

**The Fully Allocated Cost (FAC) of services on Vodafone Australia's
GSM network**

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0 Executive summary

PricewaterhouseCoopers (“PwC”) has been asked by Vodafone Australia (“Vodafone”) to assist in constructing and validating a high-level cost model to inform the determination of the appropriate price for calls terminating on its network. The model has been constructed using accounting and operational data for the financial year to March 2003.

Due to time and data constraints, the model does not conform in detail to models that have been produced in other jurisdictions for the purpose of setting mobile termination rates, which are typically Bottom-Up Long-Run Incremental Cost (“BU-LRIC”) models. However, the constructed model *does* conform to the general principles of robust cost modelling (e.g. cost causality, transparency and reconcilability) and the outputs are reasonable estimates of the forward-looking costs of services on Vodafone’s GSM network.

Based on the outputs from the model, a reasonable estimate of the average cost of terminating calls on Vodafone’s GSM network is 17.5 cents per minute. It should be noted that, due to time and data constraints, certain assumptions have been adopted based upon Vodafone’s input and experience from other jurisdictions. Model outputs could therefore change if a more detailed costing analysis was undertaken. However, based on the extent to which we have been able to use Vodafone specific data, we would not expect a more detailed analysis to change the outputs significantly.

1 Cost models used for the purpose of setting mobile termination rates

1.1 Bottom-up LRIC models are being used in most jurisdictions

National Regulatory Authorities (“NRAs”) are increasingly scrutinising the level of mobile termination rates, and in numerous jurisdictions have either undertaken, or are in the process of undertaking, studies to determine the costs of terminating calls on mobile networks, with a view to determining the appropriate levels and structures of prices, i.e., those which would yield in a competitive environment.

In most countries where NRAs are actively examining the issue of mobile termination rates, they have opted to determine the costs of all network services, including call termination, by developing a Long-Run Incremental Cost (LRIC) model. Countries where such a process has been or is being undertaken include the UK, Sweden, Greece, Italy, Tanzania and Israel. The LRIC models used by NRAs are typically bottom-up in construct, although there is now an increasing focus on ensuring the outputs from the model can be reconciled with top-down accounting data.

1.2 The modelling approach

Due to time and data constraints,¹ a bottom-up LRIC model has not been developed for Vodafone. The model that has been developed is essentially a top-down fully allocated cost (“FAC”) model, using a mixture of Vodafone’s accounting and operational data comprising inputs from the following sources: (i) the general ledger; (ii) fixed asset register; (iii) call data recording systems; other inputs – including asset prices and routing factors – have been sourced directly from Vodafone. An FAC model differs from an incremental cost model in that it does not distinguish between costs that are incremental to the services being modelled and costs that are common across two or more services, or more strictly costs which are fixed, common or joint.

¹ Regulatory processes in respect of call termination rates which rely on detailed cost modelling exercises typically last between 1 and 2 years (the UK, Sweden and Greece are examples of such); with access to necessary staff and availability of data, the construction of a bottom up model consistent with prevailing best practice can take in order of 4 to 6 months; Vodafone have informed PwC that the necessary data were not available within the timescales of this exercise.

The model uses Vodafone’s accounting data as a starting point. However, for network capital costs (depreciation and return on investment), the accounting-based straight-line method of depreciation has been replaced with a tilted annuity calculation which reflects changes in the value of assets over time. It should also be noted that the tilted annuity approach is underpinned by a current cost valuation of the asset base, which is appropriate in determining the welfare maximising level and structure of prices.² Furthermore, the current cost valuation is based upon the actual deployment of Vodafone’s network (in terms of existing equipment quantities in the network); such an approach – where the outputs from an "optimised" model are reconciled to actual operational data – is consistent with the approaches being adopted by NRAs (for example, the PTS in Sweden) in arriving at estimates of the efficient costs of service provision.

Economic depreciation is defined as the change in the value of an asset from one period to the next, and is the theoretically-appropriate basis for determining the annualised costs of service provision. In contrast to cashflow-based depreciation, the tilted-annuity approach does not, for example, consider the effect of changes in the output level of assets over their lifetime; it does, however, recognise changes in the replacement cost of assets over their lifetimes and the impact this has on the appropriate timing of cost recovery. The cashflow-based approach, which has been used in jurisdictions such as the UK, Sweden and Greece, is extremely data-intensive; given the typical S-curve output profile of mobile output since inception, experience in the UK suggests that the adopted tilted-annuity approach may, other things equal, *understate* the annual capital costs in current and future years when compared to the cashflow-based method.

