MALAYSIAN COMMUNICATIONS AND MULTIMEDIA COMMISSION

A CONSULTATION PAPER ON ACCESS PRICING

13 May 2002

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Preface

On 11 March 2001, the Malaysian Communications and Multimedia Commission (MCMC) published a final report entitled "Access List Determination and Statement on Access Pricing Principles". MCMC's draft statement set out both the principles for the application of cost based access prices and a methodology for determining cost based interconnection charges. In that report, MCMC acknowledged that the modelling of long run incremental costs (LRIC) was complex but that the economic benefits of using forward-looking costing approaches outweighed the costs. Against this background, the statement included a commitment to embark on a costing study that may result in a set of benchmark prices for some facilities or services included in the access list.

MCMC had engaged National Economic Research Associates (NERA) to carry out a LRIC study for both fixed and mobile interconnection charges. NERA has concluded the first phase of the study and MCMC is now holding a public inquiry in relation to the approach and implementation that was recommended by NERA, which is set out in this document.

MCMC invites submissions from interested parties on the contents of this public inquiry document. Written submissions should be provided to MCMC by **12 noon, 1 July 2002.** Submissions should be provided in hard copy as well as electronic form and addressed to:

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45 Jalan Tun Ismail
50480 Kuala Lumpur

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Any confidential material should be provided under a separate cover clearly marked 'Confidential'.

MCMC thanks interested parties for their participation in this consultative process.

TABLE OF CONTENTS

ABBREVIATIONS

BHCA	Busy Hour Call Attempt
BHE	Busy Hour Erlangs
BSC	Base Station Controller
BTS	Base Transceiver Station
CoC	Cost of Capital
DLS	Digital Local Switch
DRS	Digital Remote Switch
DTS	Digital Tandem Switch
FAC or FDC	Fully Allocated Cost or Fully Distributed Cost
FCC	Federal Communications Commission
GFIA	General Framework of Interconnect and Access
GSM	Global System for Mobile Communications
HLR	Home Location Register
ISDN	Integrated Services Digital Network
MCMC	Malaysian Communications and Multimedia Commission
LRIC	Long Run Incremental Cost
MSC	Mobile Switching Centre
OLO	Other Licensed Operator
NERA	National Economic Research Associates
PSTN	Public Switched Telephone Network
SDH	Synchronous Digital Hierarchy
SMS	Short Messaging Service
STP	Signal Transfer Point
TRX	Transceiver
TSLRIC	Total Service Long Run Incremental Cost
TS	Tandem Switch

SECTION 1: INTRODUCTION

In August 2001 MCMC had engaged National Economic Research Associates (NERA) to calculate the long run incremental cost (LRIC) of fixed and mobile interconnection services in Malaysia.

To conduct this study, an industry taskforce was formed (the Taskforce), comprising of licensees who provide PSTN and public cellular services in Malaysia. This forum was created to enable MCMC to explain to the licensees the process MCMC was embarking on and the data that would be needed as inputs to the cost models. A number of meetings were held to promote and maintain interactive exchange of information between MCMC and the members of the Taskforce.

Licensees were provided with detailed data requests and were encouraged to provide feedback to ensure that their costs were fully taken into account during the cost modelling process.

The deadline for data submissions was extended in the light of licensee's requests for such an extension, to ensure that licensees were given the opportunity to submit meaningful data that could then be incorporated into the cost models. Clarifications of the nature of the data requested were provided by MCMC; and in addition MCMC sought clarification from the licensees where particular data points appeared to be anomalous.

Telekom Malaysia Berhad (TMB) faced particular difficulties in providing sufficient cost data for the fixed interconnection cost model. Due to the additional data required from TMB (the incumbent and the largest PSTN service provider in Malaysia), a series of additional meetings were held to explain the nature of the data required and additional time provided. To summarise, MCMC went to considerable length to provide licensees, in particular TMB with additional time and support to submit the relevant data.

In addition, once the cost models had been prepared, MCMC held a viewing period, during which each licensee had the opportunity to view the cost models (specially prepared with dummy data to avoid releasing confidential material) individually, and to provide MCMC with comments. These comments were carefully considered and the model has been amended to reflect these comments, where appropriate.

The purpose of the current public inquiry process is to provide industry with opportunity to provide further comments, as well as to open up the process to a wider audience. MCMC does not expect licensees to submit any further data and indeed does not intend to incorporate any unsolicited new data at this stage.

This consultation document is structured in the following manner:

> **Section 2** provides a summary of the relevant background.
>
> **Section 3** provides an overview of the approach MCMC has taken to modelling LRIC fixed interconnection services. Further details are provided in Appendix B.
>
> **Section 4:** provides an overview of the approach MCMC has taken to modelling LRIC mobile interconnection services. Further details are provided in Appendix C.
>
> **Appendix A** presents a review of cost standards for Interconnection services.
>
> **Appendix B** provides more details on the fixed LRIC model.

Appendix C provides more details on the mobile LRIC model.

SECTION 2: BACKGROUND

2.1 Current interconnection regime

The obligation for licensees to set cost based interconnection charges for call conveyance in PSTN and public cellular services is set out in TRD006/98, *Determination of Cost-based Interconnect Prices and the Cost of Universal Service Obligation*. TRD006/98 is a regulatory instrument issued under the now repealed *Telecommunications Act 1950*. Whilst these regulatory instruments have been preserved under the transitional provisions of the Act, it is intended that the interconnection and access regime would be replaced by the access regime established under Chapter 3, Part VI of the Act.

The interconnect call conveyance services stipulated in TRD006/98 are:-

Cost based charges apply to the following interconnect call conveyance services[1]:

- *Fixed networks*
  - Local call termination;
  - Single tandem origination and termination;
  - Double tandem origination and termination.
- *Mobile networks*
  - Call termination from a Point of Interconnection (POI) in the called-party's home area;
  - Call termination from a POI outside the called-party's home area.
- *Fixed and mobile*
  - For a fixed interconnect service that require the use of the submarine cables between Peninsula Malaysia and Sabah/Sarawak, an additional charge will added to the relevant interconnect charge.

The above services are regarded as 'well established' and utilize 'bottleneck facilities'. Cost-based prices are available to licensees providing public switched telephony network (PSTN) and public land mobile network services.

The relevant cost based pricing principle for fixed network interconnect services, is close to Fully Allocated Costs (FAC) and for mobile interconnect services, long-run incremental costs (LRIC).[2] The actual charges are set out in Appendix IV of TRD006/98. These charges apply to all licensees.

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1 Para 2.2.2 TRD006/98.

2 Para 2.4.1 of TRD006/98.

SECTION 3: ESTIMATING LRIC OF FIXED NETWORK INTERCONNECTION SERVICES IN MALAYSIA

Appendix A contains a summary review of the rationale for using LRIC as the cost standard when setting interconnection charges. This section provides an overview of the approach MCMC has taken when modelling LRIC of fixed interconnection services in Malaysia; presents the results of the model; and invites comments on a number of key issues, in particular on the choice of options (section 3.5) and the role MCMC should play in determining LRIC rates for fixed services (section 3.6). Further details of the model are provided in Appendix B.

3.1 Overview

The cost definition MCMC has adopted is **total service long run incremental cost (TSLRIC).** The first question to address is therefore the definition of the increment of output that constitutes "total service" when considering fixed network interconnection services.

Box 3.1: TSLRIC

MCMC has taken the interconnection service as being the whole of TMB's inland fixed (including ISDN) wholesale services together with its leased line (or "private circuit") service. Both TMB's own customer services as well as the traffic for interconnect licensees are taken into account. Only traffic related costs are relevant to interconnection services. Line related costs are considered in the access network.[3]

This definition is consistent with that used in the UK, Western Europe and the US. It ensures that:

- there is a consistent basis for determining a single cost underlying both the price for interconnecting licensees and the internal transfer price for TMB's own retail customers;
- where costs are shared between more than one service (e.g. the cost of trenching is shared between PSTN and leased line services), the cost saving is also shared between the different services;
- services do not have to be listed "in order" - all of the services listed have "equal priority" and share costs equally thus avoiding arbitrary decisions as to which service "came first". It is also the case that causality should be determined on a forward-looking basis and hence who comes first is irrelevant.[4]

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[3] For the purpose of this costing exercise, the boundary of the access network is taken to be the line card.

[4] If, for example, PSTN services were arbitrarily deemed to have "come first", they would pick up all of the costs associated with duct and trench and leased lines would bear none of these costs; conversely if leased lines were deemed to have "come first" the PSTN services would bear none of the costs of duct and trench.

The main steps taken to calculate the LRIC of fixed interconnection services are:

Step 1	A network capable of providing TMB's inland fixed (including ISDN[5]) and inland leased line services is modeled, considering only traffic related costs (such as switch processors, multiplexing equipment, cable and trench in the conveyance network).
Step 2	The TSLRIC of providing these services is identified.
Step 3	Direct network costs which are common to call conveyance and access (e.g. the site cost for a local switch) are treated as a cost mark up on fixed conveyance costs
Step 4	To estimate fixed conveyance costs, leased line conveyance costs are eliminated by splitting transmission costs according to the proportions of capacity used for leased lines[6] and call conveyance respectively.[7]
Step 5	Indirect costs are modelled as a percentage mark up on either total network investment costs or total network operating costs as appropriate.

3.1.1 Scorched node assumption

The "bottom-up" approach MCMC has adopted involves calculating the (annualised) cost of re-building and operating TMB's network, while retaining the current network structure. This is a standard approach, which is sometimes described as a "scorched node" assumption, since the model is based on TMB's existing number of exchange sites and transmission links.[8] The scorched-node assumption means that best switching technologies would be employed at existing nodes and best transmission technologies would be used to connect up the various nodes using the existing transmission links. By way of contrast, under a "scorched earth" assumption, the number of exchange sites and transmission links may also be varied. In general, there are quite strong arguments for using the scorched node approach on grounds of:

5 Note that ISDN services are included to make sure that any costs which are common to both services are shared. Certain additional costs which arise for ISDN services only (eg the cost of an ISDN line card is greater than the cost of a PSTN line card) have been included in the model.

6 By taking leased line capacity into account in the model, PSTN transmission unit costs will be lower than they would otherwise be due to the sharing of trenching, cables and multiplexing equipment. PSTN and leased line services share these facilities and consequently there are fixed costs that are common to the two services. Failure to take this into account will exaggerate the PSTN costs.

7 Note that switching costs are only relevant to call conveyance.

8 See also Appendix A.

- **practicality** - determining an "optimal" TMB network structure would be a major task. Moreover, it is by no means clear that a unique view exists of what constitutes an optimal network;
- **relevance and realism** – TMB's current network nodes are, to an extent, determined by historical factors. It is not necessarily reasonable (or even cost effective) to suppose that its network structure can be significantly reorganized in the near future.[9]

3.1.2 Network component based approach

In line with other telecommunications cost modelling studies, MCMC uses a network component based approach (e.g. deriving costs for the different components of the network, such as remote concentrators, local and tandem switches, and the different types of transmission links in the network). This approach is adopted for two principal reasons.

- first, a component-based approach is the most practical since component costs are relatively easily identified in a "bottom-up" model;
- secondly, and more importantly, the costs imposed on the network by different forms of usage (eg local exchange interconnection or interconnection at tandem exchanges) are strictly related to the components utilised by each of these services. If for example TMB provides local exchange interconnection to a competitor, it will be required to provide capacity only in its local exchanges and transmission links between local exchanges and remote units. In this case, TMB will not incur any tandem switch costs. However, if the competitor received single or double tandem interconnection, then the cost implications with respect to TMB's tandem switches and associated transmission links should be included. A component cost approach will achieve this.

The linkage between component costs and service costs (whether retail services such as local calls, or interconnection services such as local exchange interconnection segments) is provided by so-called "routing factors". These specify the average number of units of each network component used by a particular type of service. Routing factors are commonly measured from traffic samples. In the case of interconnection services, many of the routing factors can often be established almost by definition. For example, a single tandem interconnection segment typically makes use of one tandem switch, one tandem to local transmission link, one local switch, and lastly a proportion of transmission links between the local switch and remote units (less than one due to co-location of some concentrator units with local switches).

3.2 Fixed Shared and Common Costs

The definition of cost MCMC considers is TSLRIC. For a new service TSLRIC measures the increase in costs causally associated with the supply of the new service at the full volume of its likely demand. For an existing service, TSLRIC measures the decrease in costs associated with discontinuing supply of the service in its entirety. Under this definition fixed costs (ie costs that do not vary with output) that are specific to the service

[9] Note that this approach includes efficient switching technologies and transmission links between the nodes.

being considered are included in the definition of costs. There are, however, two other types of cost that are also relevant to interconnection charges:

- shared fixed costs: fixed costs associated with the supply of a group of services comprising more than one, but less than all, of a firm's services; and
- common fixed costs: fixed costs that are shared by all services produced by the firm.

In principle applying TSLRIC would imply that shared and common costs are not included in our cost estimates for interconnection services. Some kind of "mark-up" over the costs estimated using TSLRIC is then needed to ensure adequate cost recovery. The simplest way to do this is to apply a uniform mark up. Alternatives, such as investigating demand elasticities and using Ramsey pricing, are relatively complex (and require detailed information on demand) and have not been considered.[10]

3.2.1 Shared fixed costs

Examples of fixed costs shared between the access and conveyance network are:

- the cost of the site for a local switch which is shared between fixed and customer access - the site hosts both line related pieces of equipment (such as line cards) and traffic related pieces of equipment (such as the switch processor). The cost of the site itself, however, is fixed and does not depend directly on lines or traffic;
- trenches that are shared between the access network and the conveyance network.

