, the available evidence from industry bodies such as the Metro Ethernet Forum suggests that there is not a significant technical barrier to interconnecting Ethernet services from alternative providers (and still retain monitoring and other functionality). Moreover, the empirical data shows that MNOs procure backhaul circuits from a number of CPs.[207] So there does not appear to be any intrinsic technical barrier to an MNO sourcing demand from more than one supplier.

4.241 Clearly, any customer must make a trade-off between sourcing from a pool of competitive suppliers and minimising the overhead associated with managing more than one supplier relationship. But the issue is whether the competitive conditions for the supply of wholesale lease lines inputs to mobile operators are different to normal business customers. We do not consider it unique to MNOs that there could be certain benefits of supply from a single provider. Therefore, we do not consider that that this justifies separate markets for mobile backhaul. There do not appear to be specific technical barriers to mobile networks interconnecting with more than one supplier that is distinct from other leased lines services.

First-mover advantage

4.242 Some stakeholder responses to the CFI suggested that there are differences in the competitive provision of mobile backhaul based on BT's 'first-mover' advantage. C&WW in particular argued that RBS backhaul displayed features of "access-type" markets (i.e. more like wholesale local access markets).[208] C&WW contended that BT has a similar first-mover advantage in the provision of mobile backhaul because of its physical connectivity (ubiquitous copper and an extensive fibre network) to most base stations in the UK. Therefore, according to C&WW, this makes the competitive conditions in the supply of mobile backhaul more like an access service and potentially different to TISBO and AISBO services.

4.243 As discussed in paragraph 4.188, we do not propose to define separate access and backhaul markets as the competition conditions for access and backhaul are fairly similar. On this basis, whether RBS backhaul and mobile Ethernet backhaul are "labelled" as access products or backhaul products may have limited significance for market definition and subsequent market power determination. But a question raised by C&WW's comment is whether the nature of demand arising from mobile backhaul

[207] For example, Vodafone purchases mobile circuits from C&WW. Virgin has recently agreed a £100 million deal to provide circuits to a number of mobile base stations on behalf of MBNL using SyncE.

http://www.virginmediabusiness.co.uk/News-and-events/News/News-archives/2011/MBNL/

[208] The type of access markets that C&WW has referred to are often presented as an enduring bottleneck. This reflects the economies of scale that create an advantage to an incumbent that was the first to connect physically to most households in the UK.

combined with any potential first-mover advantage results in different levels of wholesale competition for mobile backhaul than for other wholesale leased lines services.

4.244 At one level, any first-mover advantage may not differ very much in relation to mobile backhaul as compared to supplying wholesale leased lines inputs to supply retail business customers. For example, consider a site (be it a business site or a mobile base station) that an incumbent is already supplying with fibre (or has fibre close-by). A CP seeking to compete for a retail business connectivity consumer (for which BT has physical connectivity) would face a similar disadvantage to a CP seeking to compete with BT for provision of a circuit to a mobile site (where BT already has physical connectivity).

4.245 If a CP has fibre presence near to the customer or base station site then it may be willing to build out to that site. One difference may be that the *extent* of any incumbency advantage is greater for RBS backhaul or mobile Ethernet backhaul markets than it is for other leased lines. In particular, this may reflect differences in the overall scale of mobile backhaul demand and the location of base stations, which we discuss in the following section.

The location of base stations

4.246 Competitive conditions for mobile backhaul may be different from those for standard leased lines (AISBO or TISBO services) to the extent that the geographic location of, and the nature of demand for backhaul from, mobile base stations differ from those of the typical leased line customer. For example, MNO networks are configured in a hierarchical structure whereby a group of RBS sites are often parented to a single core switch or node. Given this network configuration, MNOs may in general only seek to procure mobile backhaul for a group of cell sites parented to a single core node from a single provider. On this basis, for a wholesale provider to compete it would need to have sufficient fibre presence for a significant number of cell sites within the footprint of that core node. BT's greater network presence may therefore prevent competition from emerging for mobile backhaul.

4.247 In addition, the location of base stations (and hence demand for mobile backhaul) extends to more remote and difficult to serve areas. Given MNOs' national coverage requirements, mobile base stations are often in rural locations or areas where for any network build may be subject to protracted and difficult planning processes or restrictions. Given the remote nature of those sites, it may be the case that fewer OCPs have a network presence to serve base stations in those areas.

4.248 However, our analysis of geographic markets suggests that if OCPs do not have fibre-presence in rural locations, then they are unlikely to be able to compete either for a mobile site or a business site. The observation that demand for mobile backhaul is in more remote locations and CPs may be required to serve a number of cell sites does not fundamentally alter the competitive picture. In particular, in our geographic market analysis in Section 5, we note that fibre-presence is only likely to provide a sufficiently effective competitive constraint on BT in and around the London area (in a geographic area that we call the WECLA).

4.249 Therefore, since the available evidence shows that OCPs cannot compete effectively for businesses outside of these main urban areas then they are also unlikely to be able to compete in the provision of connectivity to mobile base stations. Similarly the evidence shows that in the main competitive urban areas (the WECLA) the relevant CPs have sufficient coverage of the area (based on their fibre presence) such that a

mobile network should be able to rely on an alternative provider for its backhaul needs to a large number of cell sites. Our geographic analysis does not indicate that the competitive conditions for mobile backhaul are fundamentally different to AISBO and TISBO services.

4.250 Overall, we do not consider that any of the above factors identified suggest fundamental differences in competitive conditions. There do not seem to be significant technical barriers to interconnecting with multiple providers (not also faced by enterprise customers). Further, we do not consider that the scale of first-mover advantages in the supply of mobile networks and the location of base stations suggest separate markets. In paragraphs 4.251 to 4.263 below we now assess whether self-supplied mobile backhaul provides a reason for different competitive conditions.

Microwave links

4.251 Another reason why competitive conditions might vary for mobile backhaul is the existence of microwave links that are often self-supplied by mobile operators. For competitive conditions to vary on this basis would require that MNOs are able to: (a) switch between microwave links and fibre-based circuits at the margin in response to a SSNIP; and (b) such self-supplied links would prevent a SSNIP being profitable on mobile backhaul services. If these two conditions are met then this might suggest that competitive conditions in mobile backhaul supply differ from those in AISBO and TISBO markets.

