FLLRIC Model for the Cayman Islands
Mobile Network Document Draft Costing Manual

Cable & Wireless Cayman Islands

Submitted 14 December 2005

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LRIC mobile Network model

1. Introduction

1. This document is the third part of a three part submission to the ICTA representing C&W latest contribution to the development of the LRIC model in the Cayman Islands and, in particular, its fulfillment of requirements set out in the Authority's *Public Consultation on Costing Manual* (CD 2005-1), dated 27 October 2005, to submit a draft LRIC costing manual. As required by the Authority, this submission includes

   a) our proposed costing manual along with supporting rationale and explanations;

   b) two example costing studies developed using this manual, the first being mobile termination service, the second being the residential fixed line access service;

   c) our proposal on how to allocate common costs, proposed determination and level of expense factors, and proposed economic asset lives;

   d) additional information from other jurisdictions where competition exists regarding the determination and level of expense factors as well as any information supporting the applicability of such factors to the Cayman Islands; and

   e) any supporting asset life studies used in developing its proposed economic asset lives.

2. We also use the opportunity to propose two WACCs for use in the fixed and mobile network models.

3. The submission is divided into three parts:

   1. The Background Document:

      - explains our understanding of the principles and guidelines set out in the Authority *Decision for the Forward-looking Long-Run Incremental Costing Consultation* (ICT Decision 2005-4);

- describes the overall methodological approach and treats issues common to both the fixed and mobile issues, including the cost of capital, expense factors, asset lives and treatment of retail costs; and

- provides definitions for terms and acronyms used in the other parts of the submission.

2. The Fixed Network Model Manual, which describes the structure and functioning of the fixed network model. The Manual includes a Retail Case study—Residential Fixed Line Service, which traces the inputs and calculations of costs relevant to the retail residential fixed line service to identify how outputs are determined.

1. 3. The Mobile Network Model Manual, which describers the structure and functioning of the mobile network model. The Manual includes an Interconnection Case study--Mobile termination, which traces the inputs and calculations of costs relevant to mobile termination to identify how outputs are determined.

2. This document is the Mobile Network Model Manual. It describes the structure and function of the mobile LRIC model. The services, assumptions and calculations are identified. Appendices are provided which contain the template input and workings sheets. The manual concludes with a case study that demonstrates how the inputs flow through the model to determine incremental costs.

3. The mobile service set is smaller than the fixed one. Mobile traffic services are split in a similar way to the fixed ones: retail, wholesale and interconnect. Mobile Data services cover SMS and other data services. The subscriber product covers the handset costs and any other subscriber related costs such as customer care for instance.

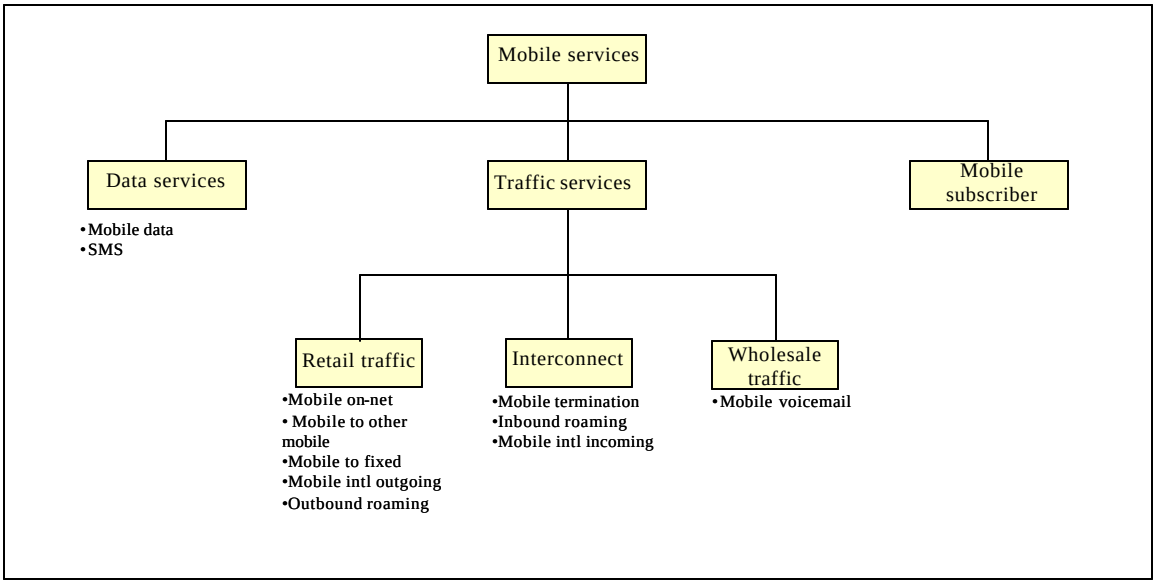


Figure 1 Mobile services in the LRIC model

2. Methodology

4. A GSM network consists of cell sites, BTS, BSC and MSC switches. In addition to these basic network building blocks (shown below) there are several other pieces of equipment, including TCUs and HLRs, that require consideration in a comprehensive costing exercise.

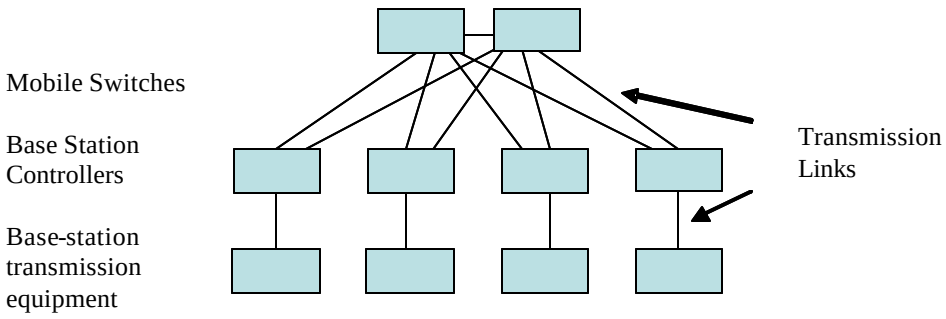


Figure 2 Mobile Network Architecture

Mobile Network - Radio

5. Radio transmission is provided by base-stations which have the following components:

- Antennas

- Towers
- Base-station transmission equipment (BTS)
- TRX units which provide the transmission capacity

6. Base stations may be of two types:

- Omnidirectional, where a single antenna gives coverage in all directions
- Sectored, where three directional antennas are used, each providing coverage in a 120 degree arc. This allows greater traffic-handling capability.