MCMC has adopted the following approach to these shared fixed costs:

- trench costs are allocated in equal proportion based on a 50:50 split between access and conveyance for the portion of total core trench that is shared with access. This is the most practical and straightforward option, and this approach has been used elsewhere, e.g. in the Netherlands and Ireland;
- site costs are allocated to in proportion to total access costs and total conveyance costs[11].

MCMC recognises that there is also an issue of how to treat costs that are shared by different parts of the conveyance network. Examples of this include:

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[10] Ramsey pricing implies that the mark-up is greater for services with lower demand elasticities and vice-versa.

[11] One accurate way to mark up access costs for common fixed cost is to model the total core and total access network costs, and use this to devise the correct mark up for access as a whole. In the absence of access network costs, then marks up the core switching equipment as a means of recovering the common site costs in proportion to the total non site (ie access and conveyance) equipment costs located at the site. Here information about the proportions of non-site equipment costs at a site are used to split the common (site) cost. In Malaysia, since access and conveyance network costs are estimated, it is appropriate to use an equi-proportional mark up to recover common fixed site costs.

- the transmission link costs in the conveyance network that are shared between leased line and fixed services;
- equipment such as synchronization clocks which are used throughout the network.

MCMC has decided to treat these costs in the following way:

- transmission link costs are allocated on the basis of the capacity required;
- shared equipment is allocated on the basis of a simple physical driver (e.g. the cost of synchronisation clocks are allocated on the basis of the number of different switch types).

3.2.2 Common fixed costs

In estimating costs, MCMC has defined a category of "indirect" costs. Examples include:

- human resources;
- accounting services;
- the executive function; and
- non-network buildings.

Part of these costs will be incremental to conveyance and part of these costs will be common to all services produced by TMB.

For example, the cost of the company's headquarters and the chairman's salary are likely to be mainly common costs. However, human resources costs can in principle be split into a part that is incremental to different services produced by TMB (including a part which is incremental to conveyance) and a part that is common.

MCMC's model enables both Malaysian service provider data and international benchmarks to be used to estimate "indirect" costs (applied by means of a mark up to direct network costs). Further details of both of these sources are given in Appendix B, Section 4. Using this approach it is not possible to distinguish between indirect costs that can be attributed and those that are genuinely common.

The issue of what level of indirect (and operating) costs is appropriate is a key issue in deciding on the level of LRIC rates, and given the differences between FCC and Taskforce data, separate options are included in the model (see Section 3.5).

3.5 Model Run Options

The LRIC model for fixed interconnection service contains four main options that bring into effect changes to a given selection of input assumptions. These are set out below.

3.5.1 Option 1

This assumes the modeled network is using pure TMB and Taskforce cost and network assumptions including Malaysian-specific benchmarks for operating costs and indirect costs.

3.5.2 Option 2

This model run is the same as Option 1 except for the following:

Lower cost of overhead route cost per metre	The average cost of overhead route length has been re-estimated (based on TMB submissions about cable and pole costs), in order to cross-check TMB's own estimated figure, which appeared to be relatively similar to the cost of average underground routes. Using a bottom up approach an estimate of RM 29 per meter was produced.
Lower cost of DLS switch unit cost	The justification for adjusting the Malaysian DRS and DLS site costs is that the cost of land and labour would be expected to be cheaper in Malaysia compared to more developed countries. This justification is also supported by international experience of what would be the expected range of costs for housing modern-sized switches in other countries.
Reduced number of logical transmission routes connecting switch nodes	The total number of logical rotes for DLS-DLS links and DLS-DTS links have been re-estimated using the logical switch parenting data provided by TMB. TMB's estimates of total numbers of logical routes for DLS-DLS links and DLS-DTS links: ▪ were inconsistent with the logical switch parenting data provided by TMB; and ▪ implied excessive over-provisioning of logical routes for DLS-DLS links and DLS-DTS links for the amount of traffic expected to be carried by these links.

3.5.3 Option 3

LRIC assumes new equipment and efficient operating costs. This is a basic paradigm for estimating forward-looking costs. To allow for the possibility that TMB/Taskforce operating and indirect cost information does not represent a level associated with an efficient network, MCMC considered 2 variations that are Options 3 and 4.

Under Option 3, the model run is the same as Option 2 except for the following:

- direct operating cost factors are estimated using the mid-point percentage value between Taskforce and FCC international benchmarks; and

- indirect cost factors are estimated using the mid-point percentage value, between Taskforce and FCC international benchmarks.

3.5.4 Option 4

This model run is the same as Option 2 except for the following:

- direct operating cost factors are estimated using FCC benchmarks; and
- indirect costs are estimated using FCC benchmarks.

Question 1

Please comment on the main assumptions for each option.

Question 2

Should all 4 options be considered? If not, why and please explain which options should be taken into consideration.

3.6 Initial Model Results

The results of running the fixed LRIC interconnection model for each option are as follows:

Table 3.1
Final Results for Per Minute Interconnection Charges under the 4 Model Run Options (Sens per minute)

	Option 1 – Pure TMB / Taskforce	Option 2 – Pure Taskforce with reduced data input problems	Option 3 – mid way efficient opex and indirect costs	Option 4– fully efficient opex and indirect costs
Local	3.1645	2.0300	1.8124	1.5114
Single Tandem	4.1520	2.9040	2.5934	2.0380
Double Tandem	6.9298	5.6822	5.0936	4.0454
Double Tandem with submarine cable	13.2894	12.2904	11.9389	10.7997

Source: NERA

The above figures imply the following ranges for each interconnection service:

It is important to note that there are a number of other key structural assumptions that remain unchanged throughout the use of model runs options, including:

- the pre-tax nominal cost of capital = 10.15%;[12]
- the calculation of annual capital charges using tilted straight line function adjusted for changes in prices;
- the figures for the number of DRS and DLS nodes (TMB's figures are used).

The next section illustrates the sensitivity of the results to key assumptions that could be varied in the model.

MCMC recognises that on the whole, implementation of interconnection rates in the above ranges would be a significant departure from the current rates in TRD 006/98. Should MCMC decide to set revised benchmarked rates, it may consider very carefully the use of a gradual or phased introduction of LRIC-based rates and what the appropriate time frame should be.

Question 3

Should MCMC

- **determine a single value for each service?;**
- **determine a range of values for each service?;**
- **leave it to industry to negotiate the interconnection rates.**

Question 4

If MCMC were to set fixed network LRIC-based interconnection rates how do you think it should implement them? For example, should the implementation be gradual / phased and if so over what time period? Please explain your answer.

3.7 Sensitivities

It is clearly of interest to understand how sensitive the model results are to various input assumptions and a range of sensitivities has been carried out, the results of which are reported in this Section.

For simplicity, MCMC uses Option 4 **as an example**, for the purpose of illustrating the impact of changes in the assumptions in this public inquiry document only. The choice of Option 4 should not be taken as an indication of MCMC's preference for this option.

The following sensitivities have been considered:

[12] The calculation of the cost of capital is set out in a separate Public Inquiry on Cost of Capital.

- change the cost of capital by +/- 1%;
- use of different depreciation profiles;
- varying the level of traffic and numbers of lines;
- varying the percentage of successful calls;
- varying the cost of duct;
- switching between Taskforce and international benchmarks for operating costs and other (indirect) costs.

3.7.1 Cost of capital sensitivity

The effect of altering the cost of capital by ± 1% is shown in Table 3.3.

Table 3.2
Cost of Capital Sensitivity

	Option 4 Model Run	Increase CoC by 1%	Decrease CoC by 1%
Local	1.5114	+5.52%	-5.52%
Single Tandem	2.0380	+5.59%	-5.59%
Double Tandem	4.0454	+6.23%	-6.22%
Double Tandem with submarine cable	10.7997	+6.94%	-6.93%

Source: NERA

A one-percentage point change in the cost of capital results in a change in costs of between 5% to 6%. This parameter is relatively important given that estimates of the cost of capital can range across a number of percentage points.

3.7.2 Depreciation sensitivity

Option 4 model run uses tilted straight-line function to estimate the annual capital charge for each equipment type.

The other profiles MCMC has considered include:

Straight line depreciation with no price change	This will not approximate economic depreciation; if it is applied to current costs each year then over time the depreciation will not recover the cost of the asset where prices are falling
Annuity function with no price change	This will not approximate economic depreciation; if it is applied to current costs each year then over time the depreciation will not recover the cost of the asset where prices are falling
Annuity function with price changes	A "tilted" annuity function, ie one in which price changes are taken into account, will tend to

	flatten the depreciation profile implicit in the annuity function (where prices are falling), and could even produce a downwards sloping deprecation profile for sufficiently large price decreases. However, the profile will still tend to understate depreciation in early years of an asset used compared to in later years
Sum of digits	Depreciation applied to assets with rapid technological progress, such as switching and transmission equipment. Sum of digits depreciation is thought to be a reasonable approximation to economic depreciation in cases where there is rapid technological progress. It is not appropriate for assets where there is little technological progress

Question 5

Which of depreciation profile do you consider to be most appropriate here and why?

The result of each depreciation method is shown in Table 3.3.

Table 3.3
Depreciation Method Sensitivity

	Option 4 Model Run	Straight line – no price change	Annuity – no price change	Annuity – with price change	Sum of digits
Local	1.5114	+19.1%	+2.4%	-9.3%	+57.8%
Single Tandem	2.0380	+18.7%	+1.8%	-9.7%	+57.3%
Double Tandem	4.0454	+17.8%	-0.3%	-12.0%	+54.7%
Double Tandem with submarine cable	10.7997	+28.1%	+7.5%	-10.3%	+68.5%

Source: NERA

The results are relatively sensitive to changes in the choice of depreciation profile, with profiles which accelerate the depreciation for assets with technological progress showing results up over 50% higher than the results for tilted straight line.

3.7.3 Volume Change Sensitivity

Option 4 uses TMB's fixed network traffic for 2001. Since the modeled costs are for 2002, the 2001 traffic volumes are uplifted using TMB's internal traffic forecasts for growth in 2001. The following table presents the results of the sensitivity test.

Table 3.4
Volume Change Sensitivity

	+10% Growth over Base Run	+10% Decline over Base Run
Local	-8.4%	+10.2%
Single Tandem	-7.4%	+9.3%
Double Tandem	-7.9%	+9.7%
Double Tandem with submarine cable	-8.6%	+10.4%

Source: NERA

3.7.4 Percentage of successful calls sensitivity

Table 3.5 shows how the results change when the successful call rate is altered by 10 percentage points.

Table 3.5
Percentage of Successful Calls

	Option 4 Model Run	Reduce Successful calls by 10%	Increase Successful calls by 10%
Local	1.5114	+0.2%	-0.1%
Single Tandem	2.0380	+1.2%	-0.7%
Double Tandem	4.0454	+1.0%	-0.7%
Double Tandem with submarine cable	10.7997	+0.9%	-0.6%

Source: NERA

3.7.5 Cost of duct sensitivity

Option 4 assumes a duct cost that reflects the Taskforce views. This sensitivity measures the impact of increasing or reducing the cost of duct by 10%.

Table 3.6
Cost of Duct Sensitivity

	Option 4 Model Run	Increase Duct Cost by 10%	Reduce Duct Cost by 10%
Local	1.5114	+0.4%	-0.4%
Single Tandem	2.0380	+0.7%	-0.7%
Double Tandem	4.0454	+2.8%	-2.8%
Double Tandem with submarine cable	10.7997	+1.0%	-1.0%

Source: NERA

3.7.6 Alternative approaches to modelling operating costs

Option 4 model run ("Adjusted TASKFORCE run with FCC operating cost benchmarks") uses FCC international benchmarks for estimating direct operating cost factors and other (indirect) costs. This sensitivity (shown in Table 3.7) compares the impact on the results of using either Taskforce only, or using the mid-point percentage value (between Taskforce and FCC international benchmarks).

Table 3.7
Operating Cost and Indirect Cost Sensitivity

	Option 4 Model Run – "Adjusted TASKFORCE run with FCC operating cost benchmarks"	Taskforce Average	Midway between Taskforce opex and FCC opex
Local	1.5114	+24.5%	-12.3%
Single Tandem	2.0380	+24.5%	-12.2%
Double Tandem	4.0454	+23.8%	-11.9%
Double Tandem with submarine cable	10.7997	+5.0%	-2.5%

Source: NERA

SECTION 4 : ESTIMATING LRIC OF MOBILE NETWORK INTERCONNECTION SERVICES FOR MALAYSIA

As noted in Section 3, Appendix A contains a summary review of the rationale for using LRIC as the cost standard. This section provides an overview of the approach MCMC has taken when modelling LRIC of mobile interconnection services in Malaysia; presents the initial results of the model; and invites comments on a number of key issues, in particular on modelling a network carrying 20% of the market; cost differences between licensees with 900 Mhz and 1800 Mhz and the role MCMC should play in determining LRIC rates for public cellular services. Further details of the mobile cost model are provided in Appendix C.

4.1 Overview

The cost definition used here is also total service long run incremental cost (TSLRIC).

Box 2: Mobile TSLRIC

MCMC has taken the relevant service to be public cellular service providers' circuit switched services, excluding valued added services such as SMS, and Voicemail storage. Both mobile operators' own customer services as well as the traffic for interconnecting operators are taken into account.

This definition is consistent with that used in the UK and other parts of the world. The definition ensures that there is a consistent basis for determining a single cost underlying both the price for interconnecting licensees and any internal transfer price for public cellular service providers' own retail customers.

The costs of a mobile telecommunications network can be considered as those costs that are coverage related and those that are traffic related. Both coverage-related[13] and traffic-related costs are relevant to the interconnection service provided by public cellular service providers.

