ANNEXURE D

Report of Dr Bridger M. Mitchell

APPROPRIATENESS OF TELSTRA'S 2005 COST MODELLING METHODOLOGY

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1 PRELIMINARY MATTERS

1.1 Confidentiality

1. The information in this statement is confidential to Telstra Corporation Limited **("Telstra")**. I have prepared this statement on the assumption that it will remain confidential, subject to disclosure for the purpose of assessing Telstra's undertakings and to the terms of confidentiality undertakings signed by persons involved in that process.

1.2 Scope of statement

2. I have been asked by Telstra to provide a report as to the appropriateness of Telstra's methodology for the estimation of efficient network costs ("**EN costs**") of the following services: PSTN originating and terminating access services (**"PSTN OTA")**, local carriage service (**"LCS"**) and unconditioned local loop service (**"ULLS"**) -- together the "**UT Services**".

3. Telstra has constructed a bottom-up engineering-based cost model – the PSTN Ingress Egress II (**"PIE II"**) model – to estimate those efficient network costs. In preparing this report I have examined a description of the PIE II model as well as several inputs and results worksheets used by the model. I have assessed the PIE II model's cost estimating methodology from the perspective of economic principles of cost estimation and the practice of TSLRIC modelling in regulatory proceedings in other countries.

4. In reaching my opinion in this report, I have had reference to the approaches taken in formulating forward-looking cost models in the US, UK, NZ, and Malaysia and I have relied on a description of the PIE II model provided to me by Telstra and on the documents and data sources that are referenced in the footnotes of this report.

5. Following the executive summary (chapter 2) this report discusses efficient costs and pricing (chapter 3) and how network cost models can be constructed to estimate those costs (chapter 4). Chapter 5 discusses provisioning for future and uncertain demand and recovery of the costs of efficient provisioning. Chapter 6 then examines the methodology used in the PIE II model and compares it to forward-

looking cost models in several other jurisdictions. Finally, Chapter 7 summarized the use of the PIE II model to estimate costs for 2005/06, 2006/07 and 2007/08.

2 EXECUTIVE SUMMARY

6. As a matter of regulatory policy in Australia and in a number of other countries, the prices for UT services have been based on Total Service Long-Run Incremental Cost ("**TSLRIC**"), plus an allocation of common costs. Such EN costs are consistent with the Australian legislative criteria for determining access prices.

7. In practice, estimates of EN costs have been calculated by constructing engineering-economic models of a telecommunications network based on individual network elements.[1] These models are called Total Element Long-Run Incremental Cost ("**TELRIC**") models. In TELRIC models each service is well defined by its uses of the network elements. This approach substantially reduces the magnitude of the problem of measuring and allocating common costs, as many of these costs are attributed directly to individual network elements.

8. In most countries, the scope of the modelled network includes supplying basic PSTN services to residential and business customers, and access services such as the UT services. Several models also include leased lines. The PIE II model includes these services and, in addition, leased lines, ISDN services, and copper-based access services.

9. An efficient network must be provisioned with sufficient capacity both to meet current demand and to provide spare capacity to serve future growth. In international practice, some of the costs of spare capacity are recovered in the prices of services in both current and future periods.

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[1] The UK has moved from using an early bottom-up (engineering-economic) cost model to a top-down model to estimate Long Run Incremental Costs (LRIC) based on current cost accounts of the incumbent's network. The top down model is described in BT: Accounting Documents, 17 August, 2004, available at http://www.btplc.co.uk/Thegroup/Regulatoryinformation/Financialstatements/PDF2004/AccountingDocuments17August2004.pdf. Henceforth, BT's LRIC Methodology. The implementation of this methodology is described in BT: Long Run Incremental Cost Model, Relationships and Parameters, 17th August 2004, available at http://www.btplc.com/Thegroup/Regulatoryinformation/Financialstatements/PDF2004/LRIC_RP17August2004.pdf. Henceforth, BT's LRIC R&P.

10. The major requirements for a TELRIC model include efficient production of services, employment of best-in-use technology, and a forward-looking perspective that accounts for current and future prices and technological advances. In international practice, regulators have adopted a "scorched-node" approach that optimises the design of a new network given the existing switching locations. The PIE II model is consistent with these requirements but includes some features that achieve greater efficiency than would be obtained from a strict scorched-node model.

11. The PIE II model dimensions the customer access network using data for each local service area. Copper access cables connect subscribers to remote access units. Local and transit network switches are connected by fibre-optic cables and rings. I am advised by Telstra that the major network elements, including distribution and main cables, remote access units, switches, cable trenches, and transport facilities are dimensioned using current best-practice design principles. In line with international cost modelling practice, operating and maintenance expenses, common support expenses, and indirect capital costs are estimated by adjusting current actual expenses to reflect a forward-looking view.

12. In my opinion the PIE II model is a forward-looking cost model based on best-practice network technology. The model was first used with subscriber and traffic forecasts for the years 2002/03 – 2004/05. The model calculations have been updated with revised traffic forecasts for the years 2006/07 and 2007/08. I am informed by Telstra that provisioning of each network element is based on efficient engineering principles that take into account subscriber and traffic density. Asset prices and operating, maintenance, and indirect expenses are estimated based on recent experience with current-technology equipment.

13. Forward-looking TSLRIC models have been used to assess pricing of telecommunications services in a number of jurisdictions. The structure and basic assumptions of the PIE II model generally correspond to those of the bottom-up cost models used in the US and NZ and are broadly consistent with assumptions underlying the top-down LRIC model used in the UK. For a number of central modelling decisions -- estimation of trench distances and the extent of trench sharing, provisioning of spare capacity, calculation of operations and maintenance

costs, and incorporation of network planning costs – the calculations used in the PIE II model are commensurate with the corresponding approaches in other models.

14. In my opinion, the cost-estimation methodology in the PIE II model and the PIE II model more generally appropriately incorporate the principles for TELRIC modelling that have been developed and applied in international practice.

3 EFFICIENT COSTS AND PRICING

3.1 Forward-looking total service costs (TSLRIC)

15. The ACCC has, in the past, stated that prices for declared services should, in general, be based on the Total Service Long-Run Incremental Cost **("TSLRIC")** of providing the relevant declared service[2] and has used a cost model to calculate an estimate of the TSLRIC of various declared services[3].

16. As applied to services provided over the PSTN **("PSTN Services")**, TSLRIC embodies the following concepts:

- *Total service* requires that the cost of producing the entire output of the service be evaluated. The total output is the sum of the quantity of output used by the incumbent network supplier plus all output required for services used by other operators.
- *Long-run* incremental costs permit all inputs to be considered variable, so that all fixed costs and capital costs are included. The technology of production should be best in use, one that is most cost-effective in current networks.
- *Incremental costs* measure the increase in total costs of providing PSTN Services from a *baseline* in which the services in question are not produced, but other services may be produced. The incremental costs are the difference between the total costs of producing both the baseline

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[2] ACCC, "Access Pricing Principles: Telecommunications," July 1997, p. 21 ("Access Pricing Principles").

[3] ACCC, "A report on the assessment of Telstra's undertaking for the Domestic PSTN Originating and Terminating Access services," July 2000 ("Assessment of Telstra's Undertaking").

services and the increment, and the total costs of producing only the baseline services.

17. A *common cost* is one that the access provider must incur in order to produce the relevant service, another service, or both of those services together[4]. For example, a common cost would be the cost of a local area switch with the minimum capacity necessary to provide either the relevant service or another service. Such costs would be incurred even if only the other service, but not the relevant service, were produced. As a consequence, common costs are not incremental to producing the relevant service. In its *pure* form, the TSLRIC of a PSTN Service therefore excludes any common costs that are shared with other services.

18. However, it is recognized both in Australia and internationally that, in addition to pure TSLRIC, prices should include some recovery of costs that are common to both other services and the relevant service[5]. In this report, I will refer to TSLRIC

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[4] Some costs are likely to be common to *all* services produced by the firm. These may include such things as the costs of general corporate management and network planning.

Other costs can be common to a *subset* of two or more services, but not common to the remaining services. For example, local, long distance and fixed-to-mobile services all use PSTN switching; therefore, some investment and maintenance costs of switching equipment, and their supporting buildings and land, are likely to be common to those services. However, those costs are not common to leased line services, which make no use of PSTN switching.

The TSLRIC of a service includes not only the costs directly associated with that service but also any changes (increases or decreases) that occur in any costs of shared resources when that service is produced with the other baseline services. Increases in the costs of shared resources could, for example, be due to investment in a larger capacity network element that is required because total demand increases due to including the relevant service. The costs of shared resources could also change if efficiently producing that service in conjunction with the other services involves shifting to a different technology. For example, if the service to be evaluated were a high-bandwidth data service, the efficient method of production could result in shifting from a distribution network based on twisted-pair copper cables to one using coaxial or fibre-optic cables. In this case, it is likely that the magnitude of costs shared by the relevant service would change.

[5] (A) The FCC concluded that "the prices that new entrants pay for interconnection and unbundled elements should be based on the local telephone companies [*sic*] Total Service Long Run Incremental Cost of a particular network element … plus a reasonable share of forward-looking joint and common costs." See FCC, "In the Matter of Implementation of the Local Competition Provisions in the Telecommunications Act of 1996," CC Docket No. 96-98, First Report and Order, Released: August 8, 1996, ¶ 29 ("FCC Local Competition Order").

(B) Oftel, in setting charges for call termination and for general network baskets, "decided to use an equal proportionate mark-up" to recover the common costs between conveyance and access. See Oftel, "Network Charges from 1997," July 1997, ¶ 3.18 ("Oftel Network Charges"). This approach has been described in BT's LRIC Methodology, Section 5.3.5.1.

(C) In the ACCC's terminology, "TSLRIC also includes common costs that are causally related to the access service" and the ACCC found that, "where appropriate, TSLRIC can include a portion of common costs." See Access Pricing Principles, pp. 22, 32. More recently, the ACCC has used the term "**TSLRIC+**" to refer to TSLRIC plus a portion of common costs. ACCC, "Local Carriage Service Pricing Principles and Indicative Prices - Final Report," 5 April 2002.

(D) **"**TSLRIC, in relation to a telecommunications service, (a) means the forward-looking costs over the long run of the total quantity of the facilities and functions that are directly attributable to, or reasonably identifiable plus an allocation of common costs as "Efficient Network Costs" or "**EN costs**". If prices include the recovery of common costs for all products and services produced by the access provider, then prices based on those costs should allow the access provider to just recover the full cost of all its products. In my opinion, it is desirable for prices of individual services to be based on EN costs in order to recover common costs as well as pure TSLRIC.

19. EN costs measure the cost of producing all units of the relevant service. When EN costs are divided by the number of units of service produced, the resulting value measures the cost per unit, averaged over the entire increment of the service[6].

20. Much of the access provider's network consists of capital investment in network elements, whose costs must be recovered over the lifetimes of those assets. Because demand for services is often changing and technology is changing, the efficient recovery of such costs requires analysis of dynamic conditions over many years.

21. The TSLRIC concept has been widely used by telecommunications regulators in other countries to set the price of services such as the UT Services"[7]. The guiding

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as incremental to, the service, taking into account the service provider's provision of other telecommunications services; and (b) includes a reasonable allocation of forward-looking common costs". New Zealand Telecommunications Act 2001, 20 December 2001, Designated services and specified services, Schedule 1.

[6] "The forward-looking economic cost per unit of [a network] element equals the forward-looking economic cost of the element … divided by a reasonable projection of the sum of the total number of units of the element that the [access provider] is likely to provide to requesting telecommunications carriers and the total number of units of the element that the [access provider] is likely to use in offering its own services, during a reasonable measuring period." FCC Local Competition Order, Appendix B – Final Rules, Section 51.511 (a).

[7] (A) US: "[P]rices for interconnection and unbundled elements … should be set at forward-looking long-run economic cost. In practice, this will mean that prices are based on the TSLRIC of the network element, which we will call Total Element Long Run Incremental Cost (TELRIC), and will include a reasonable allocation of forward-looking joint and common costs." FCC Local Competition Order,¶ 672.

(B) Europe: "[The Independent Regulators Group] endorses the view of the European Commission that the FL[forward-looking]-LRIC approach to cost allocation is the one that will lead to results that best reflect interconnection tariffs that would occur in a competitive environment;" "Principles of implementation and best practice, regarding FL-LRIC cost modelling" as decided by the Independent Regulators Group, 24 November 2000. Henceforth, IRG Principles of Implementation.

(C) UK: "[T]he cost methodology used should be long run incremental cost **(LRIC)**, as that most closely reflects the way in which charges would be set in a competitive market." Oftel's submission to the Monopolies and Mergers Commission inquiry into the prices of calls to mobile phones, May 1998, ¶ 1.12. Henceforth, Oftel's Submission.

(D) NZ: "Final pricing principle: Either-- (a) TSLRIC; or (b) … (i) a pure bill and keep method; or (ii) a pure bill and keep method applied to two-way traffic in balance (or to a specified margin of out-of-balance traffic) and TSLRIC applied to out-of-balance traffic (or traffic beyond a specified out-of-balance margin)", Telecommunications Act 2001, 20 December 2001, Designated services and specified services, Schedule 1.

principles that have evolved from this practical experience in the US, the UK and elsewhere in Europe, in NZ and in Malaysia are directly and appropriately applicable to measuring the EN costs of the UT Services. Like the ACCC, the regulators in those countries are responding to similar legislative imperatives, including promoting competition in the market for the relevant services, encouraging economically efficient production and investment, and promoting the long-term interests of end-users.