Mobile Network - Transmission

7. Fixed transmission connections are needed to connect the BTS units to the Base Station Controllers (BSC), and the BSC units to the switches. We assume in the model that transmission capacity is provided by renting leased circuits, using market prices. The mobile network is thus assumed not to own any fixed transmission infrastructure.

Mobile Network - Switching

8. There are two main divisions of mobile switching equipment:

- Base-station controllers – each one can control several BTS units
- Mobile Switching Centres (MSC) – these provide the switching of mobile traffic and the interface

Mobile Network - Radio and Switching

9. There are a number of technical assumptions which underpin the dimensioning of the mobile radio network – these are indicated in the table below:

Key Assumption	Description
Spectrum Availability	Provides details on the total spectrum that the operator has. In this model we assume the operator could use either 850MHz/1900MHz or 900/1800MHz spectrum combinations. It is assumed that the spectrum is available to the operator in adequate supply, and that the 850 and 900, and the 1800 and 1900 MHz bands, respectively, are functionally equivalent..
Sector Reuse Figure	Frequency has to be re-used across adjacent cells so each cell only gets a proportion of the total spectrum bandwidth
Carrier Bandwidth in KHz	This is the bandwidth of each TRX. It is used to calculate the number of TRXs that can be accommodated within the available spectrum
Maximum Carriers per sector	This is the maximum number of TRXs that can be assigned to a particular sector
Traffic Distribution in	Splits the traffic into that carried in dense, medium and rural areas.

Key Assumption	Description
Cayman by land type	This is combined with the coverage area assumptions to calculate the traffic split in different areas of Cayman.
Capacity Planning Maximum Load Factor	The maximum capacity of a cell, before a new cell is added to the network. The higher the loading factor, the larger the capacity of each cell and the lower the number of required cells
Coverage areas (square km)	Splits the area of Cayman into dense, medium and rural. Used to calculate the number of cells and sites that are required for (i) coverage; and (ii) traffic conveyance purposes
Cell Sectorisation	Determines whether a cell is omni or sectorised. A sectorised cell has 3 sectors each with its own antenna and TRXs, whilst an omni cell only has 1 antenna and corresponding TRXs. Therefore a sectorised cell has a larger capacity, and a larger cost
Maximum Cell Radii Km	The theoretical maximum radius of each cell given radio propagation and path loss calculations. In practice, the average cell radius is generally calculated to be smaller than this, so this assumption is not usually significant in the dimensioning process
Grade of service	Allows the user to determine the grade of service at which the network should perform in the busy hour. Used to determine the amount of equipment that is required in the busy hour in order to meet this grade of service
Non Perfect Cell Tessellation	Recognises that, in reality, cells do not fit together as perfect hexagons. The number of calculated cells are multiplied by this number to calculate the true number of cells that are required
Network Increments	Details the number of subscribers that each unit of equipment can cater for
% of BTS collocated with other network nodes	Details the % of BTS that are co-located with BSCs. A co-located BTS does not require transmission capacity to link it to the BSC

Required number of nodes

Radio Nodes

10. The GSM network consists of a number of cell sites. Within the model, cells are assumed to be hexagonal, and are located so as to provide tessellating coverage as shown in the following diagram.

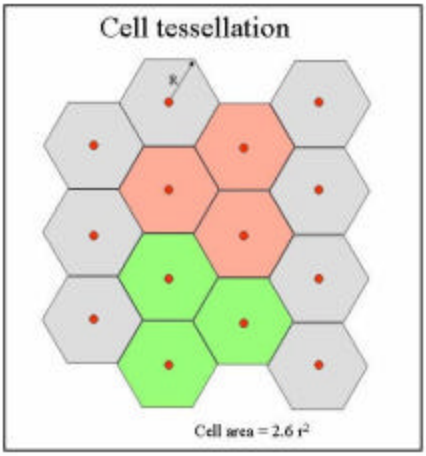


Figure 3 GSM Cell Tessellation

11. Each site is assumed to provide omni directional coverage (i.e. 360^{o} coverage around the cell centre) or sectorised coverage (i.e. 3 x 120^{o} arcs of coverage around the cell centre). Each cell site will have one or more BTSs, and each BTS will be equipped with one or more TRXs.

12. The number and size of the equipment depends on the coverage area of the cell and the required level of traffic within the cell. Typically, it may be expected that a number of cells are employed in the network mainly for the purpose of providing coverage in order to meet legal coverage requirements. However, due to the relatively small geographic area of the Cayman Islands and the population dispersion, it is assumed that no cell sites were required purely for coverage and that all cells had a traffic-handling requirement.

13. To calculate the required number of cells, it is first necessary to split the area of the Cayman Islands into dense, medium and rural.

14. The model then determines the number and type of cells required to provide both coverage and to carry the traffic load. It does this separately for dense, medium and rural areas. In order to determine the number of cells the model has to perform an iterative calculation as shown below.