4.252 However, as we discuss below, we consider that microwave links are outside the market because they do not constrain fibre-based mobile backhaul prices, or vice versa. Consequently, the ability of MNOs to self-supply microwave links is unlikely to be a reason why the competitive conditions associated with mobile backhaul might vary from the other services in the TISBO or AISBO markets.

4.253 In the following paragraphs 4.254 to 4.263, we discuss the case for including microwave links in the same market as RBS backhaul based on:

- *Technical assessment:* we discuss the technical capabilities and some issues associated with the use of microwave links; and
- *Demand-side substitution:* we consider whether a hypothetical monopolist would be constrained in its ability to increase the price of mobile backhaul by the threat of MNOs switching to microwave links.

Technical assessment of microwave links

4.254 In our formal S135 information request to MNOs we asked them to provide details of the technologies they use in different parts of their networks. The information submitted by MNOs in response to our information request shows microwave is currently used for the following types of network connectivity between the different types of mobile network nodes:

- RBS to RBS;
- RBS to Base Station Controller/Radio Network Controllers (“BSC/RNC”);
- BSC/RNC to Mobile Switch Sites, Media Gateway or Gateway Support Nodes (“MSC/MGW/GSN”).

4.255 However, microwave is most typically used at the edge of the network or to 'daisy chain' RBS sites to RBS sites back to a RBS site that acts as collector hub. From this location, traffic from other RBS sites (provided over microwave) may then be backhauled back to the core network (using fibre). In some cases, these RBS to RBS links are self-provided and predominantly carry 2Mbit/s SDH transmission. Some microwave links also carry Ethernet transmission.

4.256 In current network deployments, some MNOs make use of microwave to a significant extent while others have only very limited deployments.[209] On a forward-looking basis we expect however that there will be far greater demand for fibre-based solutions. This is because 4G / LTE network deployments and continuing growth in data demand are driving significant increases in required backhaul capacity. MNOs have told us that in response to this they plan to reduce the extent of fixed wireless usage for backhaul applications and to rely increasingly on fibre deployments.

4.257 Although microwave links are used for mobile backhaul needs, they cannot meet MNOs' backhaul requirements in all cases and therefore technically microwave cannot act as substitutes for mobile backhaul products under all scenarios. A particular issue with microwave backhaul is that it requires line of sight connectivity and presently it only supports lower capacity links compared to fibre-based backhaul.[210] The transmission range is significantly lower than the range of fibre-based backhaul links. In addition deployed microwave antennas are exposed and have higher risk of failure.

Demand-side substitution assessment

4.258 We discussed some of the issues relating to microwave for mobile backhaul with a major provider of microwave, MLL, who said it saw microwave as a complement rather than a substitute for fibre-based solutions. For example, where an MNO has microwave connectivity to link its RBS sites, one of the reasons for this may be the local topology, planning and street work costs that would not allow fibre or copper as an alternative.

4.259 There may be instances, however, where an MNO currently using fibre could in theory rely on a fixed wireless-link as an alternative (from a technical perspective). The question in these circumstances is whether switching to microwave links would impose a sufficient competitive constraint on a hypothetical monopolist imposing a SSNIP on fibre-based backhaul solutions.

4.260 An MNO that already has in place a fibre-based link would also incur various costs in switching from fibre to microwave. These arise from the line-of-sight requirements of microwave technology. As was noted in the 2007/8 Review:

> "This is because many of their [i.e. MNOs'] sites would not necessarily have line of sight that could enable microwave radio

[209] We do not provide specific details for the various mobile operators due to commercial confidentiality. Moreover, the current installed base of fixed wireless links may not provide an accurate forward-looking picture. For example, Orange and T-Mobile are currently consolidating their networks and they (along with Three) will increasingly rely on MBNL to manage their network infrastructure and provide capacity over shared infrastructure where possible. Moreover, the deployment of LTE and increasing data requirements is likely to be associated with much greater demand for fibre-based solutions.

[210] Although next generation microwave might support high bandwidths, it is not clear whether cost effective microwave backhaul supporting more than 1Gbit/s would become available during the period covered by this review. In addition, the same technical considerations are still likely to apply, such as overall performance guarantees and length of transmission ranges of microwave backhaul links.

> technology to be used. Hence these operators would find many of their sites unsuitable for self-provision through radio. They would need to incur significant investment costs in acquiring new sites to provision RBS backhaul circuits through microwave radio. Hence the threat of self-provision by these operators will only become effective if the costs of self-provision are below the costs of buying from BT."

4.261 This quotation highlights that operators who have not designed their networks to use microwave would not be able to switch to microwave at a later date. In our 2007/8 Review, we considered that the costs of switching to microwave are likely to prevent microwave links being an effective substitute to fibre links in respect of low bandwidth links for existing installed supply. We also considered microwave links might only provide an effective alternative to fibre/copper-based solutions where it is technically feasible. Furthermore, where it is feasible to use microwave, it is already likely to be in use and there is likely to be little opportunity for switching at the margin.

4.262 In the context of a SSNIP applied to RBS circuits over fibre/copper (or Ethernet mobile backhaul), it is unlikely that an MNO would switch to microwave provision. In particular, the costs of doing so are likely to be prohibitive (and it may not be a technically feasible solution).[211] We continue to consider that the reasoning set out in the 2007/8 Review remains valid. As such, it is unlikely that a SSNIP would prompt sufficient switching from fibre/copper links to wireless to impose a competitive constraint. On this basis, we propose to exclude microwave links from both the AISBO and TISBO market definitions.[212]

4.263 From a technical perspective there are limitations to microwave technology that make fibre the preferred and potentially the only viable technology choice for many backhaul applications. In other circumstances, however, fibre may not be feasible and therefore fixed wireless links may be the only option. However, the use of wireless is often limited to the edge of the network rather than for the major backhaul links to MNOs core switches. On a forward-looking basis, increasing backhaul capacity will be needed. This suggests that fibre, which is more future-proof, will be increasingly preferred in most circumstances. Microwave will continue to be seen as a complement where fibre deployment is not viable for operational or economic reasons.

