TSLRIC price review determination for the Unbundled Copper Local Loop and

Unbundled Bitstream Access services:

Modern Equivalent Assets and relevant scenarios

Commerce Commission

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TERA Consultants
39, rue d'Aboukir
75002 PARIS
Tél. + 33 (0) 1 55 04 87 10
Fax. +33 (0) 1 53 40 85 15
www.teraconsultants.fr

S.A.S. au capital de 200 000 €
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1 Context and objective

The Commerce Commission (the “Commission”) is issuing a paper which sets out, and seeks the view of interested parties, on its proposed regulatory framework for the UCLL and UBA TSLRIC cost modelling exercises and its preliminary views on a number of fundamental assumptions for the development of a TSLRIC cost model for the UCLL and UBA services. Having reviewed the Commerce Commission paper, the purpose of this report is for TERA Consultants to provide our views on some key methodological choices related to the calculation of TSLRIC. This report does not go into the details of the modelling approach it is not a model specification document.

Section 2 deals with general Modern Equivalent Asset (MEA) considerations: 2.1 defines the concept of MEA, 2.2 explains the need for MEA in the cost modelling, 2.3 explains the issues of consistency between the MEA for UBA and the MEA for UCLL. Finally, Section 2.4 treats the issue of MEA functionality.

Section 3 gives recommendations with respect to UCLL modelling elements. 3.1 defines technologies eligible for MEA and compares them in order to give recommendations on MEA for UCLL. 3.2 gives recommendations on methods used to adjust the modelled UCLL. 3.3 discusses other important modelling choices – cost standard, demand and depreciation – and makes final recommendations on UCLL modelling elements.

Section 4 deals with UBA modelling elements. 4.1 makes recommendations on the choice of MEA for UBA. 4.2 compares different UBA modelling scenarios in terms of network size and geographic scope. 4.3 defines services that need to be supported by the modelled network.

Section 5 discusses the issue of adjustments that are needed in order to avoid double recovery in the case the selected MEAs for UCLL and UBA are different.

2 High-level MEA considerations

2.1 The concept of MEA

MEA is a technology that would be selected to replace an existing technology. This is typically the technology which a new operator deploying a network today would choose. Identifying the MEA of Chorus' access and core networks is therefore an essential step to determining forward-looking costs. This has been recognised by the Commission:

- *"Forward-looking costs reflect the costs that a network operator would incur if it built a new network today using assets collectively referred to as the modern equivalent asset…The costs of these assets are the costs of currently available equipment as opposed to the costs of older equipment that may actually still be in use".*[1]
- *"Forward-looking costs are costs that will be incurred in the future in providing the service. This involves estimating costs on the basis of current and future prices of inputs and given the availability of modern technologies and assets. The aim is to estimate the cost of providing the services in the future rather than the past".*[2]

This suggests that on top of the analysis of whether the asset produces the same type of services as the existing asset at lowest cost, it is also necessary to look at operating costs and other performance characteristics in order to determine what the MEA is. Such an understanding is in line with MEA definitions available and enables the Commission to be consistent with European countries. Indeed, the European Regulators Group (ERG) (now the Body of European Regulators for Electronic Communications (BEREC)) stated in 2005:

> *"Gross MEA value is what it would cost to* ***replace an old asset with a technically up to date new one with the same service capability, allowing for any differences both in the quality of output and in operating costs****. For the replacement cost valuation to be appropriate it is not necessary to expect that the asset will actually be replaced.*
>
> *The new technologies are usually superior in many aspects to the older technologies in terms of functionality and efficiency. However, since MEA values are required to reflect assets of equivalent capacity and functionality****, it may be necessary to make adjustments to the current purchase price*** *and also the related operating costs - for example, the new asset may require less*

[1] Commerce Commission, "Process and issues paper for determining a TSLRIC price for Chorus' unbundled copper local loop service in accordance with the Final Pricing Principle", 6 December 2013.

[2] Commerce Commission "Application of a TSLRIC Pricing Methodology - Discussion Paper" 2 July 2002, paragraph 32.

> *maintenance, less energy and less space. Other adjustments may also be required in the calculation of current costs, e.g. surplus capacity."*[3]

The ITU (The International Telecommunication Union) also states that the MEA value should reflect the cost that a new efficient operator would face:

> *"Modern Equivalent Asset (MEA) should be used whenever it is possible, as it is the most accurate valuation criterion to* ***reflect the cost of an efficient operator****, since it will* ***capture the associated costs (and efficiencies) that an entrant/alternative operator would face****, if entering into the market at a specific time.*
>
> *This valuation criterion is accurate when besides a technical change; the asset with the same functionalities is no longer being marketed. Therefore, the aim is to calculate the* ***cost of an analogous (replacement) asset****."*[4]

In other industries, regulatory authorities tend to define the MEA in the same way[5], and the Commission has adopted this view which is aligned with best practise.

Therefore, based on the definitions and views above, this report will assess the technology of a new efficient operator who decides to enter the market and who is not necessarily linked to the infrastructure that is in place when deciding on which technology to deploy.

This report will therefore assume that the MEA is the asset that a new operator taking efficient decisions would choose to deploy today for a new network.

2.2 Why do we need to define the MEA?

The MEA concept enables us to calculate the cost that a new efficient operator investing today in telecommunications networks would face.

TSLRIC is forward-looking and therefore a MEA should be defined as the network to be modelled.

From a regulatory point of view, the MEA concept can be very useful as:

- It enables the Commission to better understand forward-looking costs;

[3] Source: ERG Common Position: Guidelines for implementing the Commission Recommendation C (2005) 3480 on Accounting Separation & Cost Accounting Systems under the regulatory framework for electronic communication.

[4] Source: ITU Regulatory accounting guide, March 2009, p.18.

[5] E.g. *"The gross MEAV [modern equivalent asset value] represents the equivalent replacement cost of the asset and should reflect both the most technically up to date new asset and the most technically up-to-date method of constructing that asset."* Source: Water commission-UK, Scottish Water First Draft Business Plan – Guidance, Appendix B, p.10.

"The gross capital cost of replacing an existing asset with a technically up-to-date new asset with the same service capability" Source: OFWAT, glossary of terms, p.26.

- It calculates efficient costs and therefore enables the Commission to make sure that operators buying access for a regulated asset are not paying for the inefficiencies of the regulated operator;
- It enables the Commission to send appropriate “build or buy” signals. Indeed, as the regulated prices for access are set on the basis of the MEA, it is equivalent for an alternative operator to buy access or to build an equivalent asset. This therefore does not deter investment in alternatives and promotes infrastructure based competition. This is one of the key aspects of the MEA definition. This aspect would not be achieved if the definition of the MEA was only referring to the lowest cost technology.

One of the potential features of the TSLRIC MEA is that it is not necessarily linked to the costs actually incurred by the regulated operator.

2.3 Consistency between MEAs for UCLL and UBA

The UBA service provides access to the end-user from a first data switch (or equivalent facility), other than a digital subscriber line access multiplexer (DSLAM). Therefore, this service includes two parts: the access provided through a part of the core network and the access provided through the access network. The latter is in fact equivalent to the UCLL service.

Therefore, the cost of UBA contains two components:

UBA cost = UCLL cost + core network UBA cost (DSLAM and backhaul cost).

Where you have a consistent MEA for both UBA and UCLL, the costs recovered by the UCLL and UBA components are straightforward to identify. However, where you have different MEAs there may be a portion of the two costs that overlap.

In Section 5 we explain the adjustments that could be made if different MEAs were chosen for UCLL and UBA.

2.4 MEA functionality

When choosing the MEA technology for UCLL or UBA services, we need to define the requirements of the MEA in terms of services it provides.

Two main options are possible:

- The MEA network replicates the full functionality of the existing network;
- The MEA network only replicates the main functionality of the existing network and may omit some non-crucial features.

The second option is preferable since it allows a wider choice of eligible MEA technologies and will better achieve TSLRIC outcomes the Commission favours.

The Commission's approach is that a MEA technology should share the same core functionality[6] as the regulated service but not necessarily share the same technological features. In our view this choice better reflects how operators behave when choosing a new technology.

2.5 Conclusion

The choice of MEA is directed at determining the efficient cost today of an equivalent service unconstrained by the historic technology choices of Chorus and capable of delivering the core functionalities of the regulated service, UCLL or UBA. This is the technology which a new operator deploying a network today would choose.

[6] The expression "core functionality" is used by James Every-Palmer in "Opinion of James Every-Palmer, 12 March 2014. It should not be confused with the functionality of the core part of the network.

3 UCLL modelling elements

3.1 What is the MEA for UCLL?

3.1.1 Eligible technologies for UCLL MEA

Consistent with the Commission's framework, this section presents the characteristics defining the eligibility of various technologies for the MEA and selects technologies based on these characteristics.

The following characteristics are appropriate for considering the eligible technologies for modelling a UCLL MEA:

- Layer 2 input – the UCLL MEA must enable access seekers to provide layer 2 (and higher) services to end-users,
- Services – the UCLL MEA must be able to provide telephony (voice services) and broadband (via bitstream services) as the two primary services, and
- Point-to-point – it is recommended that the UCLL MEA provides access seekers with a point-to-point path from the node to the end-user where economically rational.

Several access network technologies providing voice and broadband services are present today in New Zealand:

- Copper/FTTN - operated by Chorus,
- FTTH (Fibre to the Home) - operated by Local Fibre Companies (LFCs) being either Chorus or an alternative operator,
- FWA (Fixed Wireless Access) - operated by Vodafone, for example in the (Rural Broadband Initiative) RBI areas,
- HFC (Hybrid Fibre Coaxial) - operated by Vodafone,
- Mobile - operated by Telecom, Vodafone, and 2degrees.

Among these technologies, only copper/FTTN and FTTH fully respect all three of the above characteristics. FWA, HFC and mobile do not respect the point-to-point characteristic (but it may be economically rational to deploy such technologies). All of these five access networks technologies will be studied in more detail below. They are also representatives of the typical technologies currently deployed by operators around the world to provide both broadband and voice[7].

[7] Satellite is also sometimes considered in very rural areas which are difficult to connect by wired or wireless networks. However, it generally requires to be used in combination with a wired or wireless network to provide a return path and is therefore not considered here. Satellites can also be used sometimes to provide the return path but this is considered as more expensive than the technologies listed above because the required VSAT (Very Small Aperture Terminal) terminal is relatively expensive.

3.1.2 Factors for choosing a UCLL MEA among eligible technologies

The MEA technology is chosen from the five eligible technologies. As explained in section 2.2, the question at stake is by which technology an operator today would replace Chorus' copper/FTTN access network. The comparison of technologies is done on the basis of the following factors:

- **Technological performance.** Comparing performances and capabilities of different technologies.
- **Cost.** Comparing the costs for rollout of the access networks under different technologies based on benchmarking data.
- **Operator strategy.** Studying current deployment in New Zealand to determine technologies preferred by operators.
- **Subscriber and retail price.** Studying consumers' subscription choices to determine technologies preferred by consumers and comparing prices of retail products based on different technologies. This factor is however considered as less relevant than the others as the number of subscriptions and retail price levels do not necessarily reflect users' preferences towards one or another technology.

3.1.3 Comparison of eligible technologies

In this section, five eligible technologies – copper/FTTN, FTTH, FWA, HFC and mobile – are compared along the four factors above.

3.1.3.1 Technological performance

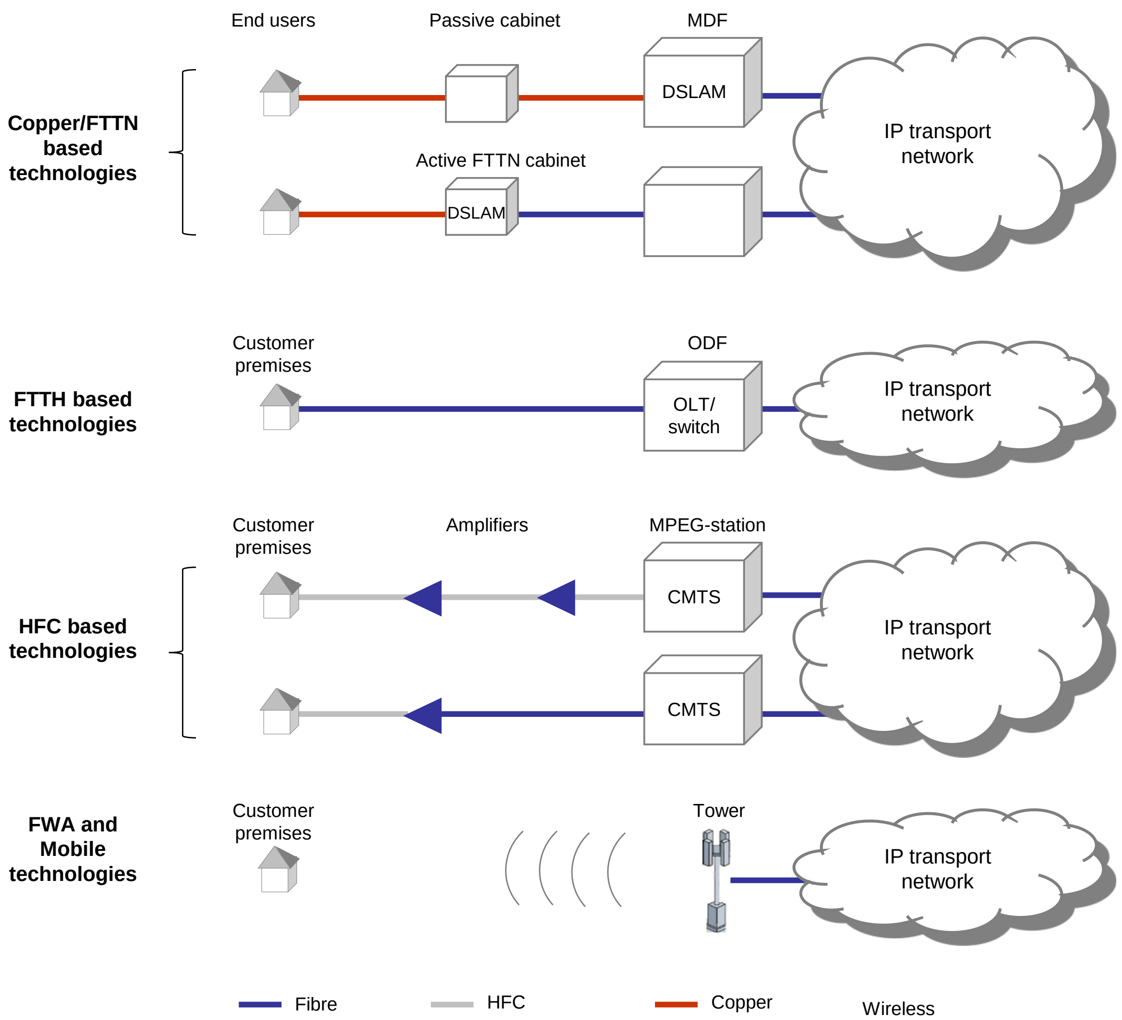
The technological performance compares performance and capabilities of different technologies. In this section, network structure and main characteristics of each technology are described.

Technologies are based on different network elements and connections, as described below and shown on Figure 1:

- **Copper/FTTN based technologies** (see section 3.1.3.1.1) are using copper cables to access the end-user. Two different configurations of copper networks are possible:
  - the copper cable is used from the MDF to the end-user,
  - the copper cable is used only from the street cabinet to the end-user and fibre is laid down from the MDF to the street cabinet. This is fibre to the node (FTTN).
- **FTTH based technologies** (see section 3.1.3.1.2) use only optical fibre between MDF and the end-user.
- **HFC based technologies** combine optical fibre, laid down to the MDF or to the amplifier, and coaxial cable, laid to the end-user (see section 3.1.3.1.3).
- **Mobile technologies** connect customers through wireless technologies (see section 3.1.3.1.4).

- **FWA technologies**, similar to mobile technologies, connect customers through wireless technologies, but the equipment used for receiving signal is different and usage is fixed (see section 3.1.3.1.5).

Figure 1: Broadband access network technologies



MDF – main distribution frame, ODF – optical fibre distribution frame, DSLAM - digital subscriber line access multiplexer, OLT - optical line terminal, CMTS - Cable modem termination system

Source: TERA Consultants

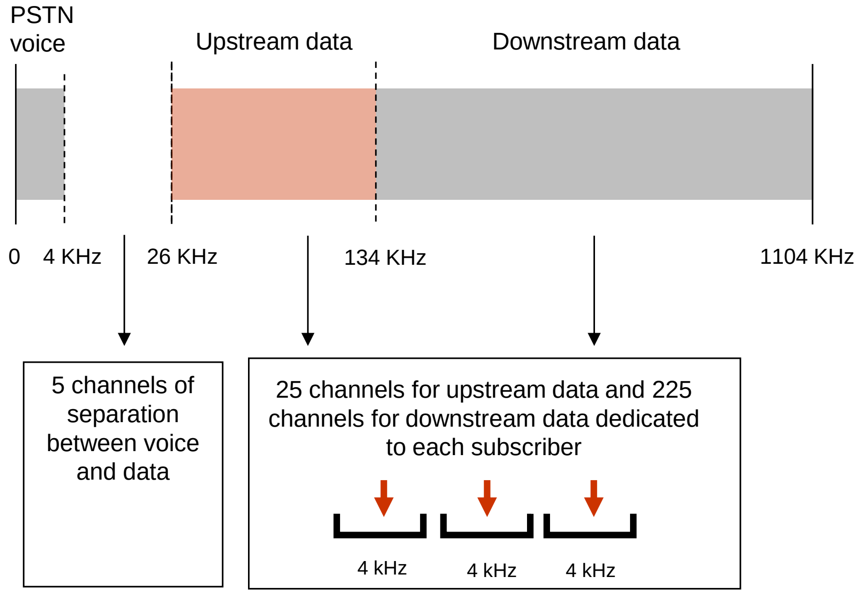
The performance of each access network technology is assessed in the next sections.

3.1.3.1.1 Copper/FTTN based technologies

Copper/FTTN based technologies use copper cables to access the end-user.

The bandwidth available on the copper cable is distributed between voice, downstream data and upstream data. Typically, the frequency band from 0 KHz to 1,104 KHz,is divided into 256 channels, each channel using 4 KHz out of available 1,104 / 256 = 4.312 KHz.

Figure 2: Typical structure of the bandwidth available on ADSL



Source: TERA Consultants

Two main types of DSL technology are available to operators today (see Figure 1, copper/FTTN based technologies):

- **ADSL2+** where the DSLAM, which is the active equipment, is generally located at the MDF and the copper cable is used from the DSLAM to the end-user. This technology enables to deliver theoretically up to 24 Mbps downstream and 1.5 Mbps upstream[8].
- **VDSL2** where, in general, fibre is deployed to the street cabinet and the DSLAM is located at the street cabinet (can also be provided from the MDF but VDSL2 is more efficient for short distances). Theoretically this technology enables to deliver approximately up to 50 Mbps downstream and up to 5 Mbps upstream[9].

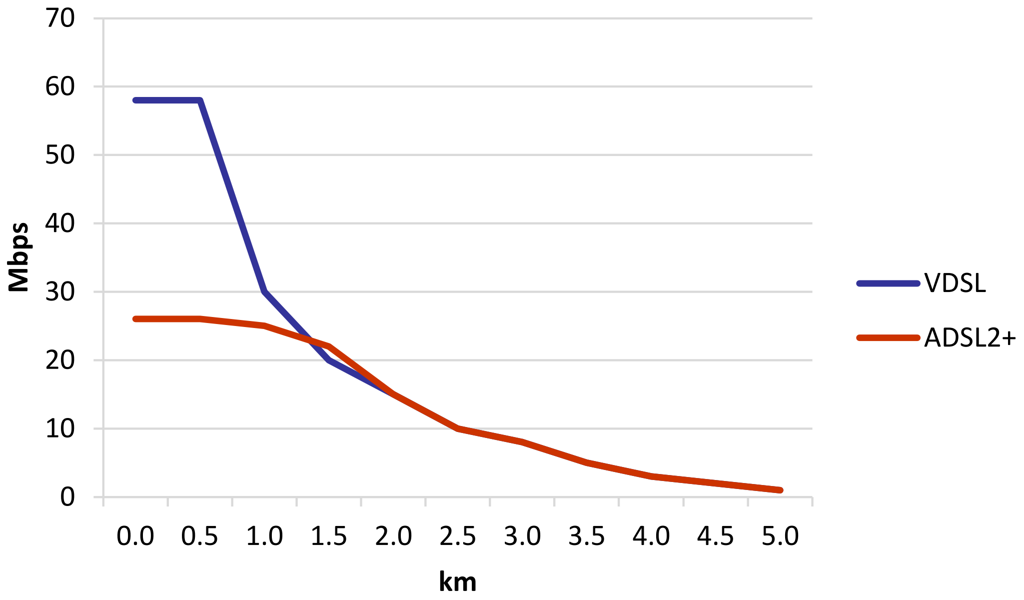
It is to be noted that these downstream and upstream performance levels are only achieved when the end-user is adjacent to the MDF or cabinet where the active equipment is installed: a line's performance in terms of downstream and upstream capacity degrades with its length.

[8] Source: ARCEP, Etude sur le très haut débit: nouveaux services, nouveaux usages et leur effet sur la chaîne de la valeur, February 2012 and FTTH Council Europe, FTTH business guide dated 16th January 2011.

[9] Source: ARCEP, Etude sur le très haut débit: nouveaux services, nouveaux usages et leur effet sur la chaîne de la valeur, February 2012.