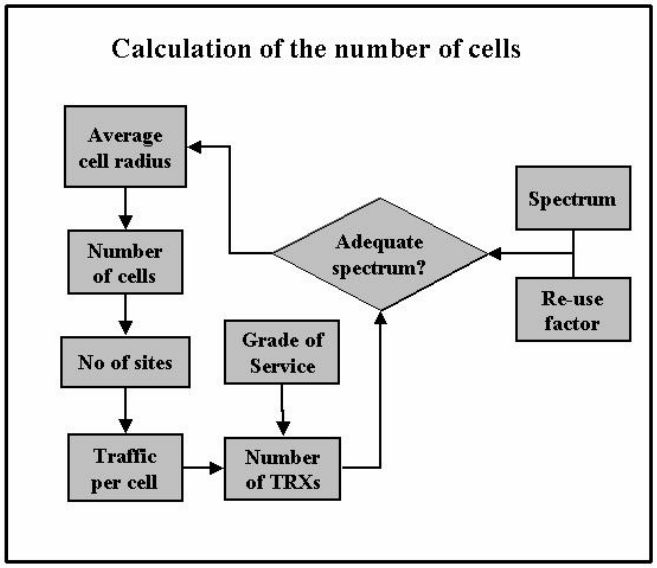


Figure 4 Calculating the number of GSM cells

15. The starting point for this iteration is the maximum cell radius. This is set by a path loss calculation, assuming given transmit and receive powers, antenna gains and propagation characteristics. The assumed maximum cell radii are given in the following table.

Maximum cell radius:	km
Dense	1.5
Medium	3
Rural	5

Figure 5 Maximum Cell Radius

16. Using these maximum cell radii, the model calculates the required number of sites and cells (assuming both omni and sectorised sites), and then determines the traffic per cell. The traffic per cell will consist of both voice and data traffic, and the traffic loads to be carried on 850/900MHz and 1800/1900MHz cells.

17. The model then uses an Erlang-B calculation at a defined grade of service for the radio path (which can be changed in the model from 0.5% to 5%) to determine the required number of TRXs per site. This number is compared to the maximum available number of TRXs per site as determined from the available overall spectrum and the re-use pattern. If the model determines that the required number of TRXs exceeds the maximum available then it reduces the average cell radii and repeats the calculation. This process will stop when the bandwidth required by the calculated number of TRXs matches the available spectrum. To avoid circular references within the Excel model this iteration is actually done by

simultaneously repeating the calculation at different cell radii and then selecting the optimum cell radius using an HLOOKUP function.

18. From this calculation the model can separately determine the number of sites and the number of cells required in dense, medium and rural areas, the number of omni and the number of sectorised cells and the number of 850/900MHz and 1800/1900MHz cells. The model also determines the total number of TRXs required. This calculation is performed separately for voice and data.

Switching Nodes

19. Having determined the number of BTSs required, the model then determines the number of BSCs and MSCs required using ratio calculations as below:

- Each BSC is assumed to serve 20 BTSs
- Each MSC is assumed to be able to cater for 125,000 subscribers (equivalent to a traffic load of approximately 3000E of busy hour traffic)

Sizing the nodes

20. Each BTS has either one cell (omni cell) or three cells (sectorised). Each cell has a number of TRXs. Each TRX produces one 200 KHz wide radio carrier. Each carrier has a set bandwidth (200 kHz) and 8 timeslots. Typically 1 -2 timeslots per sector are devoted to signalling, and the remaining are traffic carrying timeslots. In the model, a site if defined as a BTS, an omni cell is one antenna and a sectorised cell is 3 antennas.

21. Each BTS is assumed to be connected to a single BSC. The number of BSCs is determined by the number of sites, since each BSC is assumed to cater for a maximum of 20 sites.

22. Each BSC is connected to 2 MSCs. The number of MSCs is determined by the number of subscribers, since each MSC is assumed to cater for a maximum of 125,000 subscribers

Transmission

23. For the purposes of constructing a standalone mobile network, it is assumed that the mobile network uses leased line obtained at commercial rates from a fixed network operator to provide backhaul connectivity.

24. BTS-BSC backhaul is required to connect BTSs that are not co-located with the BSC. Where the nodes are co-located, no backhaul transmission is required. The model allows the user to specify what percentage of BTSs are co-located. Where transmission capability is required it is provided as leased lines purchased from the fixed network and these are used to provide the cable links between the BTS and BSC. It is assumed that each BTS-BSC cable link requires one leased link on

2Mbit/s for omni cells or 8Mbit/s for sectored cells, costed at current C&W commercial leased line prices.

3. Model Structure & Operation

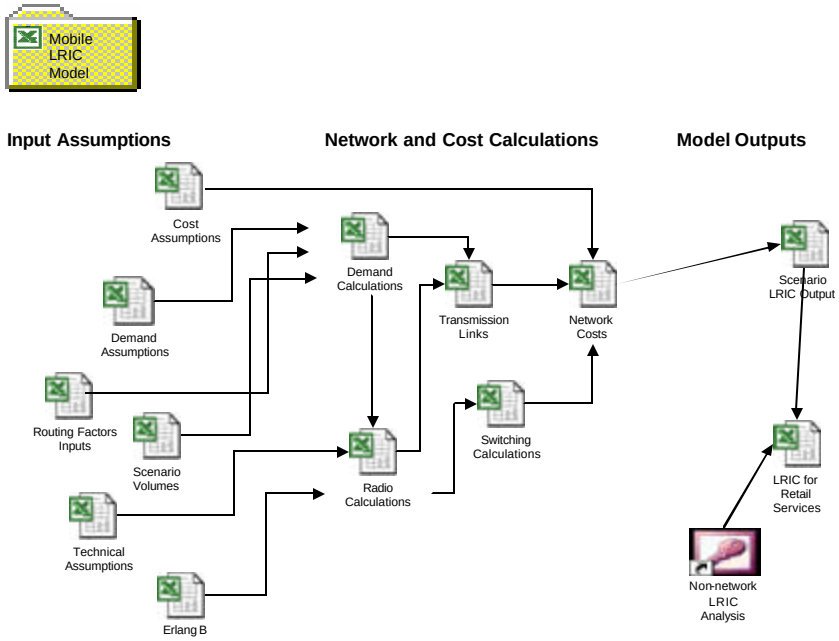
25. This section describes the various worksheets in the MS Excel Bottom-up model and provides and overview as to operating procedures.

Mobile Model Structure

26. The mobile model is divided into the following modules:

- Model Inputs
- Network Calculations
- Cost Calculations
- Model Outputs

These modules are made up of a number of worksheets. The figure below outlines the structure of these modules and their composite sheets.