Ofcom's proposals

4.264 On the basis of the above analysis, we consider that we should include mobile backhaul in the AISBO and TISBO markets respectively (depending on the interface used). We note the potential for mobile backhaul to be provided using existing leased line inputs (including certain solutions for synchronised Ethernet). We further note that our assessment does support the arguments some stakeholders made in

[211]For example, we estimate that the price of a 2Mbit/s PPC is around £2,915 per annum for a 10km circuit. We would anticipate that, in a competitive market, an RBS backhaul service (that uses the same underlying inputs) should be priced in a similar manner. Therefore, it is unlikely that an MNO would seek to incur significant sunk costs of installing self-supplied microwave links in response to a SSNIP on a TISBO service (assuming that this was technically feasible).

[212]We have nevertheless discussed in our market power assessment the effect that the inclusion of self-supplied microwave links would have on BT's market shares. However, the possible limitations on the use of radio links suggest that there are limits to the competitive constraint that this form of connectivity might impose. Any constraint is highly likely to be very weak and, even if it did exist, is likely to be confined to higher bandwidths.

support of separate markets (i.e. that the competitive conditions in the supply of mobile backhaul and leased lines are fundamentally different).

4.265 We therefore propose that RBS backhaul be defined in the TISBO markets and mobile Ethernet backhaul in the AISBO market. We have not included mobile backhaul over wireless links in the respective markets as we consider that its use will increasingly be limited to specific circumstances (e.g. where line of sight requirements can be met). These technical limitations and the costs of switching suggest that wireless links would not impose an effective competitive constraint.

Issue 4b: LLU backhaul

4.266 In this part of our wholesale market definition, we assess whether Local Loop Unbundling ("LLU") backhaul services are part of the AISBO market. LLU backhaul services provide a link between OCPs' LLU co-location facility and their core network nodes.[213]

4.267 As a result of the analysis set out below, we propose that LLU backhaul is in the AISBO market. We note that Ethernet circuits can be used by CPs either for LLU backhaul or as a terminating segment for retail AI services. Indeed, BT's own Ethernet product set makes no distinction between circuits used for LLU backhaul or to support business connectivity users. The wider evidence is that the competitive conditions associated with the provision of AISBO services and LLU backhaul are sufficiently homogenous consistent with our proposals for a single market.

4.268 In the assessment below (paragraphs 4.295 – 4.297) we also consider low bandwidth Ethernet services that are provided over copper-access links known as Ethernet in the First Mile (EFM). Similar to LLU, these services employ copper-based access links based on unbundled local copper loops. Therefore, we think that it is relevant to consider demand for backhaul from EFM services in this part of our wholesale assessment. Our conclusion is that the backhaul element of EFM should fall in the AISBO market (as is the case for LLU backhaul).

2007/8 Review

4.269 In the 2007/8 Review, we included LLU backhaul circuits in the AISBO market largely because they are analogous services to other AISBO products and have similar technical characteristics. We noted that the same competitive conditions existed in providing backhaul transmission from local exchanges to an LLU operator's core network. We considered that this similarity means that an LLU operator faces the same type of entry barriers and economies of scale and scope in providing LLU backhaul. In particular, we saw no evidence to suggest that LLU operators or were self-providing LLU backhaul anymore than any other type of AISBO backhaul circuit.

4.270 We also considered whether EFM was in the AISBO market. We noted that EFM used bonded copper-access links (and Ethernet backhaul) to provide low bandwidth Ethernet circuits. We did not consider that the fact that the access part of these services was provided over bonded copper-pairs (rather than fibre) was a reason to identify a separate market for "Ethernet over copper". It provides a point to point Ethernet service similar to any other AI services. We therefore thought it appropriate

[213]LLU backhaul connects a CP's co-location facility to its relevant point of handover. Presently most CPs have their co-location equipment at BT local exchanges. However, our LLU backhaul definition would include co-location at a point closer to the end-user, including at the street cabinet level. Similarly, the definition could include co-location at a point more distant from the end-user.

to include any demand from EFM for wholesale Ethernet backhaul in the same market as other AISBO services.

Call for inputs

4.271 In the CFI, we explained that there was growing demand for backhaul circuits from operators using LLU to provide retail broadband services. We asked stakeholders whether they thought that separate markets could now exist for broadband backhaul products.

Stakeholder views

4.272 Telefónica, INCA and Geo highlighted some general trends in downstream broadband demand suggesting that it would become more difficult to differentiate this demand from business connectivity. For example, demand for residential broadband is becoming more symmetrical in nature. Hence, distinctions are becoming increasingly irrelevant to technologies and network topologies.

4.273 BT considered that as long as broadband backhaul consumed the same inputs, there was not a justification for defining different markets according to how CPs use them. Another stakeholder [✂ ✂] also did not agree that there was a separate market for broadband backhaul.

4.274 In its response to the CFI, C&WW expressed concerns about the competitiveness of backhaul (generally), but did not identify a specific problem with LLU backhaul. C&WW said:

> "Backhaul products are required at high bandwidth between a defined number of locations (BT exchange buildings to CP PoPs). When installing backhaul for our own services we use our own fibre wherever it exists. In a large proportion of exchanges we do not have our fibre presence and neither do alternative suppliers other than Openreach.
>
> Even where we do have our own fibre to a location - that may not be enough to enable us to provide our own backhaul in its entirety. Increasingly the availability of backhaul on a resilient basis is essential. In order to provide for diverse routing for resilient backhaul (akin to SDH expectations) it is necessary to source a separate fibre route. For these resilient connections it is not economic to install additional new fibre routes. For sites at which we are not present, and / or where we require a second link we seek to purchase from Openreach or other suppliers. In order to obtain resilience we would ideally be able to purchase two separately routed services from Openreach or alternatively a service from Openreach and another service with a diverse reassurance from another supplier. Therefore when examining the availability of fibre between backhaul locations resilient supplied fibre must be an analysis criteria.
>
> We conclude that backhaul supply is not competitive nationally."[214]

[214]Pages 7-8, http://stakeholders.ofcom.org.uk/binaries/consultations/bcmr-inputs/responses/Cable_Wireless_Worldwide.pdf

4.275 Sky also argued for separate markets, on the grounds that:

> "LLU backhaul, for example, has several distinct characteristics that could support the view that it, or at least backhaul generally, is in a separate market:
>
> a) Backhaul is often purchased separately from access (copper loops), unlike business connectivity;
>
> b) There is little scope for indirect demand-side substitution at the retail level should wholesale prices rise;
>
> c) Backhaul is purchased as a total networking solution that could include over 2,000 circuits to exchanges and is not purchased on a circuit-by-circuit basis. As a result, there may not be a common pricing constraint between LLU backhaul and business connectivity; and
>
> d) Unlike the financial district of London, there is insufficient demand for circuits at higher bandwidths on most LLU backhaul routes to justify the very high fixed entry costs for alternative network operators in constructing competing duct and fibre networks."[215]

4.276 The CMA believed it is essential that we improved our focus on: "the ability of the incumbent to manipulate the provision of backhaul in the fixed broadband market to the detriment of competing providers."[216] It argued that this suggested the need for the creation of a separate market, including the provision of appropriate remedies.