The approach adopted by MCMC is as following:

Step 1	A licensee's network capable of providing efficient public cellular services for 20% of the Malaysian market is modeled, considering costs such as radio net, switch processors, multiplexing equipment, microwave, cable and trench in the transmission network, but excluding elements for value added services
Step 2	The TSLRIC of providing these services is identified
Step 3	Indirect costs are modeled as a percentage mark up on either total network investment costs or total network operating costs as appropriate.

MCMC has again used a network component approach, and the rationale for this approach is the same as set out in Section 3.1.2. In addition, the approach taken to shared and common costs is essentially the same as that set out in Section 3.2.

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13 An interconnecting call must be able to reach a user wherever that user is on the mobile network

4.1.1 Modified scorched node approach

The use of a scorched node approach for mobile is not as straightforward as for fixed network interconnection in Malaysia. There are five licensees providing public cellular service; each developing their own networks independently. Each licensee providing public cellular service has a different network size. Therefore a key decision is what size of network should be modelled, given that there is no existing network that could be considered representative?

The size of a mobile network is in principle governed by the number of BTS sites - most other network element quantities either depend on, or are related to, the number of BTSs. For example, vendor limitations mean that only certain numbers of BTSs can be handled by a BSC, so the number of BSCs is not simply a licensee's efficiency choice, it is dependent on the number of BTSs.

The number of BTSs are in turn dependent on coverage decisions and traffic levels. In Malaysia, licensees providing public cellular services are free to decide on the coverage levels that they provide. In a competitive market in the medium run, MCMC would expect the coverage achieved by each licensee to be the similar. (Although one licensee providing public cellular services may provide greater coverage of a particular village, if such business decisions were to confer a material competitive advantage, other licensees would mimic that coverage, to avoid loss of market share.)

MCMC does not believe that interconnection charges should be set as a result of public cellular service providers' arbitrary business decisions. The role of a regulator in setting interconnect prices is to emulate an otherwise perfectly competitive market. In Malaysia, in a competitive market for indistinguishable products, each licensee providing public cellular service would have a 20% market share. In effect this means that MCMC is adopting a modified scorched node approach.[14]

Question 6

Do you agree that it is appropriate to consider the LRIC interconnection charges for a generic licensee providing public cellular services with a 20% market share? Please explain your answer.

4.2 Number of BTSs

The Malaysian mobile market is growing at the moment. It is not yet mature in the sense that mobile penetration is still not high in the areas covered, and in the sense that some population areas are still not covered. Overall penetration rates within covered areas will depend on service pricing – when mobiles are affordable for all, everyone will have them, but while they are expensive, they will remain out of reach of some sectors of society.

In a competitive market of equally mature licensees providing public cellular services, the average number of customers per base station would be the same for all licensees,

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[14] For further description of the scorched node assumption, see Appendix

and the actual number of customers per base station would vary only by 'depth' of the market, i.e. penetration rate of reachable customers.

In the absence of a coverage obligation (an obligation which in other jurisdictions has set a benchmark for expenditure necessary to provide the required coverage), MCMC has employed an efficient measure of customers per BTS derived from the licensees. The licensees appear to be efficient, and differences in the number of customers per BTS can primarily be attributed to different levels of maturity of each network.

MCMC has used customer acquisition as a proxy for coverage based on the feedback from licensees on their investment decisions. Licensees providing public cellular services tend to create coverage in the areas with highest concentration of customers first, and then extend coverage progressively to areas with lower concentration of customers. MCMC's model reflects that business decision, and by taking a 20% market share, and using a BTS to customer ratio that is typical of the Malaysian context, MCMC's model computes the number of BTSs needed for that customer level, at the present rates of mobile penetration, and in the context of Malaysian topography and demography.

Questions 7

Do licensees have a view on the number of BTSs they believe would be necessary for an efficient licensee to handle 20% of the Malaysian mobile market? Please explain your answer.

In addition, what number of BTSs do licensees consider would be needed to obtain 50% penetration by 2005, (the target specified in MCMC's Framework for Industry Development document)?

4.3 Impact of 900Mhz and 1800Mhz spectrum use

MCMC received conflicting views on the impact of 900Mhz and 1800Mhz spectrum on costs of licensees providing public cellular services:

- one 900 licensee claimed that its higher costs were due to having 10Mhz of spectrum only compared to the 1800 licensees' 25Mhz; and
- 1800 licensees argued that their costs were higher due to the limited 'reach' of 1800 signals compared to the 900 licensees' signals. (Generally 900Mhz signals can travel twice as far as 1800Mhz signals.)

These licensees providing public cellular services were asked to justify their claims with concrete examples. Interestingly, licensees took the example of the Klang Valley, and derived exactly opposite results:

- the 900Mhz licensee calculated that 10Mhz of spectrum led to the need for more BTSs to handle the traffic; whilst
- an 1800Mhz licensee calculated that the more limited reach of 1800Mhz signals led to the need for more BTSs to geographically cover the area.

Both licensees claimed to have taken into account the needs of equipment both for area coverage, and for traffic handling.

Inconsistencies were found in the calculation of the licensees providing public cellular services, and recalculation by MCMC indicated that a 900Mhz licensee might theoretically require 334 BTSs in the Klang Valley, while a 1800Mhz licensee might require 357 BTSs, at 2002 traffic levels. The difference of 23 BTS is not considered significant since topographic and demographic variations in the Valley will mean that actual numbers will differ from these predictions.

Both the licensees stated that *as traffic levels increase, the difference in equipment requirements for 900Mhz or 1800Mhz operation will diminish* as higher traffic levels require more equipment than the minimum coverage requires, irrespective of the frequency band and propagation distances. MCMC calculations indicated that whilst 900 Mhz licensees may initially have a cost advantage at current traffic levels (fewer BTSs are needed), with additional traffic growth of as little as 7%, the 900Mhz cost advantage is eroded as 1800 Mhz licensees can use their larger quantity of spectrum to build bigger BTSs.

Therefore MCMC is not convinced that there is a material difference in the costs of an efficient 1800Mhz or 900Mhz licensee with 20% of traffic in Malaysia.

4.4 Routing Factors

The routing factors used in the mobile model are as follows, based on data provided by licensees providing public cellular services in Malaysia:

Table 4.1
Mobile Model Routing Factors

	Fixed to Mobile (local)	Mobile to Mobile (local)	Long haul increment	East / West Malaysia
BTS - BSC link cost per minute	1.000	1.000		
BSC – MSC link cost per minute	1.000	1.000		
MSC – MSC link cost per minute			0.375	
MSC – TS link cost per minute			1.000	
TS – TS link cost per minute			0.080	
OLO – TS link cost per minute	1.000	1.000		
Submarine cable link cost				1.000
BTS cost per minute	1.000	1.000		
BSC cost per minute	1.000	1.000		
MSC cost per minute	1.000	1.000	0.167	
HLR cost per minute	0.667	0.667		
TS cost per minute			0.580	

Source: NERA

Question 8

Do you consider the routing factors to be reasonable for the network that is being modelled? Please explain your answer.

4.5 Model Results

The interconnection services considered were as follows:

- Mobile termination through local MSC;
- Double tandem interconnection
- Double tandem interconnection using submarine cable

The results are shown in Table 4.2.

Table 4.2

Mobile LRIC interconnection costs (RM per minute)

	Average cost per minute (RM)	Peak	Off-peak
Fixed to Mobile (local)	0.1396	0.1824	0.0839
Mobile to Mobile (local)	0.1396	0.1824	0.0839
Long haul increment	0.0133	0.0174	0.0080
East / West Malaysia	0.0653	0.0854	0.0393

Source: NERA analysis.

MCMC recognises that on the whole, implementation of interconnection rates in the above ranges would be a significant departure from current rates. Should MCMC decide to set revised benchmarked rates, it may consider very carefully the use of a gradual or phased introduction of LRIC-based rates and what the appropriate time frame should be.

Public cellular service provider's returns suggested that around 2% of incoming or outgoing traffic involved calls from outside the home ATUR. This proportion is small and arguably calls into question why the need for a differential charge.

Question 9

Should MCMC:

- **determine a single mobile interconnection rate;**
- **determine separate rates for calls to mobiles outside the ATUR? or**
- **leave it to industry to negotiate the interconnection rates?**

Question 10

If MCMC were to set mobile interconnection rates, for how long should it do so? Please justify your answer.

Question 11

If MCMC were to set LRIC-based interconnection rates in the mobile sector, how do you think it should be implemented? For example, should the implementation be gradual / phased, and if so what time period should be used? Please explain your answer.

4.6 Sensitivities

It is of interest to understand how sensitive the model results are to various input assumptions and the following sensitivities have been carried out:

- change the cost of capital by +/- 1%;
- use of different depreciation profiles; and
- varying the percentage of successful calls.

4.6.1 Cost of capital sensitivity

The effect of altering the cost of capital by ± 1% is shown in Table 4.3.

Table 4.3
Cost per Minute for Interconnection Services - Cost of Capital

Sens	Base run	Decrease CoC by 1%	Increase CoC by 1%
Fixed to Mobile (local)	13.96	13.53	14.39
Long haul increment	1.33	1.29	1.37
East / West Malaysia	6.53	6.53	6.53

Source: NERA

A one-percentage point change in the cost of capital results in a change in costs of around 3%. This parameter is relatively important given that estimates of the cost of capital can range across a number of percentage points.

4.6.2 Depreciation sensitivity

In the "Base Run" of the model a tilted straight-line function is used to estimate the annual capital charge for each equipment type.

In this sub-section the following additional depreciation profiles are considered:

Straight line depreciation with no price change	This will not approximate economic depreciation; if it is applied to current costs each year then over time the depreciation will not recover the cost of the asset where prices are falling
Annuity function with no price change	This will not approximate economic depreciation; if it is applied to current costs each year then over time the depreciation will not recover the cost of the asset where prices are falling
Annuity function with price changes	A "tilted" annuity function, ie one in which price changes are taken into account, will tend to flatten the depreciation profile implicit in the annuity function (where prices are falling), and could even produce a downwards sloping deprecation profile for sufficiently large price decreases. However, the profile will still tend to understate depreciation in early years of an assets use compared to in later years
Sum of digits	Depreciation applied to assets with rapid technological progress, such as switching and transmission equipment, sum of digits depreciation is thought to be a reasonable approximation to economic depreciation in cases where there is rapid technological progress, it is not appropriate for assets where there is little technological progress
Mixture	This represents a mixture of depreciations profiles for different classes of assets[15]. Tilted straight line is used for switching and transmission equipment, straight line for cable and tilted annuity for duct.

The results of the sensitivity tests are shown in Table 4.4.

Table 4.4
Cost per Minute for Interconnection Services – Depreciation sensitivity

Sens	Base run	Straight line	Annuity	Tilted annuity	Sum of digits	Mixture
Fixed to Mobile (local)	13.96	13.04	11.49	12.10	17.20	16.27
Long haul increment	1.33	1.19	1.04	1.15	1.66	1.50
East / West Malaysia	6.53	6.53	6.53	6.53	6.53	6.53

Source: NERA

15 The precise "mixture" was suggested by selected participants of the Industry Group.

The results are relatively sensitive to changes in the choice of depreciation profile, with profiles which accelerate the depreciation for assets with technological progress showing results up to 15% higher than the results for tilted straight line.

4.6.3 Varying the percentage of successful calls

The base model assumes that 60% of all calls are successful. Table 4.5 shows a 0.1% to 2.5% change in the results due to a 10% change in the proportion of calls that are successful.

Table 4.5
Cost per Minute for Interconnection Services - % successful calls

Sens	Base run	50% successful calls	70% successful calls
Fixed to Mobile (local)	13.96	14.32	13.76
Long haul increment	1.33	1.37	1.31
East / West Malaysia	6.53	6.53	6.53

Source: NERA

SECTION 5: ADDITIONAL ISSUES

5.1 Data requests

Question 12

MCMC is interested to hear licensees' views on the data requests issued for the interconnection cost models. In particular, MCMC would be interested to hear the extent to which licensees' already held data that was suitable.

5.2 Access to facilities

In addition to the facilities and services explicitly considered in MCMC's final report "Access List Determination and Statement on Access Pricing Principles" there are a number of other facilities to which a licensee may wish to have access but which do not directly form part of the service provided, (e.g. towers and duct).

Questions 13

Should MCMC consider determining access prices for access to facilities such as towers and duct which support the provision of communication services?

If so, what cost principles should MCMC use?

APPENDIX A: REVIEW OF COST STANDARDS FOR INTERCONNECTION SERVICES

Interconnection charges represent a key factor in the successful liberalization of telecommunications markets. If they are set too high then the development of competition will be restricted and there will be excessive development in alternative infrastructure. If they are set too low, there will be inefficient market entry and insufficient investment by new licensees. In short, the setting of these charges has a strong influence on whether or not viable competition results from liberalization.

A variety of approaches have been used to set interconnection charges. The choice between them will depend on economic arguments, regulatory circumstances (including any precedents) and practical considerations. Also of relevance is the state of competition in the markets concerned. Where competition is limited and the service concerned is a bottleneck facility, the need for detailed estimation of costs and hence charges that are consistent with efficient entry is greater than if there are alternative facilities and competition is fully developed. In the latter case, a safeguard price cap might be sufficient, in the former case it is unlikely to be.

The charges for interconnection services and the cost methodologies used to underpin them are crucial to the continued success of telecommunication service competition in Malaysia. If competition were fully effective, in the sense that there were a number of competing suppliers of interconnection services, then such prices would be expected to be cost-based and non-discriminatory. Where competition is not fully effective then regulation of interconnection charges needs to try to replicate, to the largest extent possible, what would happen in a fully competitive market.

Experience from the US and Europe suggests that an information gap exists between dominant licensees and regulators, concerning the cost data necessary for setting cost-orientated prices. This means that the regulator should not actually set interconnection charges itself, but it should nonetheless remain its responsibility not only to choose the cost-accounting system to be used for cost modelling, but also to audit interconnection charges and their setting, *on an ongoing basis*, to ensure that these accurately reflect the cost measure decided upon.