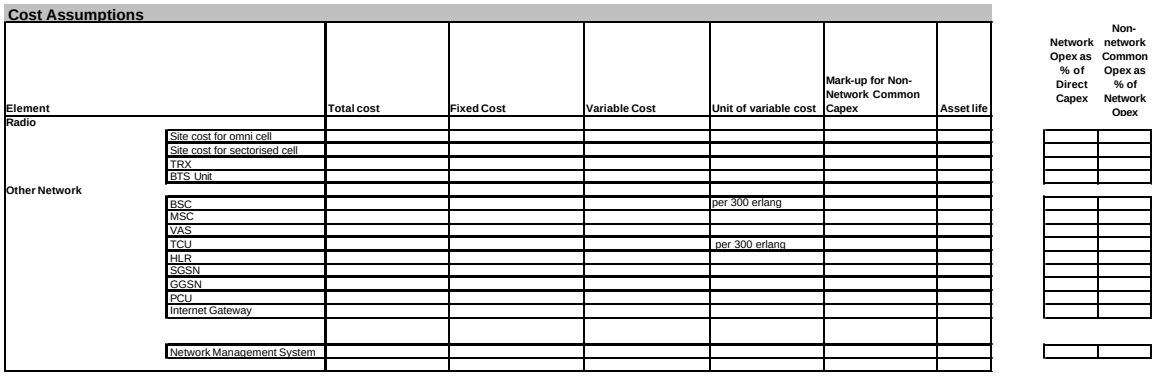


Model Inputs

27. This module contains all the data inputs needed to run the model. Here we list and discuss each sheet of the module. Please note that in Appendix VI we present a comprehensive list of inputs required.

- *Cost Assumptions* – this contains all the unit cost data.

28. The equipment costs used in the model are summarised in the following extracts from the model input sheets:



Cost Assumptions

Element		Total cost	Fixed Cost	Variable Cost	Unit of variable cost	Mark-up for Non-Network Common Capex	Asset life	Network Opex as % of Direct Capex	Non-network Common Opex as % of Network Opex
Radio									
	Site cost for omni cell								
	Site cost for sectorised cell								
	TRX								
	BTS Unit								
Other Network									
	BSC				per 300 erlang				
	MSC								
	VAS								
	TCU				per 300 erlang				
	HLR								
	SGSN								
	GGSN								
	PCU								
	Internet Gateway								
	Network Management System								

Figure 6 Radio & Other Network Costs Extract

29. Please note that, in addition to indicating the division, between fixed and variable costs, the sheet contains the assumptions on asset lives and expense factors as discussed in the Background document of this manual.

Leased Line/Microwave Tariffs for 3 yr contract

Capacity	Unit	Monthly Cost	Annual Cost
64	CI per link		
128	CI per link		
256	CI per link		
512	CI per link		
768	CI per link		
1024	CI per link		
1544	CI per link		
2048	CI per link		
4600	CI per link		
9200	CI per link		
18000	CI per link		
45000	CI per link		

Figure 7 Leased Line Tariff Costs Extract

30. These tariffs can come right off C&W tariff lists.

Element	Allocation to Traffic		Allocation to Subscriber
	Call Attempts	Minutes	
BTS			
MSC			
VAS			
TCU			
HLR			
SGSN			
GGSN			
PCU			
Internet Gateway			
Cell Site			

Figure 8 Allocation of Costs to Increments

Site Rental				
Location	Classification	Type	Own/Shared	Monthly Rental
Andy's Auto	Urban			
Lion's Centre	Urban			
Sport's Complex	Urban			
Picaddily	Urban			
West End	Urban			
Queen's Highway	Rural			
CYB P & L	Rural			
Northward	Rural			
CYB Bluff	Rural			
Northwest Point	Urban			
Prospect	Urban			
Morritts	Rural			
Colliers	Rural			
Avcom	Urban			
Lower Valley	Rural			
Midland Acres	Rural			
CYB Bluff 2	Rural			
Mount Pleasant	Urban			
Safe Haven	Urban			
GCM Airport	Urban			
Old Man Bay	Rural			
Spot Bay, CYB	Rural			
Little Cayman Arpt	Rural			
Seven Mile Beach Cow	Urban			
George Town Cow	Urban			
New sites for 2005/06	Urban			

Figure 9 Cell Site Rental Costs Extract

31. Please note that consistent with the scorched node assumption requested by the Authority, we have retained C&W's cell site locations for this costing exercise. The input sheet allows the user to specify classification, type and also an indication whether the site involves tower-sharing, all of which will obviously have an impact on the rental.

- *Demand assumptions* – this contains the demand assumptions needed to dimension the network.

Subscribers

	Numbers	
Voice subscribers		(used for HLR sizing)
Data and sms subscribers		(used for data and sms traffic sizing)

Usage Data

Conveyance Services	Annual Call Conversation Minutes	Annual Successful Calls
MOBILE DATA		
MOBILE INTERNATIONAL INCOMING		
MOBILE INTERNATIONAL OUTGOING		
MOBILE ON NET CALL		
MOBILE TO FIXED		
MOBILE TO OTHER MOBILE		
MOBILE VOICEMAIL RETAIL		
MOBILE VOICEMAIL WHOLESALE		
MOBILE TERMINATION		
INBOUND ROAMING		
OUTBOUND ROAMING		
Total		

Parameter	Value	
Voice usage		
Avg non conversation holding time (minutes per call)		
No of busy days in month		
% of daily traffic in BH		
Proportion of mobile to mobile traffic		
Ratio of total/successful calls		
Data usage		
Monthly usage per sub (kbits) (bothway)		
Usage for each SMS (kbits) (bothway)		

Figure 10

- *Scenario Volumes*—contain the volumes that will be zeroed out to determine incremental costs. Please see the discussion of the case study at the end of this document.
- *Technical assumptions* – this contains the engineering assumptions needed to dimension the radio and switching networks.