Ofcom's analysis

4.277 LLU backhaul is required to connect the end users' local loop traffic to the communications provider's core network.[217] Although LLU backhaul is predominately used to provide asymmetric broadband access, this asymmetry is only associated with the local end. The backhaul of traffic is provisioned on a symmetric basis using leased lines. Indeed, the Ethernet links to supply LLU backhaul services may also be used on a converged basis as inputs to the supply of a variety of other retail services, such as leased lines, symmetric broadband internet access and other data services. LLU backhaul services can in theory be provided using traditional or alternative interfaces, but demand has tended to be for alternative interface circuits that, at higher speeds, deliver lower cost per unit of bandwidth.[218]

4.278 As set out in this Section, there may be a number of reasons to include two wholesale products as part of a single market. These include:

- direct demand-side substitution at the wholesale level;

[215] Pages 3-4, http://stakeholders.ofcom.org.uk/binaries/consultations/bcmr-inputs/responses/Sky.pdf

[216] See page 4 of "A response from the Communications Management Association to the Ofcom Call for Inputs to the Business Connectivity Market Review". http://stakeholders.ofcom.org.uk/consultations/bcmr-inputs/?showResponses=true

[217] Consistent with our assessment of access and backhaul under Issue 3, LLU backhaul would also include connectivity between local exchanges.

[218] See for example Section 3, where we compare the wholesale charges for AI and TI services.

- indirect demand-side substitution via the impact of wholesale price increases on retail prices and retail demand; and

- supply-side substitution.

4.279 Of these, only one can be ruled out immediately (as noted by Sky): indirect demand-side substitution via the retail level (given that LLU backhaul serves a distinct retail broadband market to retail leased lines).[219] In addition, as discussed in Annex 7, we also consider that supply-side substitution is unlikely to provide an effective constraint (in the absence of regulation).[220] We also note that even if our substitution analysis points to separate markets, the supply of LLU backhaul services may face sufficiently similar competitive conditions such that we might still choose to aggregate together the AISBO and LLU backhaul markets.

4.280 Our proposal is to define LLU backhaul as part of the AISBO market. We base this on our assessment below of the following:

- direct demand side substitution at the wholesale level; and

- variations in competitive conditions in the supply of AISBO services and LLU backhaul.

Direct demand-side substitution

4.281 In the 2007/8 Review, some respondents argued that LLU backhaul and dedicated Ethernet connectivity services would employ different parts of BT's network/assets and should therefore be regarded as separate markets. Therefore, a circuit used to provide LLU backhaul would not be a direct demand-side substitute for AISBO services and vice versa.

4.282 Some notional differences previously existed between dedicated Ethernet services such as:

- WES circuits (typically used to provide leased lines), which ran from an end-user's premises to a CP's point of handover; and

- BES circuits LLU backhaul, which would start at a CP's co-location facility to a CP's point of handover.

4.283 In the 2007/8 Review, we noted that these differences could suggest that LLU backhaul links are not demand-side substitutes for AISBO services because they do not include a local end (i.e. an access segment). Similarly, a WES service could not be a demand-side substitute for LLU backhaul links because it offers a local end that is not needed and that still has to be paid for (and this is a reasonably significant element of the cost of a WES service). Therefore, demand-side substitution between

[219] In our retail market definition, we noted that while the differences between leased lines and broadband services offered to business were reducing but there were still some differences as evidenced by the pricing, marketing and service wrap associated with leased lines. On this basis, we can rule out the inclusion of LLU backhaul circuits on the grounds of indirect demand-side substitution arguments. In any case, even if we were to find retail broadband markets in the same market as leased lines services, it would not automatically follow that LLU backhaul would be in the AISBO market. This depends on the strength of the indirect constraint arising from downstream markets.

[220] In particular, for the most significant CPs in the market, we do not consider that there are any providers of LLU backhaul that are not also present in the supply of AISBO services.

WES product and a wholesale input used for LLU backhaul from a CP's co-location facility would be unlikely.

4.284 Changes associated with BT's Ethernet product set, on the other hand, have reduced these differences. Ethernet Access Direct services (which are point to point services) are the closest replacement for WES services. BT's product descriptions do not suggest there are limitations in the use of EAD.[221] While there may be some routing restrictions for EAD services, these restrictions are not based on whether the circuit is used to deliver leased lines (from an end-user's premise) or LLU backhaul (from a CP's co-location space).

4.285 In principle, Ethernet circuits can be used by CPs either for LLU backhaul or as a terminating segment for leased lines. Furthermore, BT has launched networked Ethernet backhaul services (such as BT's Ethernet Backhaul Direct service) which enable CPs to deliver converged backhaul solutions (where they have invested in necessary equipment). Therefore, a CP could provide LLU backhaul and leased lines backhaul over a common Ethernet link.

4.286 Therefore, at one level, there appears to be a greater degree of flexibility in these product offers such that they can be used to provide backhaul for both asymmetric (e.g. residential and business broadband) and symmetric broadband services (e.g. leased lines). Indeed the data from our S135 request on CPs' provision of wholesale services shows that in some cases LLU providers (e.g. [✂ ✂]) may also lease circuits to other CPs ([✂ ✂]) that use those wholesale backhaul circuits to supply business connectivity markets.

4.287 While LLU backhaul and AISBO are not identical, the backhaul element of both an AISBO circuit and LLU are used for the same purpose (i.e. to provide fixed connectivity) and both use fixed circuits using Ethernet technology from a local exchange or end-user to a relevant point of interconnection. Overall, the above analysis is generally supportive of including LLU backhaul in the AISBO market.