As shown in Figure 3, VDSL2 is more efficient for short lines; however, its performance degrades rapidly with line length. Therefore, it is worth implementing VDSL2 only in areas with short copper loops. Otherwise, ADSL2+ is preferred.

Figure 3: Line speed mitigation of VDSL2 and ADSL2+



Source: ARCEP[10]

For both technologies, some performance improvement techniques substantially increase the downstream and upstream performances:

- **Pair bonding** consists of combining logically two copper pairs which allows doubling the capacity available per household. It is applicable to both ADSL and VDSL. The upstream capacity can then reach up to 100 Mbps and the downstream capacity up to 10 Mbps[11]. One of the main drawbacks of this technique is that it requires two copper pairs and a new Customer Premises Equipment (CPE).
- **Vectoring** is a noise cancelation technology on VDSL2 lines that mitigates the effect of the electromagnetic interference that occurs on copper-based networks, also known as crosstalk[12]. This technique allows up to 100 Mbps downstream and up to 10 Mbps upstream for loops with length not exceeding

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[10] Source: ARCEP, Etude sur le très haut débit: nouveaux services, nouveaux usages et leur effet sur la chaîne de la valeur, February 2012 and Ericsson, VDSL2 Next important broadband technology, Review No.1, 2006.

[11] Source: Heavy Reading, DSL acceleration: making it work, June 2012.

[12] According to Ofcom, the UK regulator, crosstalk can reduce connection speeds by up to 50% or more.

400 meters[13]. This solution has the clear benefit of being an enhancement of the existing VDSL2 technology which is already available.

- **Phantom mode** combines the benefits of vectoring and bonding multiple pairs on VDSL2 lines. Even though this technology enables up to 300 Mbps downstream capacity[14] in principle, it may be too expensive and too complex to implement as this solution has not been standardized yet.
- **G.fast** enables higher speeds, between 500 Mbps and 1 Gbps[15], through the use of a wider frequency band, up to 212 MHz. According to Chorus, G.fast allows connection speeds above 100 Mbps for lines shorter than 300 metres[16]. However, a wider frequency band results in shorter transmission distances, higher costs and greater power consumption.

The table below shows the VDSL2 speeds that operators in Europe have achieved during trials. Speeds of between 20 and 53 Mbps have been achieved, while adding vectoring techniques allows operators to increase speed, achieving between 57 and 92 Mbps.

Table 1: Minimum downstream speed achieved on VDSL2 lines with and without vectoring

Operator	**Trial loop length** (Meters)	**Minimum downstream speed, without vectoring** (Mbps)	**Minimum downstream speed, with vectoring** (Mbps)
Swisscom	500	24	66
P&T Luxembourg	529 to 613	30	57
Deutsche Telekom	450	53	92
Slovak Telekom	505	52	90
Belgacom	500	20	65

Source: Heavy Reading specifying operators' results of preliminary lab and field tests[17]

In New Zealand, Chorus' copper/FTTN network includes two types of lines: cabinetised lines (with an active street cabinet and VDSL) and non-cabinetised lines (with no cabinet or a passive cabinet), each type representing about half of lines. The cabinetisation programme has enabled VDSL to about 60% of end-users.[18]

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[13] Source: Alcatel Lucent - VDSL2 Vectoring: The Broadband Accelerator http://www.alcatel-lucent.com/solutions/vdsl2-vectoring-broadband-accelerator

[14] Source: Alcatel http://www3.alcatel-lucent.com/features/phantom/

[15] John Williams. How Enhanced DSL Technologies Optimize the Last Copper Mile. JDSU. May 2013 and http://www.huawei.com/ilink/en/solutions/broader-smarter/morematerial-b/HW_278065

[16] Chorus Institutional Investor Briefing, 21 May 2014.

[17] Source: Heavy Reading, DSL acceleration: making it work, June 2012.

[18] Chorus Institutional Investor Briefing, 21 May 2014.

According to Chorus, the copper/FTTN broadband may provide up to 30-70 Mbps speed under the current technology and up to 300 Mbps under the next technology, per user under good conditions.[19]

VDSL speed advertised by retail operators in New Zealand is 15-70 Mbps for downloads and 5-10 Mbps for uploads.[20] Chorus claims that over 84% of lines can get at least 10 Mbps over the existing copper/FTTN network.[21]

TrueNet conducted speed tests in October 2013 based on volunteers' internet connections to all five major fixed line internet service providers: Telecom, Vodafone, Slingshot, Orcon and Snap. It has shown that in practice ADSL speed is around 8-9 Mbps, while VDSL speed is around 20 Mbps.[22]

3.1.3.1.2 FTTH access network

FTTH based technologies use only optical fibre between the Optical Distribution Frame (ODF) and the end-user.

In contrast to copper/FTTN technologies, there is very low attenuation in FTTH networks which allows serving long lines, up to 20 km, without the need for repeaters. Also, there are no grounding problems and no cross talk as observed with copper/FTTN.

The technical limit of FTTH is above 50Tbps[23] but it depends on the type of topology that has been rolled out:

- With a **point to point (P2P) topology**, each end-user is served by a single fibre that runs from the ODF to the customer premises. In such a case, the route consists of several sections of fibre joined with splice boxes[24] or connectors, but provides a continuous, uninterrupted optical path from the ODF to the home. It is therefore clear that the capacity at the wholesale level is dedicated in such situation. Operators that have deployed this solution generally offer to end-users symmetrical speeds of up to 1Gbps per subscriber[25].

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[19] Chorus Institutional Investor Briefing, 21 May 2014.

[20] http://www.vodafone.co.nz/broadband/what-is-vdsl/ and http://www.telecom.co.nz/shop/internet/ultravdsl/

[21] Chorus, "Submission in response to the Commerce Commission's Process and issues paper for determining a TSLRIC price for Chorus' unbundled copper local loop service in accordance with the Final Pricing Principle", 14 February 2014, p. 45.

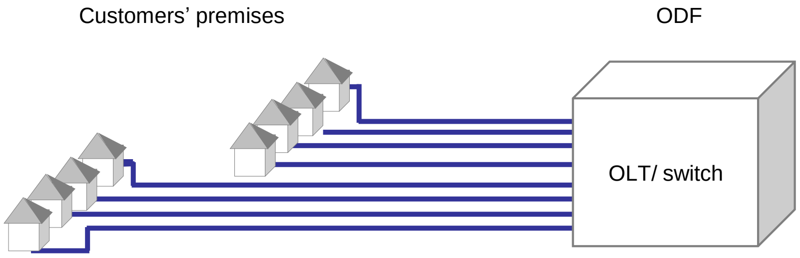
[22] https://www.truenet.com.au/articles/fibre-node-australia-new-zealand-comparison

[23] Source: FTTH Council America, FTTH Design and Network Basics PC-101-G, Mark Boxer Applications Engineering Manager, OFS Jeff Bush Professional Services Manager, OFS.

[24] Also called joint box or jointing closures.

[25] Source: FTTH Council America, FTTH Design and Network Basics PC-101-G, Mark Boxer Applications Engineering Manager, OFS Jeff Bush Professional Services Manager, OFS; Ericsson point-to-point deep fiber access, 2010-2011.

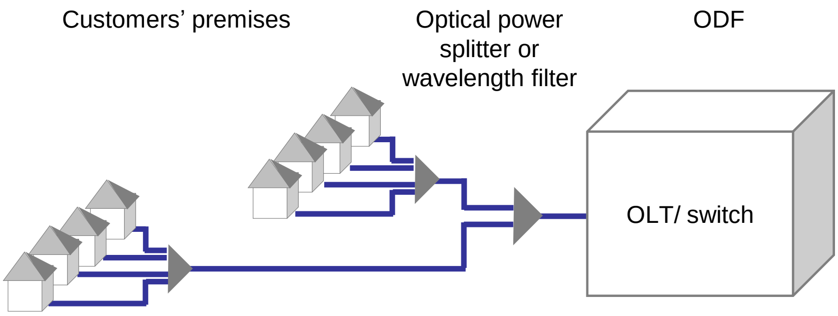
Figure 4: P2P FTTH architecture



Source: TERA Consultants

- With a **point-to-multipoint (GPON[26]) topology**, traffic is carried on a single, shared fibre from the ODF to a branching point, and from there the traffic is routed to end-users through fibres dedicated to each customer. In a passive optical network technology such as GPON, the downstream signal is broadcasted across multiple fibres with data being encoded so that users only receive data intended for them. This type of solution offers up to 2.5 Gbps downstream in total and 1.25 Gbps upstream in total (not per customer)[27]. A new GPON standard G.987 was ratified in June 2010 offering up to 10 Gbps downstream and 2.5 Gbps upstream. Contrary to the P2P solution, in GPON the capacity is shared at the wholesale level.

Figure 5: GPON FTTH architecture



Source: TERA Consultants

- An alternative to GPON is **Active Ethernet** architecture, where the traffic is routed electronically using active switch equipment in cabinets. Although the cable network has a point-to-multipoint topology as in GPON, each customer has a logical point-to-point connection.

In New Zealand, GPON topology is used for residential and small businesses while PtP is used for larger businesses. [28] According to Chorus, the FTTH model can deliver up to

[26] Gigabit-capable Passive Optical Networks.

[27] Source: FTTH Council America, FTTH Design and Network Basics PC-101-G, Mark Boxer Applications Engineering Manager, OFS Jeff Bush Professional Services Manager, OFS and CISCO, Fiber To The Home, Thomas Martin, Consulting Systems Engineer.

[28] http://www.crownfibre.govt.nz/ufb-initiative/frequently-asked-questions/

1 Gbps under the current technology and up to 10 Gbps under the next technology of connection speed per user in good conditions.[29]

High-capacity FTTH networks allow operators to propose high-speed retail products. Today on the New Zealand retail market, FTTH offers differ depending on the proposed download speeds, including offers of up to 30 Mbps downstream (10 Mbps upstream), up to 100 Mbps downstream (50 Mbps upstream) and up to 200 Mbps (50 Mbps upstream).[30]

TrueNet conducted a study in October 2013 in New Zealand based on volunteers' internet connections. It showed that in practice FTTH download speed is around 28 Mbps for FTTH offers with advertised 30 Mbps and varies between 70 and 90 Mbps depending on the time of the day for FTTH offers with advertised 100 Mbps.[31]

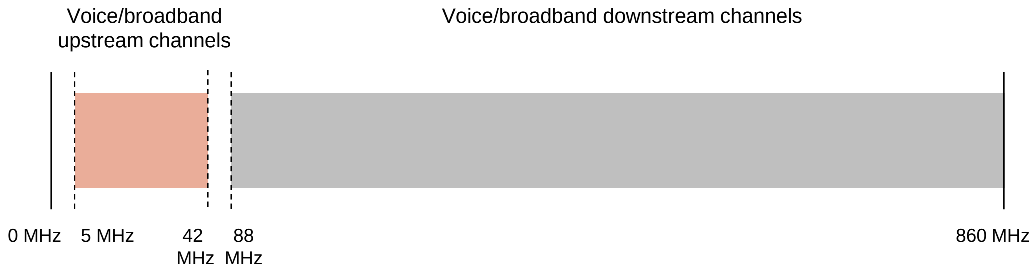
A disadvantage of FTTH is its inability to deliver certain services provided over legacy platforms such as some alarm systems or facsimiles.

3.1.3.1.3 HFC access network

Hybrid fibre-coaxial (HFC) is a broadband network that combines optical fibre and coaxial cable.

Regarding HFC access networks, it is first noted that this type of infrastructure is much less sensitive to electromagnetic disturbances than copper/FTTN infrastructures. They therefore enable much longer distances between locations where the main active equipment (CMTS, MPEG station) are located, and the end-user. This technology also uses significantly higher bandwidth: from 5 MHz to 860 MHz and sometimes even up to 1 GHz and above[32], which means a significant increase in the capacity available compared to copper/FTTN.

Figure 6: Structure of the bandwidth available on HFC for versions of DOCSIS before DOCSIS 3.0



Source: TERA Consultants; Motorola, Planning an Effective Migration to DOCSIS 3.0, 2008

[29] Chorus Institutional Investor Briefing, 21 May 2014.

[30] Source: operators' web sites accessed 14 June 2014.

[31] https://www.truenet.com.au/articles/fibre-node-australia-new-zealand-comparison

[32] Current Analysis Inc. HFC's Lucky Seven Technologies: How Can Cable Operators Compete with FTTH? March 31, 2011; Corning. Broadband Technology Overview White Paper. June 2005.

For HFC access networks, transmission is mainly handled through DOCSIS (Data Over Cable Service Interface Specification) technology that is implemented through different standards:

- DOCSIS;
- EuroDOCSIS which is the European DOCSIS standard.

Several versions of these standards have been introduced over time:

- The latest version of the DOCSIS standard, DOCSIS 3.0, uses cable modem that provides up to 16 downlink channels with four uplink channels, enabling data speed up to 800Mbps downstream and approximately 108Mbps upstream[33]. It is to be noted that in a foreseeable future, cable modems will be able to support 24 downlink channels enabling downstream capacity up to 1000Mbps[34].
- The EuroDOCSIS standard enables slightly faster data speed. Its latest version, EuroDOCSIS 3.0, supports 24 channels and is able to provide up to 1.3Gbps downstream capacity.

In order to further increase the capacity on the HFC network, several other options are generally identified:

- **Node splitting**. In a typical cable TV network, traffic is sent downstream from the cable head-end to multiple nodes which then distribute the traffic to individual end-users. Nodes generally serve from 500 to 2,000 end-users. In order to continually increase the capacity per subscriber, operators are able to split these nodes into several nodes so that it halves the number of subscriber per node (i.e., from 500 to 250). This technique therefore doubles the capacity per subscriber as it has been demonstrated by a research conducted by cable infrastructure vendor Motorola.[35]
- The use of **Radio Frequency over Glass** (RFoG). This consists in replacing the coax part of the cable operator network with passive optical fibre without changing any of the existing CMTS, head-end and hub equipment or customer premises gear. In addition to the removal of active element such as amplifiers and the use of far less power than cable TV, RFoG enables increased downstream capacity up to 160 Mbps and upstream capacity up to 120 Mbps[36].
- The use of **Ethernet Passive Optical Network Protocol over Coax**, known as EPoC. This technology could provide symmetric speeds up to 10 Gbps or

[33] Source: http://www.st.com/web/en/press/p3371

[34] Source: http://www.cisco.com/c/en/us/products/collateral/video/ubr10000-series-universal-broadband-routers/data_sheet_c78-642540.html

[35] Source: Current Analysis Inc., HFC's Lucky Seven Technologies: How Can Cable Operators Compete with FTTH? March 31, 2011.

[36] Source: Heavy Reading, Next-Gen Cable Networks: Opportunities for Fiber-Based Technologies, http://www.heavyreading.com/details.asp?sku_id=2346&skuitem_itemid=1166

asymmetric speeds up to 10 Gbps downstream and 1Gbps upstream[37]. Nevertheless this technology is still under the process of being standardized.

- **Switch to DOCSIS 3.1** released in October 2013 (alternative to EPoC) – under specification. This enhancement enables speeds of at least 10Gbps downstream and 1Gbps upstream[38].
- **Higher modulation rates**.
- **Allocating more down- or upstream channels.**

In New Zealand, Vodafone offers two different HFC packages at the retail level depending on the broadband speed: the first one with up to 50 Mbps for downloads and up to 2 Mbps for uploads, the second one with up to 130 Mbps for downloads and up to 10 Mbps for uploads.[39]

Like for FTTH, a disadvantage of HFC is its inability to deliver certain services provided over legacy platforms such as some alarm systems or facsimiles.

3.1.3.1.4 Mobile network

A broadband service can also be operated through a mobile network. Similarly to FWA, the signal is transmitted to the tower through an optical fibre connection, and then to the end-user through a radio signal. However, contrary to FWA, customers do not have a dedicated antenna and a fixed modem. They receive their signal through their personal devices: smartphones, USB modem / dongle or computer data/adapter cards.

Mobile services can use a wide range of frequencies (e.g. 900MHz, 1800MHz, 2.6GHz, etc.) and performance depends highly on the amount of frequency granted to mobile operators and the range of these frequencies. As illustrated by the figure below, mobile performance depends on the number of customers using their device at the same time in a given cell and on their distance to the base station.

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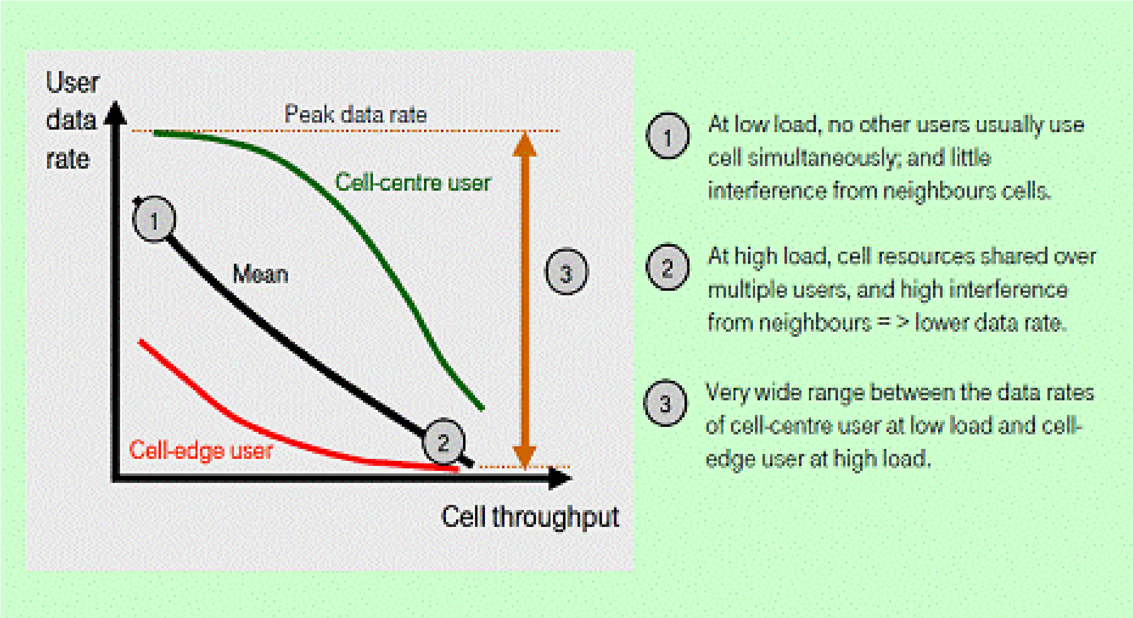
[37] Source: IEEE 802.3 Ethernet Working Group, Operating the EPON protocol over Coaxial Distribution Networks Call for Interest, 8 November 2011.

[38] Source: http://www.lightreading.com/docsis/docsis-31-targets-10gig-downstream/240135193

[39] Source: Operator's website accessed 14 June 2014.

Figure 7: Relationship between speed and distance to the base station in mobile networks



Source: An Explanatory Paper by the NGMN Alliance – User Data rates in mobile data netwoks, 24th of May 2010

3G HSPA technology can deliver theoretical speeds that range from 384 Kbps to 14 Mbps downstream. Future 4G technology will be capable of delivering 1 Gbps. The following table presents best possible theoretical download speeds for each technology:

Table 2: Maximal theoretical mobile broadband speeds by technological standard

Generation of mobile technology	Mobile standard	Speeds
2G	Basic GSM	14.4Kbps
2G	GPRS	48Kbps
2G	EDGE	236Kbps
3G	UMTS	384Kbps (64Kbps upstream)
3G	HSPA	14.4Mbps (5.8Mbps upload)
3G	HSPA+	84Mbps (22Mbps upload)
3G	WiMAX 802.16e	128Mbps (56Mbps upload)
3G	LTE	100Mbps (50Mbps upload)
4G	WiMAX2 802.16m	1Gbps
4G	LTE-Advanced	1Gbps
5G	Not specified	10Gbps

Source: ISP review, http://www.ispreview.co.uk/broadband_mobile.php

However, in practice these speeds are never achieved. According to a study by Akamai[40], in the fourth quarter of 2013, the average mobile connection speed in Europe varied between 1.2 and 8.9 Mbps, in North America between 2.2 and 8.5 Mbps, and in Australia it was equal to 5.4 Mbps. The peak speed was between 7.1 and 55.5 Mbps in Europe (i.e. average speed is around 17% of peak speed), between 7.1 and 27.7 Mbps in North America (i.e. average speed is around 31% of peak speed) and 135.6 in Australia (i.e. average speed is around 4% of peak speed).

Compared to 3G, 4G can provide higher data speeds which are similar to what can be achieved with copper ADSL connections.

In New Zealand, mobile networks are operated by Telecom, Vodafone, and 2degrees. Vodafone and 2degrees operate 2G GSM networks, and all three mobile providers operate 3G UMTS networks. 4G networks are currently being rolled out: Vodafone and Telecom started construction in 2013, and 2degrees is expected to follow later in 2014.

According to Chorus, the expected per user connection speed in good conditions is 20 Mbps under current technology and will become 50 Mbps under the next technology.[41] However, in practice these speeds cannot be achieved. In 2013 in New Zealand, the actual average speed of mobile broadband was only 2.5 Mbps, while the peak speed was 11.9 Mbps.[42]

Like for FTTH and HFC and as will be explained for FWA below, a disadvantage of mobile technologies is their inability to deliver certain services provided over legacy platforms such as some alarm systems or facsimiles.