Parameter	Data	Units
Radio and Switching		
Available GSM 850 spectrum		MHz
Available GSM 1900 spectrum		MHz
Re-use factor GSM 850		
Re-use factor GSM 1900		
GSM Carrier bandwidth		KHz
Timeslots per carrier GSM		unit
Radio Path GoS		
Traffic per T1 (Erl)		unit
Tessalation factor used for planning		
Number of MSC		unit
Traffic distribution		
Dense		%
Medium		%
Rural		%
Coverage area surface (km2)		
Dense		km^2
Medium		km^2
Rural		km^2
Cell sectorisation per area		
Dense		% omni
Medium		% omni
Rural		% omni
Maximum cell radius:		
Dense		km
Medium		km
Rural		km
Subscriber capacities and increments for MSC, HLR		
# cell sites per BTS		# cell sites
Grade of service		
% BTS served by radio		
% BTS served by cable		
% of co-located BTS		%
Average microwave hops per BTS		
Number and type of any dedicated transmission links (eg, microwave backhaul)		
Number of NMS		
Capacity planning max load factor		
GPRS Design Factors		
TS data trans. rate (kbps) (inc. overhead)		
Busy hour capacity per TS (Mbits)		
Assumed traffic per 2Mbit/s E1 (E)		
Network increments		
Mobile network		
MSC increment		
HLR increment		
Number of cell sites per BSC		
PCU Capacity		
GSN Complex		
SGSN capacity		
GGSN capacity		
Internet gateway		
Capacity increment		

Figure 11

- *Routing Factor inputs* – this contains the source for the routing factors used for all services.

	GSM: BTS	GSM: BSC	GSM: MSC -call sensitive	GSM: MSC - duration sensitive	GSM Int'l Tx	GSM National Tx	GSM: Interconnect Link Fixed - Voice	GSM: GPRS Tx	GSM: Voicemail platform	GSM: GPRS platform	GSM: SMS platform	GSM: Prepaid platform	GSM: HLR/VLR traffic sensitive	Cellsite land & masts	GSM: Handsets and SIM card/activation platform	GSM: HLR/VLR subscriber sensitive
	M	M	C	M	M	M	M	O	M	O	O	M	M	M	S	S
MOBILE DATA	1.00	1.00	1.00	-	-	1.00	-	1.00	-	1.00	-	-	-	-	-	-
MOBILE INTERNATIONAL INCOMING	1.00	1.00	2.50	1.00	-	1.00	-	-	-	-	-	0.75	1.00	1.00	-	-
MOBILE INTERNATIONAL OUTGOING	1.00	1.00	1.00	1.00	-	1.00	-	-	-	-	-	0.74	1.00	1.00	-	-
MOBILE ON NET CALL	2.00	2.00	3.50	1.00	-	2.00	-	-	-	-	-	1.50	1.00	2.00	-	-
Mobile Subscriber	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1.00	1.00
MOBILE TERMINATION	1.00	1.00	2.50	1.00	-	1.00	-	-	-	-	-	0.75	1.00	1.00	-	-
MOBILE TO FIXED	1.00	1.00	1.00	1.00	-	1.00	-	-	-	-	-	0.75	1.00	1.00	-	-
MOBILE TO OTHER MOBILE	1.00	1.00	1.00	1.00	-	1.00	-	-	-	-	-	0.75	1.00	1.00	-	-
MOBILE VOICEMAIL RETAIL	-	-	1.00	1.00	-	-	-	-	1.00	-	-	-	1.00	-	-	-
MOBILE VOICEMAIL WHOLESALE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MOBILE WHOLESALE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Figure 12

32. Here we include the actual routing factors that we propose to use for the modelling exercise. Routing factors are used to calculate the demand volumes of each network element. They tell you how often a particular network element is used in providing a given service. For example, a routing factor of 2 for a BTS supporting the service Mobile on Net calls, tells you that for each on net mobile call there are two BTSs involved, so the demand would be the actual volume multiply by a factor of 2. While most of these routing factors are self-evident from the network structure, some—the prepaid platform and call sensitive MSC elements in particular—will depend on the proportion of various traffic types. Please note the routing factors supplied in Figure 12 for the prepaid platform and call sensitive MSC above are illustrative and not meant to represent C&Ws position on what the routing factor should be.

- *Erlang B* – this contains a standard Erlang B lookup table.

Network Calculations

33. This module contains the algorithms used to dimension the network. It is divided into the following sheets:

- *Demand calculations* – this sheet simply takes the service demand from the Demand Assumptions and uses the routing factors to calculate demand by network element. See the template sheet in Appendices IA and B, which indicate how the calculations are made.

- *Radio calculations* – this sheet contains the calculations needed for dimensioning of the cell-sites. Please see Appendix II.

- *Switching calculations* – this sheet calculates the size and number required for switching equipment. See Appendix III.

- *Transmission Links* – this sheet calculates the number and size needed for the links to connect base stations to the switching network. See Appendix IV.

Cost calculations

34. This module calculates the total cost for each network component. It also contains the calculations for leased line and cell site rental. It has only one worksheet – Network Costs. See Appendix V.

Model Outputs

35. The main outputs for the BU model are as follows: the NRC, depreciation and opex outputs by network element for the different service and service groups in response to a specific set of scenario volume.

36. A sample of the model outputs are presented in the case study at the end of this document.

4. CASE STUDY

Introduction

37. The preceding section of this document dealt with the structure and functioning of the model. In this section, screen-shot extracts will be given to show how actual numbers flow through the model.

38. In order to calculate the LRIC of each service the model performs a series of iterations that simulates the following:

    1) Initially the model calculates the total costs of each network element for a given set of input cost assumptions, input technical assumptions and original input demand volumes.
    2) Removes the service volumes of each service one at a time
    3) Upon removal of each service volume, it recalculates new total costs of each network element for the given set of input cost assumptions, input technical assumptions and the reduced input demand volumes.
    4) Then it subtracts the new total cost from the original total costs to produce the pure LRIC associated with the service whose volumes were removed.
    5) It identifies the increment specific fixed costs (ISFCs) and network-wide common costs (FCCs) and marks up the pure LRIC to produce , D-LRIC and full LRIC for each service
    6) The output after each iteration is posted to the 'BU Output' sheet.