Variations in competitive conditions

4.288 Some respondents to the CFI argued that the competitive conditions were different between LLU backhaul and other AISBO services and that this might justify separate markets. In the 2007/8 Review, we found that the competitive conditions in the supply of LLU backhaul and other AISBO services seems to be quite similar. Nevertheless, we consider below whether any differences in competitive conditions between LLU backhaul and AISBO might justify identification of separate markets.

4.289 The most significant change facing LLU backhaul is the growth in the demand from asymmetric broadband markets, which will only continue with the roll-out of next generation access. The delivery of much higher bandwidths to households and business will necessarily entail much higher backhaul capacity demand (ranging from 1Gbit/s to much higher speeds in local exchanges serving the largest number or premises). This is relevant as broadband demand could be driving demand for higher capacity leased lines outside of urban areas where most of the leased lines business demand is located. Some stakeholders have put this forward as an argument for a separate LLU backhaul market. However, we do not consider that this observation alone is sufficient to identify a separate LLU backhaul market.

[221] http://www.openreach.co.uk/orpg/home/products/ethernetservices/ethernetaccessdirect/ead/downloads/eadfactsheet.pdf

4.290 We continue to consider there is significant similarity of competitive conditions in the supply of Ethernet-based LLU backhaul links and AISBO. The similarity arises because the same technology is involved in providing transparent transmission between a CP's POH and a point in the local access network. This similarity means that the same type of entry barriers and economies of scale and scope are faced, especially those relating to digging and ducting.

4.291 In addition, we have used the available data from our S135 information to estimate service shares for LLU backhaul versus AISBO services. This suggests that competitive conditions do not differ significantly between the two services. For example, for [✂ ✂] the evidence suggests that they rely on BT for [✂ ✂] of their total backhaul requirements (i.e. they only self-supply or procure backhaul from third parties for less than [✂ ✂] of their circuits). This compares to BT's share of the AISBO market (up to 1Gbit/s) of around 62% as of March 2011. These figures show that BT's share for LLU backhaul (to [✂ ✂]) and for other AISBO services is well in excess of the threshold for assumed dominance of 50%. So if we were to assess market power for LLU backhaul and other AISBO services, we are unlikely to come to a different conclusion regarding market power as BT appears to dominate the supply of both services. We note that there are some differences in our estimates of BT's shares for LLU backhaul and AISBO services, however we do not attach particular significance to these differences given the nature of our estimates.[222]

4.292 In relation to our geographic market analysis, we have also looked at the scope for competition to vary for LLU backhaul relative to AISBO services (for more details of this analysis see Section 5). For the AISBO (up to 1Gbit/s) and the MISBO (for WDM and circuits above 1Gbit/s) markets we have identified variations in competitive conditions for the WECLA (the geographic market that we define for the London area).

4.293 To assess whether competitive conditions are similar for AI services and LLU backhaul, we considered the scope for competitive provision of backhaul from the local exchanges where LLU providers were present in the WECLA. This analysis confirms that the same CP network presence that makes the WECLA prospectively more competitive than the rest of the UK for leased lines services in general is also likely to provide scope for competition for LLU backhaul. In particular, for the 40 exchanges (where 46 MDF sites are located) within the WECLA, we observed that 98% of these exchanges had two or more alternative operators present and 100% had at least one alternative operator at each LLU exchange. Nevertheless, similar to other leased lines services in the WECLA, any assessment of variations in competitive conditions cannot be governed solely by one indicator (in this case alternative operator presence). But we think that the factors that generate different competitive conditions for leased lines are likely to apply, by geography, to LLU backhaul. Hence, the comparison of shares, together with similarity of entry and cost conditions, suggests that the competitive conditions between LLU backhaul and other AISBO markets are similar.

4.294 We note that both C&WW and Sky highlighted a number of points concerning LLU, which they suggested could point to differences in competitive conditions for LLU backhaul relative to standard leased lines. Our view is that most of the concerns

[222] We base our LLU service share estimates only on two LLU operators [✂ ✂] as we could more easily identify circuits used for LLU backhaul. For this reason, we consider that it is appropriate only to make fairly high level comparisons (i.e. that both for AISBO and LLU backhaul are well in excess of the threshold for a finding of dominance).

about SMP in backhaul, raised by both C&WW and Sky, arise because it is used largely outside London. Within the WECLA (or any other given geographic area), there do not appear to be good reasons to think that competitive conditions would differ from those for other AISBO as set out in our geographic market assessment.

Ethernet in the First Mile (EFM)

4.295 EFM is a retail AI service at low bandwidths offered to businesses. The only real difference between EFM-based retail Ethernet and other low bandwidth AI services is the use of copper in the access segment (and corresponding lower costs of using existing copper access rather than new fibre).

4.296 In our retail assessment we included EFM in the AI market. The wholesale inputs used to deliver an EFM-based retail Ethernet service are based on multiple copper pairs (bonded copper) access lines and Ethernet backhaul. Copper access lines are available to all CPs due to the requirement on BT to provide unbundled local loops with charges subject to charge controls (which is a remedy arising from BT's SMP in the wholesale local access market). Based on our assessment that LLU backhaul should be included in the AISBO market we propose that any Ethernet backhaul for EFM services also be included in the AISBO market.[223]

Ofcom's proposals

4.297 We consider that LLU backhaul and other AISBO products make use of the same underlying Ethernet connectivity. Additionally, we have relied on wider market evidence. We observe that BT's new Ethernet services do not differentiate between circuits used for LLU or leased lines backhaul. Furthermore, our analysis suggests similar competitive conditions in the provision of LLU backhaul and AISBO services. The same type of entry barriers and economies of scale and scope are faced, especially those relating to digging and ducting. On this basis, our proposal is to define LLU backhaul as part of the AISBO market.

Issue 4c: Leased line inputs for other retail applications

4.298 Leased lines are used in a number of niche retail applications outside of standard business connectivity services. These include:

- CCTV circuits: dedicated Ethernet circuits are used to backhaul traffic from CCTV camera locations to CCTV control rooms.

- Broadcast circuits: used by broadcasters to send data files and video clips and to stream live video to their newsrooms. These circuits can be permanent links in established broadcast locations (such as sites outside of the Houses of Parliament) or mobile broadcast units.

