Final report for Spark New Zealand and Vodafone New Zealand

Modelling Fixed Wireless Access

UCLL and UBA Final Pricing Principle

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0 Executive summary

The Commerce Commission models the costs to a hypothetical efficient operator (HEO) of deploying a network based on fibre-to-the-home (FTTH) and fixed wireless access (FWA) technologies in order to derive forward-looking efficient prices for Unbundled Copper Local Loop (UCLL) and Unbundled Bitstream Access (UBA) services. We agree with the Commission that it is appropriate to include FWA technology in the model where the HEO would do so, using an approach that accurately represents the optimal deployment method.

The Commission has selected LTE technology using the 700MHz band as the basis of FWA deployment in its model. While we agree with these choices, we find that the implementation approach adopted by the Commission's consultants does not reflect an efficient LTE deployment. In particular:

- the coverage areas of Vodafone's actual RBI sites are assumed. As these were designed for 3G technology and spectrum bands higher than 700MHz, the assumed coverage is too conservative for LTE technology in the 700MHz band
- a cap is applied to the number of premises served per tower which is extremely conservative for LTE technology
- distance from the exchange is used to determine whether buildings are served by fibre or FWA, leading to results that are unrealistic from a network planning perspective
- no new sites are assumed to cover additional customers
- no use of microwave backhaul is assumed.

The Commission has confined the extent of FWA deployment to RBI (Rural Broadband Initiative) areas. However the RBI is a Government policy initiative whereas for an HEO the relevant footprint for an FWA MEA would be much wider than the RBI footprint, particularly given the superior performance speeds available through LTE. Applying an RBI boundary effectively constrains the HEO to inefficient FWA deployment.

The Commission has quite rightly defined a TSO-derived boundary beyond which capex-related costs should be excluded since customers pay a capital contribution. However, in examining the Commission's model we found that buildings outside the TSO boundary have in fact been included in the capex calculations. Clearly these should be removed for consistency with the Commission's stated principle.

We agree with the Commission's assumption that the HEO should have access to a 2×20MHz allocation of 700MHz spectrum at the price that operators actually paid in the real world. However it is not feasible that an HEO would pay such a price for the provision of FWA services to RBI areas only. In fact if the HEO were to be limited to FWA provision in RBI areas then it is possible that the Government may offer spectrum at a heavily discounted price to induce it to provide service. Thus we consider it more realistic that the Commission assumes that, at a minimum, the HEO would seek ways of sharing spectrum costs so that the full cost would not be allocated to FWA services.

We believe that the issues that we have identified for optimal deployment with the Commission's draft FWA model implementation cannot be remedied easily within the existing approach. As such we present an alternative model using actual Vodafone radio planning designs for a sample areas of different geo-types in New Zealand. The designs achieve 100% coverage of the same building locations as those used by the Commission's consultants, but extend beyond the RBI boundaries to encompass non-urban areas that a rational profit-maximising HEO would be expected to serve with this technology.

We have adopted conservative assumptions where choices were available and we have retained a number of the Commission's key assumptions, including:

- the availability of 2×20MHz spectrum in the 700MHz band
- throughput of FWA services in the base year (i.e. 2015) is assumed to be 250kbit/s which is the average throughput used in the Commission's model
- financial parameters such as WACC.

We recommend that the Commission adopts our model estimates (Exhibit 0.1) for use in conjunction with its own model. These estimates would replace its draft model estimates for each ESA within Chorus Zones 3a, 3b and 4.

In contrast to our estimates, the Commission's estimates for Zones 3 and 4 have been derived with the inclusion of unbundled ESAs. These ESAs are typically the more densely populated 3a Zones, and we would expect the cost of service provision to be lower in such areas than the more sparsely populated Zones with no unbundling that we have modelled. Thus our results should be regarded as an upper bound for all Zone 3 and 4 areas.

Monthly cost per line	*TERA*	*Network Strategies*
National	28.22	23.50
Urban	20.63	20.63[1]
Rural	47.73	30.86

1 TERA estimate used for urban cost per line.

***Exhibit 0.1**: Geographically averaged price for UCLL services [Source: Commerce Commission and Network Strategies]*

Our recommendation provides an immediate remedy for the issues we identified with the Commission's draft approach. We note, however, that the margin of error of our estimates could be further reduced if additional sampling were to occur, and recommend that the Commission considers extending our analysis in this manner.

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1 Introduction

TERA Consultants, on behalf of the Commerce Commission, has developed a TSLRIC model of the networks that will deliver Unbundled Copper Local Loop (UCLL) and Unbundled Bitstream Access (UBA) services.[1] The model calculates the costs of a hypothetical efficient operator (HEO) by modelling a network based on fibre-to-the-home (FTTH) and fixed wireless access (FWA) technologies. This document includes an analysis of the Commission's approach for modelling the FWA network, focussing on the assumptions and methodology adopted.

In addition, Network Strategies was commissioned by Spark New Zealand (Spark) and Vodafone New Zealand (Vodafone) to develop a TSLRIC model for modelling FWA in sample areas of New Zealand.

This report encompasses:

- a review of the Commission's FWA model (Section 2)
- a summary of our FWA model (Section 3)
- a discussion of the results from our FWA model (Section 4)
- our recommendations (Section 5).

The annexes contain details in relation to the appropriate sample for FWA modelling and radio propagation assumptions.

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1 TERA Consultants (2014), *TSLRIC price review determination for the UCLL and UBA services - Model specification, documentation, and reference paper*, available at http://www.comcom.govt.nz/regulated-industries/telecommunications/regulated-services/standard-terms-determinations/unbundled-copper-local-loop-and-unbundled-bitstream-access-services-final-pricing-principle/.

A copy of our FWA model and a model user guide is provided separately. Note that the model contains Vodafone confidential information.

Our team has had the benefit of access to confidential information (CI) and restricted information (RI) used in the modelling process. In keeping with our confidentiality undertakings any CI and RI quoted in this report is marked as such with square brackets. Vodafone New Zealand CI is marked VNZCI and Commerce Commission CI and RI is marked CCNZCI and CCNZRI respectively.

Although this report was commissioned by Spark and Vodafone the views expressed here are entirely our own.

2 The Commission's FWA model

2.1 Overview

The Commission's model calculates the TSLRIC cost incurred by an HEO to provide UCLL and UBA services over a timeframe of five years (2015 to 2019). The model comprises three components:

- **Access model** – derives the number of passive assets and the related cost
- **Opex model** – derives the opex, the indirect capex, the common costs and the transaction charges
- **Core model** – derives the number of active assets and the related costs for UBA services. This component also allocates the common costs to the different services and therefore estimates the prices of regulated services.

The model assumes a hypothetical efficient access and core network that replaces the existing copper network and the UFB fibre networks currently being rolled out. The technologies selected as modern equivalent assets (MEAs) for the access network are a combination of fibre-to-the-home (FTTH) and fixed wireless access (FWA) technologies.

Although the selected MEA remains FTTH with FWA, a fibre-to-the-node (FTTN)/copper network is also modelled to assess whether a cost adjustment is necessary. The costing of the access network is based on the most economic roll-out scenario. If the cost of the FTTH / FWA network is less than that of the FTTN network, then no adjustment is needed. If the FTTN network costs less than the FTTH / FWA network the cost of the latter is adjusted to reflect the cost of the copper network. The result of this comparison between the two networks – which is carried out at a national level – is that the FTTH / FWA network is the lowest cost, and thus the prices of the UCLL service are based on the cost of this network.

The access network is dimensioned as whole considering FTTH and FWA simultaneously. In the case of the FWA network the model encompasses:

- determining the location of the base stations and their coverage – currently the existing locations and coverage of Vodafone's RBI sites
- connecting each FWA site to the fibre network
- calculating the number of customers served by each FWA site.

The existing locations and coverage of Vodafone's RBI sites are used to model the FWA network. Rather than calculating the number of sites needed to provide FWA access to all customers within the coverage area, the Commission's approach consists of determining how many customers can be served by the existing sites.

Demand for the FWA network is based on the buildings / dwellings located within the Vodafone actual RBI coverage areas. The model takes into account capacity constraints of FWA to limit the number of customers that can actually be served by an FWA site. A cost based decision is used to identify which customers will be connected to the FWA network[2]:

> As with any mobile base station, FWA base stations have a limited capacity. Thus, only the most expensive "lines" within their coverage areas are covered by FWA, the less expensive being served by fibre.

Cost results from the access models are provided as capex and as annualised costs, ESA (Exchange Service Area) by ESA, national, urban and rural. The final cost allocation to determine service prices is performed at the total (national) level in the core model.

A top-down approach based on Chorus' copper network accounts is adopted for opex calculations. The Opex model implements the allocation to the UCLL and UBA services of a proportion of Chorus' expenses related to its regulated and unregulated activities.

2 TERA Consultants (2014), *TSLRIC price review determination for the UCLL and UBA services - Model specification*, November 2014, section 6.2, page 49.

Network common costs and non-network common costs (also known as corporate overheads) are allocated using a capacity based and an equi-proportional mark-up approach (EPMU), respectively.