3.1.3.1.5 FWA access network

Under FWA, similar to the mobile network, once the data is delivered to transmission towers (ground stations) via fibre connections, radio signals rather than cables are used to access the end-user. Towers may be either shared with the mobile network or be dedicated to FWA. Unlike mobile broadband, a transceiver (an antenna) is installed on the customer’s premises to receive the signal. A wireless modem is then installed at the customer’s premises to deliver broadband and voice services.

FWA uses the same frequencies as the mobile network. 900-960 MHz is a possible range for the 3G technology[43] and 3.5-3.6 GHz for the 4G technology.[44] The maximum

[40] Akamai’s State Of The Internet Q4 2013 Report, Volume 6 Number 4.

[41] Chorus Institutional Investor Briefing, 21 May 2014.

[42] http://billbennett.co.nz/2014/04/24/new-zealand-fast-broadband-connections-double-in-2013/

[43] Rural broadband agreement between Her Majesty The Queen in right of New Zealand acting by and through David Smol, Chief Executive, Ministry of Economic Development, of Wellington (the Ministry) and Vodafone New Zealand Limited, of 20 Viaduct Harbour Avenue, Auckland. (Vodafone), 2011.

[44] Source: http://www.ispreview.co.uk/broadband_wireless.php

distance between the tower and the user depends significantly on the frequencies used and can vary between 0.5 and 7 km.[45]

FWA tends to offer broadband speeds that are lower than copper/FTTN, FTTH or HFC but are higher than mobile broadband. Theoretically, it can deliver up to 1Gbps, however but such speed is generally unachievable. Broadband speeds advertised by operators are 21 Mbps (3G) to 25 Mbps (4G) downstream and 5 Mbps upstream.[46] These speeds are more stable than mobile broadband speed under the condition that a tower or frequencies are dedicated to FWA only and are not shared with mobile. Indeed, contrary to mobile broadband configurations, the number of FWA broadband users in a given cell is stable (because customers are not moving) and easy to identify. This makes network capacity planning easier and therefore quality of service experienced by FWA customers better. However, the speed decreases significantly with the distance. In addition, the quality of FWA service is adversely affected by obstacles such as hills, trees, walls or even rain and fog, contrary to wired networks.

Another technical disadvantage of FWA is its inability to deliver certain services available through a fixed connection, such as fax, EFTPOS, a monitored building alarm through a phone line, a medic alarm link through a phone line, 3 way calling or audio conference features.[47]

In New Zealand FWA services are currently provided through the 3G HSPA+ technology operating in the 900 MHz band. The wireless service is actually mobile 3G HSPA+ and this system serves both mobile and FWA customers. The radio equipment to be installed by Vodafone on the Grant Funded Towers under RBI will be Long Term Evolution (LTE) ready in that it will be upgradeable to LTE. Vodafone is planning to deliver 4G LTE services in 2014[48] using spectrum blocks secured during the "Digital Dividend" auction. The service is designed to provide 21 Mbps downstream and 5 Mbps upstream peak speeds. The minimum throughput per FWA customer is 45 kbps. This is based on a maximum number of FWA customers per cell site, and in general, customers get a better speed. The number of end-users who may sign up for the Enhanced Broadband Service is limited to 15 at each cell site.

3.1.3.1.6 Summary of technological performance

When comparing the different access network technologies it appears that FTTH, HFC, FWA and mobile are able to theoretically provide the same or higher downstream/upstream capacity compared to copper/FTTN. However, mobile

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[45] A benchmark of European countries by TERA Consultants.

[46] Rural broadband agreement between Her Majesty The Queen in right of New Zealand acting by and through David Smol, Chief Executive, Ministry of Economic Development, of Wellington (the Ministry) and Vodafone New Zealand Limited, of 20 Viaduct Harbour Avenue, Auckland. (Vodafone), 2011 and

http://www.nbnco.com.au/assets/documents/fixed-wireless-factsheet.pdf

[47] http://www.vodafone.co.nz/broadband/rural/wireless-and-calling/

[48] http://www.vodafone.co.nz/network/rural/

technology, even though it can theoretically provide capacity comparable to copper/FTTN network, it is rarely achieved in practice as explained above. Capacities of the different access network technologies are summarised in the table below. This table also includes an analysis of whether access network technologies provide dedicated or shared capacity between end-users: when there is dedicated capacity between end-users, the technology is said to be a “point-to-point technology” while otherwise it is said to be a “point–to-multipoint technology”. Technologies offering dedicated capacities for end-users are considered to be superior, all things being equal, to technologies offering shared capacities as they provide greater control of the physical medium and allow physical unbundling. It should be noted that the capacities of technologies using dedicated capacities are not directly comparable to the capacities of technologies using shared capacities. In the latter case, the actual per-user capacity depends on the number of users connected.

Table 3: Comparison of technological performance between different networks

	Technology	Maximum downstream capacity (Mbps/user)	Maximum upstream capacity (Mbps/user)	Maximum line length (km)	Point-to-point/ Point-to-multipoint
Copper/FTTN	ADSL2+	24	1.5	1.5	Point-to-point
	VDSL2	50	5	0.4	Point-to-point[49]
	Pair bonding	50 for ADSL 100 for VDSL	3 for ADSL 10 for VDSL	ADSL 1.5 VDSL 0.4	Depends on where the active equipment is installed
	Vectoring	100	10	0.4	Point-to-multipoint
	Phantom mode	300	N/A	0.4	Point-to-multipoint
	G.fast	1,000	1,000	0.3	Point-to-point
FTTH	P2P	1,000	1,000	20	Point-to-point
	GPON	2,500	1,250	20	Point-to-multipoint[50]
HFC	DOCSIS 3.0	960	100	10	Point-to-multipoint
	EuroDOCSIS 3.0	1,300	120	10	Point-to-multipoint
	Node split	Capacity doubled	Capacity doubled	20	Point-to-multipoint
	RFoG	160	120	20	Point-to-multipoint
	EPOC	10,000 (not standardized)	10,000 (not standardized)	20	Point-to-multipoint
	Higher modulation rates	N/A	N/A	20	Point-to-multipoint
	Allocating more channels	N/A	N/A	20	Point-to-multipoint
	DOCSIS 3.1	10,000	1,000	20	Point-to-multipoint
Mobile	3G HSPA+	21	5	0.5-6 [51]	Point-to-multipoint
	LTE 4G	100	40	0.5-6	Point-to-multipoint

[49] Because of the fact that alternative operators rarely unbundle street cabinets (due to lack of economies of scale) and because of the fact that VDSL2 technology is aimed at being deployed at the street cabinet, in the future, wholesale access to this type of technology is likely to be mainly provided at higher level in the network where capacity is shared between end-users.

[50] In a PON architecture, unbundling at the ODF is however possible with wavelength unbundling (WDM-PON). The end-user is accessed by using a separate wavelength for each, and multiplexing data onto that wavelength, so that each end-user is assigned a particular wavelength, not shared by other users. This type of PON can be unbundled by giving unbundlers access to the appropriate wavelength at the ODF on a user by user basis. However, it is considered as expensive and is rather a solution for the future when wavelength unbundling costs will drop. Commercial solutions may start being available from 2015 (http://www.telecoms.com/44949/how-viable-is-wavelength-unbundling-on-ftth-networks/)

[51] The maximal distance between the tower and the user depends significantly on frequencies used. The speed decreases significantly with the distance for FWA and mobile.

FWA	3G HSPA+	21 but average speed likely to be higher than for mobile	5 but average speed likely to be higher than for mobile	0.5-6	Point-to-multipoint
	LTE 4G	100 but average speed likely to be higher than for mobile	40 but average speed likely to be higher than for mobile	0.5-6	Point-to-multipoint

Source: TERA Consultants

As a conclusion, in terms of capacity, both FTTH and HFC are more capable than copper/FTTN-based technologies. In addition, both technologies deliver high speeds even over long lines, up to 10 km for HFC and up to 20 km for FTTH. An additional advantage of FTTH PtP is that it is a point-to-point technology: capacity is dedicated to each user. Therefore, FTTH PtP is the best candidate for MEA judging only by technological factor. However, FTTH GPON, FWA and HFC deliver capacities comparable to copper/FTTN, and therefore are also possible candidates for MEA but they are not point-to-point technologies. FWA is superior to mobile since it allows more stable download speeds.

3.1.3.2 Cost

As stated in Section 3.1.1, it is necessary to compare the cost of the different fixed access network technologies in the MEA assessment.

It is difficult to predict whether in New Zealand the modelled FTTH network will appear more or less expensive than the modelled copper/FTTN network. This depends on national circumstances. However, several data sources have allowed us to do some preliminary analysis.

Capex comparison between copper/FTTN, FTTH PtP and FTTH GPON today

First, let us consider the example of Denmark where the cost data from a bottom-up model is available. That model has shown that fibre network costs are higher than the copper network costs, and also that FTTH PtP costs are insignificantly higher than for FTTH GPON.

Table 4: Comparison of the investment required for a standalone FTTH PtP, a standalone FTTH GPON and a standalone copper access network in Denmark

Technology	Cost	Cost increase for fibre compared to copper
	Million $	%
Copper	6,113	-
Fibre PON	6,847	+12%
Fibre PtP	6,988	+14%

Customer Premises Equipment and active equipment are excluded

Source: TERA Consultants, Modification and development of the LRAIC model for fixed networks 2012-2014 in Denmark. MEA assessment, May 2013

In Sweden, PTS estimates that the costs for fully unbundled access based on copper would be similar to or slightly higher than the costs for fully unbundled access based on fibre[52]. This means that the cost difference between copper and fibre for capex is limited to probably maximum +/- 10%.

Generally, the cost difference between FTTH GPON and FTTH PtP may vary depending on national circumstances. According to several studies, these costs are close.[53] In the table above, the PtP architecture is 2% more expensive than the GPON architecture. A study for ECTA finds that the network of a hypothetical European country with a PtP FTTH architecture requires less than 10% additional investment compared to a GPON architecture.[54] A study conducted in the UK indicates that the PON architecture is 18% cheaper than the PtP architecture in terms of investment[55]. These studies are however old and the gap between PtP and GPON may decrease when fibre cable prices decrease (see below).

Capex comparison between copper/FTTN and fibre looking forward

The gap between the cost of the copper and FTTH networks is expected to narrow in the coming years due to a combination of steadily decreasing fibre prices and increasing copper cost. Indeed, the assumed price trend for fibre is on average -5% per year whereas for copper it is close to 0% per year.

[52] European Commission decision concerning Case SE/2011/1205, 2011.

[53] See for example Allied Telesis. FTTx Solutions for Service Providers. 2009 and Metro Ethernet Forum "FTTH - Understanding which market scenarios are best served by active Ethernet point-to-point (EP2P) and which are best served by point-to-multipoint PON architectures" and IDATE Digiworld summit. FTTx economics: conditions for profitability.

[54] WIK-Consult. Study for the European Competitive Telecommunication Association (ECTA). The Economics of Next Generation Access - Final Report. September 10, 2008.

[55] Analysis Mason. Final report for the Broadband Stakeholder Group. The costs of deploying fibre-based next-generation broadband infrastructure. 8 September 2008.

Table 5: Benchmark of fibre cable and of copper cable price trends in bottom-up models

Country	Fibre cable price trend % per year	Copper cable price trend % per year
Australia	-9.2%	-0.7%
Sweden	-2.4%	-2.0%
Denmark*	-5.0%	6.0%
Belgium	-4.0% (core), -6.9% (access)	-2.0%
Norway	-4.0% (core), - 9.0% (access)	+1.0%
France	-4.0%	n/a
Netherlands	-0.0%	n/a
Spain	-0.0%	n/a
Austria	-5.0%	n/a
UK	-3.4%	n/a
Average	**-4.5%**	**+0.4%**

**The model is currently being updated.*

Source: NRAs' core and access publicly available models

This average copper price trend is confirmed by the long-term evolution of copper prices that have been observed over several decades. Indeed, as shown on the graph below, the copper price increased from 1.5 US$/Lb in 1989 to 4 US$/Lb in 2012, which corresponds to a 2.7 times increase.

Figure 8: Evolution of the copper price in US$/Lb between 1989 and 2012

Source: InfoMine

This means that fibre should become cheaper than copper/FTTN in terms of capex over time.

Opex comparison between copper/FTTN and fibre

Ericsson, one of the biggest providers of telecommunications equipment in the world, emphasizes that the absence of active equipment in an FTTH network will lead to a lower level of opex compared to copper/FTTN and HFC networks:

> *"Compared to copper and hybrid fibre-coax (HFC) networks, OPEX will be considerably lower as P2P fibre provides the best distance-bandwidth solution with fewer number of active elements required in the network. This reduction in active elements in the OSP also results in a lower OPEX."* [56]

The industry organisation FTTH Council Europe also explains that the level of opex for FTTH will be lower than for copper/FTTN networks and lists the potential saving opportunities:

> *"An additional motivator for service providers is that FTTH networks have lower operating costs (OPEX) than existing copper or coaxial cable networks. FTTH networks consume less electricity with some reports putting the figure at 20 times less than HFC or VDSL. Network operation and maintenance is simplified using full automation and software control, requiring fewer staff. Maintenance costs are also reduced as there is no active equipment in the field to maintain, and optical components are extremely reliable. Optical fibre is not affected by electromagnetic interference, which is a source of downtime in copper networks."*[57]

Finally, in a presentation on next generation networks, the Italian NRA AGCOM compares copper and fibre networks and states that the fibre opex saving as compared to copper is *circa* 50%:

> *"NTT / Verizon: 40-60% OpEx decrease with FTTH networks w.r.t. copper local loop"*[58].

Comparison with HFC

To our knowledge, no cost comparison is available between HFC and FTTH or copper/FTTN. However, HFC networks increasingly composed of fibre components and therefore it can be assumed that the costs of HFC are similar to those of FTTH.

[56] Source: Ericsson, Point-to-point deep fiber access, 2010.

[57] Source: FTTH Council web site.

[58] Source: AGCOM (Italian NRA), Challenges in moving towards the Next Generation of Fixed and Mobile Networks, January 2010.

Comparison between wired and FWA networks

It is highly likely that in remote areas, where fixed lines tend to be long, the use of FWA technologies to provide voice and broadband is significantly less expensive and less capital intensive than the use of fixed wired networks. It is possible to make an estimation of per-user cost for FWA and FTTH in New Zealand in order to verify this intuition and to assess which one is likely to be more expensive.

According to different sources in Europe[59], a tower may cost approximately $200,000, including 25% of investment in active equipment and 75% of investment in passive equipment. However, additional costs need to be incurred in New Zealand due to the need to produce a seismic-resistant design: we assume that the cost of passive equipment rises by 50%, from $150,000 to $225,000. The lifetime of passive equipment is 20 years, which is three times longer than for active equipment. Therefore, investments per site calculated over 20 years are equal to $225,000 for passive equipment plus $50,000*3=$150,000 for active equipment, or $375,000 per tower. With the capacity of sites varying with the type of technology, the amount of investment per line depends on the technology used:

- A 3G site may provide services to only a limited number of users:
  - The maximum number of customers per tower is equal to 15, as indicated in the Vodafone RBI contract. This low number of users under 3G technology results in a high initial investment per customer of $25,000.
- A 4G site may provide services to a greater number of users. The cost per line depends on the estimated number of users per site:
  - Conservative assumption. Since the connection speed is about five times higher in 4G than in 3G (see Table 3), five times more (75) customers per tower may use the service, which gives $5,000 per customer.
  - Alternative assumption. According to a benchmark made by TERA Consultants in Europe, the coverage of one 4G tower varies between 0.5 km in dense urban areas and six km in rural areas. Population density in New Zealand varies between 570 residents per square km. in main urban areas and 5.5 people per square km. in rural areas, with 2.8 residents per household.[60] This allows us to calculate the average number of households in the tower coverage area: 159 in dense urban areas and 223 in rural areas.[61] Therefore, the investment per one potential customer is $2,357 in urban areas and $1,682 in rural areas. It

[59] See for example the LRIC mobile model of ARCEP in France, published 13 July 2013.

[60] Statistics New Zealand. New Zealand: An Urban/Rural Profile Update, 2006.

[61] This estimation is consistent with the following data concerning Australia: "Beyond the Coorong district, 15 more fixed wireless installations are being constructed in regional South Australia, providing access to the NBN for a further 4200 premises by the end of 2014." http://www.gizmodo.com.au/2014/06/another-step-forward-for-the-nbn-as-fixed-wireless-switched-on-in-sa/, which leads to 4200/15=280 households per site in 4G.

should be noted that not all the customers covered by the site will subscribe to the broadband service: assuming 85% penetration of broadband among potential FWA customers[62], the cost per customer will increase to $2,773 in urban areas and $1,978 in rural areas.

The amount of per-user investment necessary to build the FTTH network is not the same for all the operators:

- **Chorus.** According to Chorus, the average cost per premise, including connection and end-user equipment, will be between $2,250 and $2,750.[63] Assuming that only 85% of these customers will subscribe to broadband[64], the investment per active user is approximately $3,235. The cost per premise passed by the FTTH network varies between $1,990 and $3,500 in urban and suburban areas depending on the line length, density, building characteristics and regulations[65]. A part of the civil engineering infrastructure of the copper/FTTN network belonging to Chorus can be reused for the FTTH network. This cost is not included in the Chorus's estimations.
- **Other operators.** The cost is likely to be higher for other operators who have to construct the whole civil engineering infrastructure, except in cases where they can use other utilities' infrastructure such electricity poles. A rough estimate of the per-user investment by Waikato Networks Limited (a subsidiary of WEL Networks Limited) for example can be made: its part of the UFB network will cost $320 million for 80,000 users connected, which implies $4,000 of investment per potential user.[66] Taking into account 85% penetration of broadband, the investment per active user is $4,706. The future FTTH UFB network will only cover 75% of the population. No FTTH network is to be built in rural areas. However, if FTTH was built in rural areas, its cost in these areas would be higher than in urban areas due to low population density and longer line length.

The graph below compares FWA investment with FTTH investment: FWA 4G is likely to be less expensive both in urban and in rural areas, especially as the "FTTH Chorus" estimate in rural areas is related to areas with higher densities than FWA areas because Chorus' FTTH network only covers 50% of the country.

[62] Commerce Commission. Annual Telecommunications Monitoring Report 2013. Telecommunications monitoring report. May 2014.

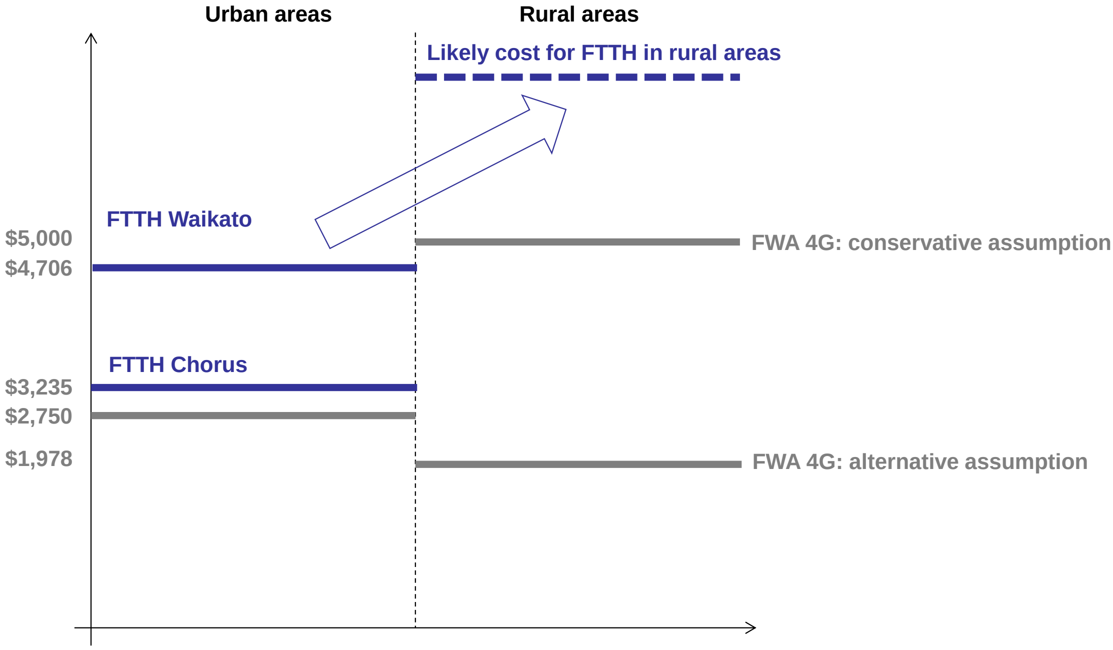
[63] Outline of UFB agreement between Chorus and Crown Fibre Holdings.

[64] Commerce Commission. Annual Telecommunications Monitoring Report 2013. Telecommunications monitoring report. May 2014.

[65] Chorus Institutional Investor Briefing. 21 May 2014; Outline of UFB agreement between Chorus and Crown Fibre Holdings.

[66] WEL networks. Annual report 2013.

Figure 9: A rough estimation of the amount of investment per subscriber



Source: TERA Consultants analysis

In conclusion, 4G FWA networks <u>in rural areas</u> tend to be less expensive than FTTH networks in <u>urban areas</u> except under conservative assumptions. We do not know what the FTTH cost in rural areas would be but the difference is likely to be even greater in these areas than what is observed in urban areas. This is because FTTH costs tend to increase significantly (and probably above Waikato Networks Limited's costs) when population density decreases. It is more difficult to compare FTTH cost with copper/FTTN replacement cost before building a cost model. However, cable prices tend to indicate that the cost of FTTH will decrease in comparison to copper/FTTN and FTTH seems to provide significant opex savings compared to copper/FTTN.