22. In my opinion, prices for UT Services that are based on EN costs are consistent with the Australian legislative criteria for determining access prices. Such EN cost-based prices ensure recovery of the efficiently-incurred costs of providing the services, promote the legitimate business interests of the access provider and the long-term interests of end-users of services, and encourage economically efficient use of, and investment in, the infrastructure that supplies those services.

3.2 Forward-looking network element costs (TELRIC)

23. As I have described in a previous report, analysing forward-looking costs in terms of services is extremely complicated and thus impractical[8]. However, the calculations required by economic theory can be very substantially simplified in practice by representing each telecommunications service as the product of the intermediate services of particular network elements or components – local loop, local switch, interexchange transport, and so on. The individual network elements are then combined in a model to produce the costs of final telecommunications services demanded.

24. In the US the FCC found that:

> "*separate telecommunications services are typically provided over shared network facilities, the costs of which may be joint*

(E) Malaysia: "The cost definition MCMC has adopted is total service long run incremental cost (TSLRIC). A Consultation Paper on Access Pricing, Malaysian Communications and Multimedia Commission, 13 May 2002 (Hereafter, Consultation Paper on Access Pricing), p. 4.

[8] Mitchell, B. M, 2003, Appropriateness of Telstra's Cost Modelling Methodology. Annexure B to Telstra's detailed submission in support of its undertaking dated 9 January 2003, Annexure D.

> *or common with respect to some services … The network elements … largely correspond to distinct network facilities*"[9].

25. Confronted with the substantial practical difficulties of EN cost analysis at the level of the final telecommunications service, the FCC established guidelines for modelling EN costs of telecommunications services at the network level. It termed the analogous incremental cost Total Element Long-Run Incremental Cost **("TELRIC")** and determined that:

> "*the amount of joint and common costs that must be allocated among separate offerings is likely to be much smaller using a TELRIC methodology rather than a TSLRIC approach that measures the costs of conventional services. Because it is difficult for regulators to determine an economically-optimal allocation of any such joint and common costs, we believe that pricing elements, defined as facilities with associated features and functions, is more reliable from the standpoint of economic efficiency than pricing services that use shared network facilities*"[10].

26. Basing TSLRIC estimates on a network elements methodology is the standard practice in other jurisdictions that estimate TSLRIC with bottom-up (engineering-economic) models. For example, network-element models are used in the US, NZ, Malaysia, Germany, and (for mobile services) in the UK.

27. At the network element level, the usage of a single network element by different PSTN Services is essentially homogeneous. For example, a minute of traffic processed at a given switch at its peak period imposes the same capacity and operating cost requirements whether the traffic is due to STD, IDD, or PSTN OTA. Consequently, the peak-period minutes of the different PSTN Services can be summed to obtain the aggregate demand for an element. The incremental cost of an additional unit of peak-period traffic supplied by that element is then the same for each of those services.

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[9] FCC, "In the Matter of Implementation of the Local Competition Provisions in the Telecommunications Act of 1996", CC Docket No. 96-98, First Report and Order, Released: August 8, 1996, ¶678. Henceforth, FCC Local Competition Order.

[10] Ibid.

28. I discuss the requirements for designing a forward-looking network elements model of EN costs in light of best international practice further in chapter 4. In chapter 6 I then examine Telstra's PIE II model in light of these requirements.

3.2.1 Services are well-defined by their uses of the network elements

29. In a TELRIC model, *routing factors* measure the uses of a network element per unit of service. Different services make somewhat different uses of the network elements and these differences are represented by different routing factor values. Differences in the UT Services supplied to an access seeker and similar services that are self-supplied by the access provider are well defined by differences in their routing factors[11].

30. If the access provider's final services (local calls, STD calls, etc.) make use of the same network elements as the UT Services, but with somewhat different values of routing factors, the cost of that self-supply differs from the cost of the UT Services.

3.2.2 Common costs in a network-elements model

31. In a TELRIC model all of the costs of a network element are included in the costs calculated by the model and the TELRIC of the element is the total cost of the element. Any common costs in a TELRIC model, such as corporate overhead expenses and indirect costs, are costs that are common to more than one type of network element. The common costs are generally allocated to the network elements in proportion to each element's asset value.

32. The analysis of costs in terms of network elements, rather than services, substantially reduces the magnitude of the problem of measuring and allocating common costs[12]. As the FCC observed:

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[11] For example, in the PIE II model, a typical metropolitan minute of voice local calls uses 2 minutes of remote access unit ("**RAU**") capacity (one RAU is required at each end of the call), about 1.9 minutes of local area switching ("**LAS**"), and about 0.3 minutes of transit switching ("**TNS**"). In contrast, a typical metropolitan PSTN originating or terminating access interconnect call uses 1 minute of RAU, 1 minute of LAS, and 0.5 minutes of TNS.

[12] I am informed by Telstra that in the PIE II model approximately 9.2% of the total costs of the PSTN are indirect costs, which are allocated to network elements in proportion to the direct investment in those elements. I understand that calculations made by Telstra using the PIE II model indicate that when an approximation of TSLRIC is calculated for each of the major PSTN Services at a network services level, rather than at the network elements level, more than 90% of the total costs of the PSTN Services are common costs. Consequently, the prices that result from a TSLRIC model based on network services, rather than a TELRIC model based on network elements, would be extremely

> "*Because the unbundled network elements correspond, to a great extent, to discrete network facilities, and have different operating characteristics, we expect that common costs should be smaller than the common costs associated with the long-run incremental cost of a service. We expect that many facility costs that may be common with respect to the individual services provided by the facilities can be directly attributed to the facilities when offered as unbundled network elements. … A properly conducted TELRIC methodology will attribute costs to specific elements to the greatest possible extent, which will reduce the common costs. Nevertheless, there will remain some common costs that must be allocated among network elements and interconnection services*"[13].

4 ESTIMATING EFFICIENT COSTS OF UT SERVICES USING A COST MODEL

33. This chapter describes the principles applicable to constructing a bottom-up engineering-economic cost model to estimate the efficient costs of supplying the UT Services and indicates how those principles have been applied in the design of the PIE II model.

34. Any model of an actual network must necessarily simplify the myriad details of building and operating a network. A TELRIC model can, however, represent in summary form the effects of a more detailed optimisation of the components of an actual network's design. EN costs estimated using TELRIC models represent current best international practice in assessing the costs of supplying the UT Services. The sensitivity of final cost estimates to the assumptions required for a bottom-up model can be assessed by calculating results under a range of alternative conditions that represent the uncertainty or imprecision of important parameters.

4.1 TELRIC models in regulatory proceedings

35. TELRIC models are ordinarily models in which a hypothetical network is designed to serve current and projected demand, based on (a) best-practice technology, and (b) efficient operation.

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sensitive to how common costs were allocated to the individual services. This would open up a huge scope for error – nearly the entire price of each service would depend on the allocation rule used for common costs.

[13] FCC Local Competition Order, ¶695.

36. In such models, the entire PSTN is designed afresh. As a result, equipment costs and operating procedures are unconstrained by past choices and past technologies. The network design should be informed by industry experience and incorporate the most cost-efficient technologies and procedures currently available and in use.

37. In Australia, Telstra has constructed a TELRIC model of its PSTN, the PIE II model. Bottom-up models have also been constructed in other major jurisdictions[14].

38. In all cases, the TELRIC cost models adopted by regulators are used to estimate the EN costs of relevant services using forward-looking principles. All of these models use broadly the same methodological approach – estimating the bottom-up, forward-looking cost of building a local telephone network employing currently efficient technologies and constructing that network using the existing locations of local switches to serve current exchange areas. Each of the models includes three fundamental structural elements: (1) a customer access or "local loop" network, (2) digital switching and signalling, and (3) digital transport connecting the switches to each other and to other operators.

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[14] The principal TELRIC models of the local telephone network include:

(1) In the US, the Benchmark Cost Proxy Model ("BCPM") (see BellSouth, INDETEC International, Sprint and US WEST, "Benchmark Cost Proxy Model Release 3.1, Model Methodology," April 30, 1998 Edition. The Hatfield Model ("HM") (see HAI Consulting, "HAI Model, Release 5.0a – Model Description," February 16, 1998, p. 56. and the FCC's Hybrid Cost Proxy Model (HCPM), also termed the Synthesis Model (which incorporates some features of the HAI Model version 5.0a and the Benchmark Cost Proxy Model version 3 (BCPM)). (See FCC, "In the Matter of Federal-State Joint Board on Universal Service," CC Docket No. 96-45, Fifth Report and Order, Released: October 28, 1998, ¶ 4. Henceforth, Fifth Order).

(2) In the UK, Oftel's Bottom-Up Network Model. BT's LRIC Model as described in BT's LRIC Methodology and associated accounting documents, and the Analysys model of UK mobile networks, described in "LRIC Model of UK Mobile Network Costs: Source of model algorithms, data, assumptions and estimates", Working paper for Oftel, 25 January 2002

(3) In Germany, bottom-up models of both local access and core (long-distance) networks constructed by the Scientific Institute for Communications Services (WIK) for the German regulator RegTP (see WIK: "Analytical Cost Model Local Loop, Consultative Document 2.0," 8 November 2000 (henceforth, WIK Local Loop Model) and "Analytical Cost Model – National Core Network, Consultative Document 2.0, Prepared by WIK for the RegTP," 30 June 2000 (henceforth, WIK Core Network Model).

(4) In Europe, the European Commission commissioned development of a flexible bottom-up model that can be used by member states of the European Union (see Europe Economics, "Study On The Preparation Of An Adaptable Bottom-Up Costing Model For Interconnection And Access Pricing In European Union Countries: A Final Report for Information Society Directorate-General of the European Commission," April 2000. Henceforth, Europe Economics Report.)

(5) In New Zealand, the Commerce Commission's model, described in "Determination for TSO Instrument for Local Residential Service for Period Between 20 December 2001 and 30 June 2002, New Zealand Commerce Commission, 17 December 2003.

4.2 Requirements for TELRIC models

39. In my opinion, the international experience accumulated in the development of TELRIC models should be used in the construction and assessment of a TELRIC model for the pricing of the UT Services in Australia. There is broad agreement in international practice on the major requirements for a TELRIC model, and in my opinion these requirements have been incorporated in the PIE II model.

40. In my view, a TELRIC model should include (a) efficient production of services, (b) best-in-use technology, and (c) a forward-looking perspective. I review these criteria below.

4.2.1 Efficient production of services

41. Efficient production of services requires that the modelled network be designed to serve the forecast number and distribution of customers and their traffic, meet the established quality of service standards, and satisfy other regulatory requirements. The model should dimension components of the network to exploit economies of scale and deploy the most cost-efficient technologies that are currently in use by access providers.

4.2.2 Best-in-use technology

42. The technology of telecommunications has evolved almost continuously since Alexander Graham Bell's invention of the telephone in 1876. Telephone networks have been constructed and expanded to take advantage of technological advances. At any given time, however, an actual network will likely include a mix of equipment from current and earlier generations of technology[15]. For example, network operators continued to use analogue electronic switches for a decade or more while installing digital switches.

43. TSLRIC principles require that costs be calculated for an hypothetical network that is newly constructed and makes use of current-generation technology. The *best-in-use* standard has generally been held to require using technology and equipment

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[15] "[A] mixture of switching technologies will usually exist at any point in time. Eventually, old technologies are entirely replaced by newer systems." R. F. Rey, ed., *Engineering and Operations in the Bell System,* Second Ed., 1983, AT&T Bell Laboratories, Murray Hill, NJ, p. 735. Henceforth, Engineering and Operations in the Bell System.

that is actually deployed in operating networks and has been proven feasible and cost-effective[16]. Therefore technologies that are not yet in commercial use in an access provider's network would not qualify for inclusion in a TELRIC model.

44. Most TELRIC models have not, as yet, explicitly incorporated a range of alternative technologies. In evaluating bottom-up cost models presented for its consideration, the FCC focused on the conditions under which fibre-optic cable in the customer access network is "more efficient" than copper cable. However, while recognizing the potential to use wireless technology in the customer access network in sparsely populated serving areas, the FCC has not required cost models to incorporate wireless technology, and a best-in-use wireless technology has not yet been defined. In reviewing submissions in the Universal Service proceeding, the FCC states: "*No party has yet come forward with an algorithm or sufficient data to incorporate wireless technology into the model*"[17]. The HM5.0a and BCPM models include only a maximum value on the per-line investment cost to represent the cost effects of alternative potential wireless access, while the HCPM envisions a future modelling upgrade that would estimate wireless technology costs. The NERA model commissioned by the ACCC makes a "*somewhat arbitrary assumption*" that radio access for a single category consisting of rural and remote rural customers is a simple multiple of the investment cost per rural customer[18].