2.2 Key issues in the Commission's FWA modelling

2.2.1 Use of FWA limited to RBI areas

The approach adopted by the Commission to model the FWA network is that:

> …it should only be deployed at the edge of the network where FTTH deployment is very expensive, not economically viable and where unbundling is unlikely to occur.[3]

Consequently the Commission has confined FWA to the current and projected RBI FWA footprint which consists of the deployment of a total of 154 new cellphone towers and the upgrade of 387 existing towers.[4]

The choice of FWA areas in the Commission's model seems to be guided by the convenience of obtaining existing radio analysis and base station locations/coverage – which are readily available for RBI areas. Citing several overseas examples we noted in an earlier report[5] that:

> …an efficient operator would utilise FWA (Fixed Wireless Access) technology in areas with low line density, reflecting real-life practice and consistent with local (from the TSO) and overseas regulatory cost modelling practices. We believe that the relevant footprint for a FWA Modern Equivalent Asset (MEA) is considerably wider than the RBI footprint, particularly given the superior performance speeds available through LTE.

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3 TERA Consultants (2014), *TSLRIC price review determination for the UCLL and UBA services - Model Reference Paper*, November 2014, section 2.2.3.2, page 11.

4 Ministry of Business, Innovation and Employment (2012), *Who is implementing this initiative?,* 27 April 2012, available at http://www.med.govt.nz/sectors-industries/technology-communication/fast-broadband/rural-broadband-initiative/implementation

5 Network Strategies (2014), *Key issues in modelling UBA and UCLL services*, 6 August 2014, page ii.

Vodafone's RBI deployment plan consists of building new sites and upgrading existing towers to provide coverage to rural areas. In many cases, coverage is provided from sites which are located outside actual RBI areas, or close to the boundaries with UFB zones (illustrated by the examples in Exhibits 2.1 and 2.2). When confining FWA to the RBI footprint the model does not capture the benefits of reusing existing assets to provide service to an extended number of customers beyond the RBI boundaries.

TERA states[6]:

> As the location and coverage of Vodafone's sites are used to model the FWA network, the identification of the customers that will be served by a FWA connection instead of a fibre connection is carried out by identifying the sections located in the coverage areas provided by Vodafone.

6 TERA Consultants (2014), *TSLRIC price review determination for the UCLL and UBA services - Model specification*, November 2014, paragraph 3.9.1.

[

VNZCI]

Exhibit 2.1: *Vodafone's RBI sites – Waiuku / Pukekohe, North Island [Source: Network Strategies]*

[

VNZCI]

Exhibit 2.2: *Vodafone's RBI sites – Masterton, North Island [Source: Network Strategies]*

2.2.2 Conservative coverage for LTE technology in 700MHz band

The Commission's model assumes that the HEO will deploy LTE (4G) technology in the 700MHz band and will have access to 2×20MHz spectrum.

However TERA also states[7] that modelling the exact coverage of each FWA site is not achievable due to time and resource constraints and hence the coverage areas of Vodafone's actual RBI sites are assumed. Vodafone's actual RBI sites were designed for 3G technology and spectrum bands higher than 700MHz and hence the assumed coverage is too conservative for LTE technology in the 700MHz band (which is capable of achieving

7 TERA Consultants (2014), *TSLRIC price review determination for the UCLL and UBA services - Model Reference Paper*, November 2014, section 2.2.3.2, page 12.

superior coverage). In fact the Commission acknowledges this in its draft determination[8] but has not made any allowances in its model:

> Generally, LTE is technically superior to 3G and is currently being commercially deployed in New Zealand cellular networks using the 700 MHz band. Consequently, we have modelled FWA using LTE on the 700 MHz band which will mean that both the performance and the coverage will be quite different to that currently achieved by Vodafone for RBI.

The use of RBI sites and their coverage is inconsistent with the approach that an HEO would follow for efficient LTE deployment. In fact we had also compared the two technologies in our earlier cross submission[9]:

> … the fade margin for LTE is lower than 3G technologies (used previously) because fast fading margin in LTE is negligible.[10] In addition LTE provides huge improvements (over the 3G technologies) in terms of higher data rates, lower latency, reduced packet loss, lower failure rates and greater spectral efficiencies. LTE also offers scalable bandwidth allowing inter- and intra-band carrier aggregation and provides improved coverage and cell edge data rates. Apart from the improvements in technology the use of 700MHz spectrum band enables better coverage (compared to the higher frequency bands which were being considered/used previously) and the slow fading margins are lower in rural areas (compared to urban areas).[11]

The impact of upgraded technology and lower spectrum bands has not been captured in the Commission's model. It appears that the reason for assuming existing RBI sites and coverage is purely convenience. However this assumption compromises the quality of the results as it does not reflect an efficient LTE deployment.

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8 Commerce Commission (2014), *Draft pricing review determination for Chorus' unbundled copper local loop service*, 2 December 2014, paragraph 604.

9 Network Strategies (2014), *Cross-submission for consultation on UCLL and UBA FPP regulatory framework*, 20 August 2014, section 4.3, page 24.

10 Holma H. and Toskala A. (2011), *LTE for UMTS: Evolution to LTE-Advanced*, John Wiley & Sons, pages 265-270.

11 Song L. and Shen J. (2010), *Evolved Cellular Network Planning and Optimization for UMTS and LTE*, CRC Press, page 139.

The only way to capture the features of the superior technology – namely, LTE in the 700MHz band – is by performing a proper radio analysis to identify appropriate site locations and accurate coverage areas.

2.2.3 Number of premises served per tower capped conservatively

The Commission's model assumes that there is one LTE base station (with three sectors) per FWA site. The model also assumes that as base stations have a limited capacity, the maximum number of end-users that can be connected per FWA sector is capped at 67 to ensure that all of the connected customers will achieve a guaranteed bandwidth of 250kbit/s. Consequently the most expensive 67 users (identified using distance from the exchange) are served by FWA and the remainder are connected by fibre to the nearest exchange.

The Commission's approach is extremely conservative when compared with Vodafone's RBI network coverage plan. The planned network will provide access to more than 250 000 rural homes through 530 sites[12] – an average of around 157 customers per sector if we assume three sectored sites.

The Commission's cap of 67 users has been calculated assuming a peak throughput (per FWA sector) of 16 666kbit/s. However this is a very conservative assumption as LTE/LTE-A sites are capable of achieving much higher throughputs, especially for stationary users. Our analysis shows that LTE sites (with two or three sectors) are capable of connecting around 260 customers while the theoretical maximum is over 300.

The result of the Commission's model calculations is that a total of 74 633 dwellings will be served by 535 FWA sites – an average of 53 dwellings per sector for a total of 1 408 sectors. This represents only 30% of the projected 250 000 homes to be served by Vodafone's RBI network.[13]

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12 Vodafone (2014), *RBI flyer*, available at http://www.vodafone.co.nz/cms/documents/1375774069267/.

13 *Ibid.*

The following exhibits show for two selected areas the distribution of FWA and fibre served buildings from the Commission's modelling approach (Exhibits 2.3 and 2.4). The outcome of the access modelling is that a significant number of buildings / dwellings – which are currently within Vodafone's RBI region but outside Chorus' RBI – are assumed to be fibred by the HEO. This situation is not restricted to these two areas, but is replicated for the rest of the RBI areas all over the country.

[

CCNZRI]

Exhibit 2.3: *Fibre/FWA in RBI areas – Te Awamutu, North Island [Source: Network Strategies]*

[

CCNZRI]

Exhibit 2.4: *Fibre/FWA in RBI areas – Rangiora, South Island [Source: Network Strategies]*

2.2.4 No new sites assumed to cover additional customers

As discussed above the Commission's model assumes that a maximum of 67 users in the coverage area of each sector of RBI sites are served by FWA with any remaining users connected by fibre to the nearest exchange. Hence no additional FWA sites are assumed to be deployed for the remaining users.

This assumption is inappropriate for an HEO which would consider deploying additional FWA sites to serve the remaining customers rather than connect them using FTTH (especially in areas with large numbers of dispersed customers). This will also affect the efficiency of deployment and again its seems that this is a simplifying assumption that has been used mainly to avoid any more detailed radio analysis. In addition it is worth noting that this assumption limits the use of FWA even further, as in the Commission's modelling FWA is not even an option for all the users in RBI areas.

2.2.5 Unrealistic network planning approach

As noted above the Commission's model applies a cost-based decision to identify FWA customers. Only the most expensive users are served by FWA with the remaining connected by fibre to the nearest exchange. Distance from the exchange is the metric used for this decision.

This approach delivers results which are unrealistic from a network planning perspective. As can be seen in Exhibits 2.5 and 2.6, the model serves clusters of buildings with FWA while less densely located customers are served with fibre. This is unlikely to represent efficient deployment decisions by the HEO.

Exhibit 2.5 shows the Commission's model results for an area located in the south of the North Island, near Pirinoa. In the upper part of the map there is a small group of four buildings served by fibre adjacent to clusters of FWA served buildings. Serving this location with FWA rather than fibre will result in a more cost effective deployment due to its distance to the exchange. Further counterintuitive results can be seen when buildings which are located next to the exchange are served by FWA while others which are further away from the exchange but closer to the base station are served by fibre.

[

CCNZRI]

Exhibit 2.5: *Fibre/FWA modelling results – Pirinoa, North Island [Source: Network Strategies]*

A similar situation is illustrated in Riversdale beach, an area located on the East Coast of New Zealand’s North Island (Exhibit 2.6). Clusters of FWA-served buildings are distributed in between fibre-served building zones, and this does not follow any logical network design criteria.