1.3 The difference between cost and price

Whilst costing plays a central role in determining the level and structure of prices that would prevail in a competitive market, the level of fixed common costs (“FCC”) and demand-side characteristics (specifically the own and cross-price elasticities) will also have a material impact on a welfare-maximising outcome. The quantum of FCCs is discussed later in this paper; issues associated with welfare maximising pricing (rather than costing *per se*) are addressed elsewhere in Vodafone’s Access Undertaking.

² When referring to welfare-maximising prices in this document, we assume this is subject to the requirement that all fixed common and joint costs are recovered.

2 FAC model

The FAC model uses Vodafone’s accounting and operational data for the year ended 31 March 2003. The model allocates all the relevant network and non-network costs associated with Vodafone’s GSM network for the financial year 2002/3 (as verified by Vodafone) to six services: incoming calls; outgoing calls; on-net calls; SMS messages; GPRS megabytes; and the subscription “service” or “event”.

2.1 General comments

The FAC model allocates the entirety of Vodafone’s costs, including network and non-network costs, to the services listed above. The costs are allocated in one of two ways: (i) directly to services or (ii) indirectly to services through secondary allocation. The direct costs are those costs which can be directly allocated to a service, or a set of services, using service routing (usage) factors. Indirect costs have been allocated in proportion to the directly allocated costs or as discussed further below.

There are two different types of indirect costs:

- i. **Network indirect costs:** these are costs which are network-based, and therefore should be allocated to network (conveyance) services only, but for which there are no clear routing factors that allow for a direct allocation of the costs, e.g., the test network and the Network Management System (NMS); and
- ii. **Non-network indirect costs:** these are costs which are not related to the network and are also not directly related to the subscription event, e.g. central finance functions and human resources. Such costs are allocated across all services, both network and non-network, using an appropriate allocation base, e.g., total cost (including network indirect costs).

The allocation of costs – and the proportion of total costs in each category – is shown in the diagram below.

Direct allocation: Subscription ([removed]%)	Direct allocation: Incoming ([removed]%)	Direct allocation: Outgoing ([removed]%)	Direct allocation: On-net ([removed]%)	Direct allocation: SMS ([removed]%)	Direct allocation: GPRS ([removed]%)
Indirectly allocated network costs ([removed]%)					
Indirectly allocated non-network costs ([removed]%)					

Table 1 – Cost allocation table

Direct costs of subscription and conveyance services are allocated in the first instance. The network indirect costs are then allocated to the conveyance services in proportion to the directly modelled network costs. Finally, the non-network indirect costs are then allocated to all services in proportion to previously allocated costs.

2.2 Model inputs

The model relies on inputs and assumptions that were provided by Vodafone. These inputs, and how they are used in the model, are summarised below.

2.2.1 Volumes

Vodafone provided annual service volumes for incoming, outgoing and on-net calls, annual SMS messages and GPRS megabytes and average subscribers in the year.

[Removed]

Table 2 – Modelled service volumes

In order to enable the allocation of network costs between the different conveyance services, SMS messages and GPRS megabytes were converted to minute equivalents. This was achieved using the standard conversion calculation that has been used in costing models in other jurisdictions, e.g. the UK, Sweden and Greece, as shown in the tables below:

SMS message - call minute equivalent

Number of bytes per SMS	40
voice channel rate for SMS message (bit/s)	767
seconds in a minute	60
bits in a byte	8
SMS per call minute conversion factor	144

Table 3 – SMS to call minute conversion

GPRS megabyte - call minute equivalent

Proportion of GPRS traffic in downlink	80%
Additional IP overheads	12%
Channel data rate (Mbit/s)	0.00905
Channel occupancy efficiency	100%
Allowance for packetisation	50%
1 Mbyte of GPRS user data = Mbits of downlink IP demand	3.584
One minute of a channel can carry Mbits of IP data	0.543
GPRS megabyte per call minute conversion factor	0.152

Table 4 – GPRS megabyte to call minute conversion

The interpretation of the tables above is that one minute of a voice call is equivalent to 144 SMS messages or 0.095 megabytes of GPRS data.

2.2.2 Routing factor inputs

Routing factors, reflecting the extent to which the different services drive network usage for the main network elements, were provided by Vodafone. These are shown in the table below. Some routing factors are universal – for example off-net calls will use one radio network per unit of output, whereas an on-net call will use two; others – for example backhaul transmission links – will reflect the network architecture in question. They are based on engineering measurements drawn from Vodafone’s actual network as provided by Vodafone; where the necessary network engineering data have not been available, the figures have been estimated by Vodafone’s network engineers.