Given the importance of having interconnection prices which are viewed as fair and reasonable by all interested parties, it is necessary that:

- interconnection charges are based on the correct economic principles; and
- furthermore, for the practical implementation of such principles, regulators need to determine on which costs the charges should be based, and how these costs should be measured.

A.1 Different Cost Bases

Broadly speaking, two main costing methodologies have been used as the basis for setting charges of specific interconnection services:

- **Fully Distributed** (Allocated) Cost: all costs caused by a specific service, and apportioned costs driven by a group of services, are distributed to the service in question, according to some accounting rule;
- **Long-Run Incremental Cost** (LRIC): incremental cost is a generic cost concept, defined as the increase in a firm's total costs as a result of an increase in output, or the costs avoided if output falls. If the increment of

output under consideration is the whole of a particular service, then the term 'total service incremental cost' is applied. The addition of 'long-run' indicates that the time horizon is sufficiently long for all costs to be avoidable. LRIC includes all variable (ie volume-sensitive) costs and also the fixed costs specifically relevant to the increment of output under consideration. Fixed costs that are shared between, and common to, a number of services are not included (as they will not be avoided if an increment of output of a particular service is no longer provided).

Once the long run incremental costs are identified, it is possible that these costs can be marked up with an amount to cover some additional costs. These additional costs can include:

- Shared and common fixed costs;
- Costs of conditioning the network and establishing access to outsiders;
- Legacy costs (ie. costs relating to investment and production decisions in the past and possibly inefficiency costs;

It is also sometimes argued that interconnection should include a contribution to the incumbent licensee's access deficit and/or to its universal service obligations. However, there are good reasons for keeping such contributions separate, not the least the fact that they are not generated by the act of providing interconnection.

A.2 Fully Allocated Costs

The starting point for most licensees is fully allocated costs. As well as providing an assessment of this costing approach, we discuss below:

- how the generic cost concepts are defined;
- historic costs and problems associated with past measures of asset values;
- overcoming some of these problems by using current costs.

A.2.1 Fully Allocated Historic Costs

This is the basis on which company management accounts and financial results by service have typically been developed. An outline of the fully allocated costing process is set out below, followed by a brief discussion of its strengths and weaknesses.

It is first necessary to group costs into a number of different categories. These are:

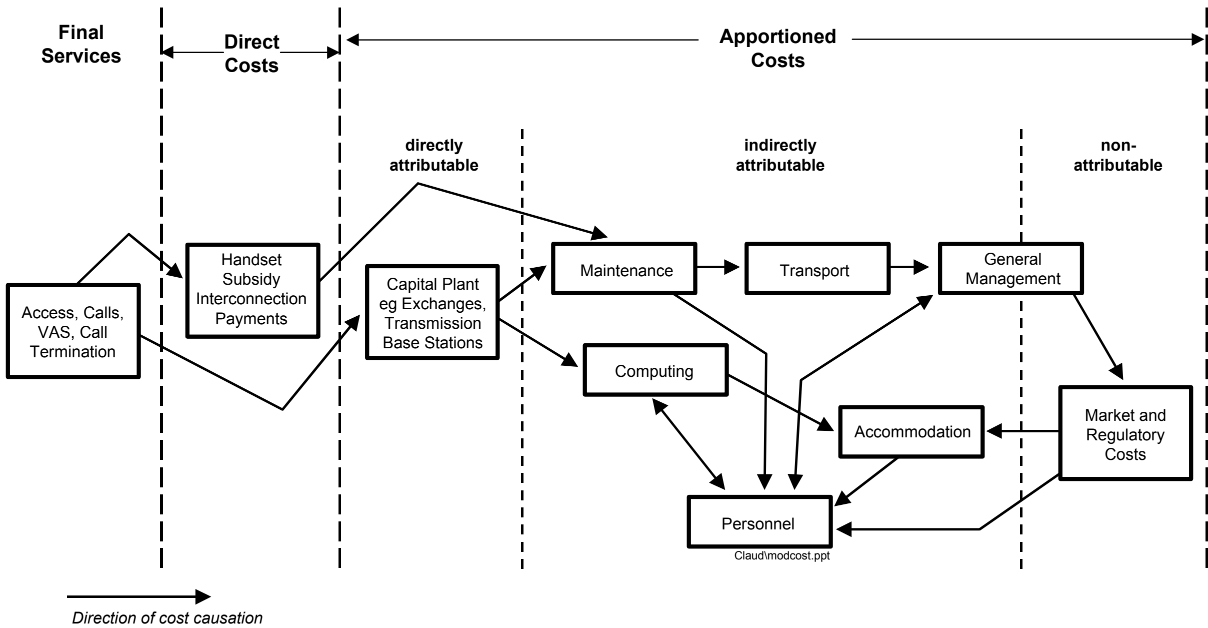
- direct costs caused by a specific service;
- apportioned *costs* driven by a group of services.

Apportioned costs can themselves be split into the following categories:

- costs directly attributable to a service;
- costs indirectly attributable to a service;
- costs *not attributable* to any particular service.

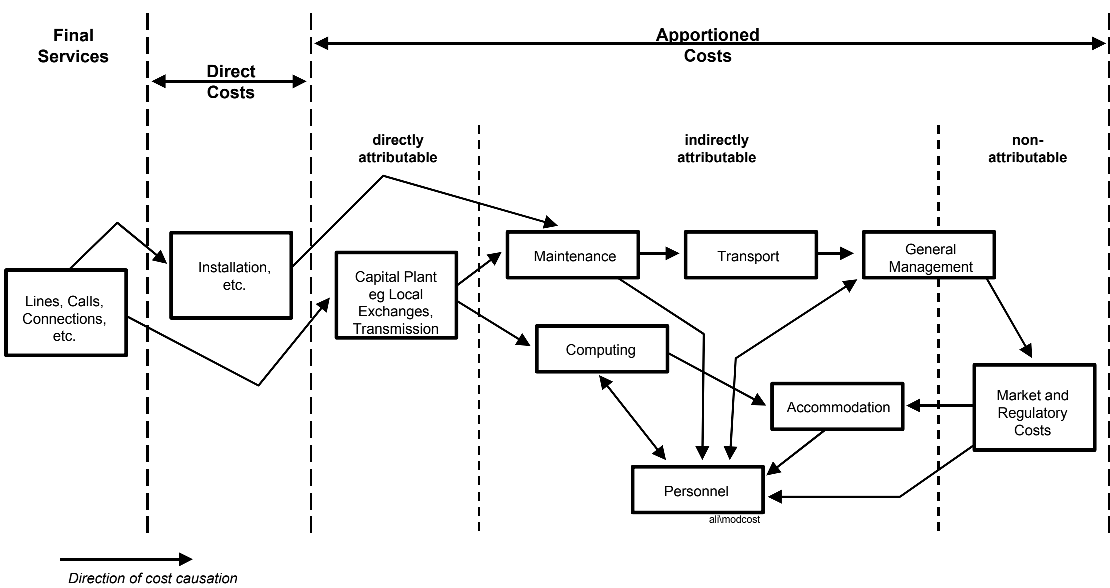
The cost categories introduced above apply to elements in all types of telecommunication network, both fixed-line and mobile. In Figure A.1 below we show a simplified view of the inputs required for the supply of mobile telecommunications services and how these relate to the calculation of fully allocated cost. The arrows show the direction of causation. Thus, for example, capital plant costs are driven by the need to provide end services. In some cases the relationship between cost categories operates in both directions (indicated by the arrows pointing in both directions). This is because one cost category both drives and is driven by another cost category.

Figure A.1
Simplified Model of Cost Causation in Mobile Telecommunications



A similar allocation must be determined for any other type of telecommunications network. For a fixed network, the model may be derived as is shown in Figure A.2:

Figure A.2
Simplified Model of Cost Causation in Fixed Telecommunications



A.2.2.1 Direct costs

There are relatively few direct costs in telecommunications industries. Examples in the public cellular sector include the cost of handset subsidies and interconnection payments made to other licensees. The provision of lines into homes for both telephones and internet access may be considered as direct costs in the fixed network.

A.2.2.2 Directly attributable costs

Directly attributable costs are essentially plant and equipment costs, which include both depreciation and a return on assets. These costs can be allocated to different services using information about what gives rise to the costs ("drivers"), volume and routing factor data. Thus, for example, switch port costs can be allocated to outgoing and incoming calls using the volume of incoming and outgoing calls and information about the number of switching stages per call.

Directly attributable costs are driven by a number of activities:

- The cost of exchange lines (links between distribution points and exchanges) is driven by the number of lines. Clearly costs will depend on the length of line and the terrain, and it may thus be useful to have this information for some regulatory purposes.
- Some elements of local exchanges are driven by the number of lines (eg a major cost associated with digital exchange concentrators is line cards). The cost of other elements, however, is driven by the number of calls (eg calls and call attempts are the primary drivers of port costs and processor costs respectively) in the peak period of use (the "busy hour"). In calculating the directly-attributable costs, the first step is to split costs into those which are line-related and those which are call-related. The next step would be to split call costs into those corresponding to different call services. This apportionment should be based on the number of exchange stages per call, the number of calls and the average duration of calls (in the busy hour).
- Transmission costs are driven by busy hour call traffic and by private circuit volumes. To calculate fully-distributed costs, information is required on the transmission capacity for both. Call costs can be apportioned using routing stages, the number of calls and call length.

A.2.2.3 Indirectly attributable costs

Indirectly attributable costs are driven by directly attributable costs – this process is illustrated in Figures A.1 and A.2 above. As can be seen, maintenance and computing are driven directly by directly attributable costs whereas transport, personnel and accommodation are driven indirectly by directly attributable costs. Allocation of these costs is described below, with reference to a number of examples:

- as a first approximation, maintenance costs can be apportioned in proportion to the underlying assets, although this process is not necessarily very precise. For example, some parts of an exchange may be more liable to faults than others;
- transport costs will be partly driven by maintenance and other plant related activities and can thus be apportioned in a similar way to these activities. In addition, transport costs may be driven by marketing costs (since marketing managers may have company cars) or by high level staff costs;

- computing costs will be driven by particular projects, which can then be related to certain activities. These costs may also be driven by the number of staff;
- accommodation costs are partly driven by plant requirements and partly by the number of people, which is in turn partly driven by plant requirements.

A.2.2.4 Non-attributable costs

Non-attributable costs are those costs that are not driven by traffic volumes, even indirectly, or for which no linkage can be established with final costs because the costs are so far removed from final services. In practice non-attributable costs are so far removed as to make relationship to specific drivers impossible to identify - perhaps general management (e.g. marketing or regulatory costs) or the CEO's office.

In practice, methods can be developed to allocate many ostensibly non-attributable costs. For example, it is possible to analyse marketing expenditure to see how much is spent on specific projects with good activity based costing.

A.2.3 Problems Related to Fully Allocated Historic Costs

The main problems with fully allocated historic costs are as follows:

- general price inflation means that the historic gross book values (and hence net book values) of long lived assets bear little relationship to the true values of the assets concerned;
- this problem is further exacerbated by technological progress, which means that the prices of different assets have evolved very differently over time. For example, there has been a lot of technical progress in switching and as a result switch costs have fallen sharply relative to prices in general. On the other hand, there has been little technical progress relevant to site costs, and as a result these have tended to rise relative to the general rate of inflation.

As can be seen from the above analysis, a large part of the cost base in (mobile and fixed) telecommunications is not directly related to final services. This means that the estimation of fully allocated costs requires a thorough understanding of a complex set of inter-linkages between the costs to be apportioned. Previous examples have already given some indication of the issues involved in this process. While this is a complex process it is one familiar to telephone companies and one that can be handled by a good activity based costing system. Consequently it is a practicable solution to estimating interconnection costs.

A.2.4 Fully Allocated Current Costs

The problems posed by general price inflation and by technological progress can be reduced or eliminated altogether by valuing capital equipment on a current cost basis.

To arrive at current cost asset valuations it is necessary to revalue capital equipment so that the gross book value of equipment is replaced by the gross replacement cost, i.e. what it would cost to purchase and install the equipment today. This involves identifying the modern equivalent asset and then attaching a price to it. Typically this can be done using recent purchase contracts. The written down value of the equipment (net replacement cost) can then be derived using normal depreciation rules. Thus, for example, if a piece of equipment is five years old and has an accounting life of 10 years, then, under straight-line depreciation, its net replacement cost will be half its gross replacement cost.

It also necessary to take asset price changes into account when moving to current cost accounting. Under the generally accepted approach of financial capital maintenance, the impact of asset price changes is included in the allowance for depreciation. If the price of an asset falls by 10%, this reduces its written down value by 10% and this loss of value (the "holding loss") is treated as additional depreciation. Conversely, if the price of an asset increases the resulting increase in its written down value (the "holding gain") is treated as negative depreciation.

While current cost accounting deals with the problems posed by general inflation and technological progress, it is worth bearing the following points in mind:

- the development and implementation of current cost accounting is not a trivial exercise; and
- the problems posed by general inflation and technological progress are, as yet, not generally as great in the mobile telecommunications networks which have mainly been constructed within the past 10 years as with fixed telecommunications networks. This means that historic cost accounting is not likely to be as inaccurate in the case of mobile telecommunications.