[

CCNZRI]

Exhibit 2.6: *Fibre/FWA modelling results – Riversdale beach, North Island [Source: Network Strategies]*

2.2.6 No use of microwave backhaul

For backhaul the model assumes that FWA sites will be connected to the network via fibre from the nearest exchange following the shortest path algorithm. Additionally, where this fibre cable passes premises on its way to the FWA site, these premises are assumed to be connected directly to the FTTH network, hence reducing the number of premises covered by FWA.

The model does not include microwave as an option for backhaul. Opting for this alternative instead of fibre will have an impact on the final results – analysis of the cost inputs provided by Vodafone indicates that the total annual cost of microwave backhaul is significantly lower than the fibre backhaul cost. Vodafone procures its fibre backhaul products as a managed service from Chorus – the service is charged in a per site basis. The annual cost per site of using this managed service is 3.6-fold higher than the cost incurred with microwave radio link (single hop).

If microwave backhaul was to be used, customers that were previously connected directly to fibre backhaul would then have to be served by FWA, so it is necessary to assess whether or not the aggregated demand will require additional capacity. The Commission's model assumes that all the premises along the path of the fibre backhaul are connected directly to the FTTH network, thus reducing the number of premises covered by FWA.

2.2.7 Inconsistent demand assumptions

While the dimensioning of the FTTH/FWA access network as a whole is based on the number of existing building/dwellings within a TSO-derived boundary, the allocation of capex and opex costs is based on the number of customers. In-use address points are used as a proxy of potential demand to model the FTTH/FWA access network.[14] The estimation of the location of buildings is based on the CoreLogic address database. Additional

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14 Commerce Commission (2014), *FPP draft TSLRIC Model questions – 18 December 2013*, available at http://www.comcom.govt.nz/regulated-industries/telecommunications/regulated-services/standard-terms-determinations/unbundled-copper-local-loop-and-unbundled-bitstream-access-services-final-pricing-principle/.

information sourced from Statistics New Zealand (2013 meshblock and census data) is used to cross-check residential address coverage.[15]

The model contains almost two million of these address points (dwellings) – **[ ]CCNZRI** million within the TSO-derived boundary which are used by the model to calculate the number of resources for the FTHH/FWA network. On the other hand, when producing final results in the core model total capex and opex are divided by the total number of copper, fibre and LFC customers (around **[ ]CCNZRI** million connections) which is approximately 6% lower than the number of dwellings within the TSO-derived boundary (**[ ]CCNZRI** million).

The number of copper connections used in the opex model are for 2013 and as stated in the model spreadsheet 'Those number [*sic*]are calculated in order to be in line with the number of subscribers in the Core model'.[16] As shown in Exhibit 2.7, copper connections used in the opex and core model differ. Even though the difference could be attributed to mismatching years since copper connections for the core model are for 2014, the number of copper connections in the opex model still differs from the 2013 values provided by Chorus (namely **[ ]CCNZRI**).[17] We note that demand was assumed to be constant, and thus we would not expect the figures to differ.

	Demand	*Unit*
Access network dimensioning	**[**	
Opex model		
Core model		
	CCNZRI]	

Exhibit 2.7: *Demand used in Commission's model [Source: Network Strategies]*

15 TERA (2014), *TSLRIC price review determination for the UCLL and UBA services - Model specification*, November 2014, table 1, section 3.1, page 22.

16 TERA Consultants (2014), CI_ComCom-OPEX model v1.10.xls, 'results' spreadsheet, table '1 Cost per service'.

17 Commerce Commission (2014), *Section 98 submission to the Commerce Commission – 17 April 2014*, Q.6.18.12 (c) Demand forecast.

2.2.8 Inclusion of premises outside TSO-derived boundary

As indicated in the previous section, the approach adopted by the Commission is to model the FTTH/FWA access network based on the number of existing building/dwellings within a TSO-derived boundary. However analysis of the model's results indicates otherwise – our analysis undertaken using a Geographic Information System (GIS) proves that a considerable number of FWA served buildings are actually outside the TSO areas' boundaries (Exhibits 2.8 and 2.9).

Out of the **[ ]CCNZRI** buildings which are served by FWA, 7 011 buildings (representing 7 111 dwellings) are outside the TSO boundaries – this represents **[ ]CCNZRI** of the total of buildings served by FWA (Exhibit 2.12).

[

CCNZRI]

Exhibit 2.8: *FWA served buildings – Upper Hutt, North Island [Source: Network Strategies]*

[

CCNZRI]

Exhibit 2.9: *FWA served buildings – Yaldhurst, South Island [Source: Network Strategies]*

Further analysis of the information provided as part of the Commission's access model indicates that the existence of FWA served buildings outside the TSO areas is the result of TERA's classification into TSO and non TSO premises using a section level rather than at a building level.

The following maps illustrate sections which extend both within and outside the TSO areas (Exhibits 2.10 and 2.11). For model calculation purposes these sections are assumed to be within the TSO areas hence, all the associated buildings / dwellings are assumed to be within as well, regardless of the actual location.

Note that in the maps red denotes buildings which are actually outside the TSO areas but considered to be within it and therefore are included in modelling the FTTH/FWA access network. Our analysis indicates that there are 8 411 of these buildings (Exhibit 2.12).

[

CCNZRI]

Exhibit 2.10: *TSO buildings and sections – Upper Hutt, North Island [Source: Network Strategies]*

[

CCNZRI]

Exhibit 2.11: *TSO buildings and sections – Greymouth, South Island [Source: Network Strategies]*

	Commission model	*GIS analysis*	*Difference*
Buildings – total	**[**		
within TSO			8 411
outside TSO			
Buildings – FWA served			
within TSO			7 011
outside TSO			
		CCNZRI]	

Exhibit 2.12: *Building breakdown according to TSO boundary [Source: TERA and Network Strategies]*

We conclude that the methodology used in the model to select which buildings / dwellings are included within the TSO-derived boundary delivers results which are inconsistent with the Commission's stated approach:

> Accordingly, our approach is to exclude the capex of the network outside the TSO derived boundary from the full network TSLRIC cost.[18]

2.2.9 Use of copper network opex for FWA network

TERA notes that the FTTH/FWA opex calculations are based on copper network opex:

> Due to the status of FTTH deployment in New Zealand, no accounting information on fibre opex for a nationwide network is available at this stage. As a consequence, FTTH opex should be assessed based on copper network opex with adjustments if needed.[19]

The model assumes that fibre opex is equal to 50% of copper opex – an assumption that is stated to be based on studies by National Regulatory Authorities (NRA) and

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18 Commerce Commission (2014), *Draft pricing review determination for Chorus' unbundled copper local loop service*, 2 December 2014, paragraph 321.

19 TERA Consultants (2014), *TSLRIC price review determination for the UCLL and UBA services - Model documentation*, November 2014, Annex 8.2, page 132.

manufacturers.[20] The model documentation quotes publications from Ericsson and the FTTH Council which state that FTTH opex should be significantly reduced as compared to copper network opex. The assumption of 50% is based on a statement from the Italian regulator AGCOM (Autorità per le Garanzie nelle Comunicazioni).

> NTT / Verizon: 40-60% Opex decrease with FTTH networks with relation to copper local loop[21]

The Commission claims in the draft determination that for FWA some ongoing charges were based on information provided by Vodafone.[22]

> FWA opex includes spectrum fees and maintenance opex (based on information provided by Vodafone).

However the TERA model documentation indicates that 'Opex model is based on Chorus' 2013/2014 accounts'[23] From our model analysis we can find no evidence that Vodafone's opex is an input for opex calculations.

2.2.10 Over-stated spectrum fees

The Commission's model includes a cost component to capture the spectrum cost that will be incurred for providing FWA services. The Commission's assumption is that the HEO will face no restrictions to gain access to the existing spectrum hence a total of 2×20MHz is assumed:

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20 TERA Consultants (2014), *TSLRIC price review determination for the UCLL and UBA services - Model documentation*, November 2014, Annex 8.2, pages 132 and 133.

21 AGCOM (2010), *Challenges in moving towards the Next Generation of Fixed and Mobile Networks*, 28 January 2010, available at http://www.agcom.it/

22 Commerce Commission (2014), *Draft pricing review determination for Chorus' unbundled copper local loop service*, 2 December 2014, paragraph 345.

23 TERA Consultants (2014), *TSLRIC price review determination for the UCLL and UBA services - Model specification*, November 2014, section 2.1, page 19.

> We have assumed that the hypothetical efficient operator has access to a 2×20 MHz allocation of spectrum. Since the telecommunications operator that we postulate in our TSLRIC cost modelling exercise is a hypothetical one, we are not constrained to reflect in our modelling all the realities of the "real world" that a business would face if it was actually building a new network. [24]

The cost of access to the spectrum is modelled as capex using the results of the last 700MHz New Zealand spectrum auction – it is assumed that the HEO will gain access to spectrum at the price that operators actually paid in the market.[25] The unit cost is then based on the price paid at the first allocation round – $22 million for a 2×5MHz lot.[26] The total spectrum cost is then determined for the total of 2×20MHz ($88 million) and annualised assuming a 17 year asset life, 0% price trend and 20% tax depreciation rate.[27] The annualised cost for the total of 2×20MHz is then allocated among all the ESAs proportionally to the share of the total FWA sites' attributable cost.