45. The PIE II model has advanced the modelling of best-in-use technology by expressly incorporating radio technology and comparing the costs of access alternatives for remote areas. In each rural ESA, the model selects between the

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[16] The FCC requires that the "technology assumed in the cost study or model must be the least-cost, most-efficient, and reasonable technology for providing the supported services *that is currently being deployed*" FCC's Universal Service Order, ¶250 (emphasis added), and be "*based on the most efficient technology deployed in the* [access provider's] *current wire centre locations*" FCC's Local Competition Order, ¶ 685. Similarly, Oftel requires that assets in a TSLRIC bottom-up model be valued in terms of "*the latest available and proven technology ... the asset which a new entrant might be expected to employ*". The Bottom-Up Model, p. 1. BT's top down approach recognizes that: "Asset values are adjusted to their value to the business, usually equivalent to their net current replacement cost." BT's LRIC Methodology, Section 4.1 (a). When new assets are superior to embedded assets, the cost of the Modern Equivalent Asset is used. BT's LRIC Methodology, Section 4.2 The ACCC emphasizes that in TSLRIC methodology, best-in-use technology must be "*compatible with existing network design*" Access Pricing Principles, p. 23.

[17] Letter from David L. Sieradzki, Western Wireless, to Magalie Roman Salas, FCC, dated July 15, 1998. FCC's Fifth Order, footnote 27.

[18] NERA Final Report, p. 19.

least-cost cable-based and radio-based access technologies. In this respect, the PIE II model provides for a more efficient network than has been modelled elsewhere.

4.2.3 Forward-looking perspective

46. A TELRIC model is forward-looking in that it should:

(a) assume that all inputs are variable and are purchased at current or future market prices;

(b) calculate the annualised capital costs of network investments using a cost of capital that reflects expected future returns in competitive markets and a depreciation allowance that takes into account the economic lifetimes of each class of assets;

(c) base expenses for maintaining and operating the network on current and future prices for labour and materials;

(d) take into account expected changes in asset prices due to technological advances, projected future prices of labour and materials, and need for spare capacity to accommodate growth in demand for services over the investment planning period.

47. Current and future regulatory and environmental constraints should be incorporated into a forward-looking perspective. In the case of Australia, I have been advised by Telstra that local government practice is such that permission to construct the PSTN above ground is likely to be refused. In most areas the cables in a freshly constructed network are likely to be placed under ground[19]. This is the assumption used in the PIE II model.

48. The extent to which future developments are explicitly incorporated into TELRIC models varies in international practice. The PIE II model projects future prices for major classes of assets and labour and incorporates these trends into the calculation of asset depreciation and annual capital costs. The ACCC's model uses the same practice. The US models estimate the costs of new assets and current operating costs but do not project future prices and implicitly assume that current prices will

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[19] "It is the ACCC's view that, on a forward looking basis, it is unlikely that there will be much aerial cabling." NERA Final Report, p. 49.

apply in future years. In the UK, BT's current cost accounting revalues existing network assets at current prices.[20]

4.2.4 Scorched-node design

49. TELRIC models are sometimes called *engineering-economic* cost models to emphasize a distinctive characteristic – that costs are developed out of a simplified engineering representation of an actual network's components and operation.

50. In determining EN costs, regulatory bodies have considered two alternative baseline scenarios: a "scorched node" design and a "scorched earth" design. For a *scorched node* approach, it is assumed that the modelled network is constructed using the existing locations of the incumbent's nodes. For a *scorched earth* approach, the network design would determine both the number and the locations of all nodes as part of minimizing overall costs. To date, the scorched node assumption has been used in almost every TELRIC model because of its substantially greater simplicity, and the recognition that, for historical reasons, a scorched earth design is not feasible for incumbents[21].

51. A scorched-earth TELRIC model of a national network would require that the model evaluate at least a substantial number of possible alternative locations for each network switch and simultaneously evaluate alternative switch sizes, technology, functionality and traffic routing. Each alternative location and switch type would potentially incur a different cost. Transport facilities connecting each alternative location would require evaluating distances, feasible routing, and construction conditions. Each potential location would need to be tested for feasibility to ensure that switching equipment could be economically housed and installed. Some locations would effectively be ruled out by existing buildings or structures, while others could be very costly. Determination of the least-cost design

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[20] BT, Current Cost Accounting – Detailed Valuation Methodology. 6 December 2002. Section 1.3. Available at
http://www.btplc.com/Thegroup/Regulatoryinformation/Financialstatements/PDF2002/Detailed_Valuation_Methodology.pdf.

[21] "Also because of reasons of feasibility, IRG considers it appropriate and reasonable to adhere to a bounded rationality approach, and thus to take the existing network topology as the starting point for the cost allocation process. Such a scorched node approach would imply that the technology at and in between existing switching nodes is optimised to meet the demands of a forward-looking efficient operator." IRG Principles of Implementation, p. 3.

from all combinations of these alternatives would require the use of advanced network-optimisation algorithms. The data requirements for such a model far exceed the scale of any TELRIC model constructed to date.

52. Constraining the cost models to locate switches at predetermined locations in the current network (i.e., the existing building locations) very substantially simplifies the analysis and calculations that would otherwise be required to design an optimal network on a “greenfield”. As noted above, in a scorched-earth model network designers would have the choice of both the number and the locations of the switches. In principle, these decisions could take into account the tradeoffs between the costs of switches, the costs of land and buildings at potential locations, and the costs of transport and the land on which it is located. However, at the current state of modelling technology this effort would introduce much greater uncertainty into the final cost estimates and require much greater time and effort than a scorched-node approach. It is likely, for example, that in some instances a calculated alternative location that reduces transport distances would be simply infeasible or only available at a higher cost for land and building than the costs currently incurred at the existing node[22].

53. In the jurisdictions I have examined, a scorched node baseline is used to fix the locations of nodes when calculating EN costs[23, 24]. In some instances, a cost model

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[22] The choice of a scorched node approach and the decision to use the number of levels of switching currently deployed in the incumbent’s network are exceptions to the principle that the most efficient, lowest cost design be used to calculate costs. However, strict cost-minimisation with respect to these two aspects of network design has not been seen as practical. In addition, wishing to encourage facilities-based entry into the supply of local services and network elements, regulators have left open the possibility that entrants, free to select node locations, could achieve lower costs. The FCC found that, while a scorched-node model would not necessarily achieve the theoretical minimum cost of a scorched-earth network, a benchmark of “forward-looking cost and existing network design most closely represents the incremental costs that incumbents actually expect to incur in making network elements available to new entrants” and that “this approach encourages facilities-based competition to the extent that new entrants, by designing more efficient network configurations, are able to provide the service at a lower cost than the [access provider]”. See FCC’s Local Competition Order, ¶ 685

[23] (A) In the US: “A model, however, must include the [access provider’s] wire centers as the center of the loop network and the outside plant should terminate at [access providers’] current wire centers.” FCC Universal Service Order, ¶ 250.

(B) In Germany: “MDF locations will follow those of the existing network architecture, as the possibility of restructuring access networks, in particular, is limited, even in the long term.” WIK Core Network Model, p. 5.

(C) In the EU: The recommended cost methodology “… models the incumbent’s current switching centres (“scorched node approach”), as well as providing an alternative option that can perform a preliminary optimisation (“modified scorched node approach”). The modified scorched option offers a high level approach, using either benchmarks or a node database." Europe Economics Report, p. 6.

provides some flexibility for the choice of equipment installed in the nodes. Thus, modern remote switches might replace existing small host switches in some nodes if that replacement results in lower costs[25].

54. In a scorched node design, the network is assumed to have the same degree of hierarchy as the incumbent's deployed network. For example, in the US, the forward-looking network consists of two levels of switching: local switches and tandem switches[26]. In the UK model, all interconnected calls from an access seeker's network are routed through a local switch. In addition, some interconnected calls will be routed through a tandem switch, and some will be routed through two tandem switches. For this reason, the UK cost model adopts a three-level switching hierarchy corresponding to local switching, single transit and double transit interconnection services[27].

55. In Australia, I am informed that interconnection of an access seeker to Telstra's network is usually at a point of interconnection associated with a local access switch, with additional points of interconnection at some transit switches. This

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(D) In the UK: "In the network model, it has been assumed that the number and location of nodes in [the access provider's] network are taken as given (the 'scorched node' assumption)." The Bottom-Up Model, p. 4.

(E) In New Zealand: The Commission has adopted a 'scorched node' methodology. Using this methodology, large telephone exchange sites are retained in the model as they exist in the real network, but the access network and very small exchange sites are optimised applying modern practice and technology." Determination for TSO Instrument for Local Residential Service for Period Between 20 December 2001 and 30 June 2002, New Zealand Commerce Commission, 17 December 2003 (Hereafter, NZ Determination 2001-2), p. 13.

[24] One TSLRIC model (LECOM) was developed to incorporate scorched-earth assumptions as part of an ongoing project described in Gabel, D. and D.M. Kennet, 1991, *Estimating the Cost Structure of the Local Telephone Exchange Network*, National Regulatory Research Institute, Report 91-16, Colombus, Ohio. A more recent description is in *Cost Proxy Models and Telecommunications Policy: A New Empirical Approach to Regulation*, by F. Gasmi, D.M. Kennet, J.J. Laffont and W.W. Sharkey. MIT Press, 2002. However, although proposed in some state regulatory proceedings, LECOM apparently has not been used to optimise local switching locations and switching and transport investment.

[25] (A) In the US: "If the user selects the explicit host, remote, standalone option, the user must specify for each wire center whether the housed switches are hosts or remotes …" Hatfield Model, p. 56.

(B) In the UK: "A point of presence is required at each of the nodes, though not necessarily the same type of switch as [the access provider] currently deploys …" The Bottom-Up Model, p. 4.

[26] In the US, remote switches are considered a part of the local-switch switching level, not a third level of switching. Tandem switches are the highest level in the hierarchy and are fully meshed: "At the highest level in the ring network, the HM must provide a path for tandem to tandem traffic for tandems that are located in the same [local access area]. This is accomplished through the use of inter-ring-system connectors." Hatfield Model, p. 61.

[27] The Bottom-Up Model, Table 3.1. Similarly, the approach recommended to the European Union member states requires that a forward-looking cost model be capable of calculating the costs of local level interconnection, single transit interconnection and double transit interconnection. However, there is a recognition in Europe that this framework may not be suitable for countries with three or four levels of (analog) switches in their networks, even though current best practice with digital switching may require a flatter hierarchy. Europe Economics Report, p. 12.

routing of interconnected traffic is reflected in the PIE II model in the dimensioning of the interexchange network.

56. In a scorched-node TELRIC model, the efficient amount of investment is calculated anew, using efficient, best-in-use technology. It is only the *locations* of the nodal investments that are determined by the existing network.

57. I have been advised by Telstra that in recent years Telstra has redesigned its network, reducing and rationalizing the total number of switches from some 5,000 switches previously used, to a network consisting of just 133 local area switch sites which are connected to remotely-located multiplexing or switching stages plus 24 transit switches. This rationalization of the network is consistent with the recommendation of the Independent Regulators Group "to modify the scorched node approach … taking the existing topology as starting point, followed by an elimination of inefficiencies (e.g. this may involve attempting to simplify the switching hierarchy)".[28] As a consequence, the locations of nodes in the PIE II model quite likely represents a more efficient design than is achieved in scorched-node TELRIC models of other networks that have retained switch locations that were designed for earlier technologies.

58. The PIE II model goes beyond a strict implementation of the scorched-node assumption in several respects because it (a) optimises the choice of equipment located in remote access sites that are connected to a local area switch, (b) determines the locations of those remote sites, and (c) optimises the number of local area switches required at each site. The PIE II model thus achieves a more cost-efficient design than would be obtained from a strict scorched-node model, which would require that each LAS and remote switching unit in the current Telstra network be retained in its current location.

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[28] IRG Principles of Implementation, p. 3.

4.3 The scope of the modelled network

4.3.1 Included services

59. To calculate the EN cost of supplying the UT Services, one must first determine:

- which services and what quantities of those services should be included in the increment whose cost is to be calculated, and
- which other (baseline) services should be assumed to be produced in the absence of those services.

60. In establishing guidelines for TELRIC models, regulators in most countries have specified the set of baseline services and the increments whose costs are to be measured by those models[29]. Typically, the services included in a cost model of access services (such as the UT services) are the basic PSTN Services offered to residential and business customers and the UT Services supplied to access seekers. The entire quantity of these services is included in the increment[30].

61. It would be incorrect to calculate an incremental cost for less than the total increment of service or to exclude fixed costs of providing the service. Such a

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[29] (A) FCC: "The cost study or model must estimate the cost of providing service for all businesses and households within a geographic region. This includes the provision of multi-line business services, special access, private lines, and multiple residential lines." FCC's Universal Service Order, ¶ 250.

(B) Oftel: "The network assumed for the purpose of developing the incremental cost methodology is a stand-alone network of inland Public Switched Telephone Network (PSTN) services and inland private circuits." Oftel's Bottom-Up Model, p. 1. "BT's approach to modelling LRIC is a top-down approach, which takes as a starting point the incurred cost arising from BT's activities. This methodology applies to the modelling of the LRIC of BT's network activities." BT's LRIC Methodology, Section 5.3.1.

(C) WIK for the RegTP: "We must also remember that network elements can be used by circuit-switched services, packet-switched services and fixed connections/leased lines alike." WIK Core Network Model, p. 4.

(D) NZ: "In the context of the TSO, the incremental cost of an obligation to provide services to commercially non-viable customers is, therefore, equal to the difference in the firm's total costs between the circumstances where it supplies those customers in conjunction with all its other customers, and where it does not." NZ Determination 2001-2, p. 23.

[30](A) "For our specific purposes it follows that traffic demand as a whole, including all the calls fully remaining in the interconnection service provider's network, is relevant as well as (additional) demand for interconnection services." WIK Core Network Model, p. 4.