[Removed]

Table 5 – Network routing factors

The routing factors shown above are then applied to volumes to allow an allocation of costs on the basis of route-factored volumes. Using cell sites as a stylised example, if the annualised cost of cell sites was A\$100m, the table below shows the effect of using routing-factors to allocate costs:

<i>Annualised cost (A\$m)</i>	<i>100</i>			
	Volume	Routing-factor	Route-factored volumes	Cost allocation
Outgoing (OLO)	500	1	500	23
Outgoing (own network)	500	2	1000	45
SMS	200	1	200	9
GPRS	100	1	100	5
Incoming	400	1	400	18
TOTAL	1700		2200	100

Table 6 – Allocation of cell site costs using routing-factors

The table above shows the difference between service volumes, totalling 1700, and route-factored volumes, totalling 2200. As a result of appropriately using route-factored volumes, a higher proportion of costs are allocated to on-net calls, and consequently, a lower proportion of costs are allocated to the other services³.

The routing factors shown above are only for network costs that are directly allocated to conveyance services. In allocating costs in the model there are three further categories of costs for which the routing factors are not applied:

1. Subscription costs;
2. Network indirect costs; and
3. Non-network indirect costs.

Subscription costs are those costs which directly relate to bringing subscribers onto Vodafone’s network, or retaining them on the network. These include costs associated with handsets, marketing and advertising, and retail outlets, which are all allocated entirely to the subscription “event”.

The manner in which network indirect costs and non-network indirect costs are allocated is summarised in section 2.1 above.

2.2.3 Capital costs

The model recognises the capital costs of Vodafone, being both the depreciation of assets *and* the required return on those assets. Given that capital costs constitute a significant proportion

³ Note, the demand shown is not the actual demand and is by way of example only.

{Removed}% of the annualised costs in Vodafone’s network, the method of valuing and depreciating the assets is an important driver of the model results.

As explained in section 1.2 above, recent models being used by regulators in other jurisdictions typically use a form of economic depreciation that explicitly takes into account the timing of cashflows relating to an asset over its useful economic life. The valuation of the asset is then a function of the asset’s ability to generate free cash flow, and the depreciation is the change in the value of the asset from one period to the next. The development and population of these models tends to be part of regulatory processes that last between 1 and 2 years, and as such a more straightforward approach has been developed in this context. The tilted annuity approach reflects the cashflow method of economic depreciation insofar as it reflects asset price changes in the valuation of assets and timing of depreciation thereof, as well as recognising the length of time it takes to bring an asset into service. The major difference relates to the recognition, in the cashflow form, of the output profiles of assets, which is absent from the tilted annuity method. The tilted-annuity formula used for all network assets is as follows:

$$C_{t=1} = I_{t=0} \left(\frac{1+r}{1+i} \right)^u \frac{(r-i)}{1 - \left(\frac{1+i}{1+r} \right)^n}$$

C = Annualised cost for a given time period (A\$)

I = Replacement cost of network element (A\$)

r = Cost of Capital (%)

u = period from payment to commencement of productive service (years)

i = Annual asset price change (%)

n = Useful life of asset (years)

It should be noted that the annualised cost that this formula calculates includes not only the depreciation of the asset, but also the required return on the capital employed, i.e. return *on* as well as return *of* investment. This differs from an accounting-based depreciation calculation, where a return on assets (i.e. net asset value x cost of capital) must be added separately.

The tilted annuity approach is only used for network assets, for which estimates of replacement costs and useful lives were available. For all non-network capital items, accounting depreciation and book values were used in arriving at the annualised capital costs. We do not expect this to represent a material distortion to results because the net book value of network assets is approximately {Removed}% of total assets. A table showing the network elements that were used in the tilted annuity calculation is shown in Appendix 1. Appendix 2

sets out information on the non-network assets, where costs have been annualised on a straight-line basis consistent with Vodafone's statutory accounting rules.

As shown in the tilted annuity formula, the calculation relies on both the replacement cost of the network elements, and the expected forward-looking annual input price change of those elements. The replacement costs and price changes, which are shown in the table in Appendix 1, have been provided by Vodafone's procurement team.

We understand the network element prices are consistent with Vodafone's Global Price Book⁴. The forward-looking price changes have been estimated by Vodafone's procurement team and reflect past price trends and expectations looking forward.

2.2.4 Operating costs

We have used the actual operating costs of Vodafone, which were provided in summary form; these costs were sourced directly from Vodafone's general ledger and were split between network and non-network cost categories. As with the allocation of the capital costs, the operating costs are either allocated directly using the routing factors, or indirectly using alternative allocation bases.