While it is unclear how the 17 year asset life for spectrum was determined, note that it would be expected to be coincident with the actual licence duration, which for the case of the New Zealand auction is 18 years.

We have found no precedents in existing publicly available TSLRIC models for the inclusion of spectrum fees for the provision of fixed services using wireless / mobile technologies. While both Swedish[28] and Australian[29] cost models include technologies reliant on spectrum availability no allowance for spectrum fees has been included. Nevertheless we agree that the Commission should consider incorporating a consideration

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24 Commerce Commission (2014), *Draft pricing review determination for Chorus' unbundled copper local loop service*, 2 December 2014, paragraph 605.

25 Commerce Commission (2014), *Draft pricing review determination for Chorus' unbundled copper local loop service*, 2 December 2014, paragraph 606.

26 Commerce Commission (2014), *FPP draft TSLRIC model questions*, 23 December 2014, question ID 18.

27 *Ibid.*

28 Post- och telestyrelsen (2013), *Hybridmodell version 10.1,* 16 December 2013.

29 Australian Competition and Consumer Commission (2010), *Analysys fixed network cost model – October 2010*, available at http://www.accc.gov.au/regulated-infrastructure/communications/fixed-line-services/fixed-line-wholesale-services-pricing-review-2009-2010/consultant-report.

for the costs of obtaining access to suitable spectrum for FWA. However the Commission's proposed approach overestimates the spectrum cost to be allocated to FWA services.

Where spectrum prices are set by a competitive market these prices reflect the demand for spectrum and the economic value placed on spectrum by companies. The price that winning bidders paid during the 700MHz auction is for a national coverage licence with no restrictions on service provision.

If 700MHz spectrum was purchased by the HEO at the price achieved at the digital dividend auction then it would only have been under the expectation of a revenue stream commensurate with that of a national mobile operator in order for the business case to assign that particular value to the spectrum. Such revenues would not be achieved by FWA subscribers in RBI areas, hence the HEO will need to offer mobile services as well in order to have a valid business case to support the spectrum fee achieved in the auction.

If the HEO was not to offer mobile services then the valuation of the spectrum must be based only on the revenues that would be achieved by RBI FWA subscribers (that is, the FWA business case). In other words, the HEO would pay less than $22 million for spectrum to be used only within the RBI areas and to deliver only FWA and no other services.

This spectrum cost assumed by the Commission currently represents around 30% of the total FWA site cost calculated in the model – around **[ ]CCNZRI** cost per month per customer given that a total of **[ ]CCNZRI** dwellings are served by FWA in the Commission's model. A more realistic spectrum cost – given the absence of revenue from cellular mobile services and the use of spectrum only in less densely populated areas – must be captured by the model.

2.2.11 Inconsistencies in Commission's and TERA's documentation

The Commission explains[30] that its approach involves:

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30 Commerce Commission (2014), *Draft pricing review determination for Chorus' unbundled copper local loop service*, 2 December 2014, paragraph 595.

> Capping the number of premises that can be served by a FWA tower at 67 end-users per coverage area. This will ensure that each end-user connected to the network is guaranteed sufficient bandwidth for the provision of voice and broadband services.

This statement appears to imply that the Commission has assumed a maximum of 67 end-users to be served per FWA tower, while TERA's documentation[31] states that the peak throughput per FWA cell/sector is 16,666kbit/s and peak throughput per FWA customer is 250kbit/s. This translates to 67 users per sector and 200 users per tower (as the model assumes that there are three sectors per tower). We asked for clarification from the Commission and were informed that the model assumes that the total capacity per site is 200 customers. Consequently the Commission's draft determination needs to be corrected.

In addition to specifying different numbers of users per base station, the Commission's and TERA's documentation is inconsistent with respect to the type of technology – LTE or LTE-Advanced (LTE-A) – used in the FWA model. The Commission's draft determination[32] states that LTE is used:

> LTE provides much better performance than 3G and is essentially the same technology as ADSL running over a radio carrier. Unlike 3G, the coverage area does not change with loading with LTE, so dimensioning is a much simpler exercise.
>
> Generally, LTE is technically superior to 3G and is currently being commercially deployed in New Zealand cellular networks using the 700 MHz band. Consequently, we have modelled FWA using LTE on the 700 MHz band which will mean that both the performance and the coverage will be quite different to that currently achieved by Vodafone for RBI.

As stated by the Commission, it is true that LTE is already being deployed by mobile operators in New Zealand. As far as we are aware LTE-A is not being currently deployed for commercial use in New Zealand, although it has been introduced by operators in other

31 TERA Consultants (2014), *TSLRIC price review determination for the UCLL and UBA services – Model documentation*, November 2014, section 4.2.2, page 56.

32 Commerce Commission (2014), *Draft pricing review determination for Chorus' unbundled copper local loop service*, 2 December 2014, paragraphs 603-604.

countries, including Australia. However TERA's specification document[33] claims that LTE-A is used in the FWA model:

> There is one LTE advanced base station at each FWA site.

In addition TERA's model reference paper[34] states that the most advanced technology should be used but does not clearly specify that LTE-A is used in the model:

> The technology used by the FWA network should be based on the most advanced technology as it would offer a higher throughput to end-users and a better coverage for a lower cost. The FWA technology should therefore be based on Long Term Evolution (LTE or LTE advanced).
>
> Criterion 15: The FWA should use the LTE technology.

LTE-A is certainly a superior technology compared to LTE and offers inter-band carrier aggregation, enhanced use of MIMO and better heterogeneous network planning with the use of Relay Nodes.[35]

The use of two different terms – LTE by the Commission and LTE or LTE-A by TERA – means that either there is lack of clarity about the technologies applied in the modelling or there is insufficient understanding of the New Zealand market. Consequently we asked for clarification from the Commission and we were told that:

> The draft FPP model uses Long Term Evolution (LTE) Advanced. Please refer to section 6.3.1 of the Model Specification.

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33 TERA Consultants (2014), *TSLRIC price review determination for the UCLL and UBA services - Model specification*, November 2014, section 6.3.1, page 50.

34 TERA Consultants (2014), *TSLRIC price review determination for the UCLL and UBA services - Model Reference Paper*, November 2014, section 2.2.3.2, page 12.

35 3rd Generation Partnership Project (3GPP), *LTE-Advanced*, available at http://www.3gpp.org/technologies/keywords-acronyms/97-lte-advanced.

This means that TERA has used LTE-A in the FWA model and hence the relevant documents need to be amended. However as we have already discussed we have doubts that TERA's assumption of peak throughput per sector – 16,666kbit/s – is appropriate for LTE and consequently it is also too low for LTE-A.

2.3 Conclusions and recommendations

It is clear that the Commission has applied a number of simplifying and inappropriate assumptions in its use of FWA technology in its model, including:

- FWA confined to RBI areas
- conservative base station coverage, based on Vodafone's actual RBI sites, which does not reflect an efficient LTE deployment
- number of premises served per tower is capped conservatively
- no new sites are assumed to cover additional customers
- no use of microwave backhaul
- over-stated spectrum fee.

In addition there are a number of inaccuracies in the Commission's approach:

- the results do not reflect an efficient network that an HEO would deploy
- buildings outside the TSO boundary are included in the modelling
- inconsistent demand assumptions
- use of copper network opex for FWA network

The net effect of the simplified assumptions and inaccuracies is a significant departure from an efficient hypothetical network, and an increase in the margin of error associated with the model results.

We recommend that the Commission considers an alternative methodology that would better reflect the efficient deployment of FWA technology in an HEO's network. The following sections describe our recommended approach in detail.

3 Network Strategies FWA model: an overview

The Network Strategies model calculates the average cost per line for a fixed wireless access (FWA) service based on a sample of ESAs (Exchange Service Areas). These sample ESAs are representative of the various geotypes defined for the country, encompassing semi-urban and rural areas. The model covers only access network costs (sites and backhaul) and does not include the core network.

The objective is to calculate an FWA cost which can be compared with the fibre cost (calculated by the Commission's model) in order to determine whether fibre or FWA would be the least-cost technology for ESAs within specified areas.

3.1 FWA network characteristics

The Network Strategies model assumes that an HEO deploying FWA today would use LTE technology. Although this is a five year model, it is assumed that during that period there will be no technology upgrades.

We assume that 2×20MHz of spectrum will be required for the FWA service to meet coverage and capacity requirements. As coverage is the key requirement in the rural areas we will assume 2×20MHz in the 700MHz band.

Throughput of FWA services in the base year (i.e. 2015) is assumed to be 250kbit/s which is the average throughput used in the Commission's model.

3.2 Geographical scope

The focus of the model is regions outside dense urban areas (that is, outside Chorus' Zone 1 and 2). The total area to be covered will encompass Chorus Zones 3 and 4 (Exhibit 3.1).

MDF zone	*Description*	*% of switched lines*
Zone 1	High density areas of Auckland, Hamilton, Wellington, Christchurch and Dunedin	48%
Zone 2	High density areas of 28 provincial centres. Key satellite towns of the five main centres.	24%
Zone 3a and 3b	High density (i.e. 50km/h) areas of small towns with greater than 500 lines	9%
Zone 4	Remaining very small towns, low density areas and remote locations (e.g. Chatham Islands, Great Barrier Island)	19%

Exhibit 3.1: *Chorus zones [Source: Chorus]*

Following the same approach as the Commission, the estimation of the location of buildings and dwellings to be served by the FWA network is based on the address points within the TSO derived boundary from CoreLogic's Terrabase road and address database.