A.2.5 Assessment of Fully Allocated Costs

Fully allocated costing systems are widely used by accountants but have been criticized by many economists for a number of reasons, including the following:

- economically efficient prices should be based on marginal cost in order to match the cost to the consumer and the cost to the supplier of an additional unit of output (this is explored in more detail below);
- in some cases fully allocated costing systems do not pay sufficient attention to the cost causation process in the business and as a result can provide a highly misleading attribution of costs;
- even where such systems do attempt to understand the cost causation process, there are certain costs which are not caused by any individual service and can therefore only be apportioned in an arbitrary way;
- the use of fully allocated current costs also does not address the need to estimate forward-looking costs (ie. avoidable) in order to make correct investment and pricing decisions. Sunk costs or costs which have been incurred as a result of past decisions, but are not avoidable if output ceases, should *not* form the basis for setting prices.

A.3 Forward Looking Incremental Costs

The forward-looking costs of an activity are the future costs that a firm would avoid if it were to cease that activity. They include variable costs (i.e. costs that vary with the level of output of the activity) and avoidable fixed costs. They exclude sunk costs (i.e. the costs of irreversible investments). For example, if a company took out a fixed price 25 year lease on a building but market rents subsequently fell, it would be left with a cost that it could not avoid even if it sublet the building (i.e. it would remain responsible for the difference between the agreed rent and the (market) rent received).

A fundamental tenet of economics is that correct resource allocation occurs when price is based on (forward-looking) marginal cost. The marginal cost of a service is literally the forward-looking cost of producing an infinitesimally small additional amount (increment) of output of that service. In practice it is both impossible and meaningless to measure the cost of such a small increment of output. The normal procedure is therefore to measure the cost of say a 5% increase in output and to divide this by the volume of additional output.

Marginal costs include forward-looking costs that vary with the volume of output of the service concerned (variable costs). However, all costs that do not vary as the volume of output of a service changes are excluded (fixed costs). Mobile base station towers and duct in the transmission network of a public cellular service provider are examples of substantial fixed costs that would not be recovered if prices were set on the basis of marginal cost.

For this reason, incremental rather marginal costs are normally used for setting prices in industries, like telecommunications, which have substantial fixed costs. In this context, the term incremental cost refers to the per-unit (i.e. average) forward-looking additional cost of providing a large increment of output, such as an entire service. In the latter case, the term total service incremental cost is often used. Total service incremental cost differs from marginal cost in two important respects:

- the per-unit total service incremental cost measures average incremental cost over the entire range of output of the service. If marginal cost varies with the scale of output (possibly due to economies of scale), then average incremental cost over the entire range of output will necessarily differ from marginal cost measured at the current level of output;
- total service incremental cost also includes service-specific fixed costs, i.e. costs that do not vary with the level of output but would be saved if the firm discontinued production of the service.

This is the basis of long-run incremental cost (LRIC), which is increasingly used as the basis for setting fixed network interconnection charges. The latter does not, however, include all fixed costs because there are some costs that are common to more than one service (e.g. trench that is shared by mobile and fixed network transmission links and some corporate overheads). A decision has to be made about how to recover these and a standard approach is to apply a percentage mark-up to LRIC.

A.4 Comparing Existing and Forward-Looking Costs

Fully allocated costs reflect the existing asset base and current levels of efficiency. Therefore any estimate of costs based on fully allocated costs will also be based on these levels of efficiency. However, the true cost of increasing the level of output of a service should include the costs of new capital investment and the benefits of improvements in efficiency that will be reflected in forward looking costs. In theory, therefore a forward-looking definition of costs should be used. If the organisation is inefficient due to over-manning, outdated technology and so on, there could be a significant gap between existing and forward-looking costs.

A.5 Practical Implementation of Different Cost Bases

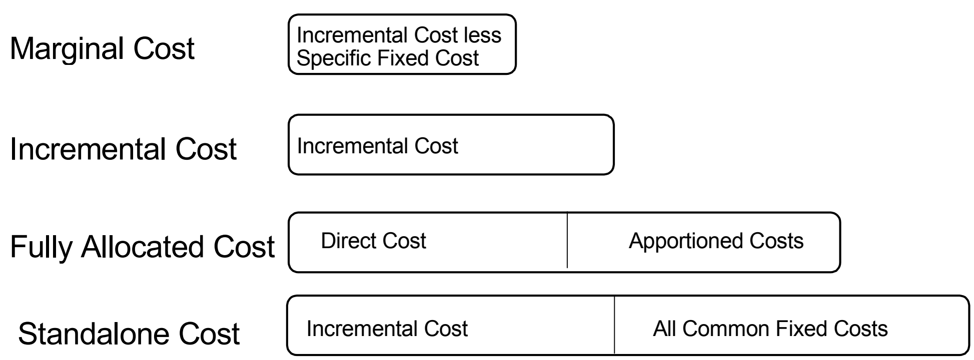
For practical implementation of the different cost bases for interconnection charges, it is important to measure the costs to be included in an accurate way. Two cost modelling methodologies can be followed: the Top-Down approach and the Bottom-Up approaches. Fully allocated costing systems usually, but not necessarily, use Top-Down modelling for deriving costs, whereas the methodology of long run incremental cost can be implemented using either a Top-down or Bottom-up modelling approach.

A.5.1 Top down Methodology

The top-down methodology is based on a highly disaggregated version of the management accounts for the business as a whole. The model reflects actual business performance, rather than some theoretical ideal.

The process begins by applying the fully allocated cost concepts such as direct and apportioned costs (as discussed in above). The way in which different methods of cost attribution relate to the incremental costing system is illustrated in Figure A.3 below.

Figure A.3
Alternative Measures of Cost of Service



As can be seen from long-run incremental costs (which are forward-looking) are not normally equal to fully allocated costs less apportioned costs (where fully allocated costs are based on historic costs). However, the fully allocated costing process can, via a relatively complicated procedure, be used to measure incremental cost, where capital costs are measured on a current cost accounting basis (and are therefore based on modern technology).

A.5.2 Deriving Top Down LRIC from Company Accounts

In order to derive LRIC for interconnection from company accounts it is necessary to have capital costs that are measured on a current cost accounting basis. Hence LRIC is essentially a further step on from fully allocated current costs.

The process involves a number of stages. These include:

- the specification of cost categories;
- identification of a cost driver or drivers for each cost category;
- establishment of the relationship between the level of costs and volume of driver;
- establishment of the relationship between cost categories and final services;
- calculation of long run incremental costs by following the steps outlined above.

A.5.2.1 Cost categories

Specification of cost categories involves disaggregating the management accounts for the business as a whole into a number of reasonably homogenous categories. Given data limitations and other problems, it is not possible to examine cost categories which are completely homogeneous and a balance needs to be struck between the more accurate results which may be obtained from the examination of a more disaggregated range of cost categories and the increasing processing costs associated with examining increasingly disaggregated cost categories;

This would also involve removing costs that are specific to retail activities, if the purpose is to identify the incremental cost of network activities.

A.5.2.2 Cost Drivers

Once the cost categories have been specified, it is necessary to identify cost drivers which are relevant for each cost category. Likely cost drivers include the:

- number and volume of calls;
- number of subscribers; or
- in some cases the number of people in the organization.

A cost driver may be either an end activity or an intermediate activity, which is an activity that is related either directly or indirectly to one or more end activities. In some cases the relationships between cost categories and end activities can be quite complex and involve a number of links. For example, finance costs are driven by both the number of business transactions and by the number of people in the organizations and it will thus be necessary to measure the extent to which business transactions and the level of employment is influenced by the interconnection service in order to measure the finance costs associated with interconnection.

A.5.2.3 Cost-volume relationships

The next step is to establish cost-volume relationships. Cost-volume relationships are an essential feature of top-down models since they show the way in which long run costs change as a result of volume changes. Where the volume of output associated with a particular service is known for a given cost category it is a straightforward matter to measure the incremental cost of that service for that cost category. Cost-volume relationships can take a variety of forms, when plotted on standard graphs, including the following.[16]

- a straight line emanating from the origin which shows that there are no common or specific fixed costs (Type 1);
- a straight line which emanates from above the origin which shows that there are common or specific fixed costs involved in establishing an activity (Type 2);
- a curved line, sloping towards the origin which also starts from above the origin. Such a relationship indicates that there are both common or specific fixed costs and that the marginal cost declines as the level of output increases (Type 3).

These relationships are shown below in Figure A.4.

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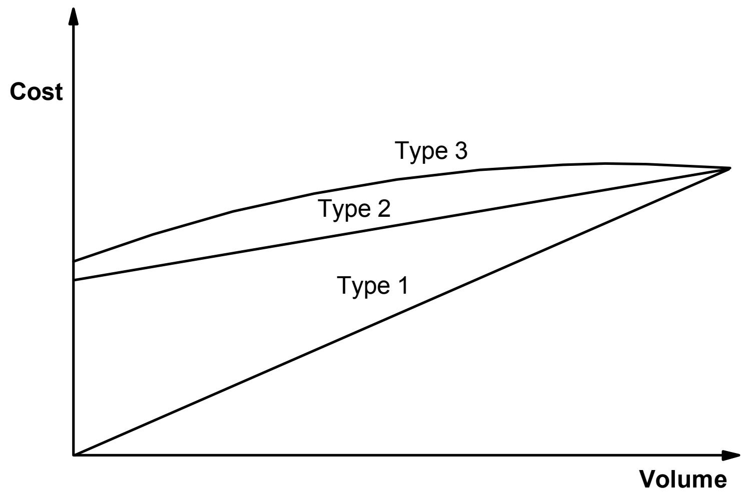
[16] For convenience we assume that the volume of the cost driver is shown on the horizontal axis and the cost itself on the vertical axis.

Figure A.4
Alternative Cost - Volume Relationships



Type 1 - Straight line emanating from origin
Type 2 - Straight line emanating from above origin
Type 3 - Curved line starting from above origin

For a cost category, such as local exchanges, which is directly driven by one or more network elements, the derivation of a cost-volume relationship is sufficient to allocate costs to network elements. However, for cost categories, which are only driven by network elements and final services in a very indirect way, such as finance and accommodation,[17] it is necessary to show how these relate to network elements and final services, before developing cost-volume relationships. Since this point has important implications for the nature of the work and for the resources required, we discuss it below in detail in relation to local exchanges and finance.

In the case of the local exchanges it is necessary to identify, at as detailed a level as possible,

- the separate elements of the local exchange;
- whether these elements are lines related, calls related, or common to both lines and calls;
- the costs associated with each of these elements[18].

Where such information is available for a sample of exchanges it is possible to identify the extent to which local exchange costs are line related or call related and how line and call related costs would change with the volume of output.

In the case of call related costs it will be possible to identify the volume of output associated with each particular call service given information on:

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17 This is something of a simplification since a small part of finance and a significant part of accommodation will be directly driven by network elements.

18 Such information may be obtainable from engineering models or through discussions with exchange manufacturers.

- the volume of calls associated with each type of call;
- the average duration of each type of call;
- the number of local exchanges used by each type of call.

This information can be used in conjunction with the cost-volume relationship to identify the incremental cost associated with a particular call service.

For indirect cost categories, such as finance, in addition to developing cost-volume relationships it will also be necessary to associate particular costs with network components, (in the case of network costs), and end services, in the case of retail costs. In order to do so, the licensee will need to carry out surveys of the way in which people spend their time within each area of finance. Thus, for example, in the case of bad debts costs, it may be appropriate to examine the bills of a range of bad debtor customers to see the mix of services used by these customers.

It can be noted that activity surveys may be required for a wide range of cost categories and the design and implementation of these surveys needs to be built into a detailed work schedule. Areas where surveys may be necessary include the following[19]:

- office accommodation,[20]
- personal computing;
- transport;
- personnel;
- customer support;
- marketing;
- general management;
- finance;
- provision and installation.

The information provided by such surveys can in combination with an appropriate model be used to show the (fully allocated costs) by network element of each cost category. In order to develop estimates of incremental cost it will further be necessary to develop cost volume relationships. The methodology will vary by area but will often involve carrying out interviews with experts in individual areas within each cost category to understand how (long run) costs vary with the volume of business.

A.5.2.4 Establishment of the relationship between cost categories and final network services

As noted, the relationship between a cost category and final services can be direct or can be indirect (in some cases being driven by a number of intermediate drivers). Thus, a clear understanding of the various inter-linkages within a firm is necessary.

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19 In the absence of these surveys it may be necessary to rely on relatively crude apportionment bases such as previously apportioned costs.

20 Ideally, the surveys in this should consider not just the activities of individuals within the organisation but the amount and value of space used.

A.5.2.5 Calculation of long run incremental costs by following the steps outlined above.

The resulting estimate of long run incremental costs may then need to be adjusted to remove the impact of inefficient operating practices. This could be done via efficiency benchmarking. Unit costs and routing factors can be derived and combined to provide unit costs for particular interconnection services.

Finally, it should be mentioned that, in the case where there is a dominant licensee or monopolist, there exists the possibility that the licensee could use top-down methodology to its own advantage, in order to overstate costs and, by doing so, understate profits. For this reason, it is very important that such a model should be subject to independent evaluation. Furthermore, there may also be a case for developing a bottom-up model (based on engineering data), to evaluate the outputs of a top-down model.

A.6 Bottom-Up Modelling

The bottom-up approach involves the development of engineering based economic models which are used to calculate the costs of particular network elements and in turn particular services.

A.6.1 Underlying Assumptions of Bottom-Up Methodology

A first point is that the bottom-up methodology can be applied using either the 'scorched-node' or 'scorched-earth' assumptions.[21] The scorched-node assumption means that best switching technologies would be employed at existing nodes and best transmission technologies would be used to connect up the various nodes using the existing transmission links. By way of contrast, the scorched-earth assumption implies that optimal-sized switches would be employed at optimal locations, and that the transmission network structure would be determined accordingly. This could result in a smaller number of switching sites, perhaps located in less densely populated areas. In general, there are quite strong arguments for using the scorched-node approach (e.g. on practicality grounds).