The operating costs used in the model are set out in Appendix 3 and represent data provided by Vodafone. Some of the categories have required further disaggregation in order to allow for improved accuracy of allocation. For example, 'other opex' has been split between, on the one hand, those which are directly related to subscription and, on the other, those which are deemed to be general business costs and which are therefore allocated in accordance with the non-network indirect costs. The way (i) network and (ii) non-network operating costs have been allocated is summarised in Appendices 4 and 5 respectively.

2.2.5 Allocation of costs

Having calculated the annualised capital costs, the model allocates those costs and the operating costs to the different services. The allocation is carried out through the routing factors that are set out in section 2.2.2.

⁴ Vodafone negotiates prices with network equipment suppliers on a global basis.

The model works by allocating a set of routing factors to each cost, both network and non-network, e.g. if a cost relates to BSCs, the model will assign to that cost line the BSC routing-factor which will then be used to allocate the annualised cost across the different conveyance services. Likewise, if a cost relates to the subscription “event”, it will be allocated directly to subscription. Where costs cannot be directly allocated to a service or group of services, they will be assigned either network indirect or non-network indirect routing factors, and will be allocated via the secondary allocations, as explained in section 2.1.

2.2.6 Working capital

Whilst working capital information was available, it was only available on an aggregate basis. The working capital is allocated proportionally to all fixed assets: the amount of working capital is approximately *[Removed]*% of the value of net tangible assets; all asset values are therefore marked up by *[Removed]*%. This appropriately allows the capital charge, calculated as the mean capital employed multiplied by the cost of capital, to be applied to all assets present in the business, rather than just the fixed assets.

2.2.7 WACC

We have used a nominal pre-tax WACC of *[Removed]*% in the model, which is discussed elsewhere in Vodafone’s Access Undertaking.

2.2.8 Estimate of fixed and common costs

Analysis has been undertaken in order to determine the magnitude of FCCs in line with prevailing best practice definitions, such as those adopted in Sweden and Greece. The following table summarises the different types of base station (which constitute the majority of FCCs), and which parts of it are considered (i) fixed and common across two or more services⁵ and (ii) incremental to services.

⁵ This high-level view of FCCs does not taken into account the modularity of network equipment as a relevant component of FCC definition; and also excludes other arguably common costs including licence fees and costs associated with the network management system. It therefore potentially understates the proportion of network FCCs in the business.

Site type	Fixed common cost	Incremental cost
Omni-sector, minimum TRXs in general and two-sector with minimum TRXs for highway sites	All costs – site, BTS, TRXs	None
As above, but with additional TRXs for capacity	Site, BTS	All TRXs
As above, but sectorised site	Site	BTS, all TRXs
Split cells	None	Site, BTS, all TRXs

Table 7 – Definition of Network FCCs

The following table shows the sites⁶, as categorised by Vodafone. They broadly map to the categories shown in the table above.

[Removed]

Table 8 – Vodafone’s site categorisation

The estimated number of coverage-related cells was then multiplied by the unit costs of the relevant equipment in order to arrive at an estimate of the network-related FCCs.

In conclusion, based on our high-level analysis, network FCCs constitute approximately *[Removed]*% of total network costs; we also include as components of FCCs those non-network costs relating to central overhead functions such as the finance and human resources departments.

This information – which provides an understanding of the cost structure of the business and conforms broadly with best-practice LRIC principles – has been used by Vodafone in developing an understanding of the welfare maximising level of prices.

2.3 Assumptions and caveats

There are a number of assumptions contained in the model and we outline these, together with a number of caveats, below.

⁶ For the purposes of this high-level view of FCCs, we have used the average site cost in the calculation. In general, coverage-related sites tend to be located in rural areas and are more expensive to build than urban sites; therefore using the average site cost in arriving at the estimate of FCCs potentially understates their magnitude.