3.1.3.3 Operator strategy

When assessing the MEA it may also be appropriate to observe the strategy followed by operators, as it provides a good indicator of what is expected to be the long term access network technology. This is relevant, if not critical, in light of the MEA definition (see section 2.1) because the MEA concept reflects the investment decisions of a new entrant, not a company which has already invested in a certain technology.

For a company that does not own copper/FTTN infrastructure, FTTH seems to be the preferred technology. Even for a company that owns copper/FTTN technology, FTTH has been chosen by the Government for its UFB programme.[67]

[67] See Annex 7.1.2 for more details on the UFB programme.

In New Zealand, a growing number of end-users now have a fibre access network running past their homes or businesses, with fibre progressively being rolled out by the winners of the UFB tenders. The wholesalers of fibre are Chorus, for most of the country; NorthPower in Northland; Ultra-Fast Fibre led by WEL Networks in Hamilton, Tauranga, Tokoroa, New Plymouth, Hawera, and Whanganui; and Enable Networks in Christchurch.

In Europe, new access network deployments have been mostly focused on FTTH. According to Idate, the number of FTTH end-users connections has increased almost threefold between the beginning of 2011 and the beginning of 2013, shifting from 1.4M to 3.9M[68] which clearly indicates that FTTH is the technology that is the most prevalent according to operators.

For both new entrants and incumbents, FTTH seems to be regarded as the long-term technology. However, the deployment strategy of incumbents differs from that of new operators.

At the same time, in remote areas, no FTTH is being developed and the FWA technology has been preferred in very remote areas: here, Vodafone is developing its FWA network with the help of the Government's RBI programme. The basic reason for the FWA approach was to achieve the community coverage target of over 80% of rural (Zone 4) premises at peak speeds of at least 5Mbps. At the time, Telecom could not commit to upgrading the fixed network to reach this target within the available RBI funding (this tends to indicate again that FWA is much cheaper than wired networks in rural areas).

There is copper/FTTN coverage in all the FWA RBI areas, delivering the TSO services to homes connected in December 2001. However, some of this copper will not currently support DSL services. The bulk of FWA customers are those who cannot get good or any broadband on their copper connection. However, there is no strong migration from copper/FTTN broadband to FWA broadband, where copper/FTTN broadband is available.

In New Zealand, Vodafone owns an HFC broadband network that covers much of Wellington and Christchurch.[69] However, like in other countries, the HFC network has not been expanded since 2001.[70]

In light of the strategy followed by operators in New Zealand and other countries, the "operator strategy" factor suggests that FTTH is the MEA for copper in most areas. We are not aware of any new large-scale copper or HFC deployment in New Zealand or in the rest of the world, contrary to FTTH. However, in some rural areas, it is more relevant to consider FWA as a MEA for copper.

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[68] Source: Idate, FTTH Council-EU, "G20 need to speed up on Fibre to the Home", Press Release, February 26, 2010, and FTTH Council, December 2012 European Ranking, February 2013.

[69] See 7.1.1

[70] Bronwyn Howell. Competition and Regulatory Implications of a Vodafone-TelstraClear Merger: first thoughts. Current comment, 2012 #3: June 14.

3.1.3.4 Subscriber and retail price

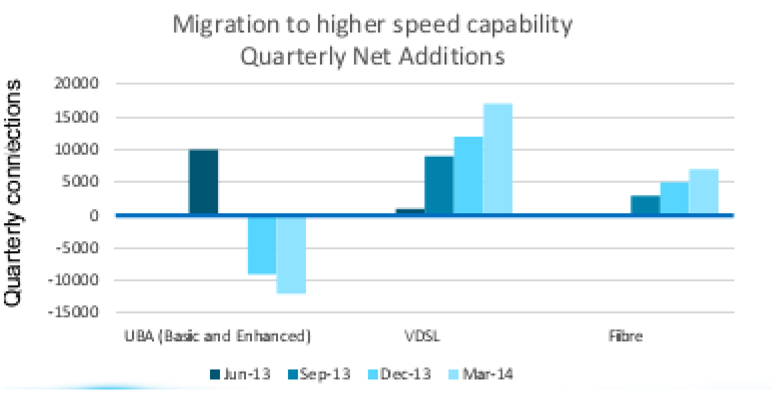
The subscriber and retail price reflects consumers' preferences: which technology is more popular in terms of subscription rate and how much consumers are ready to pay for retail offers based on different criteria. Consumers' market behaviour should be studied to assess this.

Data on demand for services provided over different technologies helps to understand consumer preferences towards one or another technological solution. Evolution in the number of end-user connections is a useful indicator.

In New Zealand, the number of consumers purchasing fibre-based services is now increasing rapidly from a small base. The government recently reported that over the last quarter of 2013, the number of customers signing up to a service under the UFB programme jumped by nearly 40%, taking the total to more than 27,000. [71] At the end of March 2014, this figure was 35,000. [72]

The graph below shows increase in the number of FTTH users:

Figure 10: Net additions of UBA, VDSL and Fibre connections to Chorus



Source: Chorus Institutional Investor Briefing, 21 May 2014

This graph tends to indicate that VDSL is preferred by consumers compared to fibre. However, when compared to the coverage of each network (VDSL was available to 60% of Chorus's lines, i.e. 1,050,000 lines and fibre is available to 228,000 at the end of March 2014), fibre penetration is 15% (35,000/228,000) while VDSL penetration is 10% (110,000/1,050,000)[73]. And the ratio of 15% has been achieved relatively quickly.

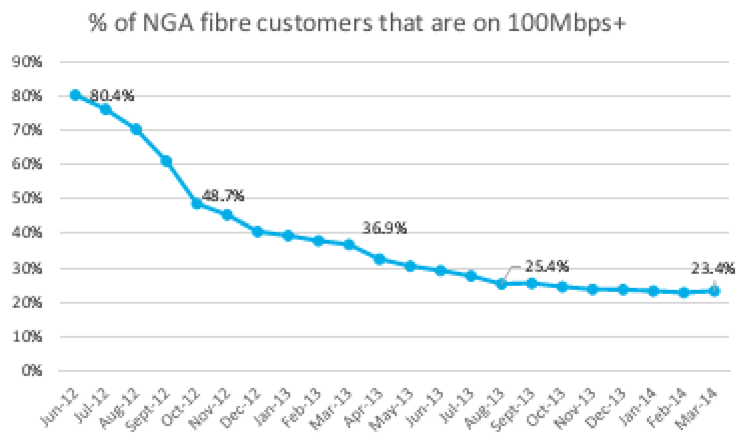
[71] Commerce Commission. Annual Telecommunications Monitoring Report 2013. Telecommunications monitoring report. May 2014.

[72] Chorus Institutional Investor Briefing, 21 May 2014; Outline of UFB agreement between Chorus and Crown Fibre Holdings.

[73] Chorus Institutional Investor Briefing, 21 May 2014; Outline of UFB agreement between Chorus and Crown Fibre Holdings.

In addition, as new services develop, consumers' demand for higher broadband speed will likely increase, and their demand for FTTH services will likely increase in consequence. However, today only a minor proportion of consumers are ready to pay for very high-speed services: the percentage of FTTH customers that are adopting 100 Mbps plans is stabilising at around 23%, as shown on the graph below:

Figure 11: Proportion of FTTH customers that have adopted 100 Mbps+



Source: Chorus Institutional Investor Briefing, 21 May 2014

In addition to the data on adoption of technologies by consumers that has been studied above, data on retail prices may also reflect consumers' preferences for one or another technology.

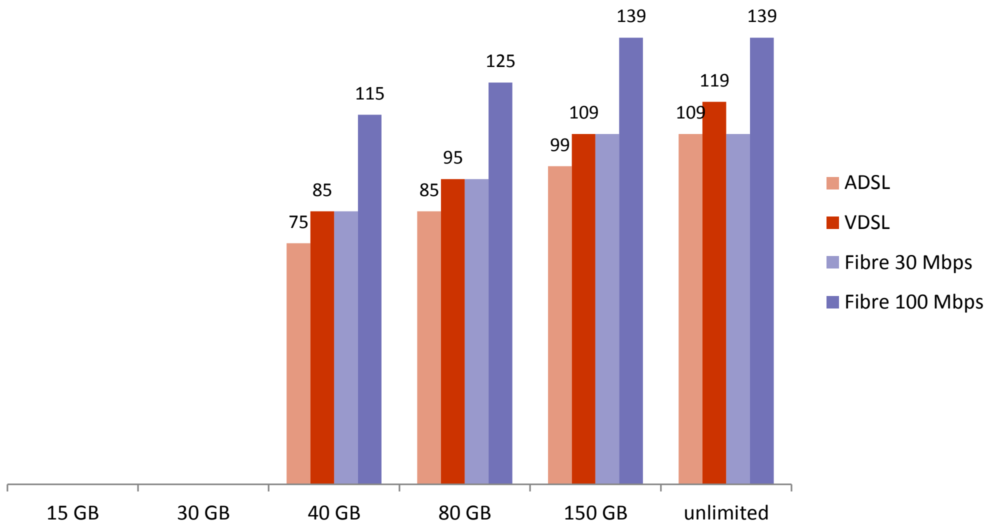
Figure 12 below compares retail offers with the same data allowance proposed on the New Zealand market.[74] Prices vary both with the technology and download speed: FTTH and HFC services provide several speed options. The price of copper/FTTN-based services varies between $75 and $115 per month, of FTTH – between $85 and $165, of HFC – between $85 and $135. Prices of high-speed FTTH offers are 17% to 70% more expensive than copper/FTTN-based services. However, 30 Mbps FTTH offers are at the same level as copper/FTTN-based offers and may even be less expensive than VDSL offers. Vodafone's HFC offers are at the same price level as their FTTH offers, with the exception of the 200 Mbps FTTH which is more expensive. End-users are therefore often paying a premium to get FTTH or HFC instead of copper/FTTN, which suggests that these two technologies may be a suitable MEA for copper.

FWA service is at similar levels to VDSL but provides a much lower data allowance. It should be noted that FWA price is not directly comparable to VDSL, fibre and HFC services since customers in FWA areas often have no access to these other technologies.

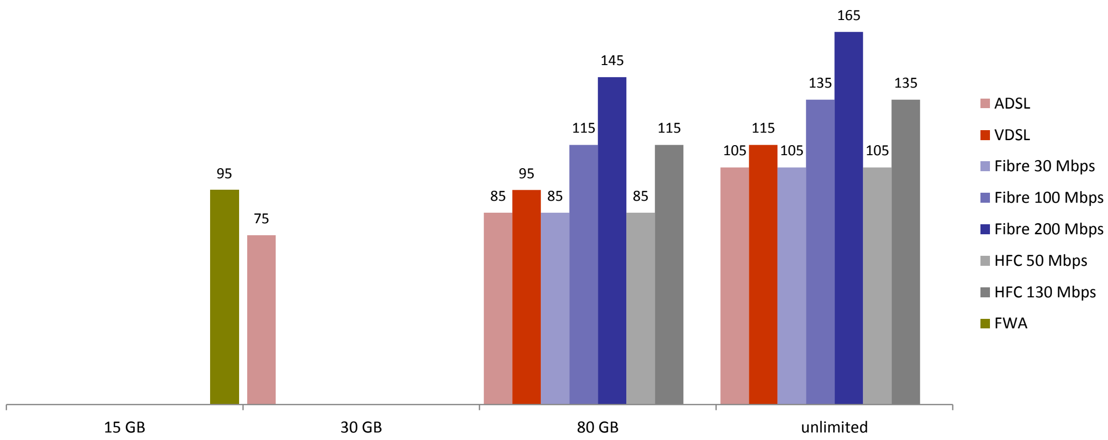
[74] It does not take into account any short-term commercial discounts and special offers of operators.

Figure 12: Monthly retail price of broadband access by data allowance, $/month

Telecom



Vodafone



Source: operators' web pages 14 of June 2014, TERA Consultants

However, the subscriber and retail price factor is less relevant for defining the MEA than technological, cost and operator strategy factors. In fact, number of subscriptions and retail price level do not necessarily reflect users' preferences towards one or another technology.

First, retail price depends on the copper/FTTN wholesale access prices, which are being reviewed below.

Second, retail prices may depend on operators' pricing strategies at a given point in time, which do not necessarily reflect underlying costs and long-term market evolution.

Third, customers' subscription decisions depend crucially on the retail price.

Fourth, the comparison of monthly retail prices is not sufficient to clearly measure the willingness of end-users to pay a premium for fibre offers. The retail price premium is not the only price premium paid by end-users for a new technology: they also bear switching costs. Indeed, many end-users already have a copper/FTTN connection and in most cases switching to FTTH or HFC includes significant set-up charges as well as the inconvenience of switching supplier and having FTTH installed. According to estimates by Telecom, the costs of migration from copper/FTTN to FTTH are significant.[75]

Analysis of the subscriber and retail prices leads to the following conclusions. The FTTH take-up rate suggests that FTTH may be a suitable MEA for copper as subscribers are more and more requiring the capabilities offered by FTTH. Retail prices suggest that both FTTH and HFC may be suitable MEAs for copper as users are often ready to pay more for services provided via these technologies. However, the subscriber and retail price is less relevant than technological performance, cost and operator strategy: in fact, the number of subscriptions and retail price levels do not necessarily reflect users' preferences towards one or another technology.

3.1.1 Conclusion

For the vast majority of factors, this analysis supports FTTH as the MEA of copper in more dense areas while FWA as the MEA in less dense areas (see summary in Table 6).

The table below summarises the comparison of technologies based on four factors:

Table 6: Comparison of different technologies based on four factors

Factor	Copper/FTTN	FTTH	FWA	HFC	Mobile
Technological performance	-	++	-	++	-
Cost	+	+	++	+	++
Subscriber and retail price	+	++	+	++	+
Operator strategy	--	++ (outside remote areas) -- (inside remote areas)	-- (outside remote areas) ++ (inside remote areas)	+	+

Source: TERA Consultants

[75] See Figure 3 of Telecom report to the Minister Of Communications And Information Technology regarding product and technical issues relating to "Primary Line Voice" services. 31 March 2011.

As a conclusion, FTTH should be the MEA for copper but in more remote areas where its cost is too prohibitive for it to be the MEA FWA should be the MEA, even though FWA is not a point-point technology.

With respect to FTTH, there are two main network architectures: PtP and GPON. It is recommended to choose FTTH PtP, since this architecture is delivering dedicated capacity to the end-users and the difference in costs compared to GPON is unlikely to be significant.

The cost difference therefore justifies both the choice of FTTH PtP over FTTH GPON and the choice of FWA over FTTH in rural areas.

It is also necessary to define the areas where FTTH and FWA are respectively the MEA for copper/FTTN. Because MEA is defined on the basis of the technology which a new operator deploying a network today would choose (see section 2.5), it is relevant to consider the planned coverage for UFB and RBI. FTTH will cover about 75% of population, corresponding to the UFB planned footprint, while the RBI is intended to will deliver broadband to 252,000[76] rural households. A large part of the households covered under the RBI will be covered by Chorus extending its existing fibre network and thereby deploying FTTN in the rural areas. The very rural areas where Chorus is not deploying FTTN will be covered by Vodafone deploying FWA. In these areas, the cost of rolling out fibre is so high that an efficient operator would not build an FTTH network there. Therefore, the definition of the MEA suggests that FTTH is not the MEA in these areas where FWA is being deployed, even though it is a superior technology in terms of broadband speed because it is not economically rational.

The areas where FWA is the MEA should correspond to the planned footprint of this technology. It therefore includes the RBI areas where Vodafone is building its FWA network, based on the operator strategy factor.

The number of end users that can receive FWA service from a single site is small (15 from a 3G site, maybe up to 100 from a 4G site). In most cases this will be a small proportion of the total number of premises within the FWA footprint. By identifying the least density end-users (i.e. those most expensive to service via FTTH), and making them FWA end-users, we can make the most effective use of the FWA technology. The remaining end users will be fed by the FTTH network.

A combination of fibre and FWA as MEA has been used in Sweden. PTS, the Swedish national regulatory authority, explains:

> *"The access network in the bottom-up model should be modelled using a fibre access network as the appropriate modern technology. However, radio may be modelled as suitable modern technology where this is cost effective."*[77]

[76] Ministry of Business, Innovation and Employment: http://www.med.govt.nz/sectors-industries/technology-communication/fast-broadband/rural-broadband-initiative

[77] PTS, Draft Model Reference Paper, Guidelines for the LRIC bottom-up and top-down models, (§12.2.2).

To justify this choice, PTS indicates that:

- Fibre is an efficient choice considering the capacity demand in the future (demand criterion);
- Fibre roll-out is observed on a large scale in Sweden whereas new deployment of copper is almost non-existent (operator strategy criterion);
- Fibre is the new infrastructure which an operator would choose to deploy in Sweden (operator strategy criterion).

PTS also considers that the wireless infrastructure should be the MEA to replace copper in low density areas where only voice or low capacity leased lines[78] are provided and where high speed services are unlikely to be offered in the foreseeable future.

The views of submitters are summarised in the table below. Telecom and Vodafone share the opinion that a combination of FTTH and FWA is the relevant MEA. Chorus, based on the report by Analysys Mason, conclude that UCLL MEA is copper.

Table 7: Views of the interested parties concerning the UCLL MEA in response the Commission's consultation paper of December 2013

Respondent	Respondent's opinion	Respondent's arguments	Quotes
Chorus[79]	UCLL MEA is copper	Copper is the only technology delivering the full UCLL functionality. The full functionality may be provided through FTTH only by making an additional investment.	"Chorus' copper network is an MEA candidate. As explained in this submission, copper is the only technology capable of delivering the full functionality of the UCLL STD service." "The shortcomings of the all-fibre options can be addressed by various "fixes" at the customer and/or RSP end. However these by their nature mean that the all-fibre technologies do not have the same functionality as the UCLL STD service. Further, these fixes are expensive, disruptive and raise operational difficulties."

[78] Low capacity leased lines means leased lines which are not capable of supporting MEA-like performances.

[79] Chorus "Submission in response to the Commerce Commission's Process and issues paper for determining a TSLRIC price for Chorus' unbundled copper local loop service in accordance with the Final Pricing Principle" 14 February 2014, paragraph 238-243.

Telecom[80]	UCLL MEA is a combination of FTTH and FWA	Reflects current deployment	"We understand there to be general agreement among network engineers that no hypothetical new network built today would be a copper network."
Vodafone[81]	UCLL MEA is a combination of FTTH and FWA	Reflects current deployment	"An MEA based on fibre (GPON or P2P) and FWA should be preferred." "Notably, as identified above, this approach mirrors ongoing network investment through the UFB and RBI programmes."
Analysys Mason (engaged by Chorus)[82]	UCLL MEA is copper	Other technologies do not provide all the functionalities of the copper network without extra cost and cannot use the same customer premises equipment (except for FTTN). FTTH-PtP is likely to be more expensive than copper accounting for the extra cost to provide the full functionality of copper. FTTN is irrelevant since UCLL is not available on lines served with FTTN.	"Our conclusions are that: Copper meets all the criteria. FTTH P2P meets most of the criteria, other than: the ability to provide voice services during a power cut <…>, which could be remedied by battery back-up; the use of existing voice CPE [customer premises equipment], which could be remedied by use of an ATA; the use of existing broadband CPE (DSL modems) is not possible using FTTH; provision of the required fax and low-speed data services may be restricted even if an ATA can be provided <…>. FTTC is irrelevant if costing NCUCLL; while UCLL is not available on loops served with FTTC, a combination of sub-loop UCLL and sub-loop extension service (where available) would be almost equivalent and meets all the criteria. Other options including wireless and FTTH PON fail to meet many of the criteria."

Source: Submissions in response to the consultation

As a consequence, most respondents agree except Chorus and its consultants who mainly highlight the fact that not all functionalities are available over FTTH. This has already been discussed in section 2.4.

[80] Telecom "Submission on Process and issues paper for determining a TSLRIC UCLL" 14 February 2014, p. 41.

[81] Vodafone New Zealand Limited "Comments on process and issues paper for the unbundled copper local loop (UCLL) final pricing principle" 14 February 2014, paragraph E3.6-E3.7.

[82] Analysys Mason "Report for Chorus - Response to Commission" 12 February 2014, pp. 27-28.

This analysis shows that outside remote areas, FTTH PtP technology is the most suitable as MEA for copper/FTTN: it gives the best value according to technological performance, subscriber and retail price and operator strategy. Even if FTTH does not necessarily offer the same functionalities as copper/FTTN, we explained in section 2.4 that the MEA technology should share the same core functionality as the regulated service but not necessarily share the same technological features. However, in remote areas, where the network cost is very high and therefore the cost factor becomes the main one, FWA should be preferred to FTTH. This technology, compared to FTTH, copper/FTTN or HFC, leads to reasonable cost levels.

3.2 Adjustments to the modelled UCLL MEA

An adjustment may be made to the MEA technology in order to reflect that the modelled technology is different from the current regulated copper technology.

Such adjustment is recommended by the European Commission in its recent recommendation. [83]

Some national regulatory authorities, for example the Danish Regulatory Authority, explain the need for such an adjustment.

> *"The MEA is the asset that can produce the stream of services produced by the existing asset at lowest cost. Where the operating cost or other performance characteristics of the MEA differ from the existing asset, **these should be reflected in the asset valuation**."*[84]

Three possible adjustments have been identified at this stage to set the price of UCLL:

- Adjustment based on consumer preference (see section 3.2.1);
- Adjustment based on technologies and performances (see section 3.2.2);
- Adjustment based on costs (see section 3.2.3).