39. The following case study provide calculation steps, intermediate outputs and final outputs to demonstrate how the model determines the LRIC for the Mobile termination service Building on the LRIC calculation, a summarised table of the Distributed LRIC and full LRIC is presented to the end of the case study. The study concludes by demonstrating the calculations involved in deriving the unit cost, using the summarised LRIC, DLRIC and Full LRIC values.

40. In order to make the presentation of results clearer, we have chosen to simplify that reporting somewhat. The simplifications are that

    a. we look at the direct capital costs NRC and depreciation components of the LRIC and leave out network opex and indirect capex derived from expense factors

    b. we explicitly trace through the impact on one network element—the BTS. However, the impacts on all network elements appear at the end of the case study.

c. We produce the DLRIC and full LRIC only in summary fashion as drilling down would require case studies of additional services.

41. Again, we have made these simplifications to facilitate presentation. Upon request we will be happy to broaden the reporting of this case study.

42. As indicated elsewhere, costs and volume numbers presented in this case study are "dummies" and may not be representative of what C&W Cayman or other operators face.

43. Three main categories of inputs are recognized, namely: Input Cost Assumptions; Input Technical Assumptions; and Input Usage Volume Assumptions.

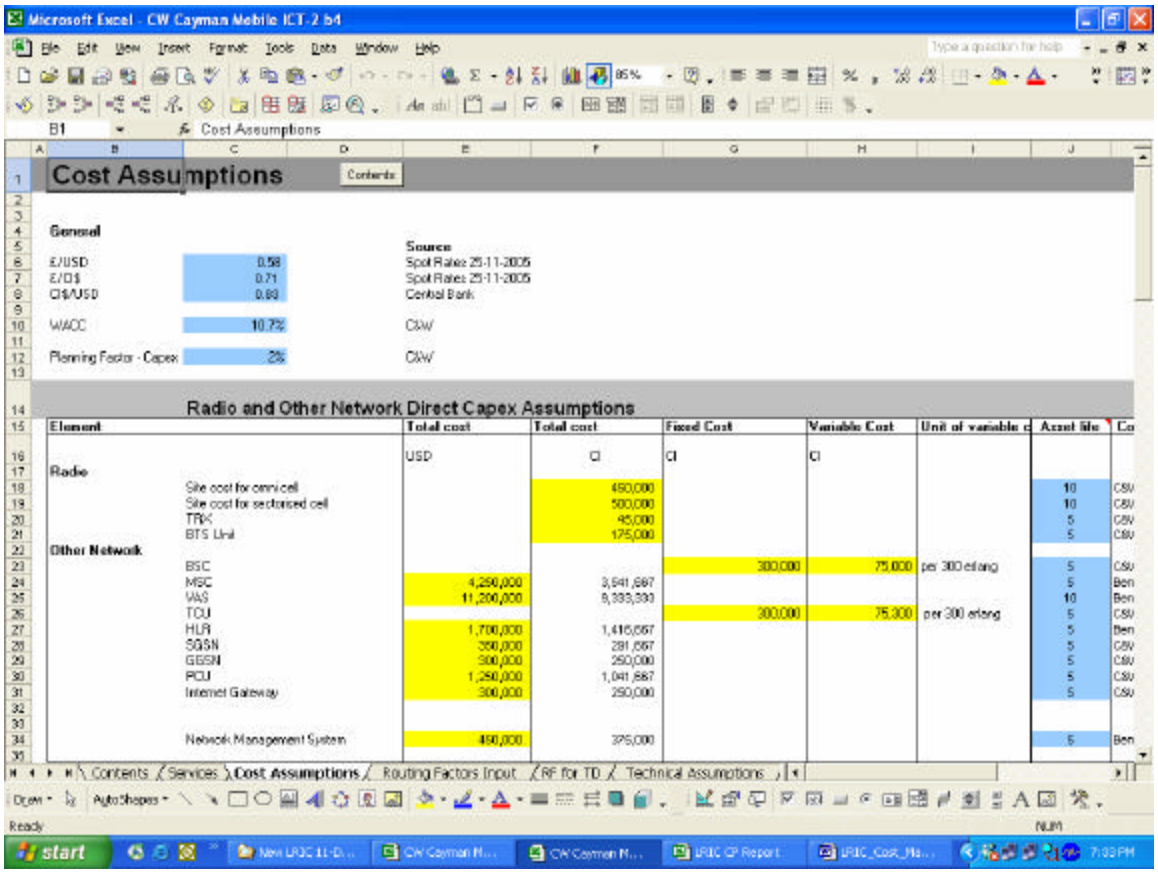
The Starting Point

44. To begin this case study, we examine first our set of assumptions by sheet.

Input Cost Assumptions

45. The Cost Assumption sheet contains the cost inputs of the model. Extract 1 captures the Capital Costs associated with the main components of the assumed GSM mobile network. This includes the capital cost of:

- Site costs of omni site
- Site costs of sectored site
- Radio units (TRXs)
- BTS
- BSC
- MSC
- VAS (Value Added Service)
- TCUs
- HLR
- SGSN
- GGSN
- PCU
- Internet gateway
- Network Management System



Extract 1

46. Please note that for the purposes of this case study we have assumed a WACC of 10.67%.

47. Extract 2 below captures the leased line tariffs assumed in the model. As stated in the Manual, the model assumes that the GSM network buys leased circuits at available commercial rates.

Leased Line/Microwave Tariffs for 3 yr contract

Capacity	Unit	Monthly Cost	Annual Cost
64	CI per link	191	2295
128	CI per link	383	4590
256	CI per link	765	9180
512	CI per link	956	11475
768	CI per link	956	11475
1024	CI per link	956	11475
1544	CI per link	956	11475
6000	CI per link	3,613	43350
9000	CI per link	4,335	52020
12000	CI per link	5,780	69360

18000	CI per link	6,503	78030
45000	CI per link	16,256	195075

48. Extract 3 captures the assumed proportions used to split the capital cost of the main network components into the three main functional areas. It shows for example that the capital cost of the BTS is allocated 100% to Minutes, a traffic related function.