(B) "The term 'total service,' in the context of TSLRIC, indicates that the relevant increment is the entire quantity of the service that a firm produces, rather than just a marginal increment over and above a given level of production." FCC Local Competition Order, ¶ 677.

(C) "In the methodology to calculate incremental costs, the increment in question is the whole of the output of a service … The long run incremental cost of conveyance is the cost that would be saved in the long run if *no* traffic were provided over the network, but access were to continue to be provided**."** (emphasis added) Bottom-Up Model, p. 2.

calculation would measure only the *additional* costs of providing some additional units of a PSTN service and would carry a very substantial risk of understating the efficient cost of that service. For example, the incremental cost of providing an increment consisting of just the originating minutes of traffic delivered to an access seeker would measure only the additional costs of expanding and operating additional capacity needed to augment an existing network of access lines, local switches and interexchange transport facilities. That calculation would exclude the fixed costs of the local switches and transport equipment that are incurred to provide the PSTN service supplied by the access provider to its end-user customers. A price obtained from such a calculation would fail to recover some costs essential to producing the service. Competition in the supply of other services that share in the common costs would limit the access provider's ability to recover those common costs from other services. This would be inconsistent with the legislative principle that any prices that are set should account for the legitimate business interests of the access provider, and the access provider's investment in facilities used to supply the service. A price that failed to provide for recovery of some common costs would also disadvantage the access provider relative to competitors and thus not be competitively neutral and would not promote competition in the market for declared services.

62. Regulators have also indicated that, for the purpose of calculating costs of services such as PSTN OTA, LCS and ULLS, the baseline is one in which there is no production of any service. With a zero baseline, the calculated TELRIC is equivalent to the *stand-alone cost* of the services included in the increment – that is, the cost of producing those services on their own with no others[31].

63. In addition to the PSTN Services, some regulators have required that certain non-PSTN Services be included in the service increment whose cost is calculated in a TELRIC model. The principal such services are *leased lines* and *Integrated Services Digital Network* **("ISDN")**[32].

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[31] Bottom-Up Model, p. 1.

[32] In the US, the services to be costed are specified by the FCC's guidelines as the total volume of all narrowband (voice and low-speed data) switched and leased line services, beginning at (and including) the network interface device at the end-user customer's premises and going to the point of interconnection with another service provider.

64. These non-PSTN Services are supplied using the network elements that are shared with PSTN Services. Including leased lines and some data services in the TSLRIC increment causes the total number of lines and aggregate volume of traffic to be increased. Because some of those components benefit from economies of scale, the enlarged definition of included services results in a lower per-unit cost for the PSTN Services, when TELRIC is measured from a zero baseline.

65. In my view, services included in the increment should include the total volume of services that are close substitutes in demand or services that use the same network elements and thus have a similar cost structure.

66. In this context,

(a) in terms of traffic, the increment should include all of the PSTN, UT and ISDN services and also the traffic from other services that use the PSTN; and

(b) in terms of access services, the increment should include all services which use copper-based lines.

I am informed by Telstra that the PIE II model includes all such traffic and access services.

67. When the increment of services included in a TELRIC model encompasses a broad set of services (in the PIE II model, all PSTN, ISDN and UT services plus other copper-based access services) the cost analysis will capture substantially all of the relevant shared costs. A zero baseline can then be used without excluding from the cost analysis any services and costs that would have a substantial effect on the EN costs estimates for the individual services included in the increment. The TELRIC

Leased lines are included in the customer access and interexchange networks, while transport for mobile and broadband services is excluded.

In the UK, Oftel's bottom-up model of the local network is a "a stand-alone network of inland Public Switched Telephone Network (PSTN) services and inland private circuits. The network ... excludes international services and advanced services such as Integrated Services Digital Network (ISDN) and Virtual Private Networks". The current BT model includes the following components of the Network Business as increments: Core, Access, International and Other Services. BT's LRIC Methodology, Section 5.3.1.

In Germany, where the ISDN is used for a substantial proportion of the switched voice services, the WIK model for RegTP includes PSTN, ISDN, and leased lines.

approach to estimating EN costs for a service includes in the definition of the increment those services that share the use of a network element, and provides the economic foundation for the use of a zero baseline.

68. In my opinion, the inclusion of the services set out in paragraph 66 above in the increment is consistent with the legislative objective of promoting competition in the market for the listed services by ensuring that the prices for the UT Services used by the access seeker are based on the same costs as are allocated to PSTN Services.

4.3.2 Forecasts

69. A TELRIC model constructs an hypothetical network to serve the forecast traffic and the forecast number of customers included in the increment for the model planning period. When the model is used to estimate costs for a future date, the number and location of customers are forecast based on recent counts of customers and the traffic volumes are forecast from measurements of recent traffic.

70. The PIE II model uses forecast values of customers and traffic. In my opinion, it is consistent with the forward-looking principles of TSLRIC analysis to use the most current forecast value available prior to the period for which the EN costs calculations are to be made.

4.3.3 Customer locations

71. The degree of geographic detail incorporated into TELRIC models varies in international practice. The FCC's hybrid cost model uses geographically-coded customer-specific location data in each individual exchange area. That model has developed optimisation algorithms to minimise the overall costs of the distribution network by first grouping customers into trial "clusters" and calculating for that grouping the total costs of cable, conduit (ducts) and trenching, and remote terminals. The grouping and calculation of costs is then revised and iterated until further iterations do not result in a lower total cost for the distribution network in

that local exchange area. Where geocoded data are not available, the FCC model uses an algorithm based on the location of roads.[33]

72. The PIE II model also uses geographically-coded customer-specific location data and optimises the layout of the distribution network by first disaggregating each exchange service area into a number of distribution areas. In most distribution areas, cable routes are constructed to end-user subscriber addresses from distribution pillars, and main cable routes linking those distribution areas are determined using a minimum distance algorithm. Very low-density distribution areas are served directly by main cable.

73. In my opinion, the PIE II model's use of location data for individual end users should provide reasonable estimates of efficient CAN and conveyance costs by accounting for differences in capacity requirements in different exchange service areas.

5 PROVISIONING OF THE PSTN

74. Network provisioning raises several related issues – the values of key provisioning parameters required to achieve efficient levels of investment and operating expenses, the efficient investment in spare capacity, and the recovery of the cost of that investment in the prices of the PSTN and UT Services. I review each of these matters in this chapter and discuss the provisioning in the PIE II model in chapter 6.

5.1 The need for spare capacity

75. The provisioning practices of telecommunications operators include investment in spare capacity – capacity that is not necessary to serve just the current subscriber locations and level of network use. These provisioning practices are efficient both for purposes of maintenance and repair, and when network components are supplied in modular sizes, when installation of and investment in network components is subject to economies of scale, when demand is growing, and when demand is uncertain or heterogeneous. All of the TELRIC models with which I am

[33] In the Matter of Forward-Looking Mechanism for High Cost Support for Non-Rural LECs, CC Docket No. 97-160, Fifth Report & Order, Released: October 28, 1998, at 26. Henceforth, FCC Fifth Report.

familiar provide for spare capacity.[34] The ACCC, too, agrees "that it is optimal to provision for excess demand where there is expected demand growth or stochastic growth in demand."[35]

76. Maintenance and repair. It is generally considered good engineering practice to permit some spare capacity in the CAN to accommodate breakdowns in service. At times, physical breaches in currently used links are most efficiently repaired by simply using other available spare cables rather than attempting to locate the source of the breach and perform a splice.

77. Modularity of components: Many network components are supplied in a series of standard sizes. In order to serve a given demand, the operator must install capacity that is at least equal to that demand. Ordinarily, some excess (spare) capacity results from use of the smallest standard-size component that is at least equal to demand.

78. The need to use discrete-sized components may result in measurable excess capacity when the standard size is large relative to the demand served. For example, in estimating cable costs, the US TELRIC models[36] calculate quantities of main (feeder) and distribution cable required for the customer access network ("**CAN**") using graduated sizes of cable.[37]

79. Economies of scale: Some network components have smaller unit costs when manufactured in larger sizes. Furthermore, for most components, a significant portion of the costs of engineering and installing equipment is independent of the

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[34] "Significantly, we note that, contrary to GTE's inference, current demand as we define it includes an amount of excess capacity to accommodate short-term growth." Forward-Looking Mechanism for High Cost Support for Non-Rural LECs, CC Docket No. 97-160, Tenth Report And Order, Released: November 2, 1999, at 201.

[35] ACCC Final Decision on Core Service Undertakings, December 2004, p. 61.

[36] Benchmark Cost Proxy Model ("BCPM") (see BellSouth, INDETEC International, Sprint and US WEST, "Benchmark Cost Proxy Model Release 3.1, Model Methodology," April 30, 1998 Edition. The Hatfield Model ("HM") (see HAI Consulting, "HAI Model, Release 5.0a – Model Description," February 16, 1998, p. 56) and the FCC's Hybrid Cost Proxy Model (HCPM), also termed the Synthesis Model (which incorporates some features of the HAI Model version 5.0a and the Benchmark Cost Proxy Model version 3 (BCPM)). (See FCC, "In the Matter of Federal-State Joint Board on Universal Service," CC Docket No. 96-45, Fifth Report and Order, Released: October 28, 1998, ¶ 4).

[37] To provide a concrete example, consider a case where cables come bundled in either 12 pairs or 24 pairs. Suppose now that the forward-looking requirement for a network would optimally be 15 pairs. The TELRIC models that have been generally employed would have to choose between 12 and 24, and would opt for 24 since it is the smallest cable that can handle the minimal requirement of 15.

component's capacity. Both factors gives rise to economies of scale that make it efficient to install larger-capacity components, and thus incur greater excess capacity, when demand is growing or uncertain. For components, such as distribution cables, that are accompanied by high fixed costs of installation it is efficient to provision sufficient spare capacity to make replacement unlikely over the physical lifetime of the components.

80. Growing demand. When demand is growing, capacity must be increased over time. Because components are supplied in discrete sizes and enjoy economies of scale, it is efficient to install larger increments of capacity and to augment capacity less frequently than would be the case if the network operator followed a program of just-in-time capacity augmentation.[38]

81. In telecommunications proceedings elsewhere, TELRIC models make explicit provision for spare capacity to serve growing demand and regulators in other jurisdictions have consistently recognized the appropriateness of recovering some of the costs of spare capacity in the current period. For example, US TELRIC models use "fill factors" to measure the fraction of the total capacity of specific network components that will be filled up in a given period, in order to account for expected growth in demand and economies of scale.[39]

82. Uncertain demand. Demand forecasts are not fully accurate and telecommunications services cannot be stored in inventory as a hedge against unexpectedly high demand. Nor can capacity be added as soon as new demand materializes – installation of additional network capacity often requires significant lead-time. It is therefore generally efficient to provision some amount of excess capacity to ensure that uninterrupted service will be available if high demand occurs. Unless expected demand is declining steadily and significantly enough to

[38] Mitchell, B. M, 2003, Appropriateness of Telstra's Cost Modelling Methodology. Annexure B to Telstra's detailed submission in support of its undertaking dated 9 January 2003, pp. 16-17.

[39] "Significantly, we note that, contrary to GTE's inference, current demand as we define it includes an amount of excess capacity to accommodate short-term growth." Forward-Looking Mechanism for High Cost Support for Non-Rural LECs, CC Docket No. 97-160, Tenth Report And Order, Released: November 2, 1999, at 201.

offset any risk associated with the variance of demand, the need for provisioning of spare capacity remains.[40]

83. With multiple suppliers of service, the demand facing any one supplier is subject to a further degree of uncertainty. As the ACCC has noted, in a competitive industry firms will maintain a degree of excess capacity to enable them to cater for the custom of their rivals' customers and be in a position to offer service if demand shifts to them.[41] Under competition the aggregate amount of industry excess capacity may then exceed the level that a sole supplier would efficiently provision. But this outcome, as the ACCC has noted, is a competitive result. The costs of provisioning such excess capacity are those incurred by an efficient incumbent, or an efficient rival, and are rightly part of the EN costs. Moreover, it may be necessary for the incumbent to bear additional costs of spare capacity when it is subject to a carrier-of-last-resort obligation.

84. Heterogeneous demand. Despite the projected decline in PSTN lines, aggregate network demand may expand or be little changed due to growth in ULLS and other non-PSTN services that share the core network elements. And even if aggregate demand, summed over all geographic areas, is steady or declining, the changes in demand over time are unlikely to be uniform. Demand at some exchanges or over some parts of the nationwide network may be increasing, particularly in towns and cities that are expanding and in suburbs growing from new developments (for example, apartment complexes and infill housing). Because large proportions of the investment in network capacity are irreversible, it is not possible to reallocate excess capacity from one geographic area to another. Instead, the network operator must expand capacity in the growing areas and employ underused components in areas of declining demand.

85. The mobility of subscribers in a constant-sized population requires the operator to maintain spare capacity in the distribution network in order to accommodate movement of customers. By doing so, the operator can reduce the time required to

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[40] Ibid. See also NECG, Annexure E to Telstra's Submission in Response to the Draft Decision on its undertakings for PSTN OTA, LCS and ULLS dated October 2004: Efficiency and Optimal Provision for Future Demand, November 2004.

[41] ACCC's ULLS discussion paper, p. 27, para. 78.

connect a service, reduce ongoing operational expenses, and satisfy its obligations to customers under regulations such as the USO and the Customer Service Guarantee (CSG) that operate in Australia.