We have selected sample areas that are representative of these zones. The sample size includes sufficient coverage of ESAs to deliver results with an 90% confidence level with a margin of error of 10% (see Annex A for further details). Four different geotypes are defined for Zone 3 and Zone 4, corresponding to those used in the wireless cap analysis for the TSO,[36] namely:

- flat, highly populated rural countryside (geotype A)
- less dense rural areas with rolling hills (geotype B)
- sparsely populated rural areas with hilly terrain (geotype C)
- very sparsely populated areas of extreme isolation or extremely difficult terrain (geotype D).

36 Commerce Commission (2005), *Draft Determination for TSO Instrument for Local Residential Service for period between 1 July 2003 and 30 June 2004,* 23 December 2005. See Table 8.

As far as possible we have attempted to group adjacent Zone 4 ESAs, with bordering Zone 3a and 3b ESAs, into a single sample area. Using mainland contours sourced from Land Information New Zealand (LINZ)[37] and building locations from the Commerce Commission[38], together with visual inspection, the selected areas were classified into the four geotypes defined above.

Note that we have followed the Commission's approach in several respects:

- only buildings within TSO areas have been considered
- we have used exactly the same building locations as the Commission
- we have only considered ESAs which currently have no unbundled lines.

With respect to the latter point, the Commission stated that:

> We consider that unbundling is likely to be more feasible in areas outside the RBI FWA footprint, and therefore we gave greater weight in these areas to technologies that can be unbundled[39].

Given the Commission's concern we reviewed the locations of currently unbundled exchanges in New Zealand to ensure that we did not include any such exchange within our sample.

We also assumed that there would be no further unbundling during the model timeframe. We believe this is a reasonable assumption since the impact of the introduction of geographical averaging for UCLL prices is uncertain, and furthermore the Commission is not actively seeking to encourage unbundling in this review:

> … the migration to fibre is affecting access seekers' investment intentions in a way that means that we cannot be sure that any incentives we attempt to introduce through these

---

37 Elevation of the land surface above or below a vertical datum, in this case of LINZ topographic mapping, this is Mean Sea Level.

38 Commerce Commission (2014),*Corelogic database.*

39 Commerce Commission (2014), *Draft pricing review determination for Chorus' unbundled copper local loop service*, 2 December 2014, paragraph 285.

> pricing review determinations in favour of unbundling will in fact lead to unbundling, or will instead simply result in end-users paying more. In terms of our obligations under sections 18 and 19, we must do what we consider best gives, or is likely to best give, effect to promoting competition in telecommunications markets for the long-term benefit of end-users. Accordingly, we would need to be persuaded that attempting to incentivise unbundling would promote efficient investment decisions in a way that is likely to benefit end-users[40].

While it is impossible to predict with absolute certainty the impact of the outcome of this price review on further unbundling, on the balance of probabilities it is unlikely to increase given interested service providers' public statements on the issue. Moreover the decrease in rural prices as a result of geographic de-averaging may not be sufficient to support a business case for further unbundling in rural areas, particularly in current circumstances in which the Government is extending RBI funding. In addition we note that the Commission's constant demand assumption effectively precludes the possibility of further unbundling.

Areas have been selected from different parts of the country to ensure diverse conditions are included. A total of eight areas were selected for the FWA modelling. The areas encompass a total of 74 ESAs (Exhibit 3.2).

40 *Ibid*, paragraph 473.

Area	*Zone 4*	*Zone 3b*	*Zone 3a*
Geotype A			
A-1	4	1	1
A-2	7	2	1
Geotype B			
B-1	15	1	1
B-2	5	2	1
Geotype C			
C-1	12	1	2
C-2	3	2	1
Geotype D			
D-1	4	2	1
D-2	3	1	1
Total	53	12	9

Exhibit 3.2: *Number of ESAs by area and zone [Source: Network Strategies]*

The following exhibits illustrate the distribution / location of the areas in the New Zealand territory (Exhibits 3.3 and 3.4). Further geographic details about the selected sample areas are included in Annex A.

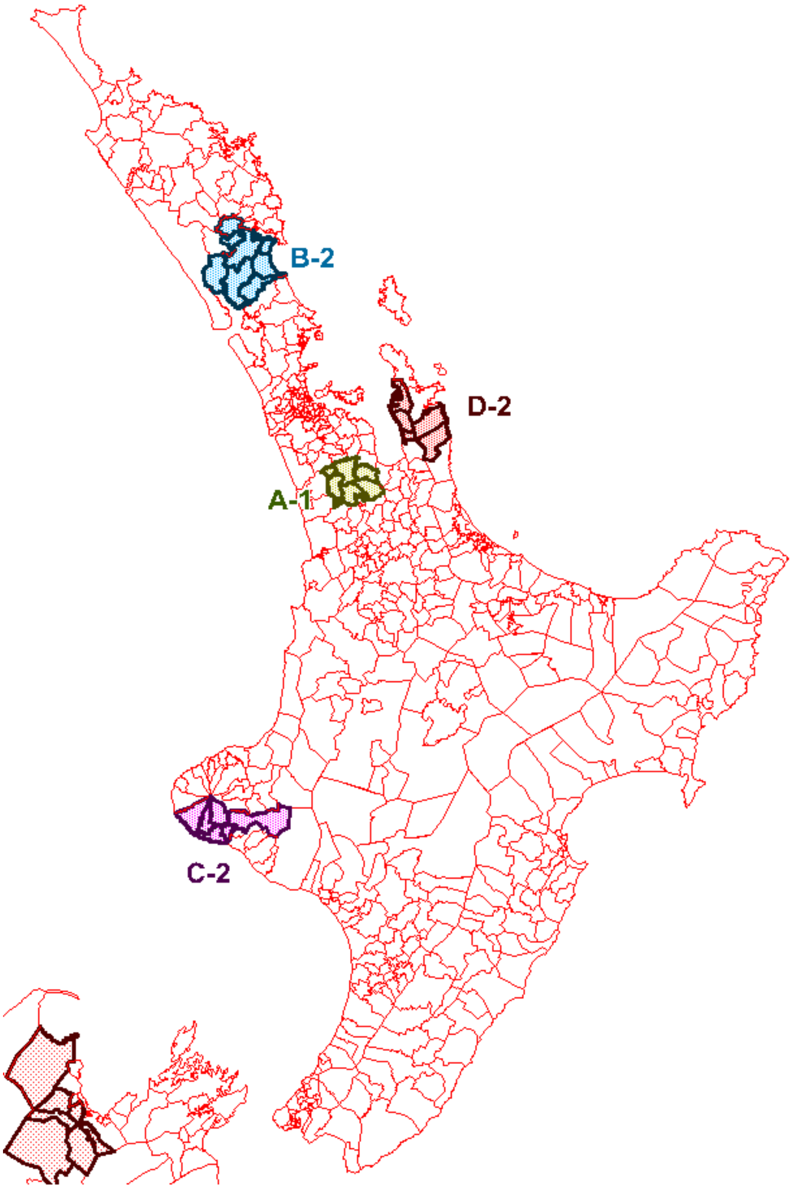


Exhibit 3.3:
Selected sample areas in the North island used in the FWA modelling [Source: Network Strategies]

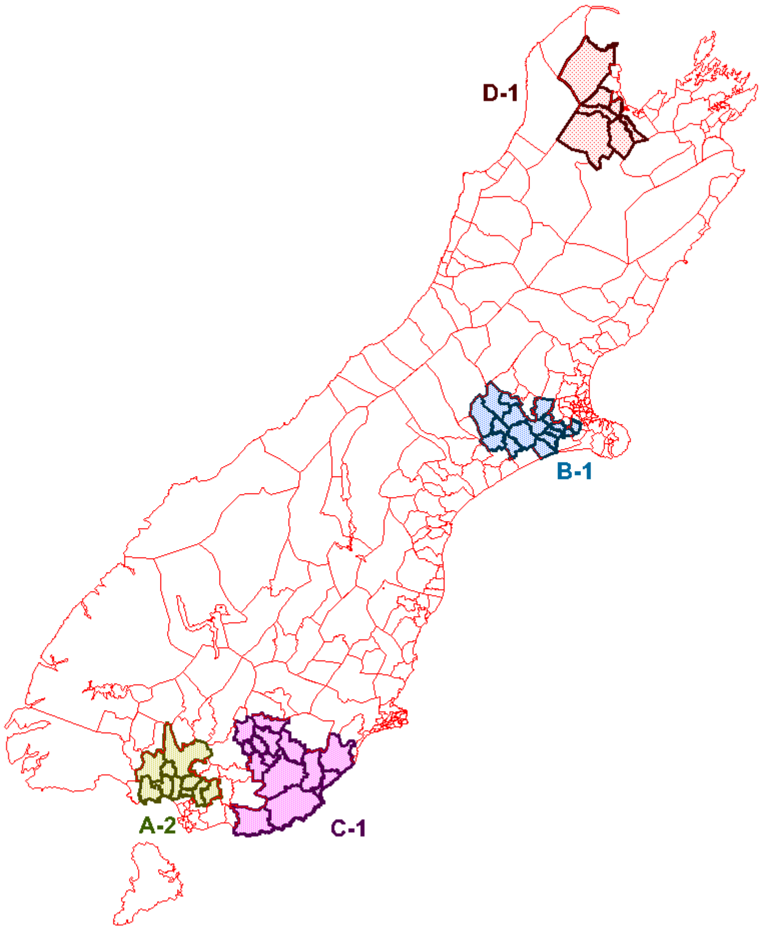
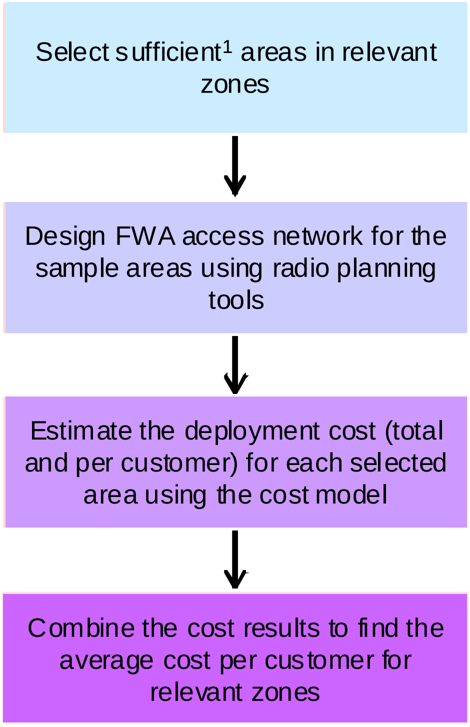