Other

Element	Allocation to Call Attempts	Allocation to Minutes	Allocation to Subscriber
BTS	0%	100%	0%
BSC	0%	100%	0%
MSC	50%	50%	0%
VAS	0%	100%	0%
TCU	0%	100%	0%
HLR	50%	0%	50%
SGSN	0%	100%	0%
GGSN	0%	100%	0%
PCU	0%	100%	0%
Internet Gateway	0%	100%	0%
Cell Site	0%	0%	0%

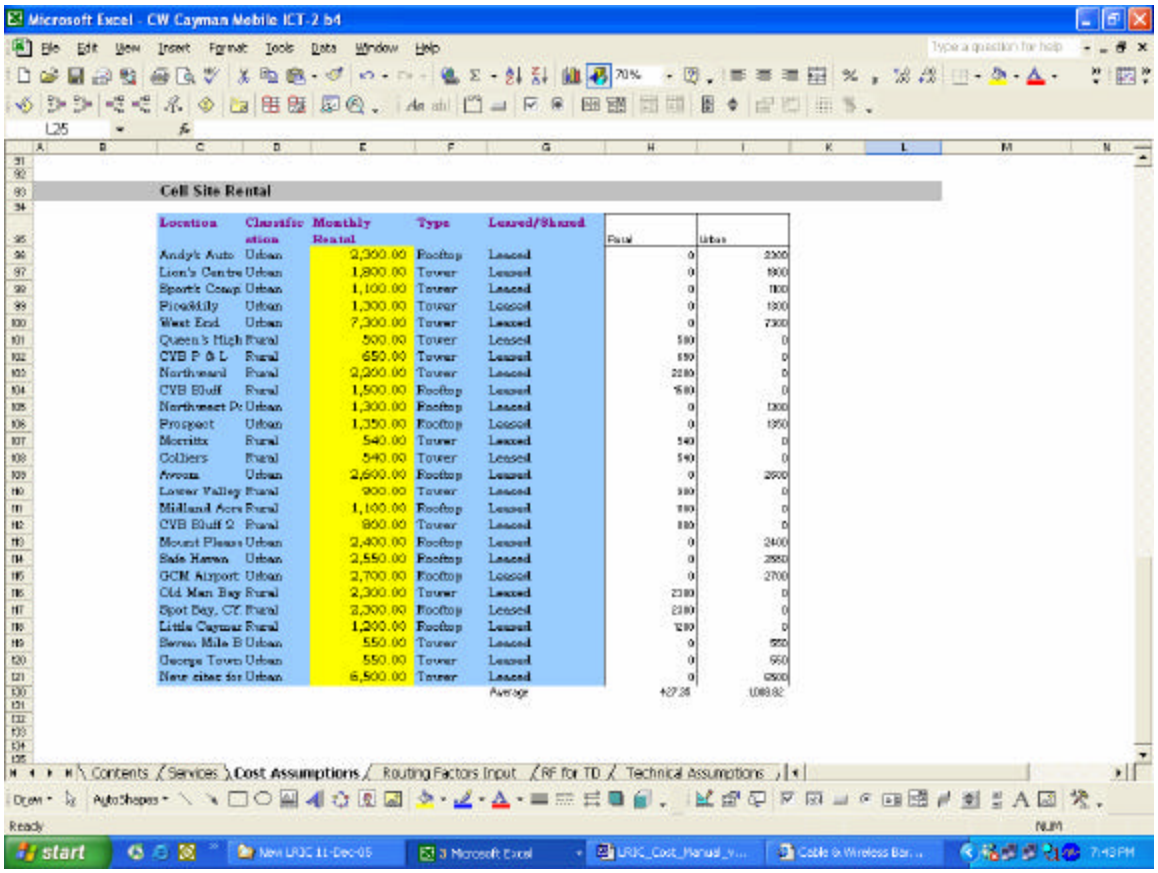
Extract 3

49. Extract 4 captures the assumptions used in calculating the cost of spares for each network component.

Element	Spares - % of total capex
BTS	5.0%
BSC	5.0%
MSC	5.0%
VAS	5.0%
TCU	5.0%
HLR	5.0%
SGSN	5.0%
GGSN	5.0%
PCU	5.0%
Internet Gateway	5.0%
Cell Site	5.0%