86. Finally, even if overall demand is declining, the operator must still provision extra capacity in some areas. As an illustration of this, Australian Bureau of Statistics ("ABS") net population change figures by local government area indicate a large variation in population changes between areas. For example, between 2003 and 2004 the biggest increase in population occurred in Perth (12.1%) while the largest decline was in Coolgardie WA (-6.8%).[42] Similarly, the mix of services using the core network is changing over time, which can be difficult to predict with great certainty.

5.2 Provisioning spare capacity

87. Efficient provisioning of spare capacity must account for future demand – both expected and uncertain – for network components from all services that require those network components. If PSTN demand declines but other services grow and require increased capacity, a changing mix of services may not reduce the need to efficiently maintain some excess capacity.

88. If demand is declining with certainty then the need for provisioning in order to service future demand is alleviated – provided that the installed capacity can service both the current demand and the changing geographic distribution of demand and provided also that capital depletion occurs at a slower rate than demand is declining. However, if capital is being depleted at a more rapid rate, then a role for provisioning would still remain. Because of economies of scale in the installation of capacity, network components such as cable and pillars would be of larger size than required to serve existing demand. In such cases extant unused capacity can be a result of economies of scale in capacity installation or of the lumpiness of installed capital. Due to the fact that cables and IEN equipment are manufactured in given sizes, there is almost always some unused capacity in an efficient network.

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[42] ABS, 2005, *Regional Population Growth,* Cat. No. 3218.0, 23 March, p. 13.

89. In other jurisdictions, forward-looking cost estimates include some provisioning for expected growth in demand. For the purposes of determining universal service support in the U.S. the FCC considers "current demand, and not ultimate demand" [43] and defines current demand to include "an amount of excess capacity to accommodate short-term growth."[44] State Commissions may use different approaches when evaluating the forward-looking costs of network elements. In Florida, the Commission determined that "enough spare capacity should exist for maintenance and to allow for a reasonable projection of growth in the network."[45]

90. In the UK, BT's LRIC model specifically includes the cost of capacity held for future demand in its calculation of incremental cost: "Thus assets which have capacity planned to be brought into use or which is needed to meet known planning margins are considered to be part of the operating capacity."[46]

91. In New Zealand, the Commission, responding to criticism that its Draft Determination had significantly underestimated the provision of spare capacity required for demand growth and repair & maintenance needs, adjusted its assumed fill factors for rural areas to 60% for feeder cable and 40% for distribution cable.[47]

92. In Malaysia, the MCMC sets utilization rates of switches to make "an allowance for growth and sparing for faults".[48]

93. In all these jurisdictions, current prices recover a portion of the cost of installing sufficient capacity to meet future demand – short-term growth in some cases, and long-term growth in others. The provisioning rules based on future demand that are used in the PIE II model are broadly consistent with international practice.

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[43] 96-45 Tenth Report and Order (Inputs Order), Federal Communications Commission, adopted October 21, 1999, at para. 201.

[44] 96-45 Tenth Report and Order (Inputs Order), Federal Communications Commission, adopted October 21, 1999, at para. 201.

[45] Final Order on Rates for Unbundled Network Elements Provided by Verizon Florida, Florida Public Service Commission, Docket No. 990649B-TP, Order No. PSC-02-1574-FOF-TP, Nov 15, 2002, pp. 105-106.

[46] Current Cost Accounting: Detailed Valuation Methodology, BT Group, 6 December 2002, p. 5.

[47] Determination for TSO Instrument for Local Residential Service for Period Between 20 December 2001 and 30 June 2002, New Zealand Commerce Commission, 17 December 2003, p. 134.

[48] A Consultation Paper on Access Pricing, Malaysian Communications and Multimedia Commission, 13 May 2002, pp 46-47.

5.3 Recovering the costs of spare capacity

94. The preceding discussion establishes that an efficient network operator will incur costs of provisioning spare capacity in order to account for both supply factors (modular component sizes and economies of scale) and demand factors (maintenance and repair, growth, uncertainty, and heterogeneity). How, then, should the costs of efficient provisioning of spare capacity be recovered in prices?

95. First, should some of the costs of spare capacity – those incurred this year to provide for future or uncertain demand – be recovered in the prices of services sold this year, or should those costs be recovered at a later time when the capacity is fully used?

96. Costs of spare capacity installed now but provisioned to serve future needs can be recovered in current period charges as well as future period charges. This forward-looking approach is employed in the PIE II model: the investment in spare capacity is recovered over the expected life of the asset, starting from the date of installation.

97. Alternatively, a backward-looking approach to recovering spare capacity costs could be adopted. In that case, current-period UT prices would need to include payments for spare capacity that had been efficiently incurred in the past. I have analysed the likely effect of the latter approach in an earlier report, a copy of which is included in Annexure C of this report.[49] That analysis suggests that for a range of realistic values for known growth and discount rates, backward-looking pricing would likely result in higher per-unit charges in the current period than would recovery of spare capacity costs based on forward-looking pricing principles.[50]

98. Second, how should the cost model account for expected, uncertain changes over time in (a) aggregate demand, (b) the geographic distribution of demand, and (c) service mix? The PIE II model takes into account the forecast number of services and traffic levels in calculating the investment cost of the capacity necessary to serve current demand and to provide some spare capacity. It dimensions major

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[49] Mitchell 2003, Annexure F.

[50] For example, charges are higher under backward-looking pricing when capital-goods prices are declining by 0% to 5%, demand is growing 3% to 10%, and the discount rate is 11% to 15% per annum. Mitchell, 2003, Op. cit. Anexure F.

components in the access and core network using engineering rules that reflect the balancing of additional costs of spare capacity against the costs of incrementally expanding capacity.

99. If demand, which is uncertain, is initially forecast to grow and requires efficient investment in spare capacity, but realized demand subsequently and permanently declines, the initially calculated prices will fail to recover the full amount of the investment over its lifetime. This commercial risk is borne by the network operator and should be accounted for when calculating the Weighted Average Cost of Capital ("**WACC**"). The fact that realized demand is below forecast demand does not mean that investment in spare capacity was imprudent. Prices should be set to recover the efficient level of investment in spare capacity for the forecast amount of demand growth.

5.4 Annualisation of capital costs

100. In order to calculate costs for one unit of service, the investment costs of capital assets, which provide services for more than a year, must first be converted to a sequence of annual costs. Annual costs are then divided by annual quantities to obtain per-unit costs.

101. TSLRIC models calculate a sequence of annualisation factors that, when applied to a constant quantity over a specified asset lifetime, will recover the present value of an efficient incumbent's investment at an assumed rate of discount and applicable tax rates. When new asset prices are unchanged from one year to the next, a fresh TSLRIC calculation in future years will result in the same annualisation factor.

102. In the future, an entrant will be able to construct an efficient network at costs based on the then-current asset prices. If, due to technological change, future asset prices are lower, the entrant will be able to recover its costs at a lower price than an incumbent's price that is calculated using a constant annualisation factor. As a result, prices calculated using constant annualisation factors will not be sustainable against competition and the incumbent will be unable to recover the initial investment.

103. In order to provide for recovery of initial investment, the PIE II model incorporates the predicted trend of future network element prices in the calculation of its annualisation factor. The resulting sequence of annual charges over the economic life of the element just recovers the present value of the investment in that element.

104. For each year of the regulatory period the PIE II model calculates a new TSLRIC, taking into account both the network element prices and demand for that year and the forecast trend in network element prices for subsequent years. When future-year network element prices follow the trend predicted at the initial year, the sequence of annual charges calculated in the initial year and the TSLRIC prices for the subsequent years are time-consistent for a given quantity of demand. As a result, the PIE II model's annual charges, when recalculated each year of the element's lifetime, neither over-recover nor under-recover the initial-year investment. [51]

105. One realistic case occurs when real prices of network elements are expected to decline over time, due to technological change. In this case, the investment annualisation factor that would be calculated if network element prices were constant must be marked up to account for falling network element prices and thus declining TSLRIC over time. Consequently, annual charges are "front-loaded" relative to the charges that would be needed if prices remained constant.

106. For some network elements (perhaps with high labor or land content) it is plausible that real element prices are expected to increase over time. On that assumption, the PIE II model methodology would mark down the initial year's annualisation factor. The capacity investment made in the initial year would again just be recovered over the economic lifetime of the network elements from "back-loaded" annual charges.

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[51] In its July 2000 assessment of Telstra's earlier undertaking, the ACCC used a different formula for determining annual charges associated with network investment necessary to serve current demand. That formula includes an annuity factor that is tilted each year by an assumed (positive or negative) growth rate so that the annuity factor, multiplied each year by the initial investment value, just recovers the present value of the initial investment. For the same level of investment and rate of return, and assuming that the rate of change of annual charges is equal to the rate of change of network element prices, this formula applied each year to the then-current value of new investment yields the same annual charges as the PIE II model. ACCC, "A report on the assessment of Telstra's undertaking for the Domestic PSTN Originating and Terminating Access services, July 2000", Appendix 6.

6 THE PIE II MODEL SATISFIES THE REQUIREMENTS FOR TELRIC MODELS

107. This chapter examines the design of the PIE II model in light of the principles for TSLRIC analysis that have been developed in international practice. Annexure A of this report provides additional comparative information on forward-looking cost models used in several other jurisdictions.

6.1 Overall methodology

108. Telstra's PIE II model is based on best-practice network design to supply the UT Services for several years beginning in 2001/02. Extensive details of the PIE II model are contained in Annexure A to Telstra's Submission in relation to the Methodology used for Deriving Prices Proposed in its Undertakings dated 9 January 2003.

109. The bottom-up PIE II model is constructed using the basic network components and processes that are required to provide the PSTN Services. It also provides cost estimates of some components required to supply leased line service and ISDN calls.

110. The overall design of the PIE II model network is based on fibre-optic cables to connect LAS and transit network switches in the interexchange network and also to link the remote access units to the LAS. The final several hundred meters' access to individual end users (except those located in high-density buildings) is over copper cable. The extensive use of fibre-optic cables allows placement of remote terminals close to end users and thus limits the length of copper cables deployed.

111. The use of fibre-optic cable, combined with CMUXs, is consistent with the network design practices of the local networks of major carriers in other advanced economies and incorporated in TELRIC models elsewhere[52].

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[52] For example, in the FCC's cost model end users are connected by copper cable to remote terminals that are fed by copper or fibre-optic cable from a local area switch. The interexchange portion of the FCC's model incorporates the HM5.0a model's interexchange network, which is engineered in a number of interlinked high-bandwidth fibre-optic rings. Hatfield Model, pp. 58-62. Similarly, the WIK model uses a mixed copper/fibre technology for the customer access network and high bandwidth fibre rings to link switches in the interexchange network. WIK Core Network Model, pp. 19-40.

112. The PIE II model calculates the major capital components required for the network from forward-looking network design principles. Annual capital costs are calculated using assumed asset-specific service lives, the PSTN operator's cost of capital and company tax rates. To estimate operating and maintenance costs of shorter-lived components, the PIE II model uses the ratios of latest-year actual costs of operating and maintaining the current components of Telstra's PSTN to the asset values of those components. It then applies those ratios to the investment for the model network components. For cabling and trenches, the model uses ratios based on actual operating and maintenance costs as fractions of model-estimated investments, as the historical costs of fully depreciated cables and trenches are not retained in Telstra's accounting system. Costs of overhead activities are also estimated from actually incurred costs and allocated to network components.

6.2 Network planning

113. TELRIC models have not attempted to model the activities associated with the tasks needed to plan (i.e., "engineer") and install the individual network components. Instead, the models have generally applied an "uplift" factor to the investment cost of each component (e.g., investment per meter of cable) to account for the average cost of these tasks.

114. In a scorched-node TSLRIC network, the costs of planning and designing a new network using the existing nodal locations is an essential expenditure. Rather than estimate the planning costs of a complete design of the entire network, the PIE II model includes the current expenditure on network planning as an annual cost factor. Because current planning activities are limited to network expansion, this provides a conservative calculation of network planning costs. As noted in paragraph 58 above, the PIE model assumes that this network design optimises the mixture of remote access units and switches.

115. In other jurisdictions, network planning costs are recognized as a component of forward-looking incremental costs. In the U.S., executive and planning costs are booked as part of General and Administrative costs,[53] and FCC rules require that

[53] CFR, Part 32, § 32.6720 General and administrative.

they be recovered as part of the cost of common support services (indirect cost) that is allocated across services.[54] In Florida, the State Commission determined that engineering costs include the costs to plan, engineer, and order equipment additions. These costs are used to develop a loading factor that is applied to the costs of the relevant assets.[55]

116. In the UK the BT LRIC model includes: "without limitation, the costs of planning, installing, removing, moving, adjusting, maintaining, monitoring and controlling, and undertaking any other necessary operations in respect of, these things and the costs of the equipment and facilities used in undertaking these activities" in the costs of the Network business (in which Core and Access are contained).[56]

6.3 Subscriber locations

117. Both the PIE II model and the US TELRIC models dimension the customer access networks by using data for each local service area to estimate the actual number of end users in that area. The PIE II model uses existing address information to define where service locations would be placed if the network were built anew. The address information includes locations where there is currently a service in operation, where there has previously been a service, or where in the near future a new service may be located.