- Street access circuits: these circuits deliver bandwidth from a local exchange to outdoor terminating units in remote street furniture such as lampposts and street cabinets. Once in place, these connections then provide low-powered radio transmitters and are used to deliver wireless networks in urban areas.[224]

[223] This is on the assumption that EFM is provided over Ethernet backhaul links.

[224] Such wireless connectivity might be for public information points - such as cinema listings and parking information - connectivity at popular events and remote telemetry such as traffic congestion monitoring. Such services are often also used on a temporary basis, to provide increased wireless connectivity in particular

4.299 We discuss below the analysis of these services in the 2007/8 Review and any comments from the CFI. We then consider the inclusion of these services in either the AISBO or TISBO markets based on the following criteria:

- *Technical assessment:* we look at the particular wholesale service requirements needed to meet demand for these retail services; and
- *Demand and supply-side substitution:* we consider direct demand or supply-side constraints arguments (as these services serve retail markets separate to the AI or TI markets we do not consider derived demand arguments based on 'indirect' demand constraints);

4.300 As a consequence of the analysis below, we propose not to find any of these services in either of the AISBO or TISBO markets.

2007/8 Review

4.301 In the 2007/8 Review, we only considered whether CCTV services were part of any of the identified product markets. (i.e. we did not explicit consider market broadcast or street access services in our market definition assessment).

4.302 We noted that the inputs to CCTV links fell outside the market. We noted that CCTV circuits were technically similar to services provided over AISBO circuits (e.g. Wholesale End to End Services). However, we also noted that CCTV circuits used different network terminating equipment and we found them to be in separate markets.

Call for inputs and stakeholders' views

4.303 In the CFI, we asked whether there were other sources of demand for symmetric broadband origination which are relevant to our assessment. There were no stakeholder comments on this market definition issue.

Ofcom's analysis

4.304 We set out our assessment below as to whether these services fall within any of the relevant product markets for wholesale leased lines services. Our analysis indicates they do not, and we propose not to include them in a relevant product market.

Technical assessment

4.305 In this part, we discuss the differences in the interface service types offered by CCTV, broadcast access and street access circuits.

CCTV circuits

4.306 In the 2007/8 Review, we considered that CCTV circuits are in many ways technically similar, but are not identical to dedicated Ethernet end-to-end services, such as BT's WEES products, which were included in the AISBO market. We identified that the key difference is in the type of Network Terminating Equipment ("NTE") used. This NTE is designed to support specific Phase Alternate Line (PAL) video signals and to allow various signalling, monitoring and video compression capabilities.

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locations (for example at music festivals). See for example, Openreach's product descriptions for further detail: http://www.openreach.co.uk/orpg/home/products/ethernetservices/streetaccess/streetaccess.do

4.307 The main technology change we are aware of since the 2007/8 Review is the greater use of CCTV camera units and converters that enable CCTV signals to be transmitted over IP and hence potentially over standard broadband connections. We discuss the potential implications of this for our market definition in paragraph 4.317 to 4.318 below.

Broadcast Access

4.308 Like CCTV circuits, broadcast access services are technically similar, but are not identical to, AISBO circuits, a key difference being the NTE used. In the case of broadcast access services, specialised NTE is needed to ensure seamless integration with the existing video equipment or networks of television, media and production companies.

4.309 This NTE is often configurable to support multiple video channels over a single fibre (either in one direction or multiple directions). Circuits are provided to permanent or temporary (mobile) broadcast locations. The services offered often required to support specific broadcasting interfaces.[225]

Street Access

4.310 Similar to broadcast access circuits, street access circuits appear to be addressing very specific retail demand. They require secure low-powered radio transmitters. Some of the drivers for this type of connectivity may include concerns over security and vandalism and resilience in outdoor environments.

4.311 Street Access services also offer options for more temporary outside broadcast applications. For example, BT offers local circuits to radio transmitters and associated mobile NTE (i.e. a van). Such services might be used to support additional mobile capacity or Wi-Fi for example at music festivals or other large public events.

Demand and supply-side substitution

4.312 In light of the above technical differences in NTE, we now consider whether demand or supply-side constraints might suggest including any of these services in our AISBO market.[226]

CCTV

4.313 In the 2007/8 Review, we did not include the supply of CCTV Access circuits within any of the leased lines markets. We noted that market definition is determined primarily by the extent of substitutability between products.

4.314 We considered that the differences between the NTE used for AISBO circuits and CCTV Access circuits and the costs of making the necessary adaptations are likely to limit demand-side substitution between them. Therefore, we considered that the two services did not belong in the same market.

[225] For example Openreach's service supports customer video signals at 270Mbit/s (SDI or ASI), 1.485 Gbit/s (HD-SDI) or 3GBit/s (HD-SDI) and 140Mbit/s framed data.

[226] We compare these services to AISBO as Openreach makes use of its Ethernet network to provide these circuits.

4.315 For supply-side substitution to be relevant to market definition, we noted that there must be providers of AISBO circuits, not currently supplying CCTV Access circuits, who would start supplying the latter rapidly and at low incremental cost in response to an increase in the price of CCTV circuits above the competitive level. The extent of the technical similarity of WEES and CCTV Access circuits may suggest that supply-side substitution is, in theory, possible but is not in itself sufficient to establish that they are part of the same market.

4.316 We consider that analysis in the 2007/8 Review is still applicable on the basis of the technical differences in each service, which means that the services are not good substitutes for each other.

4.317 As noted above, the main change we can identify since the 2007/8 Review is the greater use of CCTV camera units and converters that enable CCTV signals to be transmitted over IP technologies. This means for example that an enterprise could use standard asymmetric broadband connections (such as ADSL) to deliver CCTV signals.

4.318 The emergence of technologies that can be used to deliver CCTV circuits could in principle point to a wider market for CCTV (consisting of ADSL and standard CCTV interfaces).[227] But the fact that ADSL technologies can be used to provide CCTV, is not an argument for the inclusion of wholesale inputs to CCTV services in the same market as AISBO services. This is because ADSL services (which can now be used for CCTV) are not in general a good substitute for the Ethernet services that make up the AISBO market. Therefore, the major change seen in the market since the 2007/8 review, if anything, makes the case for separate markets stronger. This is because customers on standard CCTV connections could potentially find IP-based solutions a good substitute.