These potential adjustments were considered by the Commission in its Process and issues paper for determining a TSLRIC price for Chorus' unbundled copper local loop service in accordance with the Final Pricing Principle of December 2013[85] as well as by the Danish Regulatory Authority in 2013[86].

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[83] European Commission Recommendation of 11 September 2013 on consistent non-discrimination obligations and costing methodologies to promote competition and enhance the broadband investment environment.

[84] Source: National IT and Telecom Agency (NITA) Model reference paper dated 18 September 2008, p. 27.

[85] Commerce Commission, "Process and issues paper for determining a TSLRIC price for Chorus' unbundled copper local loop service in accordance with the Final Pricing Principle", 6 December 2013.

[86] DBA, Model reference paper, 2013.

The aim of these adjustments is to alter the FTTH and FWA price in order to set the regulated price of copper/FTTN to reflect the different capabilities of copper/FTTN. All these adjustments will be analysed below based on our understanding of the Commission's framework.

3.2.1 Adjustment based on consumer preference

An adjustment based on consumer preference is an adjustment based on the customers' point of view. Once customers' willingness to pay extra for FTTH/FWA is known, it is possible to establish copper prices by applying a discount on FTTH/FWA prices.

For illustrative purposes, if customers are willing to pay $5 per month to change their copper subscriptions into an FTTH subscription (because FTTH offers greater capabilities), and if FTTH price is $30 per month, then the copper price would be $25 per month. A key issue here is the methodology used to assess this willingness to pay. Appropriate questions need to be asked to consumers to assess such a level. The Commission's demand side study suggests that New Zealand broadband subscribers are highly price sensitive. Most respondents surveyed would not be willing to pay more than an additional NZ$5-10 per month for fibre-based services.[87]

It is to be noted that this adjustment methodology does not disadvantage the migration towards FTTH/FWA from a customer point of view, even though UCLL prices are lower than FTTH/FWA costs. As end-users accept paying more for FTTH/FWA and the differential between copper and FTTH/FWA prices reflects the higher price they are willing to pay, then end-users will neither be encouraged nor discouraged from migrating to FTTH/FWA.

As prices are based on FTTH/FWA, it could be argued that long-term efficient costs are properly recovered and incentives to invest in FTTH/FWA are present.

This methodology has drawbacks however. In particular, it is likely to be difficult to calculate consumer willingness precisely and the willingness to pay extra for FTTH/FWA is likely to change over time and depend on the types of services being provided over these networks. Also, prices may not encourage investment in the most cost-efficient technology as the price differential between copper/FTTN and FTTH/FWA does not represent the difference in costs.

In addition, price is not the only factor that determines the choice of copper/FTTN or FTTH at the retail level, it also depends on content and services available on the network.

For all these reasons, it appears that it is not practical to use this specific type of adjustment in New Zealand.

[87] Commerce Commission New Zealand, "High speed broadband services demand side study", 9 February 2012. Available at http://www.comcom.govt.nz/assets/Telecommunications/Studies/UFB-Demand-Side/High-speed-broadband-issues-paper-3-Content-and-willingness-to-pay-9-February-2012.nrl.pdf

3.2.2 Adjustment based on technological performances

The adjustment based on technologies is an adjustment based on the different capabilities of the different technologies. Under this methodology the price of copper/FTTN is set as a proportion of the FTTH/FWA price, the proportion being calculated as the ratio of copper capacity to FTTH/FWA capacity.

For illustrative purposes, let us consider the following capacities:

- Capacity of copper/FTTN is 50 Mbps (see section 3.1.3.1.1 for more details);
- Capacity of FWA is 21 Mbps (see section 3.1.3.1.5 for more details);
- Capacity of FTTH is 1 Gbps (see section 3.1.3.1.2 for more details).

The ratio to be applied on FTTH prices for copper/FTTN would be therefore 5% (= 50Mbps/1Gbps) and on FWA prices for copper would be 238% (= 50 Mbps/21 Mbps). In FTTH areas, if FTTH price is set to $20 per month then copper price would be set at $1 per month. In FWA areas, if FWA price is set to $10 per month then copper/FTTN price would be set at $23.8 per month. The national price should therefore be calculated as the average weighted by the number of lines in FTTH and FWA areas.

The main drawback of this methodology is that the current price of copper/FTTN would be completely uncorrelated to its associated cost. Indeed, the cost of copper/FTTN is not 20 times lower than FTTH which provides ultra-fast broadband whereas copper/FTTN capacity is limited.

In addition, it can be difficult to define the right level of speed to consider conducting the adjustment (peak speed, guaranteed speed, average speed?).

From a dynamic point of view, capacities improvement can also occur faster than price changes. On top of this, copper/FTTN capacities may still increase due to improvements and lead to price increases which would be inconsistent. For all these reasons, this adjustment methodology has never been used by any NRA and is not proposed to be used in the context of New Zealand.

3.2.3 Adjustment based on costs

An adjustment based on costs is an objective adjustment based on the costs of the different networks. This means that it is first necessary to compute on one side the FTTH/FWA price and on the other side the cost of copper networks. The differential in level of costs enables the Commission to calculate the differential in level of regulated prices. All things being equal (depreciation, asset lives, penetration rate, cost of capital, etc.), the technology having the better cost / performance trade-off will then be preferred by end-users, depending on their willingness to pay. This therefore enables the Commission to be neutral to migration towards NGA from a technological point of view. It also enables the Commission to make sure that efficient investment in infrastructure is incentivised.

3.2.4 Conclusion

Among three possible adjustment approaches (based on consumer preferences, technological performances and costs), a cost adjustment is the most suitable.

If it is decided that an adjustment is needed, it is more relevant to use the adjustment methodology based on costs as detailed in section 3.2.3. Copper prices are then determined by applying to the FTTH/FWA cost the difference with the FTTH/FWA cost.

It is to be noted that this methodology is in line with what is recommended by the European Commission, which recommends calculating copper costs by replacing optical elements with copper elements:

> *"NRAs should adopt a BU LRIC+ costing methodology that estimates the current cost that a hypothetical efficient operator would incur to build a modern efficient network, which is an NGA network."*[88]
>
> *"When determining the access prices of services that are entirely based on copper, NRAs should adjust the cost calculated for the modeled NGA network to reflect the different features of wholesale access services that are based entirely on copper. For this purpose, the NRAs should estimate the cost difference between an access product based on for example FttC/FttH and an access product based entirely on copper by replacing the optical elements with efficiently priced copper elements, where appropriate, in the NGA engineering model."*

The table below summarises the opinions of interested parties with respect to possible adjustment approaches. Cost-based adjustments are considered as the most relevant by Chorus and Vodafone. Telecom suggests adjustments based on willingness to pay.

[88] European Commission Recommendation of 11 September 2013 on consistent non-discrimination obligations and costing methodologies to promote competition and enhance the broadband investment environment.

Table 8: Views of the interested parties concerning the need for adjustments in response the Commission's consultation paper of December 2013

Respondent	Respondent's opinion	Respondent's arguments	Quotes
Chorus[89]	Cost-based adjustment is the only acceptable option	Adjustment based on technological capabilities is irrelevant since it does not reflect costs and lead to unpredictable prices due to constant technological changes. Adjustments based on willingness to pay are irrelevant since they do not reflect costs and willingness to pay of the wholesale market is more difficult to measure than on the retail market. In addition, it is likely to deter efficient investment.	"The only adjustment option that can be considered is one based on cost. This follows from the fact that the requirement in the Act is TSLRIC, which is a measure of cost. Neither technical performance differences nor willingness to pay are relevant to the TSLRIC cost of delivering the UCLL STD service." "The problems with an adjustment based on technical capabilities are twofold. It will lead to prices that do not reflect costs <…>. Technological improvements are a moving feast, so prices based on these will move over time in an unpredictable way. This is not good for encouraging investment." "Adjustments based on willingness to pay are equally problematic. First, such approaches are inconsistent with the requirement of the Act for a forward-looking TSLRIC approach to the FPP as they are based on value rather than based on cost <…>. Second, there are issues about how the additional value of fibre might be measured on a forward-looking basis. The thinking on this issue to date has revolved around the WTP of retail customers. However Chorus does not deal with retail customers, only RSPs. Hence any measurement would need to be of RSP willingness to pay which is more difficult to measure in an unbiased way and which may change over time. Third, <…> value-based adjustments are likely to deter efficient investment <…> and are unlikely to achieve their design aims."

[89] Chorus "Submission in response to the Commerce Commission's Process and issues paper for determining a TSLRIC price for Chorus' unbundled copper local loop service in accordance with the Final Pricing Principle" 14 February 2014, paragraph 247-257.

Telecom[90]	Adjustments based on willingness to pay are preferable	Technological and competitive neutrality Ease of implementation	"<…> the potential adjustment options involve taking account of either/or (a) differences in willingness to pay for different speeds and performance; (b) differences in technical performance (e.g. relative speed or capacity); or (c) differences in cost. a. The key difficulty with the first suggestion is that the New Zealand market generally distinguishes between plans on the basis of data caps rather than different speeds and performance. This parameter can of course be measured by observing, the price differentials that exist between services with different speeds and performance for other countries and seeking to relate it to New Zealand. <…> Key to its validity is success in establishing a link between end-user preferences in New Zealand and the countries for which data is available. In addition it is technologically and competitively neutral as relative fibre and copper access prices will remain as they are now. It does not, however, reflect relative costs. b. The problem with the second suggestion is that relative physical speeds or capacity are not necessarily strongly related to relative willingness to pay. Moreover, relative physical speeds or capacity do not accurately reflect relative costs. A simplistic adjustment based on relative speeds or capacity <…> would mean very low prices for UCLL. These would result in below cost UCLL prices <…>. c. As regards (c), relative prices should in principle reflect relative costs. In practice it is not clear how efficient copper network costs would be measured."
Vodafone[91]	Cost-based adjustment is recommended	FTTH MEA is superior to copper assets in terms of efficiency and functionality	"If a fibre MEA is selected, the Commission should calculate the difference in cost between the current and MEA technologies and apply an equivalent adjustment to the MEA cost structure (i.e., the Commission should apply the approach of the Danish regulator and ensure that the lowest cost structure is applied)."

[90] Telecom "Submission on Process and issues paper for determining a TSLRIC UCLL price" 14 February 2014, pp. 44-45.

[91] Vodafone New Zealand Limited "Comments on process and issues paper for the unbundled copper local loop (UCLL) final pricing principle" 14 February 2014, recommendation 20.

Analysys Mason (engaged by Chorus)[92]	No need for adjustments	It is more transparent and accurate to model the copper network directly instead of modelling an FTTC network and then making a cost adjustment. Adjustments based on willingness to pay do not reflect costs and therefore are not TSLRIC. In addition, wiliness to pay will change over time. In addition, LFC FTTH service prices are negotiated with the Government. Such adjustment may also deter investment.	"If a different, more expensive network is modelled, then it is potentially legitimate <…> to adjust the modelled costs so as to proxy the result of a model of the lowest forward-looking cost solution <…>. However, doing so <…> is significantly less transparent and less accurate than modelling the cost of the copper technology directly because: The network might be slightly different. For example, the constraints on the placement of cabinets may be rather different in an FTTC network (the maximum loop length constraint is different for FTTC and copper). Hybrid calibration of a copper network model (i.e. comparison to reality) is much more feasible." "<…> adjustments based on willingness to pay or value generated are not TSLRIC. They are not based on the cost of provision, and they risk under-compensating investors." "the LFC FTTH networks that are being built in New Zealand already offer real fibre services at prices which have been negotiated with the Government (which change over time)."
Frontier Economics (engaged by Vodafone, Telecom and CallPlus)[93]	If FTTH is MEA, an adjustment needs to be made	Services provided through FTTH are superior to those provided through copper and customers who do not benefit from these services should not be required to pay an increased price.	"<…> if the Commission were to pursue a non-copper MEA approach to TSLRIC modelling, it will necessarily have to tackle the issue of how to make reasonable and robust performance adjustment to avoid perverse economic outcomes. If the Commission favours a predominantly fibre MEA, adjusted to take account of the reduced capability of UCLL services, we would expect the resulting prices to be at or below the level of an anchor based approach, i.e. that customers who do not take advantage of the higher capabilities offered by NGA investments should not be required to pay increased prices to cover the costs of investments."

Source: Submissions in response to the consultation

[92] Analysys Mason, "Report for Chorus - Response to Commission", 12 February 2014, pp. 30-32.

[93] Frontier Economics "Determining a TSLRIC price for Chorus' UCLL service - A report prepared for Vodafone New Zealand, Telecom New Zealand and CallPlus" February 2014, p. 25.

Options

As explained by one respondent, adjustments based on willingness to pay and performances do not reflect costs and therefore may not be considered as compliant with TSLRIC. Therefore, the following options are possible:

1. Modelling the copper/FTTN network, which is equivalent to constructing the FTTH/FWA model and then adjusting for costs. Indeed, in theory, adjusting a FTTH/FWA network cost model for cost differences requires identifying each asset of the network and replacing the relevant assets (such as optical elements) with efficiently priced copper/FTTN elements to reflect copper/FTTN costs. In practice, it is more appropriate to do so by developing a full copper/FTTN network cost model. While it could be feasible to adjust each asset price element of a FTTH PtP network to derive the necessary adjustments, this is not possible for FWA which is not a wired network. In both cases, developing a copper/FTTN network enables the Commission to automatically derive the FTTH/FWA adjusted costs.
2. Two alternative models are constructed: the copper/FTTN model and the FTTH/FWA model. If the copper/FTTN cost is found to be lower than the FTTH/FWA cost, the cost adjustment is made so that the UCLL price is equal to the copper/FTTN cost. However, it is possible that the copper/FTTN cost is found to be higher than the FTTH/FWA cost. In this case a cost adjustment would mean that the UCLL price is set above the costs of a new efficient entrant deploying a MEA network. Such result would be inefficient: it would discourage unbundling and may encourage inefficient migration in FTTH and would mean customers would pay more for lower performances. Therefore, if the copper/FTTN cost appears to be higher than FTTH/FWA cost, adjustments are not necessary and the UCLL price is set equal to FTTH/FWA cost. It is to be noted that FWA in remote areas is always cheaper than the copper/FTTN network.
3. Modelling FTTH/FWA without adjustments because FTTH/FWA is supposed to be less expensive than full copper/FTN.

Under the first and third option, the Commission has to decide *ex ante* on whether to make an adjustment or not. Under the second option, the Commission decides *ex post* depending on the results of the model. This option gives more transparency but is more complex. Practically, constructing two models is more resource-consuming: engineering rules, unit prices, network dimensioning etc. are not the same in the copper network and in the FTTH/FWA network.

Recommendation

It is recommended to complete the 2nd approach as it will provide more transparency and does not require ex ante assumptions that may be wrong. This is consistent with what we understand from the Commission's framework which is described in its paper:

- Promote competition for the long-term benefits of end-users as it is based on technologies which are effectively deployed in New Zealand;
- Promote efficiencies by selecting the most efficient technology;
- Is consistent with the definition of TSLRIC and "forward-looking"; and
- Is consistent with the UCLL definition.

It should be noted that since the FTTH networks are under construction in New Zealand under the UFB plan, it is difficult to predict the boundaries of the coverage area of each ODF. Therefore, in absence of such information, we consider that the best approach is to model the FTTH network assuming that the boundaries of each ODF in a FTTH network would be similar to the boundaries of each MDF in the copper/FTTN network. This will solve this practical issue.

3.3 Key modelling choices

3.3.1 Presentation of key choices

When constructing a cost model, the following key modelling choices[94] need to be made at the same time as the choice of MEA:

- cost standard: bottom-up or top-down
  - for re-usable assets,
  - for new assets;
- level of demand;
- depreciation method
  - for re-usable assets,
  - for new assets.

Sections below explain the scope of the modelling choices and the likely impact of these choices on the market. The choice may differ for two types of assets: new assets and reusable civil engineering assets. In fact, some legacy civil engineering assets that are used for the copper/FTTN network can be reused to accommodate the MEA network. They include

- Chorus's assets:
  - Chorus' ducts and trenches that have spare space;
  - Chorus' poles (however, the reuse capacity is limited because of weight constraints, and the percentage of poles that can bear additional cables may be low);
- Third party assets:
  - poles of the electricity network (the percentage of electricity poles that can bear telecommunications cables is generally quite high because electricity poles tend to be more robust);
  - ducts and trenches of the electricity network;
  - the sewage network;
- Other operators' assets:
  - ducts and trenches of the alternative players (e.g. Vodafone's ducts in areas where it has its own local loop, if its network is ducted and room is available).

All the other assets need to be constructed for a new network, in particular optical fibres need to be laid.

For example, according to Chorus, it is going to re-use copper/FTTN ducts when constructing their FTTH network, the target reusability rate being 40%. They will also consider using third party ducts. For the aerial network, Chorus considers commercial

[94] These key modelling choices have been selected since they can have significant impact on cost modelling and are not easily changeable once modelling has commenced.

access to poles. The existing poles' usability depends on availability and quality of poles and on the council consent.[95]

3.3.1.1 Cost standard: bottom-up vs top-down

There are two general cost modelling approaches: a top-down approach and a bottom-up approach.

A top-down model uses data from the operator's accounts, identifies cost items relevant to different services and how common costs should be allocated to each service.

A bottom-up model rebuilds a network of a hypothetical efficient operator based on current asset prices and current technologies. The network is dimensioned to serve the demand of the entire market.

Developing a bottom-up model includes three steps:

1. Identifying relevant services by gathering demand data,
2. Calculating the number and type of network elements necessary to serve the demand, including cables.
3. Valuating each network element, calculating annual costs and costs per unit of service.

Table 9: The main advantages and disadvantages of top-down and bottom-up models

Approach	Advantages	Disadvantages
Top-down	• Regulated operator has incentives to invest. • Easier to implement.	• Limited scope for efficiency adjustments. • More difficult to provide forward-looking cost estimates. • Difficult or even impossible to publish transparently due to confidentiality issues The data may be out of date, historic data is used. • More difficult to obtain results by geographic areas.
Bottom-up	• Correct build-or-buy signal. • Easier to deal with inefficiencies. • More accurate predictions of costs over time. • Less confidentiality issues. • Possibility to estimate the cost of a network yet to be built (such as FTTH)	• The efficiency level of the modelled hypothetical operator may be difficult to achieve, some cost categories may be over-optimised or omitted. • Opex are difficult to measure. • More difficult to implement.

[95] Chorus Institutional Investor Briefing 21 May 2014.

	• Flexible to changing parameters. • May more easily provide results by geographic area.	

Source: TERA Consultants

Therefore, a bottom-up model is the most relevant where a build-or-buy signal needs to be sent, and the replication of assets is a desired outcome. It is also particularly relevant when forward-looking estimates are made. The top-down approach is the best option where the exact cost-recovery by the incumbent is the main objective.

For new assets, the bottom-up approach is the most suitable approach. Because the chosen approach must be forward-looking, the bottom-up cost standard is the most suitable approach to model those assets that should be rebuilt.

For re-usable assets, our recommendation depends on the type of the asset.

For third parties' assets (like electricity poles), we do not recommend using a bottom-up replacement cost, but instead using the price of access to these assets that can be charged, for example, by the electricity company. In fact, an efficient operator would not rebuild these assets but would prefer to rent access to them. It is clear from FTTH deployment around the world that such a practice is common.

The situation is different for reusable civil engineering assets belonging to Chorus. In fact, today in New Zealand there is not regulated access to Chorus civil engineering assets. Therefore, a new operator different from Chorus may not be able to use Chorus' assets. In addition, parts of these assets are not reusable. These assets should be valued by the replacement cost. Such approach is the most forward-looking.

It should be noted that an alternative approach would be to use the top-down approach for Chorus re-usable assets. It is in line with recommendations of the European Commission[96] and the European regulatory experience trends. In fact, the duplication of these assets, which have a relatively long lifetime and which require significant investment, is often not desirable and should be avoided. A bottom-up approach would reward the incumbent for investments that it will never make. In line with the definition of MEA, an efficient network operator that would build a new network today is likely to request access to the incumbent's civil engineering. However, it is important to note that in Europe, where such an approach is followed, duct access is often mandatory, which is not the case in New Zealand.

Valuing ducts on a replacement cost basis (bottom-up basis) may generate over compensation, as argued by some respondents. However, this issue is not directly relevant in the New Zealand context since prices should be set on the basis of forward looking TSLRIC costs. Also, one way to avoid this issue is to apply sufficiently long and realistic asset lives for these assets.

[96] European Commission Recommendation of 11 September 2013 on consistent non-discrimination obligations and costing methodologies to promote competition and enhance the broadband investment environment.

The table below summarises the responses from submissions to the December 2013 Consultation. Telecom, Vodafone and Frontier Economics suggest that Chorus' reusable civil engineering assets should be valued by taking into account the past depreciation. Chorus and Analysis Mason are in favour of valuing these assets based on their replacement costs. All submitters confirmed that sharing assets with other utilities, such as the electricity network, is possible.