- i. The model incorporates a series of checks which are designed to ensure that all costs are reflected in the model results, and no costs are included twice; however no formal model audit has been performed.
- ii. The model takes all the costs of the business on a line-by-line basis for fixed assets and operating expenses and in aggregate for working capital. We assume that the input data provided to us include all network and non-network costs and reconcile to Vodafone's financial statements where appropriate; we rely on Vodafone in respect of the appropriateness of current cost asset values and forward-looking price trends.
- iii. Whilst network costs are typically a function of busy hour traffic, we have used total call minutes in calculating the volume drivers in the model; we thereby implicitly assume no difference in the average to busy-hour call volume ratios across services. Based on our experience, we do not expect this to systematically bias the model results.
- iv. We assume the routing factors provided to us by Vodafone are accurate and appropriate. Whilst we have assessed them at a high-level against routing factors used in other jurisdictions (for example, the UK) and consider them to be reasonable, we have not reviewed the routing factors in detail or the engineering data from which they have been sourced.
- v. We do not have a detailed breakdown of net working capital and therefore have been unable to allocate its components to specific assets or services. As an approximation, we have allocated the net working capital across the asset base in proportion to net book values. Net working capital amounts to approximately *[Removed]*% of tangible net assets.
- vi. Customer care costs in their entirety have been allocated to the subscription event, rather than being defined as fixed common costs. This is a potential conservatism: there exist reasonable arguments to define at least a proportion of customer care costs as fixed and common, along with other non-network costs which are, rather than being incremental to the subscription event, incurred in the ongoing maintenance and management of the subscriber base in order to facilitate the making and receiving of calls. Defining customer care costs as common, other things equal, would mean an increase in the modelled cost of call termination from 17.5 cents per minute to *[Removed]* cents per minute;
- vii. The granularity of Vodafone's cost data is such that, in our experience, further disaggregation has been necessary in a number of specific instances, so as to prevent a biasing of results. In the absence of detailed data, the preferred alternative was to rely upon a combination of our experience in other jurisdictions (and, specifically,

information from costing modelling undertaken for Vodafone in the UK) and estimates provided by Vodafone. These further disaggregations, and the sources used in deriving such, are set out below:

- billing (capital costs) – split wholesale ([Removed]%) and retail ([Removed]%). Source: Vodafone UK cost model, with costs split consistent with the ratio of gross book value of assets.
- IT costs (to be used in allocating the hardware and software capex and opex) – split retail ([Removed]%) and non-network indirect ([Removed]%). Source: Vodafone UK cost model, with costs split consistent with the ratio of gross book value of assets.
- Furniture and fittings – split retail only ([Removed]%); network only ([Removed]%) and non-network indirect ([Removed]%). Source: Vodafone UK cost model, with costs split consistent with the ratio of gross book value of assets.
- ‘other opex’ – split between subscription related ([Removed]%) and non-network indirect ([Removed]%). Source: Vodafone estimate.

3 Results

The following table shows the model outputs. The key output is the cost of calls terminating on Vodafone's GSM network, which the model calculates to be 17.5 cents per minute.

[Removed]

Table 8 – Summary outputs

It should be noted that the costs shown for SMS messages and GPRS megabytes are combined and expressed as a minute equivalent.

4 Conclusions

The output from the model is a fully allocated current cost of terminating calls on Vodafone's GSM network of 17.5 cents per minute. We have also estimated the scale of fixed common costs in Vodafone's network, in order that Vodafone can assess the level of prices consistent with welfare-maximising principles.

It is important to note that the model estimates, *inter alia*, the *cost* of calls terminating on Vodafone's network rather than the appropriate *price*. The modelled cost is likely to understate a welfare-maximising price, for example because:

1. FCCs are significant and a Ramsey pricing solution may be expected to yield a figure in excess of that adopted under a standard FAC framework (or, broadly analogously, a LRIC approach with FCCs recovered on an equi-proportional basis);
2. We have not included any allowance to reflect the presence of a network externality. Given the low level of penetration in Australia relative to comparator countries, we expect that such an allowance should be made; this would, other things equal, increase the appropriate price level of the call termination service; and
3. The adopted tilted annuity method of economic depreciation may, in comparison with the cashflow-based approach used in regulatory processes in, *inter alia*, the UK, Sweden, Greece and Israel, understate the annualised capital costs due to the lack of recognition of the changes in output profiles of assets over time. This was borne out in the modelling undertaken by Ofcom in the UK Competition Commission inquiry into mobile termination rates and reflects, in part, the fact that output profiles in mobile telephony since launch have tended to follow the traditional 'S-curve' profiles of new technologies.

It is also important to recognise that the results of this analysis represent a reasonable estimate of the service costs of Vodafone's GSM network for the financial year 2003. No firm conclusions can be drawn as to the costs of services on the UMTS network as a result of this work.

Appendix 1 – Tilted annuity input data

[Removed]

Table 9 – Tilted annuity data

Appendix 2 – Non-network capital cost data

[Removed]

Table 10 – Non-network capital cost data

The table above shows the non-network capital costs that have been allocated either to subscription or non-network indirect. We have confirmed with Vodafone that these assets are not distinct from the assets included in the tilted annuity calculation, e.g. the software costs shown are for general software rather than specific network software.

Appendix 3 – Network and non-network operating cost data

[Removed]

Table 11 – Network Operating Costs

[Removed]

Table 12 – Non-network operating costs

Appendix 4 – Network operating cost data

[Removed]

Table 13 – Network operating costs

Appendix 5 – Non-network operating cost data

[Removed]

Table 14 – Non-network operating costs