118. The PIE II model and the US models use somewhat similar procedures to arrive at the costs of end-user access lines. To determine end-user distances from an exchange, the US models contain highly detailed algorithms for geographically grouping individual end users into clusters within individual service areas or grids and calculating distribution cable, main (or feeder) cable, and digital loop carrier (or remote multiplexer) requirements to serve those locations. In the PIE II model, each exchange serving area **("ESA")** is partitioned into a number of distribution areas. The locations of individual end users are connected to pillars, and minimum-distance algorithms are used to connect those locations to economize on the total length of main cabling. In estimating cable costs, the US models calculate main

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[54] Tenth Report, at 377.

[55] Verizon Final Order, p 174.

[56] BT LRIC Methodology, p. ix.

(feeder) and distribution cable lengths by using graduated sizes of cable; for main cable, the PIE II model also employs graduated sizes of cable in an ESA, and for distribution cable the PIE II model uses 100 pair and 50 pair non-tapered cable.

6.4 Dimensioning the major network elements

6.4.1 Distribution cable

119. The PIE II model dimensions the distribution and main (feeder) cables, the number of cables hauled through ducts, and the pillars in the customer access network based on the total number of living units and business units as well as the number of copper-based access services.

120. Each ESA is partitioned into several distribution areas **("DA"s)**. In the urban areas of the network, a DA is sized (based on the density of living units) so that it can be served by 100-pair distribution cables connected to a pillar located near the centre of the DA.

121. In some areas distribution cables are not used. In high-density urban areas in which the average number of SIOs at a single address is at least [c-i-c] these locations are instead served directly by main cable. And in non-urban areas in which cable runs do not exceed [c-i-c] km, pillars and distribution cable are not used; instead, living units are connected by main cable directly to remote access units.

122. The PIE II model's provisioning calculations, which distinguish serving areas by the density of living units, follow the provisioning rules used by Telstra's network designers as at 30 June 2000 when construction of the model began. In the US TELRIC models, differences in subscriber density are taken into account by assuming that the utilisation of distribution and main cables increases with the density of end users in a serving area[57].

123. By calculating the distribution cable required in each ESA using the current design principles for the customer access network the PIE II model obtains an estimate of the efficient costs of this network component.

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[57] HCPM: hcpm_inputs_June2001.xls - FILLFACT!

6.4.2 CMUX

124. In provisioning its remote access units the PIE II model has adopted CMUX technology as being the most appropriate best-in-use technology for the PSTN. RAUs can be provisioned either within Telstra buildings or as street furniture. The RAUs are dimensioned on the basis of the number of services required within each individual exchange service area. In the densest areas of the network, a Network Unit CMUX is provided within the exchange building, and in outlying areas the ESAs are served by remote CMUXs.

6.4.3 Main cable

125. For provisioning of main (feeder) cable, the PIE II and US cost models use the same general methodology, calculating costs based on the sizes of standard cables available for installation, and the number of SIOs in the serving area.

126. The PIE II model provides sufficient cable to service the number of SIOs in the serving area, starting from 100-pair cables for rural customers and increasing to 4,200 pair cables in high-density areas. The cable provisioning rules are not based on the number of pairs per SIO, but rather the number of SIOs connected to each pillar.

127. Each Distribution Area (DA) is provisioned as follows:

- If there are too few SIOs to warrant the placement of a pillar, all SIOs within the DA are connected to the RAU using 100-pair cable.
- Otherwise, the amount of cable, the cable lengths and the trench lengths of the reference DA are adjusted to account for the number of SIOs and the area covered by the DA.

128. By calculating the main cable required for each serving area using the current design principles for the Customer Access Network the PIE II model obtains an estimate of the efficient costs of this network component.

6.4.4 Pillars

129. PIE II dimensions the pillars that support cross-connection of main (feeder) cables to distribution cables in the CAN based on the number of distribution cable pairs and the number of main cable pairs terminated at the pillar. As with cable dimensioning, this calculation includes a provision for spare capacity.

130. I am advised by Telstra that a pillar consists of nine 100-line modules and that one module is held in reserve, in the event that a fault develops in one of the others. Each of the eight remaining modules is allocated to either the main cables or the distribution cables. Up to five modules are used to terminate distribution cables, and the remaining three to terminate main cables. The maximum number of SIOs that can be supported by one pillar is determined by the 500-line capacity of the distribution-cable-side modules, the 300-line capacity of the feeder-cable-side modules and the number of living units served within the distribution area. The PIE II model calculates the size of a distribution area so that, given the actual number of living units and SIOs, they can be supplied from a single pillar located within the distribution area.

6.4.5 Access switches

131. A local switch has a limited capacity to terminate lines that can be connected to it and to process their traffic. It is standard engineering practice to dimension switches to handle the total number of subscriber lines plus an utilisation allowance for administrative lines, moves and changes, faults, and anticipated growth[58]. The PIE II model dimensions the distribution-cable-side elements of local switches that connect to subscriber lines based on the number of SIOs connected to them, and dimensions the processing capacity of the switches using the peak-period volume of traffic those SIOs are projected to carry.

132. TELRIC models use rules of thumb to dimension the capacity of remote terminals and local switches based on the number of lines connected to them. For comparison, the HM5.0a dimensions remote terminals assuming a utilization rate of

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[58] Engineering and Operations in the Bell System, pp. 588-589.

90% of terminated lines[59]. For local switches HM5.0a assumes that a maximum of 80% of the switch's rated line capacity can be used[60]. Beginning from this capacity assumption, the FCC's hybrid cost model then dimensions the available switch at a 94% utilization rate[61].

133. Switching capacity that is sensitive to the volume of peak-period traffic is dimensioned to provide spare capacity to account for changes in traffic patterns and growth. For comparison, the HM 5.0a model calculates that an additional local switch must be added when 90% of the switch's designed capacity, measured in busy hour call attempts, is reached[62].

134. The PIE II model dimensions access switches, transit network switches, and signal transfer points based on traffic projections at each switch. Traffic forecasts are developed from separate routing factors in each state for each category of service and switch.

135. As noted earlier (paragraph 57) the PIE II model is based on a modified-scorched node network that reduces the number of switch sites previously used in the Telstra network. Following international practice, switching capacity is dimensioned based on traffic forecasts and utilisation margins to accommodate faults, subscriber mobility, and growth.

6.4.6 Transport

136. TELRIC models of local telephone networks assume that the best-in-use technology for transporting traffic and network control information between network nodes is based on high-bandwidth fibre-optic cables using synchronized transport protocols[63]. The primary transport path is supplied by a ring architecture, which establishes two paths between nodes connected to the ring. This provides an essential element of redundancy in the event of a cable fault. Traffic enters and

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[59] HAI Inputs, p. 64.

[60] HAI Inputs, p. 74.

[61] FCC's Tenth Order, ¶ 332.

[62] HAI Inputs, p.75.

[63] "The model assumes that wire centers are interconnected with one another using optical fiber networks known as Synchronous Optical Network **(SONET)** rings." FCC's Tenth Order, ¶ 15.

leaves the fibre-optic ring at several locations around the ring through add/drop multiplexers **("ADMs")**.

137. I am advised by Telstra that the PIE II model designs network transport using best-in-use technology consisting of SDH (synchronous digital hierarchy) fibre-optic rings, ADMs, and point-to-point fibre-optic links that connect remote access units to the rings. In non-metropolitan ESAs the lengths of the transport links are calculated using a minimum spanning tree algorithm. All of the transport network components that are dimensioned within the model are dimensioned to serve the peak period traffic projected for each link or segment. Rings are provisioned up to [c-i-c] of their circuit capacity.

138. The PIE II model's transport design is broadly comparable to the transport design included in the HM5.0a model and incorporated into the FCC's cost model. Those US models design an interexchange network consisting of two classes of high-bandwidth fibre-optic rings -- one that connects remote switches to local switches, and a second class for interconnecting local area switches and transit switches. Transport distances are optimised by considering several alternative placements of switches on possible rings and selecting the one with the least cost[64].

6.4.7 Trenches

139. A large proportion of the total investment in a telecommunications network takes the form of trenches and cables. In the PIE II model, the costs of trenching to install ducts and of ploughing to bury cable account are some [c-i-c] of the total network investment. The objective in estimating the length of trenches is to calculate an efficient network design that minimizes total costs affected by the trench design. The capital costs of the network's outside plant include the construction of trenches or conduit; the copper or fibre cable; electronic equipment, cross-connects and splices at intermediate nodes; and the structures supporting any intermediate nodes.

140. Because trench costs per foot substantially exceed the costs of copper cables per foot engineering-economic models of access networks have generally designed

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[64] Hatfield Model, pp 58-62.

efficient network routing by minimizing the total length of trenches. In a particular instance, the total costs of copper cable in an access network could perhaps be reduced by using an alternative configuration that connects the same nodes with greater total trench length. However, in order for the alternative configuration to be lower cost it would be necessary that each additional foot of trench result in a saving of several feet of copper cable.

141. Calculating the configuration of the nodes that would minimize just the total costs of copper cable (and disregarding trench costs) would require algorithms of greater complexity than those used to minimize trench length. The number of cable pairs running from a node in the access network to more distant "downstream" nodes is determined by the total number of copper services at those more distant nodes. In order to find the total amount of copper cable needed for a particular network configuration, the model would begin at the most distant node and calculate recursive at each network node the sizes of cables required to serve the copper services at that node plus those "downstream" of that node. To obtain the efficient configuration, the algorithm would then either need to evaluate all possible network configurations or to search over a smaller number of configurations and provably attain the one that minimizes total copper cable costs.

142. The general optimization problem of simultaneously minimizing the total costs of both trenches and copper cables is computationally intractable.[65] Even broadening the trench distance calculation used by the PIE II model to include an heuristic algorithm that incorporated cable costs would add considerable further complexity to modelling and calculating the costs of the access network.

143. Unit trenching costs vary substantially with terrain due to costs of constructing underground facilities and access for their maintenance. For example, US cost models provide for structure placement costs per foot that vary according to depth to bedrock, rock hardness, surface soil texture and water table depth.[66]

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[65] C. A. Bush, D. M. Kennet, J. Prisbrey, W. W. Sharkey, and Vaikunth Gupta, "Computer Modelling of the Local, Telephone Network", October 1999, p. 12

[66] C. A. Bush, D. M. Kennet, J. Prisbrey, W. W. Sharkey, and Vaikunth Gupta, "Computer Modelling of the Local, Telephone Network", October 1999et al., pp. 26-27.

144. For several reasons road distances connecting nodal locations are likely to provide a good approximation to the total length of trenches that minimize overall trench costs.[67] In most instances, telecommunications network operators' actual practice is to construct trenches alongside, or in, the existing roadways. Roads are generally routed to minimize travel distance, taking into account natural obstacles and limitations on grade or slope. If trenches are routed away from roads, costs would often be increased by the need to acquire rights of way, undertake construction on undeveloped land that may not be easily accessible, and to build and maintain service roads needed for continued vehicular access for future maintenance. These factors would generally offset savings that could otherwise be realized from shorter trench lengths due to more direct routing.

145. For a few network nodes, direct straight-line connections that depart from roads may be feasible and achieve minimum cost. But in many cases intervening obstacles—buildings, hills and valleys, water bodies, etc.—make a direct route either infeasible or more costly than the indirect route that follows a road.

146. Furthermore, changes in elevation between network nodes may also require less direct routing because the maximum grade for access roads between these points is limited. And some direct routes might require the construction of bridges or bored conduits, significantly increasing the cost above that required by a more circuitous route.

147. Forward-looking cost models have estimated trench lengths by first connecting known (or assumed) locations of customer terminals and network nodes with edges and then measuring the edge distances between these network points in a (two-dimensional) plane. Two measures of internodal distance have been used—Cartesian (direct) distance and rectilinear distance:

- The two-dimensional Cartesian distance is an unachievable lower bound on the efficient length of trenches. Moreover, when network nodes are at different elevations, the shortest path connecting them will have a length given

[67] This point is recognized by NERA, "Assessment of the PIE II Model," July 2003, p. 2.

by the three-dimensional Cartesian measure, which is strictly greater than the two-dimensional measure.[68]

- Rectilinear distance, when oriented to the prevailing road grid, provides a reliable measure of minimum-cost trench lengths in areas served by regular, right-angled streets. For other road configurations it provides an approximation that may over- or under-estimate road distances of a particular route.

148. The distance measure can be adjusted by multiplying it by a correction factor developed from studies that compare modeled distances with actual road and trench distances in representative sections of the telecommunications network service area. A correction factor of 1.00 would indicate that, on average, the distance measure is for the sampled points the same as the road distance, while a factor of less than 1.00 indicates that, on average, the distance measure overestimates the road distance.

149. Empirical studies have compared modeled distances to US highway road distances for several samples of urban and rural points in the US states of Ohio and Wisconsin.[69] These studies have several important findings for modelling distances in telecommunications networks.

- First, the correction factor for the rectilinear measure ranges from 0.97 to 1.05, a variation of 8%. In contrast, the correction factor for the Cartesian measure ranges from 1.16 to 1.35, a variation of 16%.

- Second, in most of the samples the variability of the rectilinear measure (measured by either absolute deviation or standard deviation) from the road distance is smaller than the variability of the Cartesian measure. On average, the uncorrected two-dimensional rectilinear measure was more reliable than the two-dimensional Cartesian measure.[70]

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[68] Even the three-dimensional Cartesian measure would typically be unachievable when the route must follow the geodesic over a sufficient distance on the surface of the sphere.