Exhibit 3.4:
Selected sample areas in the South island used in FWA modelling [Source: Network Strategies]

3.3 Study methodology

The model calculates the cost of providing FWA services to the selected areas given the radio design for each area undertaken by Vodafone on our behalf (Exhibit 3.5) .



1 Detailed discussion on the size of the sample is presented in Annex A

Exhibit 3.5: *Overview of model approach [Source: Network Strategies]*

The radio design is based on the same co-ordinates of customers used by the Commission. We were provided with the buildings / dwellings co-ordinates used in the Commission's model, namely the address points from CoreLogic's Terrabase road and address database.

The assumptions for the radio propagation analysis are detailed in Annex B.

As described in Section 3.2 the selected areas are sorted into geotypes based on a combination of terrain information and visual inspection. It is then possible to assess whether there are significant cost differences between geotypes. On the basis of a statistical analysis of the model results by area[41], we found that there was insufficient evidence to confirm cost differences between the geotypes. This then informed our decision to combine

41 A statistical test (one-way analysis of variance) found that the differences between the geotype averages was not statistically significant at the 5% level, and thus we concluded that there was not sufficient evidence to suggest that there were differences between the geotype averages. Note that this analysis was based on relatively few datapoints, and if more areas were included a more robust analysis would be possible.

the geotype results rather than classifying every ESA by geotype and deriving an overall estimate using a weighted average by geotype.

The final results are obtained by taking the weighted average of the results for each sample area based on number of dwellings in the relevant areas.

3.4 Model framework

The model encompasses a timeframe of five years, with 2015 being the base year 0 and 2020 is year 5.

The model was developed in Microsoft Excel, and is structured in a modular format that is compatible with the underlying model logic (Exhibit 3.6). Each model sheet represents a well defined model component.

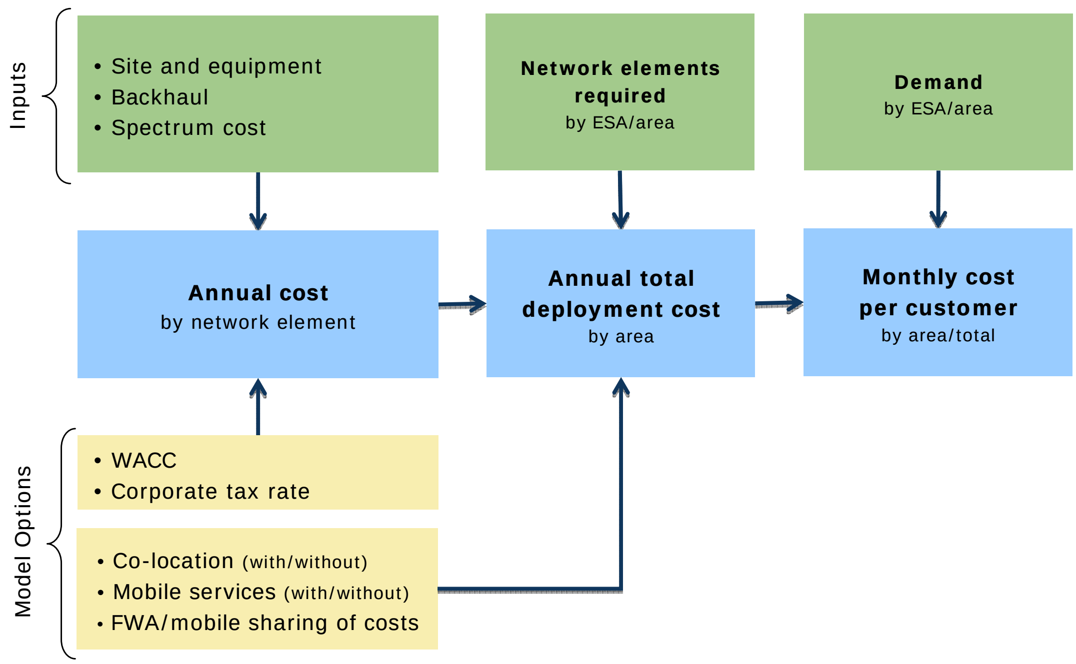


Exhibit 3.6: *Cost model map [Source: Network Strategies]*

3.5 Model inputs

The main model inputs are:

- the number of sites and base stations required to provide a defined extent of FWA geographical coverage in New Zealand, informed by radio propagation analysis of selected areas
- infrastructure, radio equipment and any other equipment required at each site
- backhaul infrastructure required to connect the sites to the core network (including repeaters where required)
- any customer infrastructure required, such as pole, antenna and cabling
- unit costs of equipment required
- spectrum cost
- revenue from co-location and the provision of other mobile services.

Co-location

The model uses Vodafone's existing sites plus any additional sites to provide service to customers outside the Vodafone footprint. While all new sites are treated as greenfields sites and thus all costs associated with establishing those sites are included, the model identifies sites that can be co-located and in these cases only co-location costs are included.

The model also assumes that other operators will co-locate capacity on the HEO's new sites. In these circumstances land rental will be shared between the HEO and the third party operator and this is captured in the model when calculating the rental cost for new sites open access.

3.6 Costs

Network elements

Evaluating the costs for the network elements requires the following inputs:

- capital cost
- capital cost trend (annual percentage change)
- financial / physical lifetime (the model will assume these are the same)
- spares (as a percentage of capital cost)
- tax depreciation rate
- operational cost
- operational cost trend (annual percentage change).

Note the capital cost trend is applied to the capital costs to obtain the costs in each year. It is important to assess whether the input capital costs are relevant for the model base year (2015) – if those costs are for an earlier year they are adjusted accordingly.

The cost inputs used in the model have been provided to us by Vodafone on 1 December 2014. Some of this data differs to Vodafone's earlier Section 98 submission to the Commerce Commission.[42] We compared the data provided to us with the Section 98 submission and where there are differences in general the Section 98 data is lower by around 5% to 9%.

Spectrum costs

The model includes spectrum costs. The spectrum cost is implemented as annualised opex based on the results of the last 700MHz New Zealand spectrum auction. Similar to the Commission's approach which allocates the whole spectrum cost to FWA, our model also assumes that the 2×20MHz spectrum is used to provide FWA services only and all the associated spectrum costs are paid by FWA customers.

In this regard our approach consists of calculating a spectrum operational cost per customer by dividing the total amount paid for the spectrum amongst the total number of potential FWA customers. In contrast to the Commission's approach, our model assumes that the

42 Vodafone submitted cost information to the Commission in response to the s98 notices sent to Vodafone. The notices are available at http://www.comcom.govt.nz/regulated-industries/telecommunications/regulated-services/standard-terms-determinations/unbundled-copper-local-loop-and-unbundled-bitstream-access-services-final-pricing-principle/.

2×20MHz spectrum will be serving customers beyond the RBI areas, hence the customer base used to calculate the cost per customer differs from that in the Commission's model.

The spectrum cost assumed in the model is around **[ ]CCNZRI** per month per customer.

Cost sharing

The model assumes that the HEO will also provide mobile services in addition to FWA hence the model captures the benefits from the provision of other mobile services. It is assumed that the HEO will serve mobile customers from its new and co-located sites.

Mobile subscribers reported by Vodafone and Spark as at June 2013 indicates that both account for around 87% of the total mobile connections – a total of 4.77 million as noted by the Commerce Commission.[43] Following a conservative approach, it is assumed that the HEO will capture the remaining 13% of the market.

Although the HEO can serve both mobile and FWA customers from the same site, we assume that it will not be sharing any spectrum or equipment. Hence the mobile customers can only be served by assigning additional spectrum and adding separate equipment. However the site costs – including base station deployment cost and rental cost – will be shared between FWA and mobile customers.