4.319 BT's pricing of CCTV circuits is also distinct to other Ethernet access links. For example, the fixed annual rental charge for a CCTV ranges from £550 to £700 per annum (compared to just over £2,000 per annum for an EAD Local Access circuit). This provides some evidence that the two services are sufficiently distinct that they are not in the same product market.

4.320 We therefore propose to continue to identify CCTV circuits as a separate market.

Broadcast access circuits

4.321 We did not explicitly consider broadcast access circuits as part of our market definition in the 2007/8 Review. Like CCTV circuits, broadcast access services are technically similar, but not identical to AISBO circuits, a key difference being the NTE used. In the case of broadcast access services, specialised NTE is needed to ensure seamless integration with the existing video equipment or networks of television, media and production companies.

4.322 Another difference between broadcast access circuits and leased lines is that broadcast access services can be used on a temporary basis, for example, for a major sporting event lasting a few weeks, using outside broadcast units. By contrast wholesale inputs used for leased lines are typically provided over dedicated fibre in

[227] It does not necessarily follow that CCTV circuits are part of an asymmetric broadband market. We note that there will be a large installed base of CCTV services, many customers would be unwilling to invest in new camera equipment or signal converters to enable them to rely on asymmetric broadband connections rather than existing CCTV circuits.

fixed locations. Even for permanent broadcast circuits in a fixed location these are likely to be used quite differently by broadcasters than is the case for business users.

4.323 These technical differences limit the possibility of demand-side substitution between broadcast access circuits and AISBO circuits as broadcast circuits are presented with such specialist interface types.

4.324 In terms of wider pricing evidence, the nature of broadcast access circuits (significant differences in interface and bandwidths) makes price comparisons with standard AISBO services quite difficult.[228] We note, however, that the annual fixed rental charge for a broadcast access circuit (with 140Mbit/s interface) ranges from £6,500 to just over £10,000 per annum (depending on the number of video channels supported). The fixed rental charge for an EAD 100Mbit/s and 1Gbit/s would be just over £2,000 and just under £5,000 per annum respectively. We cannot be certain that these charges are representative of a competitive price (which is the appropriate benchmark within the market definition framework). But if they provide a good proxy for the likely differentials between broadcast access and 'standard' AISBO services in a competitive market, then there would appear to be a significant differences in price. These comparisons of significant price differentials does not, for example, suggest including these services in the same market.

4.325 We consider that this type of network access (broadcast access) is distinct from dedicated fixed leased lines connectivity and therefore broadcast access circuits are outside the market.[229]

Street access circuits

4.326 Similar to broadcast access circuits, street access circuits appear to be addressing a very specific retail demand. They require secure low-powered radio transmitters. Some of the drivers for this type of connectivity may include concerns over security and vandalism and resilience in outdoor environments. Consequently, the access element of these connections is likely to be addressing significantly different requirements to other circuits used for the delivery of dedicated fixed connectivity to business users.

4.327 Given these requirements for secure and robust access infrastructure, we do not think that standard leased lines connections would be a good substitute. On this basis, we consider that this type of network access is distinct from dedicated fixed leased lines connectivity and therefore is likely to be a reason why street access circuits are outside the market.

4.328 We also consider that BT's pricing of Street Access circuits is also fairly distinct to other Ethernet access links. For example, the fixed annual street access rental charge is around £600 per circuit per annum (compared to just over £2,000 per annum for an EAD Local Access circuit). BT also offers temporary street access services, for which BT charges around £9,500 per 1Gbit/s circuit provided (plus £1,500 for NTE housed in a van). These charges compare to an annual rental charge of £5,000 for a standard Ethernet access service (such as an EAD Local Access service).

[228] We also note that the caveats associated with analysing markets based on BT's wholesale prices (as noted in Section 3).

[229] We note however that broadcast customers may make use of more generic leased lines products such as Ethernet links or WDM. In these instances we would include circuits sold to broadcasters in our wholesale product market definition.

4.329 Clearly the structure and nature of a one-off circuit charge for a temporary street access circuit is quite different to a permanent fixed link. But this serves to demonstrate that these services are addressing fundamentally different demand to AISBO services. In the case of more permanent Street Access services, the pricing evidence shows significant differences to AISBO services.

4.330 This provides evidence to support the identification of street access circuits as a separate market.

Analysis of competitive conditions

4.331 In response to the CFI, no stakeholders highlighted any competition concerns with respect to these markets. Given our assessment of the technical differences and the lack of effective demand-side and supply substitution; the specialist nature of these services pointing to separate markets; and the lack of comments from stakeholders, we do not propose to discuss in detail competitive conditions for wholesale circuits used to support CCTV or other niche retail applications.

Ofcom's proposals

4.332 In light of our technical assessment and available evidence on demand and supply-side substitution we propose not to include CCTV, Broadcast Access and Street Access services in either our AISBO or TISBO markets.

Issue 5: Bandwidth

4.333 In our retail product market definition, we proposed a number of bandwidth breaks for AI, TI and MI markets. Under issue 5, we consider whether these breaks also apply to wholesale AISBO, MISBO and TISBO services.

4.334 We therefore consider below whether the logic underpinning the demand and supply-side analysis used to inform our retail definition is relevant at the wholesale level for relevant AISBO, MISBO and TISBO markets. We also consider any variations in the competitive conditions to see if this lends support to our market definitions.

4.335 Our preliminary conclusion is that the bandwidth breaks identified at the retail level for AI and TI services and MI services (above 1Gbit/s and WDM at all bandwidths) are appropriate for the related symmetric broadband origination services.

2007/8 Review

4.336 In the 2007/8 Review, we considered that the breaks we identified at the retail level for different bandwidth services (e.g. retail AI low and high bandwidth services) mapped onto similar breaks at the wholesale level (AISBO low and high bandwidth terminating segments). We relied on a derived demand argument, which suggested that there was a close relationship between the bandwidth of the wholesale circuit a CP would use to deliver a retail service at a particular speed.

Call for inputs

4.337 In our CFI, we noted (as set out in paragraph 4.337 above) the findings of the last BCMR. We noted that we based any bandwidth breaks in the wholesale markets (AISBO and TISBO markets) on the corresponding breaks identified in our retail product market definition. We proposed to retain this approach such that, where the

retail market definition is unchanged, we would expect this to be reflected in an unchanged definition of the associated upstream wholesale markets.