[69] Love, R.F., J.G. Morris and G.O. Wesolowsky, (1988), "Mathematical Models of Travel Distances," in *Facilities Location: Models and Methods.* Amsterdam: North Holland, Tables 10.1, 10.2.

[70] Love, *et al.*, Tables 10.1, 10.2.

- Third, for the rural sample of points, the correction factor for the rectilinear measure exceeds 1.00. This suggests that in the sparser areas of the network the rectilinear measure may on average underestimate actual road lengths.[71]

150. The PIE II model calculates trench distances between network nodes using a two-dimensional rectilinear measure, with no correction factor. In the US, the TSLRIC model also uses rectilinear distance measures with no correction factor.[72] As suggested by the US road studies, this measure can be expected to be more reliable than a direct-distance measure and to be unbiased in measuring average distance. The rectilinear measure could potentially be made more reliable by conducting studies of representative areas and developing correction factors specific to those areas. While this methodology could improve the accuracy of trench distances in particular areas, it is unlikely to affect greatly the average trench distance across the network.

151. The trench lengths calculated in the PIE II model do not take into account increased distances and costs due to terrain. In this regard the costs calculated in the PIE II model are conservative estimates in some geographic areas. In contrast, the HCPM model adjusts feeder cable distances by factors, which depend on the maximum and minimum slope within a cluster. That model also allows the user to specify a road factor, which converts model distance computations to an empirical estimate of road distance.

6.4.7.1 Estimating trench length

152. The total length of trenches required by the modelled network is obtained by connecting all of the network nodes. A Minimum Spanning Tree is that connection of all nodes in a network that minimizes the total lengths of the edges connecting the nodes. This is the algorithm used to calculate trench distances in several major TSLRIC models — PIE II and HCPM (in the US and NZ).

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[71] The use of a GIS system that specifies the exact latitude and longitude of each node will not eliminate the requirement for correction factors. Any two-dimensional metric applied to the GIS data will ignore differences in elevation, and will have to be adjusted using an empirically derived correction factor. Even if the GIS contained information on elevation, adjustments would be required to account for obstacles or slopes that foreclose, or make inordinately expensive, the most direct routes.

[72] FCC's Tenth Report and Order, at 66.

153. In principle, the total required length can be reduced by including additional (Steiner) nodes in the network. If the sole optimization criterion is minimum total distance, a Steiner Tree design is superior to a Minimum Spanning Tree. However, for each Steiner node that is included the network operator also incurs additional costs for supporting structure, cross-connect equipment or splices, power, and maintenance of the node.

154. The use of Steiner nodes for trench design would considerably increase the complexity of telecommunications network cost models in three ways:

- First, in a network with more than a very few nodes the calculation of the actual optimum in a Steiner tree design is infeasible or very costly: the time required to evaluate potential solutions to a Steiner tree design increases exponentially with the number of nodes. Although heuristic calculation algorithms can approximate the optimal solution, even such sub-optimal methods require intensive computation.[73]

- Second, the calculated Steiner node must be evaluated for feasibility. Unlike the scorched nodes comprising the Minimum Spanning Tree, which are located at nodes of the actual network, the optimization calculation may place each added Steiner node anywhere in the two-dimensional plane.

- Third, an efficient network design that uses Steiner nodes must account for the cost of those additional nodes. Those costs offset to some degree the reduction in distance that Steiner nodes make possible and likely reduce the number of Steiner nodes that are cost-effective.

155. While the introduction of Steiner nodes would tend to reduce total trench distance in the network and can potentially reduce total network costs, a Steiner tree design is not necessarily more efficient than a Minimum Spanning Tree because each Steiner node itself adds costs to the network and is restricted to feasible locations. Calculation of algorithms to approximate an efficient Steiner tree design would

[73] This has been acknowledged in NERA, "Assessment of the PIE II Model," July 2003, p. 17.

introduce considerable complexity and cost and would thus appear at variance to the ACCC's call for a simpler and more transparent cost model.[74]

156. As noted above, road distances are likely to be a good proxy for the overall length of minimum-cost trenches. I am advised that Telstra has calculated estimates of the total trenching required in four types of ESAs (urban, major rural, minor rural, and remote rural) using road distance information and assumptions about the proportions of each type of road that would require trenching and street crossings in Australia[75]. As at 30 June 2002 that analysis estimated minimum and maximum lengths of ducted and total trenches. As shown in the following table, the PIE II model's estimates of required trench lengths are less than the minimum values Telstra obtained from the road distance calculations:

	Estimated by PIE II	**Estimated from road distances**
Ducted trenches	[c-i-c]	[c-i-c]
Total trench	[c-i-c]	[c-i-c]

157. In my opinion, the reasonably close correspondence between the PIE II model's estimate of total trench lengths and the separate calculation based on road lengths enables one to place confidence in the reasonableness of the PIE II model's estimates of total trenching costs.

6.4.7.2 Trench sharing

158. Trenches supporting the cables of the access provider's network are resources that are potentially sharable with other service providers. In a scorched-node approach, the access provider can, in theory, either construct new trenches or, if the required capacity is available, lease the capacity from another supplier.

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[74] ACCC, "Assessment of Telstra's ULLS and LSS monthly charge undertakings", Draft decision, August 2005, pp. 91, 93.

[75] Telstra's Submission dated 9 January 2003 - ANNEXURE J -TRENCH LENGTHS.

159. I am advised by Telstra that Telstra's opportunities to lease ducts and tunnels in trenches from other suppliers is limited largely to a small number of selected CBD areas in which power companies have spare ducts available. I have been further instructed that sharing of ducts with gas and water utilities is not a generally accepted practice in Australia. Although sharing of above-ground utility poles is a theoretical possibility in some areas, I understand that council approval is rarely granted. It is therefore my understanding that the opportunities for Telstra to lease trench capacity from other suppliers are *de minimis*.

160. The PIE II model assumes that all main cables in the CAN and the IEN are placed underground, running in ducts in the CBD areas, and are either placed in ducts or ploughed directly into the ground in the metropolitan, provincial areas, and rural areas.

161. According to Telstra, a large proportion of its cables are laid in trenches that run alongside existing roads. The costs of trenching depend principally on the length of trench, the type of road, and local construction conditions.

162. Two or more cables that follow the same route for a portion of their length may be able to share a common trench, reducing the total cost of trenching required in the network. For example, in some locations the copper main cable in a section of the CAN and the optical fibre cable in the IEN connecting a RAU to the LAS can be run in separate ducts within the same trench along one side of a road.

163. The opportunities for CAN and IEN cables to share trenches will vary greatly. The PIE II model assumes that throughout the CAN, nearly all (98%) of the total length of the trenches housing main cables can be shared with another cable, provided that main cable lengths are at least 1,000 metres. Trench sharing is thus determined separately in each ESA.

164. In the US, the FCC determined that the extent of trench sharing between the incumbent telecommunications provider and other utilities would depend on the density of subscribers. For underground and buried structure, the FCC assumed that the telephone carrier would bear 100 percent of the cost in the most dense areas (zones 1-2), 85 percent of the cost in density zone 3, 65 percent of the cost in

density zones 4-6, and 55 percent of the cost in the least dense areas (zones 7-9) .[76] The FCC noted that the Washington State utilities commission had adopted similar sharing rules after a review of the available record.[77] In Florida, the State Commission accepted Verizon's treatment of conduit sharing, which that carrier based on the current extent of sharing.[78]

165. In the UK the BT documents I have reviewed do not contain any explicit adjustments for trench sharing, implying that the forward-looking sharing percentages are equal to historic values.

166. In New Zealand, the Commission developed averages for metropolitan, urban/surburban, and rural density zones based on the "level of sharing that occurs in practice." For the metropolitan zone, the percentage is 15.3%. For the urban/suburban and rural zones, the corresponding percentages are 4.19% and 3.51%, respectively. [79]

167. In the PIE II model the degree of trench sharing with other utilities is based on existing levels of trench sharing in the Telstra network. This approach is consistent with cost modelling practices in other jurisdictions.

6.4.7.3 Trenches in new estates

168. When telephone service is extended to previously unserved areas, additional trenching is required beyond that needed for the already served areas of the network. I understand that it is the practice of estate developers to provide access to trenches in their estates at no cost to telecommunications operators and that per year the number of new estate services is approximately 1% of all PSTN access services nationwide.

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[76] Tenth Report, at 243. The density zones are defined by the number of lines per square mile. Zone 1 has 0-5 lines/square mile. The corresponding ranges for zones 2 through 9 are 5-100, 100-200, 200-650, 650-850, 850-2550, 2550-5000, 5000-10000, and 10000+. See HAI Model Release 5.0a, Model Description, p. 41.

[77] Tenth Report, at 249.

[78] Final Order On Rates For Unbundled Network Elements Provided By Verizon Florida, Order No. Psc-02-1574-Fof-Tp, Docket No. 990649b-Tp. November 15, 2002.

[79] Commerce Commission, Determination for TSO Instrument for Local Residential Service for period between 1 July 2002 and 30 June 2003, pages 72-73. The rural density zone consists of areas with 0-650 lines per square mile. The urban/suburban zone consists of areas with 650-10000 lines per square mile. The metro zone consists of areas with at least 10000 lines per square mile. (p. 89).

169. An efficient forward-looking network operator would anticipate being able to serve growing demand in new estate areas without incurring trenching costs for those services. The PIE II model assumes that each year estate developments represent approximately 1% of all PSTN access services nationwide and that the corresponding trenches in new estates will not be a cost to Telstra. The model therefore excludes trenching costs for services in new estates.

170. Telstra would still incur the costs of planning for, and placing, additional cable in those trenches as well as the non-trenching investment costs of provisioning network equipment to provide service in those areas. The PIE II model does not estimate the costs of these investments in new estates; instead, it calculates the costs that would be incurred to expand service to an additional 1% of SIOs in existing service areas, rather than the generally higher provisioning costs that would be incurred in new areas, and to this extent the model understates the costs of serving new SIOs.

171. If one assumes that 1% of SIOs are added each year in new estates, all served by trenches constructed by developers at no cost to the network operator, and that there is no growth in demand elsewhere in the network then in the initial year the costs of 99% of all trenches in the network are investment costs of the incumbent network operator while 1% of those costs are borne by new estates. Assuming that all growth subsequently occurs only in new estates, the network operator can meet future demand without incurring any further trench investment in future years. Taking a multi-year perspective, each year an increasing proportion of all SIOs are located in new estates, so that in future years the forward-looking per-SIO cost of trenching declines.

172. An efficient competitor who enters to supply the entire market in the initial year, uses the same nodal locations as the incumbent operator, and also anticipates annual growth of 1% of SIOs would optimize investment over forecast demand and would therefore have the same forward-looking trenching costs in the initial year as the incumbent operator. And in subsequent years that initial-year entrant would similarly benefit from growth in new estates without incurring added trenching investment.

173. Alternatively, if there is a *de novo* entrant each year, it will avoid the trench costs of only 1% of the total SIOs -- those SIOs that are trenched that year in new estates; consequently, the costs calculated for such an entrant would be higher than for an entrant that anticipates growth over several years.

174. The incumbent operator's efficient forward-looking costs therefore exclude the cost of trenches for those SIOs that are added to the network in new estates for some period of time, beginning from the start of the regulatory period.

175. In TSLRIC modelling, there is a need to define the manner and timing of network construction. The scorched-node costing methodology requires that costs are modelled from a particular point in time based on efficient build costs for the entire network at that particular date. If Telstra were to construct the network in, say, 2005/06 it is not able to avail itself of open trenches (and hence incur no trenching costs) in areas of the entire network that were previously constructed.

176. Assuming that new estates comprise no more than 1% of Telstra's network in a single year, it would be unwarranted for the PIE II model to exclude more than 1% of trench costs in its initial year. Costless trenches in new estates requires that the parties build infrastructure concurrently and co-ordinate provisioning of the buried cables. As TSLRIC models the network at the beginning of each year, it is appropriate to use only the trenches that are open at that time.

177. Rather than view the entrant as a *de novo* efficient firm each year, one could view the market as potentially contestable by equally efficient firms at the beginning of the regulatory period. The TSLRIC calculation would then calculate the costs of the hypothetical entrant who enters at the beginning of the regulatory period. Such an entrant would have 1% of trenches provided by developers in new estates in year 1, and an additional 1% of trenches in year 2. A forward-looking multi-year TSLRIC calculation based on entry at the start of the regulatory period would result in slightly lower trench costs per SIO in subsequent years than the TSLRIC estimate based on new entry each year. However, a forward-looking scorched-node cost methodology cannot consistently incorporate the past savings in trench costs that are unavailable to new entrants.

178. In summary, when telephone service is extended to previously unserved areas, additional trenching is required beyond that needed for the initial number and location of services. When it is the practice of estate developers to provide access to trenches in their developments at no cost to telecommunications operators, in my opinion it is appropriate for the PIE II model to exclude trenching costs for new estates over the regulatory period but to include the costs of additional cable to provide service in those areas.

6.5 Price trends of assets

179. The future prices of assets enter the calculation of annual capital costs in the PIE II model by determining the tilt factor used in the tilted annuity formula for annualising capital costs. As inputs, the PIE II model includes projected price trends of each major category of asset used in the network, starting from actual prices paid by Telstra in 2004/05. Future price trends for the period of the undertaking are projected using the most recent 3-year annual rates of change (to 2003/04 or 2004/05) in related communications sector equipment and labour indices sourced from the Australian Bureau of Statistics **(ABS)**.