A.6.2 Outline of Bottom-Up Modelling Approach for Interconnection Services

The “bottom-up” modelling approach for interconnection services requires the following[22]:

- specifying the physical quantities of components of the network (eg the number of local and tandem switches, the numbers and lengths of transmission links, the number of line cards);
- the required capacity for each of these components, based on the busy hour traffic levels in the network (eg the numbers of ports required in the switches and the capacity of the different transmission links);
- investment and operating costs for each of these components (both fixed costs for each switch or transmission link (dependent on route length), and variable costs);

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[21] The top-down model implicitly assumes the scorched node assumption.

[22] The term “interconnection” could apply generally to many types of services offered, for example, by fixed (core and access) and mobile networks.

- other investment costs for network and other support systems (such as network management, computer systems for network planning etc.);
- specifying appropriate depreciation schedules for each type of asset and estimating the cost of capital (ie. the required rate of return);
- averaging traffic related costs across the actual volume of traffic passed over each component to yield a unit cost for each component;
- aggregating the component unit costs according to the use made of them by different call services ("routing factors").[23] For example, local switch interconnection involves one local switch component plus (in some cases) a transmission link between the switch and a remote unit (i.e. remote concentrator or remote switch).

A.6.3 Bottom-up Approach to Modelling Network Costs

The bottom up approach involves estimating the cost of re-building the licensee's core network and access network using modern equipment (i.e. forward looking technology). This assumes that the network must provide the current traffic levels and access lines at the existing grade of service, and also that the network is operated efficiently. Cost categories that need to be considered are as follows:

- network investment costs – these can then be annualised taking both the return on capital and depreciation into account;
- network operating costs, i.e. the annual costs of operating and maintaining the network and the costs of system support and network planning;
- indirect investment costs, i.e. the investment costs for items which are associated with providing network services, but which do not form part of the network itself (such as non-operational buildings and general purpose computers) – these can then be annualised taking both the return on capital and depreciation into account;
- indirect operating costs, i.e. operating costs associated with, but not directly related to, running the network (e.g. human resource, finance, legal costs etc.); and finally
- costs that are specific to interconnection services such as interconnection links or costs of co-locating and any carrier service specific costs (e.g. interconnection billing) not captured by the categories above.

A.6.4 Reasons for Developing a Bottom-Up Model

There are various reasons why a bottom-up approach to measuring the LRIC of interconnection is likely to be necessary:

- even where a top-down model exists, a bottom-up model provides a powerful cross-check on the outputs of the top-down model and thereby aids the process of transparency and proper top-down model development;
- top-down models can normally only be accessed in detail by the dominant licensee and consequently it is difficult to verify that the outputs are correctly

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[23] Routing factors specify the average number of units of each network component used by a particular service.

derived. At the same time, the dominant licensee clearly has incentives to manipulate the results to its benefit;

- top-down models may include costs which are associated with retail activities (e.g. marketing and customer billing) rather than just the costs of network functions and associated activities (which are the only costs relevant to interconnection);
- top-down models produce costs which include inefficiencies and hence are not genuinely forward looking. Ideally the costs of inefficiencies should be separately identified so that both efficient and inefficient costs are identified and interconnection charges can be set accordingly.

A.7 Requirements and Limitations

A.7.1 Information Requirements

Both the top-down and bottom-up approaches are data-intensive, requiring:

- disaggregated information on asset quantities (e.g. the number of line systems of different capacity);
- disaggregated information on asset costs (e.g. it would be necessary to know the cost of different sub-systems within a local exchange);
- information about operating costs divided into reasonably homogeneous cost categories;
- surveys of the activity of employees and building, transport and computing usage.

In many respects, the informational requirements for a fully developed bottom-up approach could be as demanding as those for a top-down approach since, to develop a bottom-up model, it is necessary to have information on circuit utilization, fiber utilization (and the distribution of this utilization across different routes), route lengths and a number of other aspects of network topography and usage. However, it is possible to build useful bottom-up models with somewhat less comprehensive data. Whether or not the incumbent licensee's internal accounting system will be able to provide the necessary information is a matter of importance.

A.7.2 Limitations of Models and Reconciliation of Results

There are potential problems with the outputs of both top-down and bottom-up models.

Top-down models are normally based on existing costs and, as a result, include inefficiencies in operating practices.[24] If the purpose of the cost modelling is to derive the costs that would exist in a competitive environment then it is efficient costs that are relevant. It may also be the case that top-down models do not reflect cost causality and hence include costs that are not relevant. While this may be true, it is nonetheless possible to develop a model which is based on Activity Based Costing principles and which therefore is based on cost causality.

Bottom-up models can result in the underestimation of costs unless careful attention is given to assumptions on capital costs, utilization levels and other inputs. On the other

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[24] This problem is reduced, but not eliminated, when asset values and the depreciation charges are based on a rigorous application of current cost accounting principles.

hand, because they are based on the costs of new entrant they will, other things being equal, have higher asset book values than top down models and hence higher cost of capital. A further limitation of bottom-up models is that they generally do not model operating costs in a rigorous way, often relying on relatively crude high-level assumptions as an alternative.

A.8 Conclusions

Correct decisions about pricing, investment and whether to stay in business need to be based on forward-looking costs. Fully allocated historic costs do not provide a good estimate of forward-looking costs as they do not value assets correctly and include sunk costs and the legacy of past decisions and investments.

Whatever methodology is used, the derivation of LRIC for interconnection (for both fixed and mobile markets) is a resource intensive activity. It will, however, lead to costs that are based on correct asset valuations and are forward-looking and hence consistent with correct pricing and investment decisions.

When looking at interconnection charges in Malaysia, MCMC considers that the benefits of LRIC will outweigh the costs of implementation given the competitive and regulatory circumstances.

APPENDIX B: LRIC MODEL DETAILS FOR FIXED INTERCONNECTION

As discussed in section 3, MCMC's approach has been to estimate the cost of re-building TMB's forward-looking network using modern equivalent assets, assuming that the network must carry TMB's current traffic levels at the existing grade of service. Reported traffic for the year 2001 is used for estimating levels of traffic in 2002.[25]

Further details of the approach taken are set out in this Appendix.

B.1 Conveyance Network

A conveyance network is typically characterized by a hierarchy of switching layers:

- DRSs form the lowest level and customers are connected directly to these;
- DRSs are connected up to DLSs, which may also have customer lines attached directly;
- DLSs have connections to other DLSs; and
- DLSs have connections to DTSs.

In TMB's network a series of point-to-point and SDH rings form the main part of the network organised into four layers, and this is reflected in the model, which distinguishes between the different transmission link elements as follows:

- links that connect remote concentrators and host (local) switches (DRS-DLS links);
- links that connect host (local) switches and other local switches (DLS-DLS);
- links that connect host (local) switches and tandem switches (DLS-DTS); and
- links that connect tandem switches and other tandem switches (DTS-DTS).

The conveyance network is split into two main parts:

- Switching; and
- Transmission.

Each of these parts are discussed in turn.

B.1.1 Conveyance network: switching

As stated above, the switch types considered are DRS, DLS and DTS.

The costs associated with these switches can be broken down into costs that are fixed, i.e. independent of traffic (e.g. the fixed cost of the processor and the cabinet) and costs that vary with the capacity required (e.g. the cost of processor upgrades and the cost of ports). The key cost drivers then are the number of pieces of equipment of different types (required to estimate the fixed costs) and the traffic through the switches.

As well as the costs of the equipment contained in the switch units themselves, which can all be attributed directly to one particular type of switch, there are other types of equipment associated with switching but used by more than one switch type. For

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[25] The model run produces costs for the period 2002.

example, the signal transfer points (STPs) are associated with all switches as are the synchronization clocks.

B.1.2 Conveyance network - transmission

The following lists the transmission route types that occur in TMB's network and are reflected in the model:

- DRS-DLS;
- DLS-DLS;
- DLS-DTS; and
- DTS-DTS.

The key cost drivers in the transmission network are:

- the duct lengths;
- the length of optic fiber;
- the traffic across routes which determines the amount and type of multiplexing equipment needed;
- the route distances which determine the number of repeaters required;
- the amount of associated equipment such as cross connects.

Within the "scorched node" approach, it is assumed that duct lengths are fixed (i.e. by fixing the location of the nodes, the lengths of the physical routes between nodes are being fixed). MCMC's model therefore uses TMB data for these. The data provided by TMB gives:

- the total amount of trench length in the core network;
- the proportion of total trench length which is shared with the access network;
- the proportional split between link types which are underground and overhead; and
- the average lengths for the different link types described above.

Estimates of the amount and quantity of multiplexing equipment are driven by the traffic across different route types. Within the model MCMC has used the structure of TMB's network in terms of:

- the number of logical routes connecting the switching hierarchy;
- the (weighted) average lengths of logical routes which comprise point-to-point links and SDH rings; and
- the average length of trench taken up by the different link types.

B.2 Traffic

Once the network architecture has been established, it is then necessary to analyze the traffic flows in the conveyance network. The following data are important:

- as key drivers for costs; and
- for determining the denominator for deriving unit costs.

Traffic flows are needed as the first step in determining the network capacity requirements. This involves working through three stages:

- estimates of numbers of originating and terminating calls of different types;
- estimates of leased line capacity;
- application of routing factors to each call type to estimate network component usage[26].

B.2.1 Calls of different types

The following call categories have been considered:

- local calls;
- national calls;
- international calls - incoming & outgoing;
- calls to and from mobiles
- internet calls;
- a range of other retail calls; and,
- interconnection calls (termination, origination and transit).

TMB provided data on the number of minutes and the number of successful calls for each type of call.[27]

TMB has also provided financial year forecasts for the year 2002. Traffic, network and equipment cost data used in the model is based on 2001 (as declared by the Taskforce). Traffic data is then uplifted by the forecast estimates for 2002 in order to produce 2002 volumes.

B.2.2 Leased Line Capacity

TMB provided MCMC with the proportion of its total transmission capacity that is, on average, dedicated to leased lines. Other than this, TMB did not provide further information as to the distribution of leased line capacity, in 2Mb/s equivalents, across the different transmission components (eg DRS-DLS, DLS-DLS, DLS-DTS and DTS-DTS).

B.2.3 Routing factors

The analysis requires the estimation of traffic passing over different components of TMB's network. This depends on routing factors for each call type, where the routing factor allows us to translate retail service call minutes into equipment component minutes. After a number of iterations, TMB declared a final set of routing factors to MCMC on the basis of running samples of its traffic over a given period.

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[26] Routing factors convert total successful conversation minutes into total equipment component minutes which determines the total network conversation minutes used to size the network.

[27] A longer list of service types was provided by TMB. These services all fall in one of the categories listed. All the traffic has, therefore, been accounted for based on the data declared by TMB.

B.3 Network Sizing Assumptions

The parameters required to size the conveyance network are as follows:

Unsuccessful calls	TMB provided MCMC with the ratio of successful calls to all calls. The number of successful calls of each call type was increased to take account of the number of unsuccessful calls
"Ringing" time	The network is in use not only during the "conversation" minutes, but also while the phone is ringing (both for successful and unsuccessful calls). Additional minutes of use are estimated and added to the traffic figures used for sizing the network;
Equipment installed to equipment used	Additional equipment (over and above what is required to handle the traffic) is installed to provide protection against equipment faults and to provide a growth margin. The ratio of equipment planned to be in use to equipment installed is taken to be 68% through to 85% for transmission equipment and 76% for switching equipment (based on Taskforce data)
Use at peak	The network needs to be sized to handle peak hour traffic. Within the model data for the ratio of traffic in the busiest hour of the year to all traffic in the year is entered
Blocking %	The maximum acceptable level of blocking in the peak hour is entered for each network element (0.1% is used).

B.4 Costs

MCMC has categorized costs under the following three headings:

- Equipment costs (capital expenditure), including installation;
- Equipment maintenance and operating expenses;
- Other capital costs, associated operating costs and expenses (indirect costs).

B.4.1 Equipment costs

Capital equipment cost assumptions, together with assumptions about expected annual price changes, are needed for each type of equipment. TMB and other licensees provided figures for "equipment costs" including both the capital investment and the installation costs.

Based on the capital expenditure costs, it is necessary to calculate an annualized cost, taking account of:

- the depreciation of the asset over an appropriate time period, i.e. the asset life;
- an appropriate depreciation method. MCMC's model has the capability to consider the following depreciation schedules:

- annuity function – with and without price changes;[28]

- straight-line depreciation – with and without price changes[29];

- "sum of the years digits" depreciation - this is a method that gives some form of crude approximation to "economic" depreciation by tilting the depreciation schedule towards the early years (i.e. front loading it) to take account of technological progress;[30]

- the real cost of capital (CoC), i.e. the return that TMB can expect to earn on its investment.

B.4.2 Maintenance and Operating Costs

Two sources are available to model direct operating costs:

- taskforce data; or
- US benchmarks.

In either case these data measures operating and maintenance cost as a percentage of the capital cost for each equipment type. In the second case, MCMC used data for the US LECs (1999) to estimate percentage factors. The benchmarks and Taskforce data for direct maintenance and operating costs are shown in Table B.1.

Table B.1
Direct Maintenance and Operating Costs as a Percentage of Direct Network Capital Costs

Expense category	FCC Benchmark	Taskforce Data
Digital switching	3.4%	7-8%
Transmission equipment	1.1%	5%
Buried cable	3.8%	4%
Duct	0.2%	4%

Source: Adapted by NERA from FCC, Taskforce

B.4.3 Other "indirect" costs

There are a number of other capital costs and operating costs which are relevant to call conveyance but which do not form part of the direct "network" costs. Again, two sources are available to model direct operating costs:

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28 The formula used for the annual charge as a percentage of the capital investment is: (CoC) / {1 - [1 / (1 + CoC)] ^ asset life}. This can also be "tilted" using the price trend in which case the formula becomes: (CoC - price trend) / {1 - [(1 + price trend) / (1 + CoC)] ^ asset life}. Note this includes the return on investment as well as the depreciation.