These site costs can be split between the mobile and FWA customers based on customer numbers, traffic carried or revenue earned. As site costs are relatively fixed and do not directly depend on the traffic or revenue (unlike spectrum and equipment costs), splitting on customer numbers is a reasonable approach which also avoids the use of additional assumptions and calculations. Consequently we have implemented sharing by dividing the relevant site costs amongst the HEO's mobile subscribers and FWA customers, resulting in 77% of the total site cost to be allocated to FWA customers with the remaining 23% to mobile customers.

43 Commerce Commission (2014), *Annual Telecommunications Monitoring Report 2013*, May 2014.

Overheads and common costs

Overheads and common costs are not included within the model. The model is intended to be implemented in conjunction with Commission's fibre model, and thus all overhead and common costs must be allocated across both fibre and FWA services. This can only be done once the two models are combined.

4 Network Strategies FWA model: results

4.1 Radio propagation analysis

Based on the inputs and assumptions given in Annex B, Vodafone performed radio planning to find the number and characteristics of base station sites required to meet the demand in the eight sample areas (Exhibit 4.1).

Radio planning was performed to ensure that the two criteria – coverage and capacity – were satisfied. Coverage sites were planned to cover 100% of customers using co-location on existing Vodafone sites if possible and adding new multi-access sites (to allow for co-location in the future) where required. In addition repeaters were added where there were only a few customers to cover and it was more economical to do so (rather than adding a new site).

After ensuring 100% coverage, the capacity criteria were checked for all the customers, namely peak capacity of 5Mbit/s and average capacity of 250kbit/s per customer. When the capacity requirements were not met using the coverage sites, additional capacity was added. This was done by either upgrading existing sites (adding more sectors) or adding new single access sites.

Two types of backhaul options are assumed – fibre and digital microwave radio/wireless (DMR). The backhaul for new sites was estimated based on the ratio of fibre and DMR backhaul for existing sites.

[

VNZCI]

Exhibit 4.1: Results of Vodafone's radio planning for sample areas [Source: Vodafone and Network Strategies]

4.2 Cost model results

The results presented in this section assume:

- the HEO provides mobile services as well as FWA services
- cost sharing (FWA) – 77% of total site cost allocated to FWA
- co-location
- spectrum cost included
- WACC – 6.47%
- corporate tax rate – 28%.

Vodafone's radio planning results were used as inputs for the cost model to estimate the cost per customer for each of the eight sample areas (Exhibit 4.2). The results for geotypes A and B are generally lower than geotypes C and D, although as discussed in Section 3.2 the differences are not statistically significant.

The weighted average of the results (shown in Exhibit 4.2) for the eight areas gives $26.96 as the cost per customer per month for the first year. Note that this value excludes non-network costs. If we add a non-network cost mark up of 11.78% based on TERA's network cost for non-urban areas[44], the result for 2015 is $30.14 per customer per month. The smoothed value (including non-network costs) for 2015 to 2020 is $30.86 which is 35% lower than TERA's value of $47.73 per month for non-urban customers[45].

Sample area	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
A-1	21.85	22.08	22.34	22.63	22.94	23.28
A-2	23.49	23.75	24.04	24.36	24.70	25.08
B-1	22.01	22.24	22.50	22.78	23.09	23.43
B-2	26.76	27.08	27.42	27.80	28.21	28.65
C-1	37.34	37.79	38.28	38.81	39.39	40.01
C-2	24.58	24.87	25.19	25.54	25.92	26.33
D-1	33.13	33.55	34.01	34.50	35.04	35.61
D-2	26.46	26.78	27.13	27.51	27.92	28.36
Weighted average	26.96	27.28	27.62	28.00	28.41	28.85

Exhibit 4.2: *Average cost per customer per month (NZD), Zones 3a, 3b and 4 – excluding non-network cost [Source: Network Strategies]*

4.3 Sensitivity testing

We performed sensitivity testing of the model to analyse the effect on results when key inputs are changed. The parameters tested were:

- capex – site
- capex – radio access network (RAN) equipment & software[46]

44 Non-network cost mark up calculations are based on the Fibre+FWA network cost for ULL services (opex, capex and non-network) available at TERA's model. CI_ComCom – UBA model v5.1.xsls, worksheet 'OPEX and ACCESS'.

45 Commerce Commission (2014), *Draft pricing review determination for Chorus' unbundled copper local loop service*, 2 December 2014, paragraph 10.

46 Opex for radio access network (RAN) equipment & software is not part of the set of parameters tested as this cost is included within the site opex.

- capex – backhaul
- opex – site
- opex – backhaul
- cost sharing (FWA).

We found that the models results are most sensitive to site capex and cost sharing (FWA). A ±10% change in the other parameters resulted in at most ±2% variation in the cost per line. In the case of site capex, this same percentage change results in cost per line varying by between ±3.7% and ±4.0%. Varying cost sharing by ±10% resulted in cost per line changing by between ±3.1% and ±3.3% (Exhibit 4.3).

Parameter changed	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
Capex – site						
+10%	+3.7%	+3.8%	+3.8%	+3.9%	+3.9%	+4.0%
-10%	-3.7%	-3.8%	-3.8%	-3.9%	-3.9%	-4.0%
Capex – RAN & software						
+10%	+2.0%	+1.9%	+1.8%	+1.7%	+1.6%	+1.5%
-10%	-2.0%	-1.9%	-1.8%	-1.7%	-1.6%	-1.5%
Capex – backhaul						
+10%	+0.4%	+0.4%	+0.4%	+0.4%	+0.4%	+0.4%
-10%	-0.4%	-0.4%	-0.4%	-0.4%	-0.4%	-0.4%
Opex – site						
+10%	+1.7%	+1.7%	+1.7%	+1.8%	+1.8%	+1.8%
-10%	-1.7%	-1.7%	-1.7%	-1.8%	-1.8%	-1.8%
Opex – backhaul						
+10%	+1.6%	+1.7%	+1.7%	+1.7%	+1.7%	+1.8%
-10%	-1.6%	-1.7%	-1.7%	-1.7%	-1.7%	-1.8%
Cost sharing (FWA)[1]						
+10%	+3.1%	+3.1%	+3.1%	+3.2%	+3.2%	+3.3%
-10%	-3.1%	-3.1%	-3.1%	-3.2%	-3.2%	-3.3%
Spectrum cost						
+10%	+0.6%	+0.6%	+0.6%	+0.6%	+0.6%	+0.5%
-10%	-0.6%	-0.6%	-0.6%	-0.6%	-0.6%	-0.5%

1 A ±-10% change in Cost sharing (FWA) represents ±10% change in the site cost to be allocated to FWA services.

Exhibit 4.3: *Percentage point changes in annual cost per customer (weighted average) due to increase/decrease in key parameters [Source: Network Strategies]*

Similar results can be observed when analysing the impact on the cost per line for each of the areas modelled for 2015 (Exhibit 4.4).

Parameter changed	*A1*	*A2*	*B1*	*B2*	*C1*	*C2*	*D1*	*D2*
Capex – site								
+10%	+3.9%	+3.9%	+3.4%	+3.6%	+4.0%	+3.7%	+3.6%	+3.7%
-10%	-3.9%	-3.9%	-3.4%	-3.6%	-4.0%	-3.7%	-3.6%	-3.7%
Capex – RAN & software								
+10%	+2.1%	+2.1%	+2.1%	+2.0%	+2.0%	+2.0%	+1.9%	+1.9%
-10%	-2.1%	-2.1%	-2.1%	-2.0%	-2.0%	-2.0%	-1.9%	-1.9%
Capex – backhaul								
+10%	+0.6%	+0.6%	+0.3%	+0.3%	+0.3%	+0.5%	+0.4%	+0.3%
-10%	-0.6%	-0.6%	-0.3%	-0.3%	-0.3%	-0.5%	-0.4%	-0.3%
Opex – site								
+10%	+1.7%	+1.7%	+1.5%	+1.6%	+2.0%	+1.5%	+1.5%	+1.6%
-10%	-1.7%	-1.7%	-1.5%	-1.6%	-2.0%	-1.5%	-1.5%	-1.6%
Opex – backhaul								
+10%	+1.0%	+1.0%	+2.0%	+2.1%	+1.2%	+1.8%	+2.1%	+1.9%
-10%	-1.0%	-1.0%	-2.0%	-2.1%	-1.2%	-1.8%	-2.1%	-1.9%
Cost sharing (FWA)[1]								
+10%	+3.0%	+3.2%	+2.5%	+3.0%	+2.6%	+3.7%	+3.7%	+3.4%
-10%	-3.0%	-3.2%	-2.5%	-3.0%	-2.6%	-3.7%	-3.7%	-3.4%
Spectrum cost								
+10%	+0.7%	+0.7%	+0.7%	+0.6%	+0.4%	+0.6%	+0.5%	+0.6%
-10%	-0.7%	-0.7%	-0.7%	-0.6%	-0.4%	-0.6%	-0.5%	-0.6%

1 A ±10% change in Cost sharing (FWA) represents ±10% change in the site cost to be allocated to FWA services.

Exhibit 4.4: *Percentage point changes in annual cost per customer (2015) due to increase/decrease in key parameters [Source: Network Strategies]*

Site costs (including capex and opex) represent **[ ]VNZCI** of the total cost per line (Exhibit 4.5). Furthermore, the cost sharing (FWA) option determines the percentage of site cost that is split between the mobile and FWA customers. Consequently, a change on any of these two inputs will have a greater impact on the results than the other parameters tested.