Table 10: Views of the interested parties concerning the valuation of reusable assets in response the Commission's consultation paper of December 2013

Respondent	Respondent's opinion	Respondent's arguments	Quotes
Chorus[97]	Chorus' civil engineering assets should be modelled at replacement cost. Assets shared with other utilities should be valued by their access market price or by modelling their costs.	The replacement cost approach is consistent with the forward-looking definition. Shared assets can only be modelled where spare capacity is available and not prohibited by regulation.	"The requirement for forward-looking costs means that the unit costs of building the network which are incorporated into the model should reflect the current costs of that deployment. That is, the costs that would be incurred today in digging the trenches, and the current cost of purchasing and laying copper cable." "Where cost sharing would occur, the Commission should derive the appropriate cost to be apportioned to the TSLRIC of the UCLL STD service either: by the market price for sharing those assets, if shown to be robust; or by modelling the cost of those assets and making appropriate sharing assumptions." "the Commission cannot model shared costs where: there is no spare capacity on the other utilities, or there are some other constraints which prevent sharing from occurring (for example, in the case of electricity poles, where a pole would require strengthening before it could facilitate an extra telecommunications line); or local authorities or other bodies and regulations prevent shared facilities from being built."

[97] Chorus "Submission in response to the Commerce Commission's Process and issues paper for determining a TSLRIC price for Chorus' unbundled copper local loop service in accordance with the Final Pricing Principle" 14 February 2014, paragraph 187-196.

Telecom[98]	The cost model should account for cost sharing with other utilities. Re-usable civil engineering assets should be valued on depreciated replacement cost.	An efficient operator would share poles or ducts with other utilities if it were able to do so. The replacement cost approach would lead to windfall gains for Chorus.	"If the operator of that hypothetical new network were able to share infrastructure such as poles (or ducts) with other utilities, it would do so if this would reduce its costs. The TSLRIC model should therefore allow for this." "Frontier further advises that a balancing of the TSLRIC objectives in light of today's environment suggests costs based on an efficient the way to provide network services today, taking in to account the existence and utilisation of existing assets. This means recognising that that large parts of the access network will not duplicated and, resetting the values of these assets, can simply result in revaluation gains for Chorus. Frontier propose a differentiated approach whereby re-used existing assets should be valued at the depreciated optimised replacement cost. We support Frontier's proposed approach."
Vodafone[99]	For reusable civil engineering assets, the age and state of the existing assets should be accounted for.	Avoid over-compensating Chorus	"The Commission should take into account the elapsed economic life of the assets used by Chorus in providing the UCLL service to ensure that those costs are not double-recovered through the TSLRIC model."

[98] Telecom "Submission on Process and issues paper for determining a TSLRIC UCLL price" 14 February 2014, paragraph 9 and 85.

[99] Vodafone New Zealand Limited "Comments on process and issues paper for the unbundled copper local loop (UCLL) final pricing principle" 14 February 2014, recommendation 23.

Analysys Mason (engaged by Chorus)[100]	Cost sharing with other utilities is acceptable only where it is feasible and telecommunications services are bearing a part of fixed costs.	Owners of utilities will accept to share assets only if a part of fixed cost is allocated to telecommunication services.	"Question 15: Is it reasonable for us to account for costs shared with other utilities such as electricity poles? Using such deployment methods in a bottom-up method is acceptable only if such assets exist at the required location and can be used by the hypothetical operator. The feasibility of such sharing may depend on the current rules reflecting the built environment in New Zealand. Patently, there would be little incentive for utilities to allow sharing if the costs of these shared assets were not contributed to by the telecoms network provider e.g. by renting space on the pole; and we would want this cost to be included otherwise the approach is inconsistent (it would be incorrect if the Commission were to assume that some of the infrastructure can be obtained from elsewhere for only incremental cost). Coordination with the pricing approaches of other utility regulators might be needed."
Frontier Economics (engaged by Vodafone, Telecom and CallPlus)[101]	Valuation of re-usable civil engineering assets should reflect accumulated depreciation.	These assets would not be re-built if the FTTH was built today.	"For key assets used to supply the UCLL that would be likely to be re-used if a hypothetical new network was constructed today (such as the ducts and trenches) we consider the following TSLRIC modelling approach is appropriate: Assets should be initially valued at their optimised replacement cost (ORC) using a bottom-up approach. The valuation should then take account of accumulated depreciation, reflecting the average age and total expected life of these assets from Chorus' accounting data or independent engineering studies. This asset base should be fixed and efficient new capital expenditure rolled in at replacement costs. Depreciation should be recovered through the use of a standard (flat) annuity, reflecting an asset in a steady state that will not be bypassed."

Source: Submissions in response to the consultation

<u>Options</u>

3 options can therefore be identified:

[100] Analysys Mason "Report for Chorus - Response to Commission" 12 February 2014, p. 35.

[101] Frontier Economics "Determining a TSLRIC price for Chorus' UCLL service - A report prepared for Vodafone New Zealand, Telecom New Zealand and CallPlus" February 2014, page v.

1. **Re-usable civil engineering assets should be valued on a replacement cost basis.**
2. **Re-usable civil engineering assets should be valued on a top-down basis for Chorus' ducts and on existing access prices for third party assets.**
3. **Re-usable civil engineering assets should be valued on a replacement cost basis for Chorus' ducts but on the existing access prices for third party assets.**

Recommendation

For new assets and civil engineering assets, the bottom up approach is recommended so that the cost of a hypothetical network is calculated (because duct access is not mandated in New Zealand). For reusable utilities civil engineering assets, the access price is used as their valuation.

3.3.1.2 Demand

To calculate the per-customer cost, it is necessary to estimate the relevant level of future end-user demand for the MEA network services. This will determine the number of connections over which the total modelled costs will be spread. To dimension the modelled network, the demand is also needed but the impact is much less significant in access networks because access networks are primarily based on the number of premises to cover (not active customers). This section studies different options with respect to demand assumptions.

It is useful to distinguish between the following telecommunications platforms:

- the legacy copper/FTTN network (excluding non-used lines),
- the MEA network based on FTTH and FWA technologies,
- competing networks, that is to say HFC and mobile.

The total future demand for FTTH and FWA connections depends on the assumptions of FTTH/FWA take-up. The take-up rate is calculated as a proportion of the total broadband minus the demand on competing networks. Three alternative scenarios can be identified:

- slow growing demand corresponds to slow migration from the copper/FTTN network to the FTTH/FWA network, where FTTH/FWA usage reaches high levels (90-95% demand) in a period of about 8 or 10 years (this is similar to DSL take-up in most countries);
- fast growing demand corresponds to fast migration from the copper/FTTN network to the FTTH/FWA network, where FTTH/FWA usage reaches high levels (95-100% demand) in a period of about 3 or 4 years;
- 100% demand for FTTH/FWA corresponds to immediate migration from the copper/FTTN network to the FTTH/FWA network.

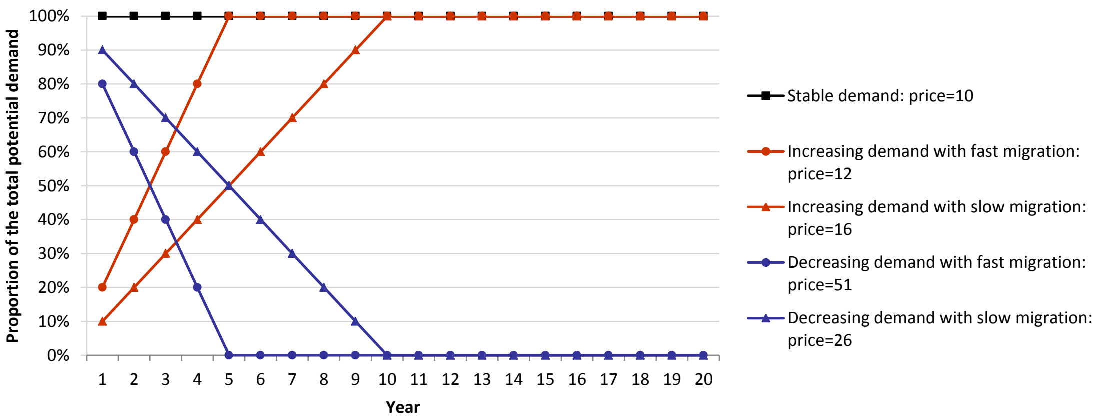
Under a slow growing demand, two parallel networks, copper/FTTN and FTTH/FWA, are operated in parallel over a long time period. This is costly and inefficient. It also leads to a high UCLL price, which discourages alternative operators from using the service. Therefore, this option should be excluded.

Fast growing migration, in its turn, sends greater build over buy signals: when a technology is chosen, migration must be fast to minimize costs and enhance welfare. A quick switch to the MEA network leads to opex savings, faster profitability, and lower costs for end-users.

Finally, 100% demand leads to the lowest UCLL price compared to the other two scenarios, and therefore leads to the most efficient utilisation of assets. In addition, its implementation is the simplest as no assumption needs to be made with respect to exact values of demand for each year.

The figure below shows the impact of the different options on the level of price calculated. The difference between a fast migration option and a 100% demand option is limited to 20% but is much greater than with a slow migration option (+60%). Decreasing demand options are not relevant for a new network being built.

Figure 13: Impact of the demand hypothesis on the UCLL price



Cost of capital = 10%

Source: TERA Consultants

The scenario of 100% is supported by Telecom, Vodafone and Frontier Economics, as shown in the table below. However, it should be noted that the argument for 100% demand that this provides greater stability is not completely true as the economic depreciation can enable to set stable prices (despite relying on a greater number of assumptions). Chorus justifies its choice of decreasing demand option because of the need to guarantee cost recovery but under a TSLRIC forward looking methodology, these are not the incumbent’s actual costs that are calculated but the costs of a new network.

Table 11: Views of the interested parties concerning the demand level in response the Commission's consultation paper of December 2013

Respondent	Respondent's opinion	Respondent's arguments	Quotes
Chorus[102]	Decreasing demand	Demand decreasing due to migration to FTTH and competition with mobile and HFC. Accounting for decreasing demand guarantees cost recovery. Stable prices can still be maintained due to economic depreciation.	"<…> it is not appropriate that demand is constant over time at the current level; demand is likely to decline over time due to competition from alternative fixed access networks (including Vodafone's HFC network and other LFC networks) and mobile substitution. Total demand for fixed connections is slowly falling over time in many countries." "<…> it is not appropriate that end-users who have migrated to Chorus' fibre network should be included in the demand for the UCLL STD service. This approach incorrectly assumes that these end-users are still taking copper services and thereby contributing to the recovery of the forward-looking copper costs. They are not, and their demand is irrelevant to the calculation of the TSLRIC of copper services."
Telecom[103]	100% demand	Stable prices	"Demand, in the UCLL FPP model should be based on all current end-users. If a single efficient next generation access network is modelled as the MEA, then demand shifts from one service to another, and cost allocations for the joint and shared assets move with them, more closely mirroring the effect on prices that would be observable in competitive markets – an outcome more consistent with section 18."

[102] Chorus "Submission in response to the Commerce Commission's Process and issues paper for determining a TSLRIC price for Chorus' unbundled copper local loop service in accordance with the Final Pricing Principle" 14 February 2014, paragraph 200-201.

[103] Telecom "Submission on Process and issues paper for determining a TSLRIC UCLL price" 14 February 2014, p. 34.

Vodafone[104]	100% demand	Stable prices	"We agree with the European Commission's conclusion that modelling a single efficient NGA network for copper and NGA access will neutralise the inflationary volume effect when modelling a copper network, and allows for the progressive transfer of traffic volumes from copper to NGA with deployment of and switching to NGA. As such, we support the principle (and the Commission's apparent view) that demand should be modelled for a single efficient next generation access network that includes end-users that may migrate to Chorus' fibre network."
Analysis Mason (engaged by Chorus)[105]	Decreasing demand	Demand decreasing due to migration to FTTH and competition with mobile	"Total demand for fixed connections has been static in New Zealand and slowly falling for several years in many countries. This is as a result of a number of factors including lower demand for multiple lines (e.g. second phone lines for Internet or for supporting PABX) and competition from wireless services for that subset of customers whose voice and data needs are better met by wireless." "Instead of assuming a constant level of demand, we are arguing for a demand level that is changing over time and an explicit acknowledgement that the technology used will also be changing over time (e.g. a migration from copper to FTTH P2P to WDM PON), which can either be implicit, just reflected in the copper demand dropping to zero over time, or explicit with two network technologies included in the modelling."
Frontier Economics[106]	100% demand	Maintains a stable price and provides incentives to efficiently transition to new technology.	"For <…> assets that will not be re-used, such as loops (copper or fibre), we suggest that these assets are best modelled assuming that the unit costs of these assets also should remain relatively stable. This approach <…> should neither promote nor deter efficient migration <…>.

Source: Submissions in response to the consultation

<u>Options:</u>

2 options are identified:

1 Assuming 100% demand for all assets

[104] Vodafone New Zealand Limited "Comments on process and issues paper for the unbundled copper local loop (UCLL) final pricing principle" 14 February 2014, paragraph D1.2.

[105] Analysys Mason "Report for Chorus - Response to Commission" 12 February 2014, pp. 7-10.

[106] Frontier Economics "Cross-submission on UCLL TSLRIC modelling principles - A report prepared for Vodafone New Zealand, Telecom New Zealand and CallPlus" February 2014, p. 28-29.

2 Assuming a fast growing demand for all assets except Chorus' reusable assets which should be divided by a 100% demand in the migration from copper/FTTN to FTTH

In both cases, the "demand" is the demand for copper/FTTN + FTTH + FWA.

Recommendation

TERA recommends 100% demand to model the number of active lines on the MEA network: this is the most efficient and the simplest in implementation.

3.3.1.3 Depreciation methods

In order to annualize the network investments, a depreciation method should be chosen. The annual payment (annuity) includes a part of an asset's initial price and the corresponding cost of capital. Each asset is depreciated over its useful life.

Annuities related to an investment must verify the following equation to make sure that costs are recovered exactly:

$$I = \sum_{i=1}^{n} \frac{A_i}{(1+w)^i}$$

Where *I* is the investment, *n* is the asset life, *w* is the cost of capital, and A_i is the annuity for the year *i*. This means that the discounted sum of annuities recovers exactly the investment.

Depreciation methods generally used are the following:

- Straight line or linear depreciation (also called HCA, Historic Cost Accounting),
- CCA-OCM (Current Cost Accounting – Operational Capital Maintenance),
- CCA-FCM (Current Cost Accounting – Financial Capital Maintenance),
- standard annuities,
- tilted annuities, and
- economic depreciation.

The following are the main properties of these methods:

- Straight line/HCA depreciation is widespread in statutory accounts, but is not well suited in regulation as it does not take into account the changes in asset prices and does not provide price stability at the time of replacement;
- CCA-OCM is never used in regulation as it does not ensure cost recovery;

- CCA-FCM takes into account changes in asset prices and ensures cost recovery, but is an accounting methodology and does not provide perfect price stability at the time of replacement;
- The standard annuity approach gives an annuity that is stable over time, however, changes in asset prices are not accounted for;
- The tilted annuity approach is the most widespread approach used in electronic communications regulation. The annuities evolve over the asset's lifetime following price trends, meaning that regulated prices derived from this method evolve smoothly over time. Price trends used in tilted annuities are price trends specific to each asset and not CPI. This approach is relatively easy to implement even though it requires assessing price trends, which can be a difficult exercise.
- Economic depreciation is the most robust approach from a theoretical point of view, but is also the most complex one to implement because it requires several assumptions. When both asset prices and the number of customers are changing over time, economic depreciation calculates regulated prices that remain stable over the economic lifetime of assets. The "adjusted tilted annuity" is broadly used as a proxy for economic depreciation[107]; this method adds an additional demand-based adjustment to the tilted annuity approach. However, this "adjusted tilted annuity" assumes a constant increase (or decrease) of the demand which is not necessarily realistic (typically logistic curves are often observed for the demand).

A comparative table of different depreciation methods is presented below.

Table 12: Comparing depreciation methods

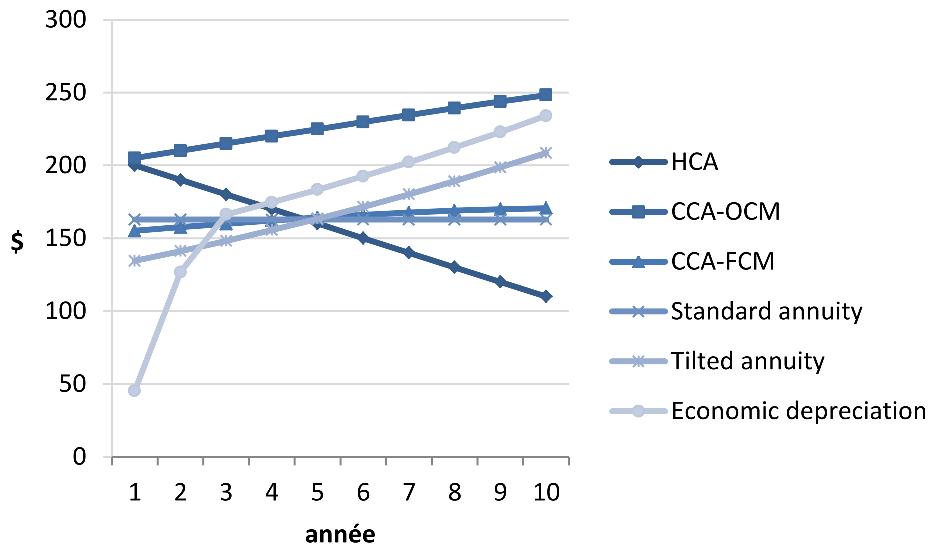
Methodology	Cost recovery	Inclusion of price trend	Evolution of consumer demand	Simplicity of calculation
Linear depreciation/HCA	✓	×	×	Easy
CCA-OCM	×	✓	×	Normal
CCA-FCM	✓	×	×	Normal
Standard annuity	✓	×	×	Normal
Tilted annuity	✓	✓	×	Normal
Economic depreciation	✓	✓	✓	Complex

Source: TERA Consultants

The figure below shows that the depreciation profiles are significantly different depending on the choice of the method. In particular, annuities under economic depreciation are growing with the demand.

[107] See for example Analysis Mason Report for Ofcom. Study of approaches to fixed call origination and termination charge controls. 15 May 2012. Ref: 34541-193.

Figure 14: Comparing depreciation profiles



Assumptions: asset life=10, investment =$1000, cost of capital=10%, price change=5%, fast demand growth
Source: TERA Consultants

In general, tilted standard annuity and economic depreciation are used in bottom-up TSLRIC models. The latter should be preferred when the demand is changing over time. Therefore, economic depreciation is the most suitable approach for the UCLL bottom-up model, assuming fast growing demand (see 3.3.1.2), as it ensures better price stability.

As summarised in the table below, all the operators agree that economic depreciation should be used with changing demand and a simple tilted annuity should be used with a stable demand.

Table 13: Views of the interested parties concerning the depreciation approach in response the Commission's consultation paper of December 2013

Respondent	Respondent's opinion	Respondent's arguments	Quotes
Chorus[108]	Adjusted tilted annuity or another economic depreciation method	Such approach is the most relevant during migration	"The Commission should use an alternative depreciation approach to tilted annuity: **superior approaches include both an "adjusted tilted annuity" approach and also other economic depreciation methods**, as discussed in the attached Analysys Mason Response Paper. As noted in that paper, both "adjusted tilted annuity" (with an additional tilt for demand changes) and simple economic depreciation are superior to tilted annuity if, as here, demand levels are changing over time. And economic depreciation methods are superior to adjusted tilted annuity where there is, as here, the possibility of a future migration to an alternative access technology (for example, fibre)." (emphasis added)
Telecom[109]	Economic depreciation; tilted annuity accounting for the output is acceptable as a proxy	Corresponds to the outcome of a competitive market, accounting for revenues and price trends.	"Telecom is of the view that in general**, economic depreciation would be preferred** to the tilted annuity approach in telecommunications cost models. Economic depreciation is, in effect, the depreciation that a network operator would be expected to recognise in a workably competitive telecommunications market. This approach takes account of expected revenue, operating costs and asset prices and how they change over time, (inflationary and deflationary costs)." (emphasis added) "<…> we agree that **a tilted annuity approach may well provide an acceptable proxy for economic depreciation** if all relevant factors are fully considered. At a high level, at least four crucial factors need to be taken into account when selecting and implementing a depreciation approach under a TSLRIC model; the current cost of the MEA, the forecast MEA cost, the output of the modelled network over the duration of the regulatory period, the best estimate of the economic lifetime of the MEA." (emphasis added)

[108] Chorus "Submission in response to the Commerce Commission's Process and issues paper for determining a TSLRIC price for Chorus' unbundled copper local loop service in accordance with the Final Pricing Principle" 14 February 2014, paragraph 279.

[109] Telecom "Submission on Process and issues paper for determining a TSLRIC UCLL price Submission Commerce Commission" 14 February 2014, pp. 48-49.

Vodafone [110]	Tilted annuity	Tilted annuity is the most relevant for non-reusable assets	"A **titled annuity approach** (using CPI adjustments) **should apply** to assets valued at optimised replacement cost." (emphasis added)
Analysis Mason [111]	Adjusted tilted annuity or economic depreciation	Such approach is the most relevant with changing demand	"We believe **"adjusted tilted annuity"** (with an additional tilt for demand changes) **or economic depreciation are superior to tilted annuity** if, as here, demand levels are changing over time." (emphasis added)
Frontier Economics [112]	Tilted annuity	Economic depreciation is complex, straight line depreciation is front loaded.	"A tilted annuities approach should be used for depreciation" "We do not recommend the use of economic depreciation (due to the complexities involved in implementing the approach) or straight line depreciation (given the tendency to front load allowed revenues). Therefore, **we suggest that the Commission pursue an annuity approach to depreciation**." (emphasis added)

Source: Submissions in response to the consultation

<u>**Options**</u>

The choice between economic depreciation and tilted annuity depends on the chosen demand scenario.

<u>**Recommendation**</u>

If the "100% demand" scenario, as recommended, is accepted then TERA recommends the tilted annuity approach, which takes into account price trends but not the demand evolution.