29 The formula used for the depreciation as a percentage of the capital investment is: 1/asset life + price trend x remaining life/original life.

30 The formula used for depreciation as a percentage of the capital investment is, for eg an asset life of 10 years: 10/55, where 55 = 10+9+8+7+6+5+4+3+2+1

- taskforce data; or
- US benchmarks, derived from US LECs data, as reported to the FCC (1999).

These are shown in Table B.2.

Table B.2
Indirect Capital Costs as a Percentage of Direct Network Capital Costs

Expense category	FCC Benchmark	Taskforce Data
Land and building	2.3%	1.09%
Vehicles	1.1%	0.39 %
General purpose computers	1.2%	3.64%
Other equipment	1.6%	1.27%
TOTAL	**6.2%**	**6.39%**

Source: Adapted by NERA from FCC data, Taskforce.

A similar procedure is followed for estimating the indirect operating costs associated with each of the capital cost items listed in Table B.2, where here the LEC/Taskforce costs are expressed as a percentage of total indirect network capital costs. The benchmarks for indirect operating costs are shown in Table B.3.

Table B.3
Indirect Operating Costs as a Percentage of Direct Network Operating Costs

Expense category	FCC Benchmark	Taskforce Data
Land and building	8.8%	15.1%
Vehicles	7.3%	15.9%
General purpose computers	47.3%	13.2%
Other equipment	5.0%	10.5%

Source: Adapted by NERA from FCC data, Taskforce.

For other operating costs, the cost items that MCMC considers relevant are shown in Table B.4.

Table B.4
Indirect Operating Costs as a Percentage of Direct Network Operating Costs

Expense category	FCC Benchmark	Taskforce Data
Executive and planning	1.0%	3.9%
Accounting and finance	2.8%	3.0%
External relations	1.6%	2.8%
Human resources	3.0%	3.7%
Information management	6.6%	8.6%
Legal	0.8%	1.0%
Procurement	0.5%	2.0%
Other general and administrative	5.0%	6.2%
TOTAL	**21.3%**	**31.2%**

Source: Adapted by NERA from FCC data, Taskforce.

It is important to note that this uplift applies to the direct network operating cost only, not to the total annualised cost (which also includes depreciation and return on capital).

B.5 Modelling the Costs of Conveyance

The following steps are now discussed:

- determination of capacity requirements;
- treatment of shared and common costs;
- modelling of switch costs
- modelling of transmission costs

B.5.1 Determining Capacity Requirements

The first stage in deriving the costs of the conveyance network is to "size" the network in terms of the amount of capacity required in different parts of the network to handle the traffic. The steps required to calculate the network capacity are as follows:

Step 1	multiply end user call minutes and call attempts by routing factors to give equipment minutes (these –TMB provided-figures are used to derive unit costs)
Step 2	include an allowance for unsuccessful calls (for call attempts) and ringing time (for call minutes)
Step 3	use the ratio of minutes in the peak hour to minutes over the year to estimate busy hour erlangs (BHE) and busy hour call attempts (BHCA);
Step 4	use the erlang table together with the blocking rate to estimate the number of channels required, taking into account modularity
Step 5	take into account the utilisation rate - this has two aspects: an allowance for growth and sparing for faults
Step 6	capacity requirements for call minutes and for leased lines can be added together to give overall capacity required

B.5.2 Shared and Common Costs

Certain network assets are shared between the access and the conveyance network. The main assets shared between these networks are the switch sites (including power equipment) for DRS, DLS and DTS.

In the absence of data for an appropriate physical driver for costs, MCMC has treated these costs as shared. The costs are separately identified and used to define a mark-up on access and conveyance costs. MCMC has considered doing this in two different ways:

- using switch site costs to define a mark-up over switching equipment (i.e. site costs are allocated in proportion to the costs of the line and traffic related equipment – for a given switch type - at the site); or
- using switch site costs to define a mark-up over the total cost of conveyance and access: in this case the mark-up is applied to the results for interconnection services (this method requires the costs of access as well as the costs of conveyance).

There is also the question of ducted trench that is shared between the access and conveyance networks. The data on total duct length for the conveyance network has also been accompanied by data on the proportions of duct that is exclusively used by the conveyance network and that which is shared by access and conveyance.

The equipment volumes relevant for modelling shared assets are simply that the number of DRS, DLS and DTS sites are equal to the number of switch nodes of these types in TMB's network (as indicated by TMB data).

To estimate the annual shared costs MCMC has carried out the following steps:

- unit equipment costs were applied to equipment volumes to estimate total equipment investment;
- investment costs were annualised, taking account of asset lives, anticipated price changes and the cost of capital;

- maintenance /operating costs were estimated and added in; and
- finally other support investments (annualised plus their associated opex) and (other) expenses were added.

B.5.3 Modelling Switch Costs

The key equipment volumes required to model switching costs are as follows:

- for DRS:
  - the number of fixed cost elements of the concentrator (eg the cabinet and other elements) is just given by the number of DRSs;
  - the number of lines;
  - the number of ports is calculated as a function of the traffic, i.e. the number of ports = the number of 2Mbit/s of traffic through the DRS.

- for DLS:
  - the number of fixed cost elements for the initial processor unit (eg the cabinet and processor) is just the number of DLSs ;
  - the number of lines;
  - the number of BHCAs for DLSs has been calculated (BHCA for DLSs has been calculated as part of the capacity requirements) and is used to estimate the variable cost associated with processor capacity upgrades;
  - the number of access facing ports is equal to the number of ports on DRSs for DRSs which are connected to DLSs ;
  - the number of conveyance facing ports is equal to the number of 2Mbit/s of traffic for DLSs;
  - the number of DLS level synchronisation equipment units is given by the number of DLSs.

- for DTS:
  - the number of fixed cost elements (the cabinet, processor and other elements) is equal to the number of switches;
  - the number of BHCAs for TSs has been calculated (as part of the capacity requirements) - this is required to calculate the variable cost associated with processor capacity upgrades;
  - the number of conveyance facing ports is equal to the number of 2Mbit/s of traffic for TSs;
  - the total number of DTS sites;

- the number of DTS level synchronisation equipment units is given by the number of TSs.

To estimate the annual cost for switching investment costs, the following tasks were conducted:

- unit equipment costs are applied to equipment volumes to estimate total equipment investment;
- investment costs are annualised, taking account of asset lives, anticipated price changes and the cost of capital;
- maintenance /operating costs are estimated and added in;
- finally other support investments (annualised plus their associated opex) and other (ie. indirect) expenses are added.

There are also certain assets that are shared between different switch types. These are:

- the signal transfer points (STPs);
- the synchronisation clocks.

The costs of these assets have been allocated across the DLS and DTS equipment in proportion to the number of each switch type.

B.5.4 Modelling Transmission Costs

The three main asset categories required for transmission are:

- the infrastructure (the duct and trench);
- the optic fiber cables;
- the multiplexing equipment and repeaters.

TMB provided transmission route length, duct length and cable length data for the conveyance. The model also uses TMB's data on the proportion of total trench in the core network that is shared by the access network.

Within the model MCMC considers the size and quantity of multiplexing equipment for transmission links that are on point-to-point routes and SDH rings.

The estimation of equipment quantities is done as follows:

- total capacity required has been estimated including an allowance for equipment and route diversity;
- capacity is divided by the number of routes of a given type to give the average capacity per route;
- for each route type there is a distribution of traffic which can be applied to the routes to give the number of routes with different levels of capacity - to do this the distribution needs to be re-scaled to ensure that the total amount of capacity is the amount required;
- for a given level of capacity required, the appropriate equipment size is then selected;
- aggregating over all routes provides estimates of the equipment required.

Cable size is determined as follows:

- total optic fiber length is estimated as typical route length multiplied by the number of pieces of transmission equipment;
- the optic fiber length is then divided by cable length to obtain an estimate of the number of fibers per cable;
- this estimate of fiber per cable is then matched with one of a number of standard cable sizes.

Repeaters also need to be taken into account - the number of repeaters for a given transmission route type is determined by the length of actual routes and the distance between repeaters.[31]

Having determined all the relevant lengths and pieces of equipment, costs are then derived in the standard way:

- unit equipment costs are applied to equipment volumes to estimate total equipment investment;
- investment costs are annualised, taking account of asset lives, anticipated price changes and the cost of capital;
- maintenance /operating costs are estimated and added in;
- finally other support investments (annualised) and expenses are added.

B.6 Summary of Model Assumptions and Sources

LRIC Base Run Model Assumptions are as follows:

▪ Depreciation method	tilted straight line
▪ 2001 call and line volumes	TMB
▪ 2002 call volume forecast assumptions	TMB
▪ Distribution of lines by switch site	TMB
▪ Routing factors	TMB
▪ Traffic profile assumptions	TMB
▪ Leased line transmission	TMB
▪ Trench and cable sheath length	TMB
▪ Switching network	TMB
▪ Equipment prices	Taskforce average
▪ Number of switch sites and units	TMB
▪ Equipment utilisation	Taskforce average

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31 The calculation is: (rounded up value of route length)/(distance between repeaters) less one, multiplied by the number of logical routes. On average, the calculated route lengths for different types of links turned out to be less than the minimum distance requirement between repeaters for most of the link types. TMB declared that it has a total of 325 repeaters in its network. The model derived a total of 322.

▪ Number of logical links of different types	TMB
▪ Size distribution of traffic volumes for different types of link	TMB
▪ Asset lives	Taskforce average
▪ Price changes	Taskforce average

APPENDIX C: LRIC MODEL DETAILS FOR MOBILE INTERCONNECTION

MCMC's approach has been to estimate the cost of re-building a public cellular service provider's forward looking network using modern equivalent assets, assuming the network must carry the licensees' traffic levels at an industry/market acceptable grade of service[32]. Reported traffic for the year 2001 is used in the base model for estimating levels of traffic in 2002.[33] Further details of the approach taken are set out in this Appendix.

C.1 The Conveyance Network

A conveyance network is typically characterised by radio networks parented on individual MSCs; in addition:

- BTSs form the core of the radio network and mobile customers are connect to these when their phones are switched on and in coverage of at least one BTS;
- BTSs are connected up to BSCs, where traffic is aggregated for bulk transmission to the parenting MSC;
- MSCs have links to other MSCs; and
- MSCs have links to TSs.

In public cellular service providers' networks a series of SDH rings of fiber or microwave form the main part of the network organised into two layers:

- the BSC rings are the shorter distance transmission networks linking BSCs to mobile switches (MSCs);
- the MSC ring is the regional distance transmission network linking mobile switches (MSCs) to other mobile switches and mobile switches to transit switches (TSs);

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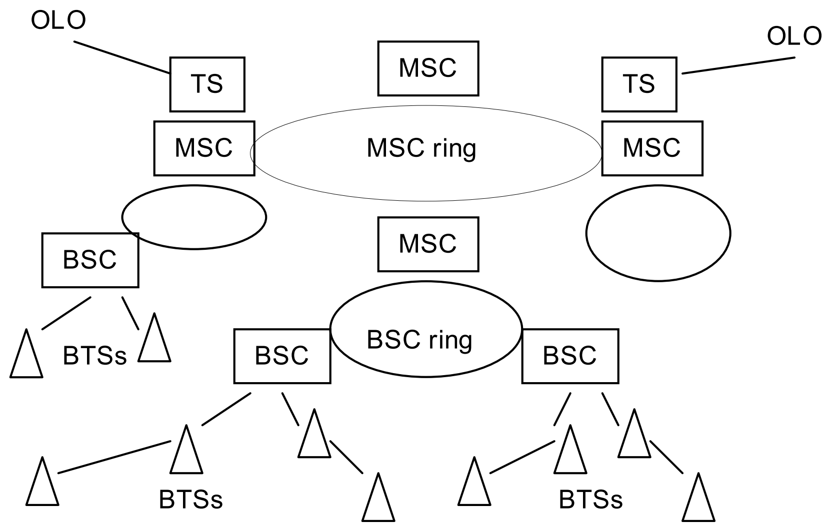
32 Otherwise market share might be gained or lost.

33 The base model run produce costs for the period January 2002 through to December 2002.

The diagram below provides a simplified structure of the network.

Figure C.1
A generic mobile architecture



The diagram illustrates a ring connecting MSCs, each of which link to their own subset of the radio network. Interconnection to other licensees is through tandem switches.

For convenience the model distinguishes between the different transmission link elements as follows:

- links that connect Base Transceiver Stations and Base Station Controllers (BTS-BSC);
- links that connect Base Station Controllers and Mobile Switching Centers (BSC-MSC);
- links that connect Mobile Switching Centers to Mobile Switching Centers (MSC-MSC);
- links that connect Mobile Switching Centers and Tandem Switches (MSC-TS);
- links that connect Tandem Switches to Tandem Switches (TS-TS); and
- links that connect Tandem Switches and Other Licensed Operators (TS-OLO).

The following sub-sections look in more detail at the assumptions made regarding the conveyance network that is split into:

- switching; and
- the different parts of the transmission network.

C.1.1 The conveyance network - switching

As discussed above, the switching types considered are as follows: BTS, MSC and TS.

The costs associated with these switches can be broken down into costs which are fixed, i.e. independent of traffic (for example the fixed cost of the equipment and cabinet), and costs which vary with the capacity required, i.e. which are driven by the amount of traffic (for example the cost of transceivers and antennas). The key cost drivers then are the number of pieces of equipment of different types (required to estimate the fixed costs) and the traffic through the switches.