[

Exhibit 4.5: *Breakdown of total cost per line by cost component, 2015 [Source: Network Strategies]*

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4.4 Implications

The significant reduction in costs for non-urban areas will have an impact on national results. TERA’s national average is $28.22 per customer per month and is based on $20.63 for urban areas and $47.73 for non-urban (Zones 3 and 4) areas[47].

In contrast to our estimates, TERA’s estimates for Zones 3 and 4 have been derived with the inclusion of unbundled ESAs. These ESAs are typically the more densely populated 3a Zones, and we would expect the cost of service provision to be lower in such areas than the more sparsely populated Zones with no unbundling that we have modelled. Thus our results should be regarded as an upper bound for all Zone 3 and 4 areas.

47 Commerce Commission (2014), *Draft pricing review determination for Chorus’ unbundled copper local loop service*, 2 December 2014, paragraph 10.

Consequently if we recalculate the national average assuming the same urban and non-urban ratio as TERA and $30.86 as the cost for non-urban areas, the national average result would be $23.50 per customer per month (Exhibit 4.6). This means that the national cost will reduce by $4.72 per customer per month.

Monthly cost per line	*TERA*	*Network Strategies*
National	28.22	23.50
Urban	20.63	20.63[1]
Rural	47.73	30.86

1 TERA estimate used for urban cost per line.

***Exhibit 4.6**:* *Geographically averaged price for UCLL services [Source: Commerce Commission and Network Strategies]*

5 Conclusions and recommendations

5.1 Conclusions

In modelling FWA the Commission notes that it is required 'to choose the optimal deployment method, and also where we consider a hypothetical efficient operator would deploy FWA'[48].

Optimal deployment

As regards the optimal deployment method, we agree with the Commission's choice of LTE technology using the 700MHz band. However the implementation approach adopted by the Commission's consultants does not reflect an efficient LTE deployment. In particular:

- the coverage areas of Vodafone's actual RBI sites are assumed. As these were designed for 3G technology and spectrum bands higher than 700MHz, the assumed coverage is too conservative for LTE technology in the 700MHz band
- the cap applied to the number of premises served per tower is extremely conservative for LTE technology
- the Commission's use of distance from the exchange to determine whether buildings are served by fibre or FWA leads to results that are unrealistic from a network planning perspective

48 Commerce Commission (2014), *Draft pricing review determination for Chorus' unbundled copper local loop service*, 2 December 2014, paragraph 594.

- no new sites are assumed to cover additional customers
- no use of microwave backhaul is assumed.

FWA footprint

The Commission has confined the FWA footprint to RBI areas. However the RBI is a Government policy initiative whereas for an HEO the relevant footprint for an FWA MEA would be much wider than the RBI footprint, particularly given the superior performance speeds available through LTE. Applying an RBI boundary effectively constrains the HEO to inefficient FWA deployment.

We agree with the Commission's decision to assume that customers outside a TSO-derived boundary would be required to make a capital contribution to obtain service, and therefore capex-related costs for these customers should be excluded. However, in examining the Commission's model we found that buildings outside the TSO boundary have in fact been included in the capex calculations. Clearly these should be removed for consistency with the Commission's stated principle.

Other assumptions

We agree with the Commission's assumption that the HEO should have access to a 2×20MHz allocation of 700MHz spectrum at the price that operators actually paid in the real world. However it is not feasible that an HEO would pay such a price for the provision of FWA services to RBI areas only. In fact if the HEO were to be limited to FWA provision in RBI areas then it is possible that the Government may offer spectrum at a heavily discounted price to induce it to provide service. Thus we consider it more realistic that the Commission assumes that, at a minimum, the HEO would seek ways of sharing spectrum costs so that the full cost would not be allocated to FWA services.

We also identified a number of other inaccuracies in the Commission's approach, including inconsistent demand assumptions, and the use of copper network opex for the FWA network.

5.2 Recommendations

In conjunction with Vodafone, Network Strategies has developed cost estimates for the efficient deployment of FWA using LTE across eight sample areas, excluding locations outside the TSO-derived boundary and any locations with unbundled lines. Our estimates are based on network designs using radio propagation modelling. The designs achieve 100% coverage of the same building locations as those used by the Commission's consultants, but extend beyond the RBI boundaries to encompass non-urban areas that a rational profit-maximising HEO would be expected to serve with this technology.

We have retained a number of the Commission's assumptions, including:

- the availability of 2×20MHz spectrum in the 700MHz band
- throughput of FWA services in the base year (i.e. 2015) is assumed to be 250kbit/s which is the average throughput used in the Commission's model
- financial parameters such as WACC.

Where choices were available we have also attempted to select conservative options:

- LTE was selected as the technology to model rather than LTE+ although the latter is commercially available
- Only limited cost sharing has been implemented in the model with 77% of total site cost still allocated to FWA
- Conservative market share assumptions were used for cost sharing calculations – HEO with 13% mobile subscribers market share
- Conservative assumptions underlie the allocation of spectrum fees between FWA and mobile services – its was assumed that 700MHz spectrum will not be used to serve subscribers in Zones 1 and 2

We believe that the issues that we have identified for optimal deployment with the Commission's existing FWA model implementation cannot be remedied within the Commission's existing approach. As such we recommend that the Commission adopts our model estimates for use in conjunction with its own model. These estimates would replace its draft model estimates for each ESA within Zones 3a, 3b and 4. This recommendation provides an immediate remedy for the issues we identified with the Commission's draft approach since the model estimates are based on actual radio planning designs. We note, however, that the margin of error of our estimates could be further reduced if further sampling were to occur, and recommend that the Commission considers extending our analysis in this manner.

Annex A: Area selection

A.1 Area sampling

A key aim when using a sample to represent a wider population is to ensure that the sample is large enough to give an acceptable level of accuracy for the results.

If we assume a simple random sample, we can estimate the sample size based on:

- total number of ESAs
- confidence interval
- margin of error.

Zones 4, 3b and 3a encompass 533 ESAs with no unbundled lines. The table below (Exhibit A.1) shows the sample sizes required for given confidence intervals and margins of error. For example, with a sample size of 39 ESAs we would be 80% sure (the confidence interval) that the sample estimate would have a margin of error of ±10%.

Confidence interval	*Margin of error*	*No of ESAs*
95%	±5%	224
	±7.5%	130
	±10%	82
90%	±5%	180
	±7.5%	99
	±10%	61
80%	±5%	126
	±7.5%	65
	±10%	39

Exhibit A.1: *Sample size for given confidence intervals and margins of error, for a simple random sample [Source: Network Strategies]*

A.2 Selected sample areas

The following exhibits illustrate the selected sample areas including the distribution of the buildings to be served by FWA, ESA boundaries and elevation profile (Exhibit A.2 to Exhibit A.9). Map legends are included in Exhibit A.10.

Geotype A

[

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Exhibit A.2:

Area A-1 [Source: Network Strategies]

[

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Exhibit A.3:

Area A-2 [Source: Network Strategies]

Geotype B

[

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Exhibit A.4:

Area B-1 [Source: Network Strategies]

[

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Exhibit A.5:

Area B-2 [Source: Network Strategies]

Geotype C

[

CCNZRI]

Exhibit A.6:

Area C-1 [Source: Network Strategies]

[

CCNZRI]

Exhibit A.7:

Area C-2 [Source: Network Strategies]

Geotype D

[

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Exhibit A.8:

Area D-1 [Source: Network Strategies]

[

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Exhibit A.9:

Area D-2 [Source: Network Strategies]

Map legends

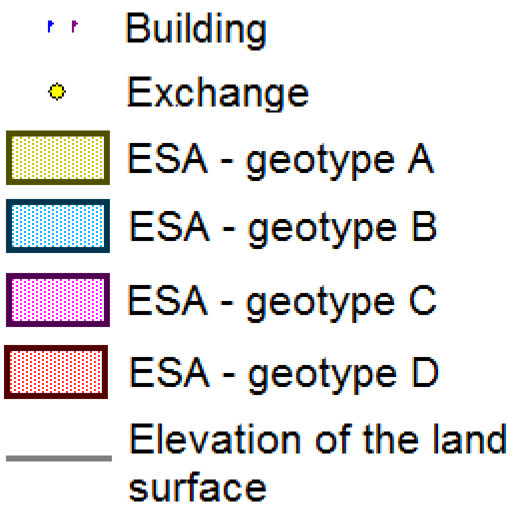

Exhibit A.10:
Map legends
[Source: Network Strategies Limited]

Annex B: Radio propagation assumptions

The radio parameters shown in Exhibit B.1 were used for designing the FWA network. The values for the parameters are based on inputs collected from Vodafone, Spark and the Commission.

Category	*Parameter*	*Value*
General	Technology	LTE Rel 8
	Frequencies of operation	700MHz
	Total spectrum bandwidth	2x20MHz
	Peak capacity requirements per customer	5Mbit/s
	Average capacity requirements per customer in 2015	250kbit/s
	Modelling period	2015 (Year 0) to 2020 (Year 5)
	Coverage requirements	100% customer coverage

[

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Exhibit B.1: *Radio planning parameters [Source: Network Strategies]*