180. In my opinion, it is appropriate to include price projections for the relevant years in modelling EN costs. Economic depreciation of investment in new network assets is directly affected by changes in the prices of new assets over time, and taking price changes into account improves the reliability of estimates of the annual capital costs. Oftel's TELRIC model explicitly provided for assumed annual changes in the prices of switches, optical fibre, and transmission electronics, and for increases in future operating costs for each major category of asset[80]. By comparison, the US cost models use only a less advanced, entirely static methodology of capital costs with asset prices that are unchanged over their economic lifetime.

6.6 Operating and maintenance expenses and common support expenses

181. TELRIC models have, to date, not attempted to model the activities and supporting assets used to supply operating and maintenance **("O&M")** services to the

[80] Bottom-Up Model, Annex D, March 1997.

network[81]. Instead, the models have turned to historical accounts of actual expenses and sought to adjust expense amounts to more nearly reflect a forward-looking view of expenses[82].

182. Telstra has calculated ratios of current O&M costs to asset values for shorter-lived network assets by detailed examination of its regulatory accounts for both expenses and assets. I am informed by Telstra that the O&M ratios used in the PIE II model have been based largely on the O&M expenses incurred for current-generation assets. For example, Telstra has disaggregated expenses associated with an individual asset category so that expense ratios for maintenance of fibre optic systems are limited to those applicable to SDH equipment, and excludes the earlier-generation PDH equipment. This qualified use of historical accounts captures the maintenance expense experience for the most recently installed assets and avoids the use of O&M costs associated with earlier technologies. It is thus the most nearly forward-looking calculation that can be extracted from accounting models of operating experience. In the PIE II model these expense ratios are then applied to calculated investment to estimate current expenses.

183. For long-lived cabling and trench assets, which have been substantially depreciated in the regulatory accounts, Telstra has calculated the ratio of current operating costs to the new asset costs estimated by the PIE II model. This procedure avoids the overstatement of O&M costs that would result from using ratios based on regulatory asset values of long-lived, substantially depreciated assets.

184. In other jurisdictions, O&M expenses and common support expenses are also developed from historical costs recorded in the incumbent's accounts. The specific approaches, which vary from one model to another, generally calculate the

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[81] (A) Oftel: "[O]ne approach would be to model the impact of all of the key drivers that affect the level of operating costs in the network. This was considered by the Working Group to be an unduly large and complex modelling task." Bottom-Up Model, p. 32.

(B) WIK: "[T]he complex work processes … make it hard to identify the cost drivers [of asset-related operating costs], and the company-specific nature of the processes" WIK Local Loop Model, Section 4.2.

(C) FCC: The FCC did not "develop [general support facilities] investments on some other basis, such as an activity based approach, rather than as a ratio of investment. .... Such an approach also would require changes to the model platform." FCC's Tenth Order, ¶ 415, footnote 1308.

[82] "[W]e use … factors that express the operating costs for various asset categories as a percentage of the investment sum." WIK Local Loop Model, Section 4.2.

expenses either as a fraction of the investment in the corresponding assets, or as an amount per line. In the UK, BT's accounting systems identify separately the labor costs and related stores costs incurred in maintaining a particular type of local exchange.[83] Maintenance expenses related to customer-facing activities and those related to direct plant are identified and assigned to specific activities – no allocation is required for the bulk of such expenses. After maintenance expenses have been assigned to activities they are included in relevant Cost-Volume relationships, and are included in the LRIC calculated by the model. BT illustrates its approach with an example based on maintenance of vehicles.[84]

185. In the US, the FCC developed expense-to-investment ratios from the expense and capital accounts of five major incumbent carriers. For each of 17 primary asset categories the FCC first calculated a composite current-to-book ratio of assets for two successive years (1997 and 1998) from the data for all five carriers and then estimated for each carrier the current mid-year value for each asset. Next, each carrier's 1998 expenses assigned to that asset category were divided by the estimated current asset value to obtain the expense-to-investment ratio. Finally, each ratio was applied to the TELRIC estimate of investment of the corresponding asset category.[85]

186. In Florida, the State Commission used a similar approach to determine Verizon's rates by applying indices developed by a recognized financial publication (C.A. Turner) to each vintage of plant investment to express booked assets at year-2000 replacement cost. The ratio of year-2000 expenses to these replacement costs was calculated, and then applied to the model's calculated investments to obtain forward-looking maintenance expenses.[86]

187. In New Zealand, the Commission relied on data for maintenance costs provided by Telecom to develop the inputs for its CostPro model, which treats these expenses as

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[83] BT's LRIC Methodology, p. v.

[84] BT's LRIC R&P, p. 31.

[85] Tenth Report, at 341 and 346. Footnotes omitted.

[86] Final Order on Rates for Unbundled Network Elements Provided by Verizon Florida, Florida Public Service Commission, Docket No. 990649B-TP, Order No. PSC-02-1574-FOF-TP, Nov 15, 2002, p. 183-4.

a percentage of the total capital value of the installed plant.[87] In modelling the costs of network access, the Commission assumed that direct network operating costs would be 12% of annual capital costs.[88]

188. In Malaysia, the MCMC considered four options for modelling the incumbent's cost. For operations and maintenance expenses, the MCMC has considered both Malaysian-specific data and an international benchmark based on FCC data.[89] In a Consultation Paper issued in May 2002, the MCMC used expense-to-capital-cost ratios based on data generated by a Malaysian Taskforce.[90]

189. In none of these instances does the method of calculating O&M expenses include an explicit adjustment for "efficiency" – the adjustments made by the FCC are for the purpose of developing expense-to-investment ratios that are commensurate with the forward-looking investments calculated by the cost model.[91]

190. As shown in Annexure B, the historical O&M expense-to-asset ratios of the largest access providers in five US states vary considerably. For example, the factor for buildings varies from 6.95% to 11.59%. In its investigation of input values for its TELRIC model, the FCC established a factor of 9.06% for buildings, based on nationwide historical cost data. In comparison, the PIE II model uses an O&M expense factor of [c-i-c] for the consolidated land and buildings account.

191. International comparisons of expense factors across access providers are problematic because operators use different accounting practices to classify expense activities. Telstra's expense factors are not easily compared to factors used in overseas models. For example, I am advised by Telstra that the expenses recorded in the standard regulatory accounts for the SDH Transmission (SD) asset category include both "SDH equipment" and "PDH equipment" as well as "echo

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[87] NZ Determination 2001-2, p. 151.

[88] "Determination for TSO Instrument for Local Residential Service for period between 1 July 2002 and 30 June 2003", New Zealand Commerce Commission, 24 March 2005, ¶286.

[89] Malaysian Communications And Multimedia Commission, A Report On A Public Inquiry Under Section 65 Of The Communications And Multimedia Act 1998 On Access Pricing, 31 JULY 2002, page 5.

[90] Malaysian Communications And Multimedia Commission, A Consultation Paper On Access Pricing, 13 May 2002, p. 58.

[91] Tenth Report, at 342.

cancellers" and "common synchronisation network". In the US accounts, the most closely corresponding asset category is Circuit Equipment (USOA 2232). However, that category includes not only SDH and PDH equipment, but also copper-based transmission equipment. In the case of switching equipment, Telstra has advised me that its accounts distinguish between local and remote access switches, transit switches, and signalling switching equipment, whereas the US accounts have a single category for digital electronic switching.

192. The PIE II model's O&M expense factors for main cable, distribution cable, and optical fibre are obtained from a composite account of Telstra's expenses for maintaining aerial, buried, and underground cable in its current network. However, aerial cable is not used in the forward-looking network in the PIE II model, and in overseas TELRIC models aerial cable is assumed to be generally more costly to maintain than cable that is buried or in underground conduit. Consequently, a composite O&M factor will somewhat overstate the cost of maintaining an entirely underground cable network. Nevertheless, because aerial cable is, I understand, only about [c-i-c] of total cable in Telstra's network, this factor, in my opinion, can cause at most only a small bias in the overall O&M expense estimate.

193. Bearing in mind the irreducible differences in expense categories produced by different accounting practices in Australia and the US, the data in Annexure B suggest that the PIE II model's expense factors are broadly consistent with TELRIC models in the US. In my opinion, the PIE II model's expense factors are appropriate for calculating the efficient costs of the UT Services.

6.7 Indirect capital costs

194. For indirect capital costs, the PIE II model estimates the investment in supporting assets, including non-network land and buildings, office furniture and equipment, light and power, etc. on the basis of asset values recorded in its regulatory accounts. These indirect assets are expressed as a percentage of four categories of directly employed assets recorded in the accounts for access, IEN, switching, and network support.[92] These percentages are then multiplied by the levels of direct investment

[92] Telstra's Methodology Submission.

calculated by the model and the amount of the resulting indirect investment is expressed as an annual cost.

195. A similar approach to indirect capital costs is used in the German national core network model. The regulator notes that "It is not possible to model the investments directly by using the cost drivers considered because of their common cost characteristics"[93] and that model therefore marks up the investment in each network element by a common percentage to reflect indirect capital investment.

196. The PIE II model's approach is consistent with the method prescribed in the FCC's cost model, which relies on historical accounts to estimate general support facilities investment (including buildings, motor vehicles, and general purpose computers) in each access provider's statewide service area. This investment is then adjusted by a nationwide allocation factor derived from a statistical analysis of the proportion of common support expenses and plant-specific operations expenses attributable to local service.[94]

197. In my opinion, the PIE II model's methodology for estimating indirect capital costs is appropriate and consistent with international practice.

6.8 Indirect O&M costs

198. The PIE II model estimates the costs of indirect operations and maintenance expenses – for finance, employee relations, and corporate centre activities – by applying an indirect cost factor to the direct O&M costs in each asset category. The indirect O&M cost factors are derived from regulatory accounts.

199. For common support services expenses (such as corporate operations, customer service, and other non-plant specific expenses) the FCC calculated expenses on a per-line basis in order to statistically adjust historical data from all non-rural carriers to remove expenses attributable to special access lines and long-distance services. The estimated expenses are then expressed as an expense-per-subscriber-line factor in the HCPM model.

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[93] WIK, "An Analytical Cost Model for the National Core Network," Consultative Document Prepared by WIK for the Regulatory Authority for Telecommunications and Posts; Project Team: Dr Frank Schmidt, Florentín González López; Contributors: Prof Klaus Hackbarth, Antonio Cuadra; 14 April 1999; page 50.

200. The PIE II model generally follows international practice in estimating indirect O&M costs by deriving cost factors from expense ratios calculated from actual expenses recorded in regulatory accounts.

6.9 ULLS

201. The unconditioned local loop service is supplied using resources shared with other access services in the CAN plus resources that are dedicated to ULLS. The PIE II model calculates the costs of the shared access resources and allocates the costs of distribution trenches and cable in each ESA to all copper-based services – PSTN, ISDN, and ULLS. The model distinguishes between services that are connected directly to network units and services connected to remote CMUX units. Costs associated with pillars are allocated according to the number of services connected to each type of unit. Costs associated with main trenches and cables are allocated to services connected to main units.

202. The network costs of ULLS are aggregated and ULLS-specific costs, calculated outside the PIE II model, are then added to the average network costs per ULLS to obtain the forward-looking cost per ULLS.

6.10 Allocation of PSTN CAN costs

203. Both the PIE II model and the US models calculate the total costs of each of the major individual network elements (e.g., local loop, remote multiplexers and remote switches, local switch, interexchange transport). The total costs of the portion of the CAN accounted for by copper lines are allocated to PSTN, ULLS, and other lines in proportion to the number of copper services. The PSTN's share of the CAN costs is then used to calculate OTA and LCS prices. In contrast, the US models first convert leased lines to an 'equivalent' number of voice-grade lines using the number of channels supported by a leased line.[95]

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[94] FCC's Tenth Order, ¶ 418.

[95] Forward-Looking Mechanism for High Cost Support for Non-Rural LECs, CC Docket No. 97-160, Tenth Report And Order, Released: November 2, 1999, at 393.

7 CALCULATING TSLRIC FOR SUBSEQUENT YEARS

204. Once the PIE II model has calculated the TSLRIC of UT services in the base year, it can be rerun using new input values for the subsequent years of the regulatory period. To use the model in this way, for each year the forecast values of demand, asset and input prices and the WACC is revised and a new calculation carried out. This is the procedure that was used in the previous undertaking. I am advised by Telstra that effectively the same procedure has been used to obtain the total costs of each network element for each year covered by the current undertaking.

205. For ULLS, the roll-forward calculation updates the costs calculated in the PIE II model to account for updated WACC and price trend values but using an unchanged total number of copper lines over the period of the undertaking. As total copper lines are forecast to decline slightly, and assuming that some costs will not fall commensurately with this decline in demand, unit access network costs will be understated by a small amount, resulting in a conservative calculation of ULLS rates.

8 CONCLUSION

206. The PIE II model is based on Telstra's best-practice network technology. It is forward-looking, with the original model incorporating subscriber and traffic forecasts for the years 2003/03 to 2004/05. Forecasts for 2006/07 and 2007/08 of subscribers and traffic have replaced those for 2004/05. Provisioning of each network element is based on efficient engineering principles that take into account subscriber and traffic density. Asset prices and operating, maintenance, and indirect expenses are estimated based on recent experience with current-technology equipment.

207. In my opinion, Telstra's cost-estimating methodology incorporates the principles for TELRIC modelling that have been developed and applied in international practice and the PIE II model appropriately calculates TSLRIC costs for the UT Services.