Stakeholder views

4.338 There were no comments on our proposal to derive the wholesale bandwidth breaks for wholesale terminating segments from the relevant retail markets. There was no disagreement that our retail definition was relevant for the wholesale market definition.

Ofcom's analysis

4.339 In the following section we explain why we think it is appropriate to continue to inform our wholesale bandwidth breaks by referring to our retail analysis. On the basis of our retail market definition, this would suggest the following TISBO markets:

- Low bandwidth TISBO (up to and including 8Mbit/s);
- Medium bandwidth TISBO (above 8Mbit/s up to and including 45Mbit/s);
- High bandwidth TISBO (above 45Mbit/s up to and including 155Mbit/s); and
- Very high bandwidth TISBO (at 622Mbit/s).

4.340 For the retail AI markets, we have identified a low bandwidth market up to and including 1Gbit/s. Above 1Gbit/s, we have identified a single market for all interface types including Ethernet and other interfaces and all WDM-based services. This would suggest the following wholesale markets:

- Low bandwidth AISBO (up to and including 1Gbit/s); and
- MISBO (for WDM-based services at all bandwidths and leased lines services provided delivered with any interface above 1Gbit/s).

4.341 Where we identify separate wholesale markets by bandwidth we have relied on there being a close relationship between the bandwidth of the wholesale circuit a CP would use to deliver a retail circuit at a particular bandwidth. If wholesale bandwidth closely reflects retail bandwidth demand, then to the extent that the latter falls into distinct markets of non-substitutable bandwidths, so will the former.

4.342 We do not consider that there have been significant developments in the market that would undermine this relationship for legacy TI services. For AI low and MISBO services, we also continue to identify a break in the market at 1Gbit/s. This break in the market was the result of (among other things) significant differences between the cost of equipment associated with dedicated Ethernet services (AI) and the cost of equipment needed to use WDM-based services. We noted that for low bandwidth AI services, the cost of equipment was very similar at low bandwidths (10Mbit/s, 100Mbit/s and 1Gbit/s). This reflects the fact that similar equipment is used for the delivery of Ethernet services at 1Gbit/s or below.

4.343 By contrast, there is a more significant 'step-up' in the cost of equipment above 1Gbit/s (e.g. 2.5Gbit/s and 10Gbit/s Ethernet equipment and WDM-based solutions are significantly more expensive). Therefore, it would be inefficient for a wholesale provider to supply a low bandwidth customer with demand for 1Gbit/s or below with higher capacity equipment.

4.344 In addition to looking at derived demand arguments, we explain below that wider evidence on variations in competitive conditions are supportive of the proposed bandwidth breaks for AISBO and TISBO markets. Reflecting the nature of MISBO services, we do not consider it relevant to analyse the competitive conditions by bandwidth given the modular nature of these services is unlikely to lead to variations in competitive conditions or a break in the chain of substitution above 1Gbit/s.[230]

Bandwidth breaks for terminating segments

4.345 Our assessment of competitive conditions in Section 7 lends support to the breaks we identified for retail TI and AI and hence for AISBO and TISBO markets. In particular, the evidence suggests the following differences in competitive conditions:

- **Medium and High bandwidth TISBO services (34/45Mbit/s and 140/155Mbit/s):** for both markets we observe that the competitive conditions in the London area are fairly similar (as both markets are competitive). For both 34/45Mbit/s and 140/155Mbit/s there is often little alternative to BT outside of the metro areas. However, there are some apparent differences in the rest of the UK, reflected in BT having 74% share at 34/45Mbit/s and 49% share at 140/155 Mbit/s. So it appears that CPs have in some cases been able to overcome the high barriers to entry and expansion for 140/155Mbit/s. On this basis we consider that it remains appropriate to identify a break in the market between 34/45 and 140/155Mbit/s services.

- **High (155Mbit/s) and Very High (622Mbit/s) bandwidth TISBO services:** the competitive conditions for 155 and 622Mbit/s differ significantly. One reason for this difference is that the revenue available from even a single 622 Mbit/s circuit makes it more likely that it will be economic for a competing operator to supply a 622Mbit/s circuit than a 155Mbit/s circuit. The deterrent effect of sunk costs on potential entry is likely to be more significant in the latter market. This is supported by evidence that OCPs have provided on their ability to self-supply 622Mbit/s circuits, which has resulted in low market shares for BT at the wholesale level. BT appears to have around 5% of the market for TISBO services above 155Mbit/s, but around 49% of 155Mbit/s TISBO in the UK excluding the Hull area and the WECLA.

- **Low bandwidth TISBO services (up to and including 8Mbit/s):** there is strong evidence that circuits up to and including 2Mbit/s face different competitive conditions to higher bandwidth markets. In particular, we estimate that BT has a very high share of the TISBO market (86% for the UK excluding the Hull area).

- **Low bandwidth AISBO (up to and including 1Gbit/s) and very high bandwidth MISBO services:** the analysis of current competitive conditions tends to support our proposed finding of separate markets. In the London area (the WECLA), our calculations suggest that BT's share of the wholesale AISBO services at 1Gbit/s and below is somewhere above 41% compared to only 15% for the MISBO market.[231] In the rest of the UK (excluding Hull), the competitive

[230] At any particular point in time an end-user will have an installed amount of bandwidth. However, given the scalable nature of demand from retail WDM customers, such bandwidth requirements can change quite quickly. On this basis it would be difficult to identify a break in the chain of substitution or to analyse competitive conditions meaningfully between customer types based on their current bandwidth demand.

[231] Even if we did not combine AI services above 1Gbit/s with WDM, we would still observe similar competition conditions in London (and in the rest of the UK) for these services. For example, we estimate that BT's service share in WECLA for AI high bandwidth services (above 1Gbit/s) is around 20% compared to 14% for WDM-based services.

conditions are more similar on average, although there may be pockets of competition for the MISBO market.

4.346 Overall, the above evidence on competitive conditions in the supply of different bandwidth AISBO, TISBO and MISBO services supports the proposed wholesale definitions by bandwidth discussed in paragraphs 4.339 to 4.340 above.