3.3.2 Conclusion

This section summarizes recommendations with respect to UCLL costing and presents the main regulatory options. They are presented in the table below:

[110] Vodafone "Comments on process and issues paper for the unbundled copper local loop (UCLL) final pricing principle" 14 February 2014, recommendation 25.

[111] Analysys Mason "Report for Chorus - Response to Commission" 12 February 2014, p. 34.

[112] Frontier Economics "Determining a TSLRIC price for Chorus' UCLL service - A report prepared for Vodafone New Zealand, Telecom New Zealand and CallPlus" February 2014, p. 41.

Table 14: Key choices of UCLL modelling

	Cost standard		MEA adjustment	Demand	Depreciation method	
Type of assets	**New assets**	**Reusable assets**	**New assets**	**New assets and reusable assets**	**New assets**	**Reusable assets**
Available options	Bottom-up Top-down	Bottom-up Top-down Market price of access	No adjustment Adjustment for cost difference with copper/FTTN (= copper/FTTN) Adjustment for cost difference with copper/FTTN except if copper/FTTN is more expensive	Fast growing demand Slow growing demand 100% demand	Straight line depreciation CCA-OCM CCA-FCM Standard annuities Tilted annuities Economic depreciation	Straight line depreciation CCA-OCM CCA-FCM Standard annuities Tilted annuities Economic depreciation
Recommended options	Bottom-up	Market price of access for utilities Bottom-up for Chorus civil engineering	Adjustment for cost difference with copper/FTTN (= copper/FTTN) Adjustment for cost difference with copper/FTTN except if copper/FTTN is more expensive	100% demand	Tilted annuities	Tilted annuities

Source: TERA Consultants

Among the available options some will not be considered further:

- The top-down methodology cannot be used for non-re-usable assets as it is not forward looking;
- The top-down methodology cannot be used for Chorus' reusable assets as it is not forward looking and duct access is not mandated in New Zealand;
- Accounting depreciation methodologies do not provide appropriate build or buy signals, and therefore only tilted annuities and economic depreciation can be relevant (standard annuities are inferior to tilted annuities);
- Slow growing demand would not provide efficient signals and would generate access prices that are too high.

As a consequence, only a few relevant combinations are relevant:

- Option 1: bottom-up for new assets – bottom-up for reusable assets, except third party assets (valued at market access price) – 100% with tilted annuities – Copper/FTTN is modelled only
- Option 2: bottom-up for new assets – bottom-up for reusable assets, except third party assets (valued at market access price) – fast growing demand with economic depreciation (except for reusable assets) – Copper/FTTN is modelled only
- Option 3: bottom-up for new assets – bottom-up for reusable assets, except third party assets (valued at market access price) – 100% with tilted annuities – Copper/FTTN and FTTH/FWA are modelled
- Option 4: bottom-up for new assets – bottom-up for reusable assets, except third party assets (valued at market access price) – fast growing demand with economic depreciation (except for reusable assets) – Copper/FTTN and FTTH/FWA are modelled

Recommendation

In light of the recommendations above, that it is not possible to know *ex ante* which technology is cheaper, and to ensure efficient use of infrastructure in a migration period, option 3 is recommended.

This approach promotes efficiency as it consists of selecting the most efficient technology to set UCLL prices and to ensure efficient migration. Also, this approach promotes competition by ensuring that access prices will not be too high (contrary to fast/slow growing demand scenarios) but are representative of the costs faced by an efficient new operator (which can buy access to third party networks but not Chorus' ducts). This approach is consistent with the definitions of UCLL, TSLRIC and "forward looking". Also, the 100% demand assumption and the choice of the tilted annuity provide more predictability.

4 UBA modelling elements

This section deals with UBA. As explained in 2.3, it should hold that the UBA price is equal to the UCLL price plus the relevant core network elements costs:

**UBA price (often called "Full UBA price" in New Zealand) =
UCLL price + core network UBA costs.**

Since the UCLL price has already been discussed in 3, this section deals with the core network component of the UBA price. It discusses the best choice of MEA technology (see section 4.1), compares possible modelling scenarios of economies of scale and geographical scope (see section 4.2), and defines services to be modelled (see section 4.3).

4.1 What is the MEA for UBA?

This section deals with the choice of MEA for UBA.

4.1.1 Eligible technologies for UBA MEA

The following criteria are appropriate for identifying the eligible technologies for the MEA of UBA:

- Network; the UBA Service must be capable of working over Chorus' existing input infrastructure; and
- Services; the UBA Service must be able to provide voice services and broadband as the two primary services.

Two technological choices need to be made, with respect to the access network and the core network:

- For the access network, the same technological options as for the UCLL service are eligible for UBA MEA (see 3.1.1).
- For the core network, two technologies meet the eligibility criteria: Ethernet and ATM (Asynchronous Transfer Mode) protocols. ATM uses asynchronous time-division multiplexing, and encodes data into small, fixed-sized packets called cells. This differs from Ethernet that use variable sized packets and frames.

4.1.2 Choice of MEA among eligible technologies

In this section, the technologies that meet the eligibility criteria are assessed and discussed:

- For the access network, given the Commission's view that by definition the UBA is provided only on the copper/FTTN network and considering the UBA FPP, copper/FTTN is recommended as the MEA for UBA. If FTTH was the MEA for example, the level of demand on the network to be modelled would be inconsistent with the actual level of economies of scale experienced by operators in New Zealand because the network would support the traffic of ultra-fast broadband only customers. This would therefore not provide a good signal in terms of price setting. This issue is less relevant in the access network since access network costs (and access prices) do not directly depend on the level of traffic supported.

- For the core network, Ethernet is a modern technology with a higher speed than ATM. It is the technology used today by operators all over the world, including New Zealand, where it is used by Chorus.[113] Therefore, Ethernet is the most relevant as a UBA MEA in the forward-looking context: it is the technology that would be used by any new entrant. It is to be noted that this is widely used in bottom-up TSLRIC models developed by regulatory authorities across the world (France, Denmark, Sweden, Ireland, etc.).

Recommendation

The MEA for UBA is the copper/FTTN access network architecture with an NGN Ethernet core network to support broadband.

4.2 What UBA scenario? Size of the modelled operator and geographic scope

This section summarises conclusions of possible UBA scenarios analysis. A detailed analysis is proposed in the annex, section 7.2.

Compared to other countries, New Zealand's regulatory framework has a number of characteristics. First, Chorus is structurally separated from Telecom and provides only special wholesale services. Second, the price for UBA service has to be nationally averaged.

Cost standard

As explained in 3.3.1.1, a choice needs to be made between the two general modelling choices: the bottom-up approach, where a hypothetical operator's costs are modelled, and the top-down approach, where cost estimation is based on the incumbent's accounts. For the UBA service, the bottom-up approach should be preferred since it is a forward-looking approach that best reflects the costs of a new entrant.

Size of the modelled operator

It is necessary to make an assumption on the potential number of customers served by the modelled operator in order to dimension the network and define economies of scale. In fact, since the core network equipment is shared between customers, their number has a crucial impact on the per-customer cost. There are two different assumptions that can be made:

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[113] http://www.chorus.co.nz/euba

- The modelled operator has the same economies of scale as the incumbent, Chorus.
- The modelled operator is an alternative operator with a smaller number of customers than Chorus, so that the cost base is distributed among a smaller number of customers and economies of scale are less significant.

Geographic scope

The core network price may be set equal to either the national average cost, or to the cost value in a limited geographic area. For our purposes, the national territory may be divided, depending on the access service used, into two types of areas where:

- UCLL is likely to be used by alternative operators,
- UBA is likely to be used by alternative operators (UBA footprint and areas where UBA is likely to be used in the future) because UCLL is not economically viable.

Figure 15 below traces for illustrative purposes only per-customer core network cost under two alternative assumptions: demand of Chorus and demand of an alternative operator. The per-customer core network cost increases as the MDF size decreases.

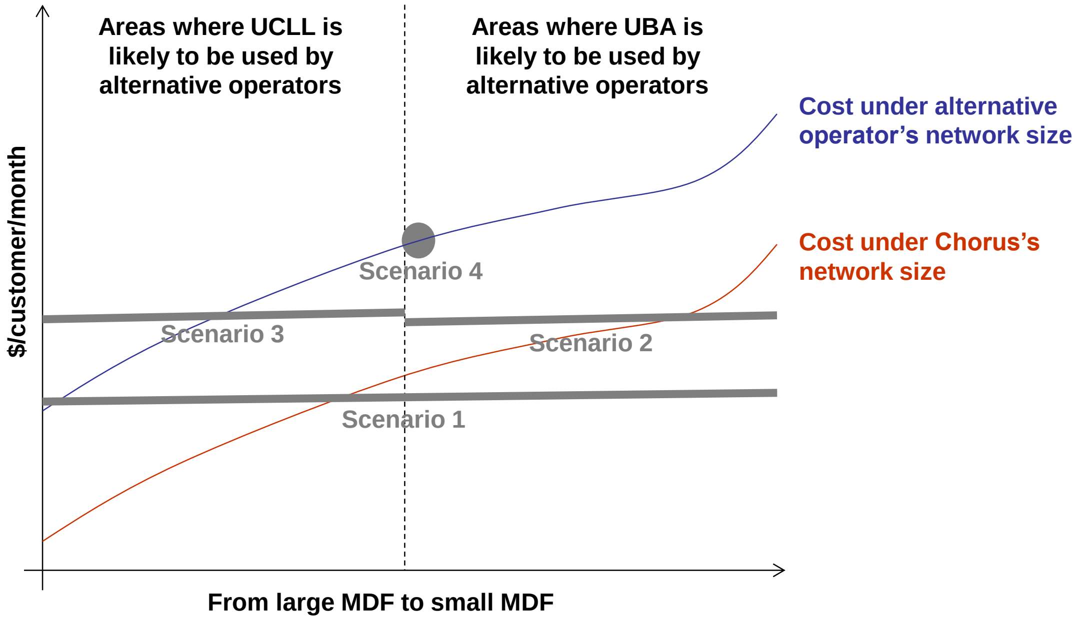
Since using UCLL requires significant investments from alternative operators to deploy the network to the MDF, it is likely to be used in those areas where this deployment cost per line is lower: in urban areas with larger MDFs.

Comparing scenarios

Four approaches are considered, combining choice of the modelled operator and definition of the geographic scope:

- **Scenario 1.** The UBA price is equal to the national average cost of an operator with the same scale as Chorus. This is called Equally Efficient Operator (EEO),
- **Scenario 2.** The UBA price is set equal to the cost of an EEO operator with the same scale as Chorus over only those areas where UCLL is unlikely,
- **Scenario 3.** The UBA price is set equal to the cost of an alternative operator with a lower scale than Chorus. This is called Reasonable Efficient Operator (REO) over those areas where UCLL is likely,
- **Scenario 4.** The UBA price is set equal to the cost of an REO of the next exchange to unbundle.

Figure 15: Core network UBA price (in grey) under different UBA scenarios



Note: Scenario 2 price may appear higher or lower than scenario 3 price, it cannot be predicted before the cost model is accomplished.
Source: TERA Consultants

Table 15 below summarises the impact of each of the four UBA scenarios.

Table 15: Comparing different UBA scenarios

#	Network size	Geographical scope	Advantages	Drawbacks
1	**Chorus/EEO**	**National**	Reflects Chorus's long-term costs Low price leads to an intensive UBA usage on the whole national territory	Low price may impede further development of UCLL. However, the fact that a national average cost is calculated increases costs compared to an alternative operator using UCLL in some urban parts only
2	**Chorus/EEO**	**Areas unlikely to be unbundled**	Reflects Chorus's long-term costs Intensive UBA usage in rural areas	Since UBA price is higher than in Option 1, UBA usage is less promoted (in particular, low UBA usage in urban areas compared to Option 1). UBA is also bought in urban areas in New Zealand.
3	**Alternative operator/REO**	**Areas likely to be unbundled**	Ensures that an access seeker purchasing UCLL	Inferior to scenario 3. Price is not the only reason

			and potentially selling bitstream to other access seekers would not be squeezed by UBA prices	for operators to select UCLL against UBA.
4	**Alternative operator/REO**	**Last MDF likely to be unbundled**	Sends the correct build or buy signal: investments by alternative operators are encouraged	Price is not the only reason for operators to select UCLL against UBA. May lead to too high UBA prices which may be inadequate to maximise customer welfare

Source: TERA Consultants

Scenario 2 is not recommended since it leads to higher prices than scenario 1 and does not send a correct build or buying signal in contrast to scenario 4. Scenario 3 is inferior to option 4 in terms of incentives and economical signal sent.

Two options remain therefore available: scenario 1 and scenario 4.

<u>Recommendation</u>

Among the four proposed scenarios, scenario 1 or scenario 4 is recommended in the New Zealand context:

- If the Commission concludes that UCLL is already sufficiently developed in New Zealand and the UBA price is unlikely to have significant impact on operators' UCLL incentives, scenario 1 is the most suitable. It reflects Chorus' long-term cost adjusted for efficiencies and leads to lower UBA prices than scenario 2. However, it risks deterring investment in UCLL, especially in more rural areas. Indeed, an alternative operator does not benefit from the same scale effect as Chorus.
- If, on the contrary, the Commission decides that the key objective is encouraging UCLL and the UBA price may have significant impact on operators' incentives, then scenario 4 is the most suitable since it sends a correct build or buy signal to an alternative operator who plans to unbundle an additional MDF. Then, the national UBA price is equal to the cost of the incremental exchange. It gives incentives to an alternative operator to unbundle an additional exchange.

Considering the fact that there are many other reasons than the UBA price to choose to unbundle an exchange, it is believed that scenario 1 will provide greater competition through lower prices and will promote efficiency by calculating the costs of an operator with a large number of customers.

4.3 What types of services supported by the modelled network?

When modelling the network, it should be decided what is the scope of services to be supported via this network. There are two main options:

1 Include only broadband services,
2 Include both broadband services and other services, such as voice and leased lines.

The second option seems to be the most relevant to the current modelling exercise as it incorporates benefits from economies of scope. This is the strategy followed by most large alternative operators in the world and promotes efficiency.

Note that demand for UBA also includes demand for all the variants of the UBA service (basic and all the enhanced variants) because it is necessary to take into account the level of economies of scope of Chorus.

<u>Recommendations</u>

The services modelled should include both broadband services and other services, such as voice and leased lines.

5 Adjustments required where UCLL and UBA MEA's are different

This section outlines the modelling issues that are likely to arise if the Commission elects to model UCLL and UBA services with different MEAs, outlines the adjustments that could be made to address these issues, and discusses how these adjustments could be implemented.

The cost of UBA contains three components:

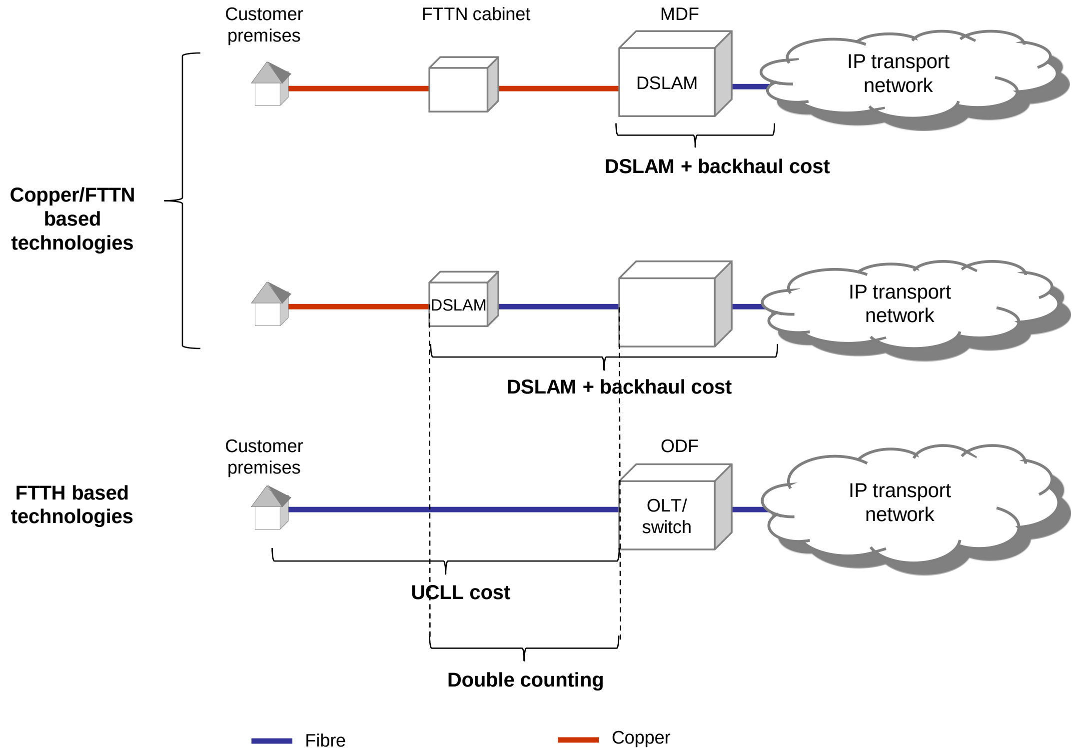
UBA cost = UCLL cost + core network UBA cost (DSLAM + backhaul cost).

To ensure consistency between UBA and UCLL, the UBA price should be set as follows:

UBA price = UCLL price + core network UBA cost (DSLAM + backhaul cost).

Figure 16 below shows the location of these cost components in the network in the case where the UCLL MEA is FTTH and the UBA MEA is copper/FTTN. UCLL cost is the cost of the fibre network between the MDF and customers' premises. The DSLAM may be either situated in a MDF or in a cabinet (for a cabinetised MDF). In the latter case the backhaul cost includes the part of the network situated between a cabinet and a MDF. Then, this part of the network is counted twice: both in the UCLL cost and in the backhaul cost.

Figure 16: The problem of double counting when UCLL MEA is FTTH and UBA MEA is copper/FTTN



Source: TERA Consultants

Avoiding double counting is one of the objectives of the Commission. Double counting would be limited to this part of the network because MDF and ODF (in FTTH) are likely to have similar locations in New Zealand according to discussions with the industry.

The double counted cost should be deducted from the UBA cost. This may be done by supposing that the FTTH network passes near the copper/FTTN network, identifying cabinetised MDFs and deducting the cost of the network between the MDF and the cabinet (fibre cables and civil engineering):

UBA price (also called “full UBA price”)
= UCLL price + core network UBA cost – double counted costs

Similar issues would occur for FWA and copper/FTTN networks for example.

Recommendations

If UCLL and UBA do not have the same MEA, double recovery should be identified and removed. The identification of the double recovery will be conducted by comparing the network architectures and footprints in both cases (UCLL and UBA) to identify overlaps. In particular, if fibre is chosen for UCLL and copper/FTTN for UBA, then the core network UBA cost should be reduced by the amount of the network between the MDF and the active cabinet, for those areas where MDFs are cabinetised.

6 Acronyms and abbreviations

Act	The Telecommunications Act 2001
ADSL	Asymmetric Digital Subscriber Line
ATM	Asynchronous Transfer Mode
CMTS	Cable modem termination system
CPE	Customer Premises Equipment
DOCSIS	Data Over Cable Service Interface Specification
DSLAM	Digital subscriber line access multiplexer
FPP	Final Pricing Principle
FTTH	Fibre to the Home
FTTN	Fibre to the Node
FWA	Fixed Wireless Access
GPON	Gigabit-capable Passive Optical Networks
HFC	Hybrid Fibre Coaxial
IPP	Initial Pricing Principle
ITU	The International Telecommunication Union
LTE	Long-Term Evolution
MEA	Modern equivalent asset
MDF	Main Distribution Frame
NGN	Next Generation Network
ODF	Optical Fibre Distribution Frame
OLT	Optical Line Terminal
P2P	Point to Point
RBI	Rural Broadband Initiative
STD	Standard terms determination
TSLRIC	Total Service Long Run Incremental Cost
TSO	Telecommunications Service Obligations]
UBA	Unbundled Bitstream Access
UCLL	Unbundled Copper Local Loop
UFB	Ultra-Fast Broadband programme
VDSL	Very-high-bit-rate Digital Subscriber Line

VSAT	Very Small Aperture Terminal

7 Annex

7.1 A brief market overview

This annex presents a brief market overview: the main market players are identified and two government broadband initiatives are described.

The primary fixed market operators are Chorus, Telecom and Vodafone. The mobile market has three mobile network operators: Telecom, Vodafone, and 2degrees.

The Government has put in place two initiatives to improve broadband services in New Zealand - the Ultra-Fast Broadband Initiative and the Rural Broadband Initiative. Together, the new broadband programmes will bring faster broadband to 97.8% of New Zealanders.

7.1.1 Main market players

Telecom continues to be the largest retailer: it provides nationwide services to its own customers on the retail level and also to operators at the wholesale level.

Operators which use UCLL to provide their own broadband and voice services are Vodafone, Orcon, Slingshot/Flip/CallPlus, and Compass.[114]

Other operators, including WorldxChange, Woosh, TrustPower, and Snap, use UBA services.

More and more end-users are connecting to the FTTH network that is being rolled out as a result of the UFB programme. It is deployed by Chorus, for the most of the country; NorthPower in Whangarei; Ultra-Fast Fibre led by WEL Networks in Hamilton, Tauranga, Tokoroa, New Plymouth, Hawera, and Whanganui; and Enable Networks in Christchurch. Consumers get access to fibre via an independent retailer: Telecom, Vodafone, Orcon, Slingshot/CallPlus, or Snap.