As well as the costs of the equipment contained in the switching units themselves, which can all be attributed directly to one particular type of switch, there are other types of equipment *associated* with switching but used by more than one switch type. For example, the synchronisation units are associated with all switches. Based on data provided by licensees providing public cellular services, the model assumes that the network requires synchronisation supply units at each MSC.

C.1.2 The conveyance network - transmission

The following lists the transmission route types that occur in public cellular service providers' network and are reflected in the model:

- BTS-BSC;
- BSC-MSC;
- MSC-MSC;
- MSC-TS;
- TS-TS; and
- TS-OLO.

The key cost drivers in the transmission network are:

- the duct lengths;
- the length of optic fiber; and
- the traffic across routes which determines the amount and type of multiplexing equipment needed, and the opportunity to employ microwave instead of fiber for less busy routes.

Within the coverage approach, it is assumed that duct lengths are fixed (i.e. the nodes predicted by the model will be placed largely where the existing licensees have, on average, placed their nodes, thus in fixing the location of the nodes the lengths of the physical routes between nodes are also fixed). The data provided by public cellular service providers gives:

- the total amount of trench length in the core network (a proportion of which is shared with the access network); and
- the average lengths for the different link types described above.

Estimates of the amount and quantity of multiplexing equipment are driven by the traffic across different route types. Within the model the structure of public cellular service providers networks has been used in terms of:

- SDH rings connecting MSCs;
- SDH rings connecting BSCs to MSCs
- the types of transmission from BTSs to BSCs; and
- the average distances between BTS, BSC, and MSC.

C.2 Traffic

Once the network architecture has been established, it is then necessary to analyse the traffic flows in the conveyance network. This data is important both:

- as one of the key drivers for costs; and
- in determining the denominator for deriving unit costs.

Traffic flows are needed as the first step in determining the network capacity requirements. This involves working through two stages:

- estimates of numbers of calls of different types; and
- application of routing factors to each call type to estimate network component usage.[34]

C.2.1 Terminating calls of different types

The following call categories have been considered:

- on-net calls;
- calls to and from mobiles on other networks;
- calls to and from users on other fixed networks; and
- roaming calls.[35]

Licensees have provided data on the number of minutes and the number of successful calls for each type of call.[36]

Public cellular service providers have provided financial year forecasts for the year 2002. The Base Run model is based on traffic provided by public cellular service providers reported for the year 2001, which is then uplifted by the forecast estimates for 2002.

C.2.2 Routing factors

The analysis requires the estimation of traffic passing over different components of public cellular service providers network. This depends on routing factors for each call type, where the routing factor allows us to translate retail service call minutes into equipment component minutes. NERA employed routing factors provided by the industry group Taskforce.

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34 Routing factors convert total successful conversation minutes into total equipment component minutes which determines the total network conversation minutes used to size the network.

35 Sometimes the roaming figures were included in other categories by some operators

36 We have in fact been given data covering a longer list of service types but these services fall in one of the categories listed. All the traffic has, therefore, been accounted for.

C.3 Network Sizing Assumptions

The parameters required to size the conveyance network is as follows:

Unsuccessful calls	The ratio of successful calls to all calls is 60%, based on public cellular service providers data. The number of successful calls of each call type is increased (ie. uplifted) to take account of the number of unsuccessful calls.
"Ringing" time	The network is in use not only during the "conversation" minutes, but also while the phone is ringing (both for successful and unsuccessful calls). Additional minutes of use are estimated and added to the traffic figures used for sizing the network.
Equipment installed to equipment used	Additional equipment (over and above what is required to handle the traffic) is installed to provide protection against equipment faults and to provide a growth margin. The Taskforce provided data justifying their decisions in Malaysia. The ratio of equipment planned to be in use to equipment installed is taken to be 75% through to 95% for transmission equipment and 80% through to 90% for switching equipment.
Use at peak	The network needs to be sized to handle peak hour traffic. Within the model data for the ratio of traffic in the busiest hour of the year to all traffic in the year is based on Taskforce data. Figures of up to 600% were initially proposed by the Taskforce, but on enquiry by NERA, this was scaled back to 110%.[37]
Blocking %:	The maximum acceptable level of blocking in the peak hour is entered for each network element (values between 1% and 2% are employed in Malaysia).

C.4 Costs

Costs have been categorized as follows:

- equipment costs (capital expenditure), including installation;
- equipment maintenance and operating expenses; and
- other capital costs and expenses (ie “indirect” costs).

C.4.1 Equipment costs

Capital equipment cost assumptions, together with assumptions about expected annual price changes, are needed for each type of equipment. Licensees providing public

37 Special occasions such as Chinese New Year result in 6 times higher traffic in some Northern parts of the country, but that traffic increase only affects some 20% of the network. Furthermore, despite the traffic demand, operators do not provision for that overload at the same grades of service; instead budget constraints limit the network dimensioning headroom to 110%

cellular service have provided us with these figures for "equipment cost" including both the capital investment and the installation cost.

Licensees providing public cellular services have also provided data on:

- price trends;
- operational costs;
- software charges; and
- asset lives.

Based on the capital expenditure costs, it is necessary to calculate an annualised cost, taking account of:

- the depreciation of the asset over an appropriate time period, ie the asset life;
- an appropriate depreciation method. The model has the capability to consider the following depreciation schedules:

  - annuity function – with and without price changes;[38]

  - straight-line depreciation – with and without price changes.[39]

  - "sum of the years digits" depreciation - this is a method that gives some form of crude approximation to "economic" depreciation by tilting the depreciation schedule towards the early years (ie front loading it) to take account of technological progress;[40]

- the real cost of capital (CoC), ie the return that public cellular service providers can expect to earn on its investment. A figure of 12.3% has been used. The calculation of this value is set out in MCMC's Consultation Paper on Cost of Capital.

C.4.2 Maintenance and operating costs

International benchmarks for network operating costs are not available in the public domain. Only one source is available to model direct operating costs: Taskforce data.

These data measure operating and maintenance cost as a percentage of the capital cost for each equipment type. The Taskforce data for key direct maintenance and operating costs are shown in Table C.1.

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[38] The formula used for the annual charge as a percentage of the capital investment is: (CoC) / {1 - [1 / (1 + CoC)] ^ asset life}. This can also be "tilted" using the price trend in which case the formula becomes: (CoC - price trend) / {1 - [(1 + price trend) / (1 + CoC)] ^ asset life}. Note this includes the return on investment as well as the depreciation.

[39] The formula used for the depreciation as a percentage of the capital investment is: 1/asset life + price trend x remaining life/original life.

[40] The formula used for depreciation as a percentage of the capital investment is, for eg an asset life of 10 years: 10/55, where 55 = 10+9+8+7+6+5+4+3+2+1

Table C.1
Direct Maintenance and Operating Costs as a Percentage of Direct Network Capital Costs

Expense category	TF data
BTS Greenfield site	9%
BTS equipment	31%
MSC	10%
Fiber	6%
Duct	3%

Source: Adapted by NERA from Taskforce returns

C.4.3 Other "indirect" costs

There are a number of other capital costs and operating costs which are relevant to call conveyance but which do not form part of the direct "network" costs. To model these costs data from the Malaysian group of public cellular service providers has been used.

Table C.2
Indirect Capital Costs as a Percentage of Direct Network Capital Costs

Expense category	TF data
Non-operational buildings	1.0%
Vehicles	0.3%
General purpose computers	6.1%
Other equipment	1.2%
TOTAL	**8.6%**

Source: Adapted by NERA from Taskforce data.

A similar procedure is followed for estimating the indirect operating costs associated with each of the capital cost items listed in Table C.2, where here the Taskforce costs are expressed as a percentage of total indirect network capital costs. The indirect operating costs are shown in Table C.3.

Table C.3
Indirect Operating Costs as a Percentage of Direct Network Operating Costs

Expense category	TF data
Non-operational buildings	13%
Vehicles	10%
General purpose computers	18%
Other equipment	8%

Source: Adapted by NERA from Taskforce data.

For other operating costs, the cost items that MCMC considers relevant are shown in Table C.4.

Table C.4
Indirect Operating Costs as a Percentage of Direct Network Operating Costs

Expense category	TF data
Executive and planning	3.87%
Accounting and finance	2.92%
External relations	1.88%
Human resources	3.77%
Information management	8.79%
Legal	0.71%
Procurement	1.91%
Other	20.11%
TOTAL	**43.96%**

Source: Adapted by NERA from Taskforce data.

It is important to note that this uplift applies to the direct network operating cost only, not to the total annualised cost (which also includes depreciation and return on capital).

C.5 Modelling the costs of conveyance

The following steps are outlined here:

- determination of capacity requirements;
- modelling switch costs; and
- modelling transmission costs.

C.5.1 Determining Capacity Requirements

The first stage in deriving the costs of the conveyance network is to "size" the network in terms of the amount of capacity required in different parts of the network to handle the traffic. The steps required to calculate the network capacity are as follows:

Step 1	Multiply end user call minutes and call attempts by routing factors to give equipment minutes (these figures are used to derive unit costs)
Step 2	Include an allowance for unsuccessful calls (for call attempts) and ringing time (for call minutes).
Step 3	Use the ratio of minutes in the peak hour to minutes over the year to estimate busy hour erlangs (BHE) and busy hour call attempts (BHCA)
Step 4	Use the erlang table together with the blocking rate to estimate the number of channels required, taking into account modularity.
Step 5	Take into account the utilisation rate - this has two aspects: an allowance for growth and sparing for faults.

Step 6	Capacity requirements for call minutes and for leased lines can be added together to give overall capacity required.

C.5.2 Modelling switch costs

The key equipment volumes required for switching are as follows:

- for BTS:
  - the number of fixed cost elements of the Base station electronics (eg the cabinet and other elements) is just given by the number of BTSs;
  - the number of transceivers (TRXs) and antennas is derived from the traffic requirements at the BTS level in the network using ratios specific to Malaysia to take proper account of the effects of topography, and demography;
  - the number of BTS sites is estimated as the number of BTSs less the number of BSC sites and less the number of MSC sites, since it is common practice to mount BTS at BSC sites and MSC sites to reduce the need for site acquisition;
- for BSC:
  - the number of fixed cost elements of the controller station electronics (eg the cabinet and other elements) is just given by the number of BSCs;
  - the total number of BSC sites is estimated as the number of BSCs less the number of MSC sites since normally one BSC is co-located with an MSC to reduce the need for site acquisition
- for MSC:
  - the number of fixed cost elements for the initial processor unit (eg the cabinet and processor) is just the number of MSCs;
  - the number of BHCAs for MSCs has been calculated (BHCA for MSCs has been calculated as part of the capacity requirements) and is used to estimate the variable cost associated with processor capacity upgrades;
  - the number of MSC level synchronisation equipment units is given by the number of MSCs.
  - the total number of MSC sites.
- for TS:
  - the number of fixed cost elements (the cabinet, processor and other elements) is equal to the number of switches;

- the number of BHCAs for TSs has been calculated (as part of the capacity requirements) - this is required to calculate the variable cost associated with processor capacity upgrades;
- the total number of TS sites.

C.5.3 Modelling Transmission Costs

The three main asset categories required for transmission are:

- the infrastructure (the duct and trench, or microwave units);
- the optic fiber cables;
- the multiplexing equipment and repeaters.

Licensees providing public cellular services have provided transmission route length data from which it was possible to produce calculations of public cellular service providers' total duct and cable lengths for the conveyance network.

Within the model the size and quantity of multiplexing equipment for transmission links which are on SDH rings are considered.

The estimation of equipment quantities is done as follows:

- total capacity required has been estimated including an allowance for equipment and route diversity;
- capacity is divided by the number of routes of a given type to give the average capacity per route;
- for each route type the distribution of traffic is applied to the routes to give the number of routes with different levels of capacity;
- for a given level of capacity required, the appropriate equipment size is chosen;
- aggregating over all routes produces estimates of the equipment required.

For the rest of the network, an SDH ring structure is modeled.

Cable size is determined as follows:

- total optic fiber length is estimated as typical route length multiplied by the number of pieces of transmission equipment;
- the optic fiber length is then divided by cable length to obtain an estimate of the number of fibers per cable;
- this estimate of fibers per cable is then matched with one of a number of standard cable sizes.

Repeaters also need to be taken into account - the number of repeaters for a given transmission route type is determined by the length of actual routes and the distance between repeaters.[41]

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[41] The calculation is: (the rounded up value of route length)/(distance between repeaters) less one, multiplied by the number of logical routes. On average, the calculated route lengths for different types of links turned out to be less than the minimum distance requirement between repeaters.

Having determined all the relevant lengths and pieces of equipment, costs are then derived in the standard way:

- unit equipment costs are applied to equipment volumes to estimate total equipment investment;
- investment costs are annualised, taking account of asset lives, anticipated price changes and the cost of capital;
- maintenance /operating costs are estimated and added in;
- finally other support investments (annualised) and expenses are added.

C.6 Summary of LRIC Base Run Model Assumptions and Sources

▪ Depreciation method	Tilted straight line
▪ 2001 call and line volumes	Licensees
▪ 2002 call volume forecast assumptions	Licensees
▪ Routing factors	Licensees
▪ Traffic profile assumptions	Licensees
▪ Trench and cable sheath length	Licensees
▪ Switching network	NERA
▪ Equipment prices	Taskforce average/NERA
▪ Number of switch sites and units	NERA
▪ Blocking factors	Taskforce average
▪ Equipment utilisation	Taskforce average
▪ Number of logical links of different types	Licensees
▪ Size distribution of traffic volumes ▪ for different types of link	Licensees
▪ Asset lives	Taskforce average/NERA
▪ Price changes	Taskforce average/NERA
▪ Direct operating costs	Taskforce average
▪ Indirect operating costs	Taskforce average