The HFC network covering much of Wellington and Christchurch is owned by Vodafone.

Three operators are present on the mobile market: Telecom and Vodafone since the 1990s and 2degrees since 2009. All three providers operate 3G UMTS networks; Vodafone and 2degrees are also operating 2G GSM networks. In 2013, Vodafone and Telecom started building their 4G networks, while 2degrees is expected to follow in 2014.

[114] Commerce Commission. Annual Telecommunications Monitoring Report 2013. Telecommunications monitoring report. May 2014.

In February 2013 Vodafone was the first to launch 4G services, which cover 1.3 million customers and 36 towns and cities as at the beginning of 2014.[115]

In terms of coverage, both Vodafone and Telecom have nationwide networks covering about 97% of the population, while 2degrees' own network reaches 88% of the population. 2degrees has a roaming agreement with Vodafone to cover remaining areas.

7.1.2 The ultra-fast broadband programme (UFB)

The purpose of the Government's Ultra-Fast Broadband programme (UFB) is to provide homes, public organisations and businesses with a high-speed fibre connection.

The Government is planning to connect 75% of New Zealanders with fibre by 2020. Schools, hospitals and 90% of businesses will be connected by 2015. Private customers and the remaining 10% of businesses will be connected by 2019.

The UFB will enable downstream speeds of at least 100 Mbps, and upstream speeds of at least 50 Mbps.

Four companies are involved in the project:

- Chorus will construct 69.4% of the future UFB network,
- Enable Services – 15.3%,
- Waikato Networks Limited (a subsidiary of WEL Networks) – 13.7%,
- Northpower – 1.6%.

The Government is contributing $1.35 billion, including $929 million of funding to Chorus.[116] Private UFB partners are planning on significant amounts of co-investment.[117] According to Chorus, the cost of covering 50% of the country is $3 billion, excluding costs of reused assets.[118] Therefore, Chorus needs to invest at least $2 billion in addition to Government's funding. Northpower has already invested $4.2 million and has built 70% of its network.[119] Waikato Networks is building a network with an estimated cost of $320 million, including the Government contribution. [120]

7.1.3 The Rural Broadband Initiative (RBI)

The purpose of the Government's Rural Broadband Initiative (RBI) is to deliver broadband to 252,000 rural households at prices and quality of service comparable with urban areas. Before this initiative started, only about one out of five of rural homes

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[115] http://www.vodafone.co.nz/press-release/vodafone-nz-4g-will-just-get-better-and-better/

[116] Outline of UFB agreement between Chorus and Crown Fibre Holdings.

[117] http://www.med.govt.nz/sectors-industries/technology-communication/fast-broadband/ultra-fast-broadband-initiative

[118] Chorus Institutional Investor Briefing. 21 May 2014 and http://milfordasset.com/chorus-maximum-uncertainty/ and http://www.chorus.co.nz/chorus-provides-20m-fund-for-free-ufb-residential-installs

[119] Northpower Annual Report 2012-2013.

[120] Wel Networks. Annual report 2013.

and businesses had broadband with speed of 5Mbps. 86% of private customers and businesses will be delivered with a service of 5Mbps minimal peak speeds. The RBI incorporates copper, fibre and FWA networks to deliver better broadband, so that more than half of rural customers could choose between copper and FWA broadband. Additional mobile coverage of 6,200 km^2 will also be subsidised, so that the total coverage achieves 125,700 km^2.

The RBI tender has been awarded to Chorus and Vodafone which began to roll out the network in mid-2011.

The initial focus of RBI is 16% of the population in those areas where the broadband quality is the lowest, with the long-term goal of covering 25% of the population not covered by the UFB.[121] As of the time of writing, approximately half of these customers have access to dial-up speeds only. These areas are not a part of Chorus's cabinetisation programme. As a result of the RBI programme, 86% of customers in these areas will be able to benefit from FWA services provided by Vodafone or from the extension of the cabinetisation programme.[122]

Funding will total $300 million, and will come:

- $48 million from the Government,
- $42 million per year for 6 years ($252 million in total) from the Telecommunications Development Levy.[123]

[121] http://media.nzherald.co.nz/webcontent/document/pdf/ruralbroadband.pdf

[122] http://www.med.govt.nz/sectors-industries/technology-communication/fast-broadband/rural-broadband-initiative

[123] http://media.nzherald.co.nz/webcontent/document/pdf/ruralbroadband.pdf

7.2 What UBA scenario? Size of the modelled operator and geographic scope: detailed assessment

UBA costs depend significantly on two key choices:

- Size of the operator – number of users of the modelled operator,
- Geographic scope – defining geographic area over which the cost is calculated.

This section discusses possible responses to these key choices and proposes scenarios that combine these responses. It then outlines the market impacts of each scenario.

Size of the modelled operator

It is necessary to make an assumption on the potential number of customers served by the modelled operator in order to dimension the network and define economies of scale. In fact, since the core network equipment is shared between customers, their number has a crucial impact on the per-customer cost. There are two different assumptions that can be made:

- The modelled operator has the same economies of scale as the incumbent, Chorus.
- The modelled operator is an alternative operator with a smaller number of customers than Chorus, so that the cost base is distributed among a smaller number of customers and economies of scale are less significant.

Geographic scope

The core network price may be set equal to either the national average cost, or to the cost value in a limited geographic area. For our purposes, the national territory may be divided, depending on the access service used, into two types of areas where:

- UCLL is likely to be used by alternative operators,
- UBA is likely to be used by alternative operators (UBA footprint and areas where UBA is likely to be used in the future) because UCLL is not economically viable.

In order to define the areas where UCLL is likely to be used, the following information may be used:

- MDFs where UCLL is already developed,
- dynamics of UCLL development,
- plans of future unbundling announced by operators,
- The characteristics that make unbundling of MDFs more likely[124].

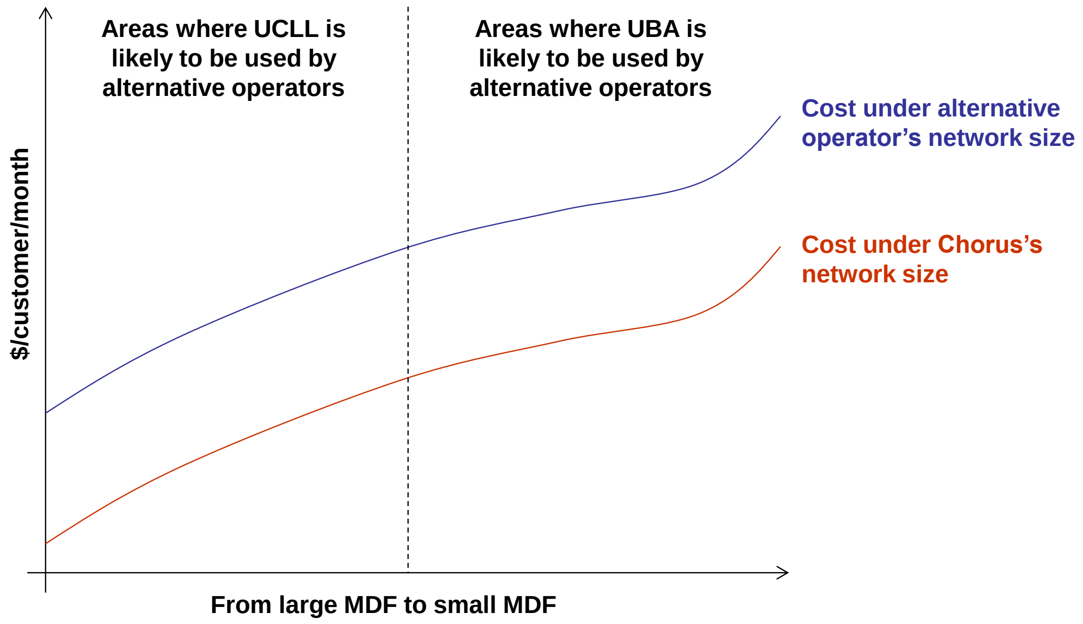
[124] For example, in France operators usually unbundle sites with size lower than 500 lines. Some operators in France believe that there is no limit to unbundling. Such a level of unbundling has been made possible especially thanks to private-public partnerships and a specific offer for fibre links to small exchanges provided by the incumbent (called LFO). This latter is a dark fibre offer and is not set at a “cost oriented” price but at a price which should enable the unbundling of smaller sites. When this dark fibre offer is not available, duct access must be provided.

Comparing scenarios

The figure below traces for illustrative purposes only per-customer core network cost under two alternative assumptions: demand of Chorus and demand of an alternative operator. The per-customer core network cost increases as the MDF size decreases.

Since using UCLL requires significant investments from alternative operators to deploy the network to the MDF, it is likely to be used in those areas where this deployment cost per line is lower: in urban areas with larger MDFs. It is not profitable for alternative operators to deploy the network to small MDFs, therefore, in rural areas with smaller MDFs they prefer the UBA service.

Figure 17: Core network cost of the UBA service per customer and per line



Source: TERA Consultants

Four approaches are considered:

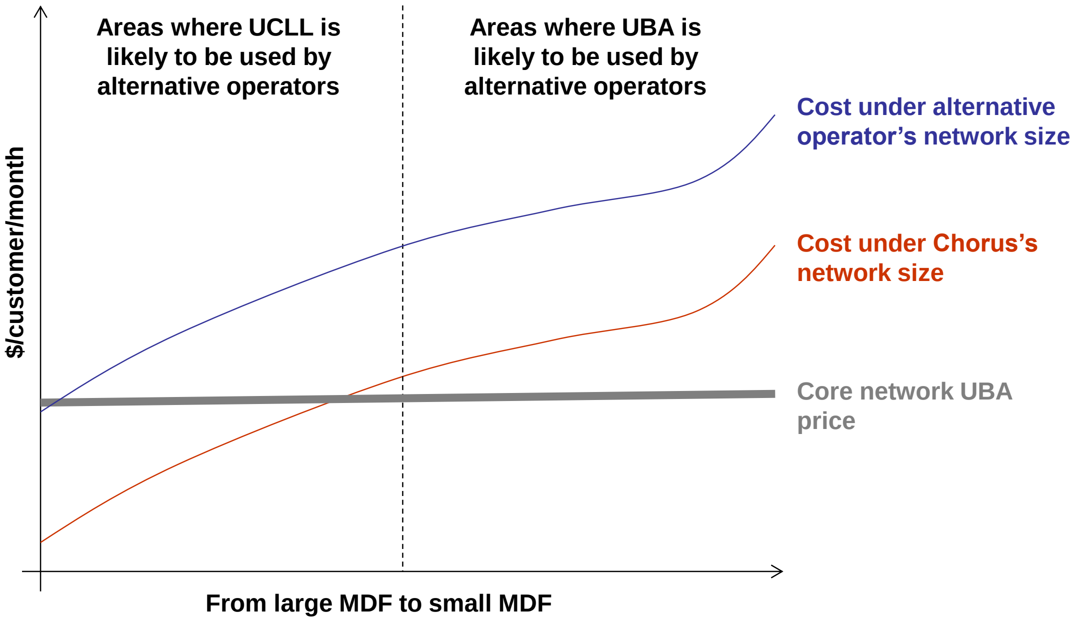
- **Scenario 1.** The UBA price is equal to the national average cost of an operator with the same scale as Chorus. This is called Equally Efficient Operator (EEO),
- **Scenario 2.** The UBA price is set equal to the cost of an EEO operator with the same scale as Chorus over only those areas where UCLL is unlikely,
- **Scenario 3.** The UBA price is set equal to the cost of an alternative operator with a lower scale than Chorus. This is called Reasonable Efficient Operator (REO) over those areas where UCLL is likely,
- **Scenario 4.** The UBA price is set equal to the cost of an REO of the next exchange to unbundle.

In Ireland the objective of the regulator ComReg is to cover 60% of lines (149 exchanges, representing 12% of the total number of exchanges). They have more than 2,500 active lines in general.

7.2.1 Scenario 1 – Chorus's network size and nationwide network

Under Scenario 1, the network size of the modelled operator is the network size of Chorus. The core network UBA price is equal to the nationally averaged cost. In fact, even in areas where UCLL is generally preferred by operators, UBA may still be used, at least by Telecom NZ who is today forbidden from purchasing UCLL. Therefore, UBA may be used on the whole national territory and a nationally averaged price is a reasonable approach.

Figure 18: Scenario 1 – Chorus's network size and national costs (grey line)



Source: TERA Consultants

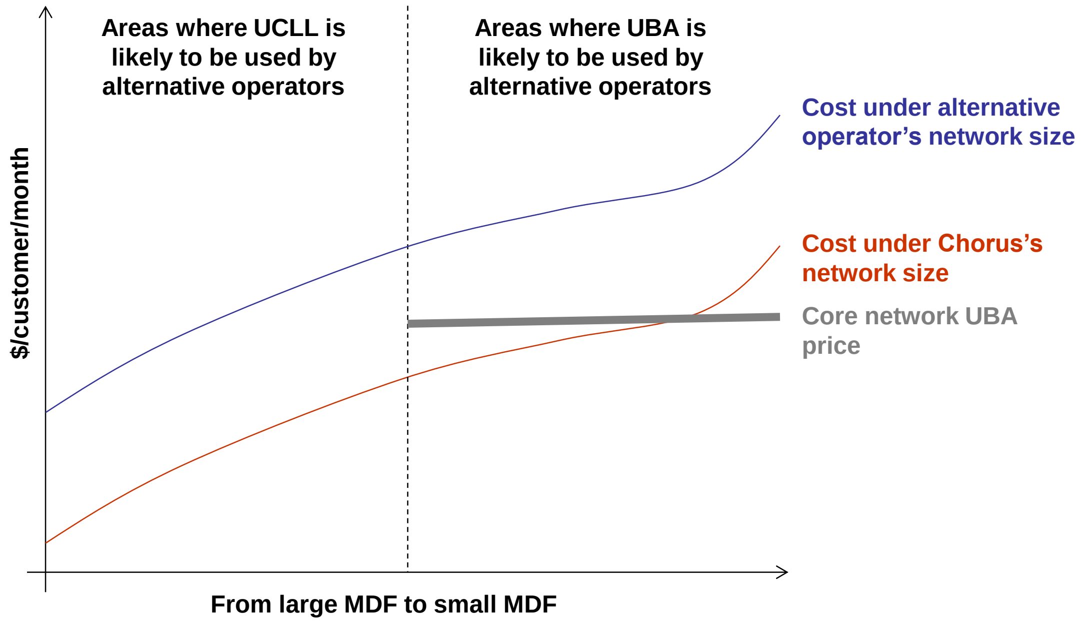
Such approach reflects Chorus's long-term costs corrected for efficiency. The resulting UBA price is relatively low, so that alternative operators are incentivised to use the UBA service on the whole national territory; consequently, UBA-based competition would be rapidly developing.

However, alternative operators are not incentivised to use UCLL service and so to invest in their own infrastructure. This may impede competition in the longer term. But it is important to keep in mind that the level of the UBA price is not the only reason to unbundle an exchange (other reasons are ability to differentiate, lower opex, etc.).

7.2.2 Scenario 2 – Chorus's network size and costs of areas where UCLL is unlikely

Under Scenario 1, the network size of the modelled operator is the network size of Chorus, and the UBA price of the core network is equal to the average cost in areas where UBA is likely to be used by alternative operators.

Figure 19: Scenario 2 – Chorus's network size and costs of areas where UCLL is unlikely (grey line)



Source: TERA Consultants

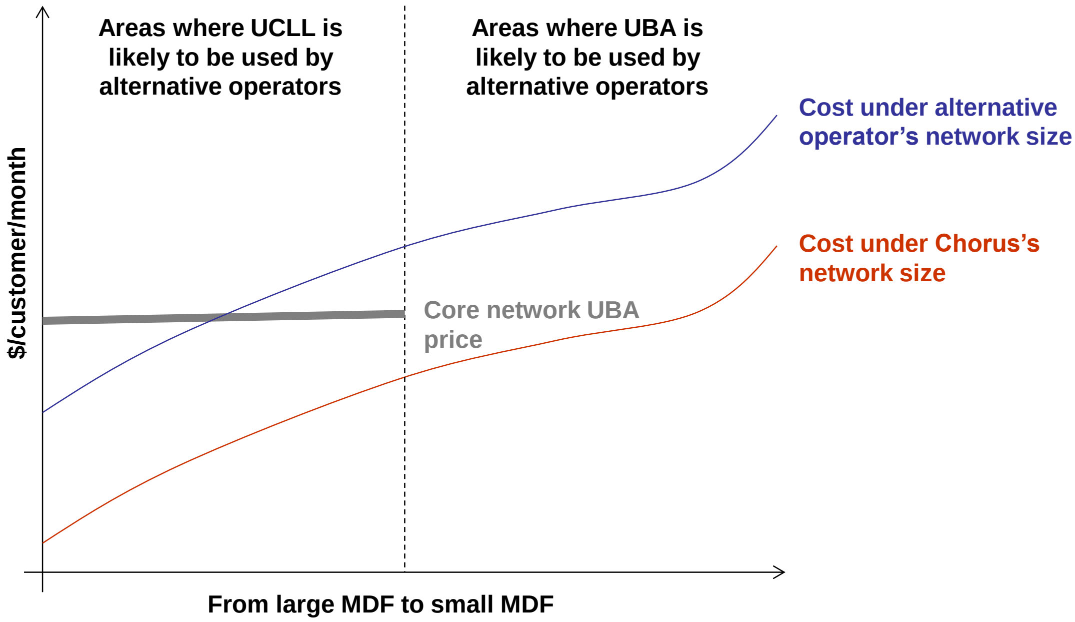
Such an approach reflects Chorus's long-term costs corrected for efficiency. It encourages intensive UBA usage in rural areas.

Since the UBA price is higher than in scenario 1, UBA usage is less promoted, even if UBA usage depends more on the gap between UBA and retail prices. It may provide more incentives to unbundle than under scenario 1, but the cost calculated under this option does not reflect in any way the cost of alternative operators.

7.2.3 Scenario 3 – Alternative operator's network size and costs of areas where UCLL is likely

Under this scenario, the network of an alternative operator with a reduced number of users is modelled. The core network UBA price is set equal to the average cost in the areas where UCLL is likely.

Figure 20: Scenario 3 – Alternative operator's network size and costs of areas where UCLL is likely (grey line)



Source: TERA Consultants

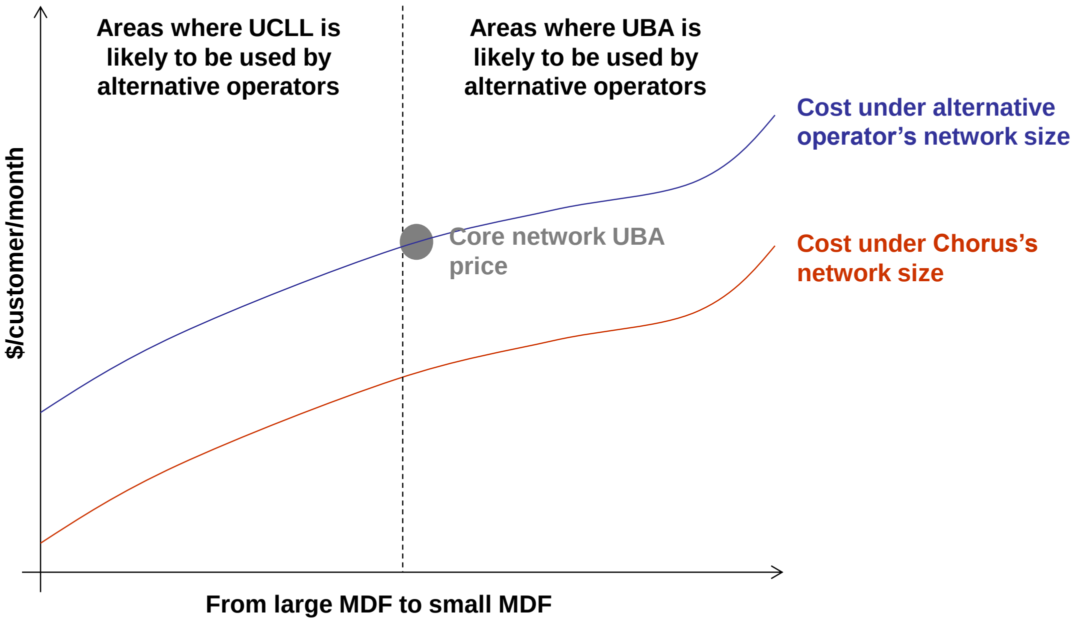
This scenario ensures that an access seeker purchasing UCLL and selling bitstream to other access seekers is not squeezed by UBA prices.

However, under this scenario, the average price remains lower than the cost of most expensive unbundled exchange and therefore this scenario is inferior to scenario 4 in terms of incentives to use UCLL.

7.2.4 Scenario 4 – Alternative operator's network size and costs of the next exchange to unbundle

Under this scenario, the network of an alternative operator with a reduced number of users is modelled. The core network UBA price is set equal to the core network cost of the next exchange to unbundle, or of the least expensive exchange among those that are unlikely to be unbundled.

Figure 21: Scenario 4 – Alternative operator's network size and costs of the next exchange to unbundle (grey point)



Source: TERA Consultants

This scenario sends correct build or buy signals to encourage investments by alternative operators, and ensures that an access seeker purchasing UCLL has an incentive to unbundle an extra MDF.

However, under this scenario, Chorus probably over-recovers its costs. In addition, since UBA price is higher than in Option 1, UBA usage is less promoted.