Extract 4

50. Extract 5 captures the cost assumptions used in calculating an average rental rate for urban and rural locations.

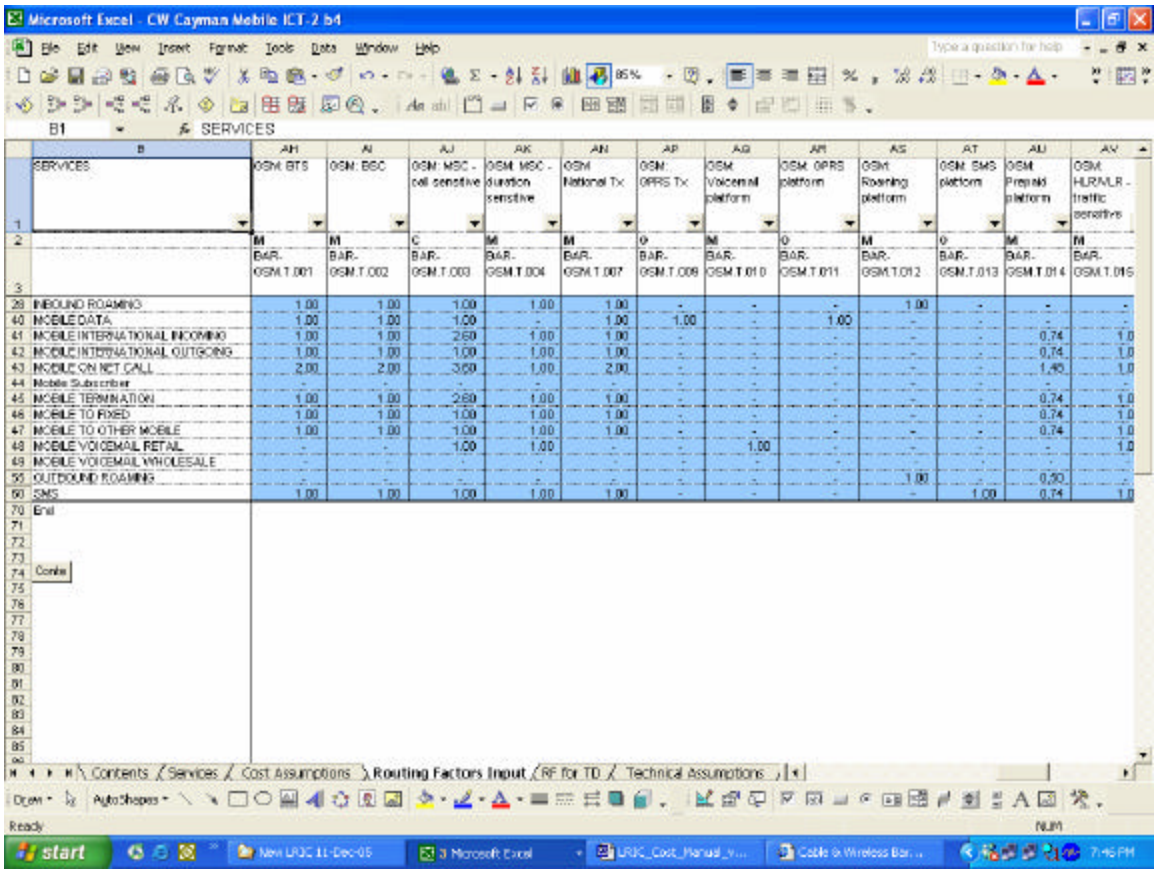


Extract 5

Input Technical Assumptions

Routing Factors Input Sheet

51. This sheet captures the routing factors (Extract 6) used in calculating the demand volumes for each network component. For a given service, routing factors reflect the level of usage of each network component by that service.



Extract 6

Technical Assumptions Sheet

52. Extract 7 captures the key technical assumptions employed in dimensioning the mobile network.

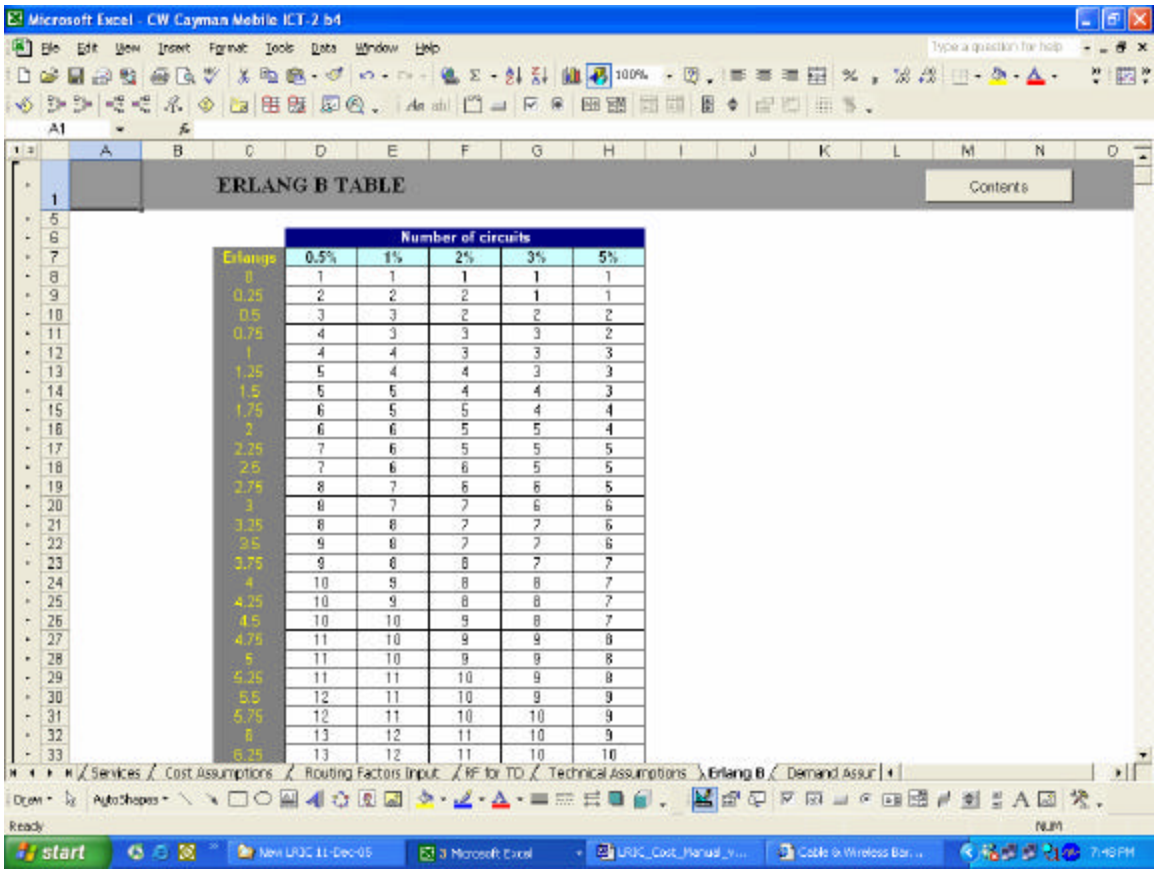
Technical Assumptions

Parameter	Data
Radio and Switching	
Available GSM 850 spectrum	10
Available GSM 1900 spectrum	15
Re-use factor GSM 850	7
Re-use factor GSM 1900	7
GSM Carrier bandwidth	200
Timeslots per carrier GSM	8
Radio Path GoS	2.0%
Traffic per T1 (Erl)	28 Erlangs typical
Tessalation factor used for planning	22.50%
Number of MSC	1
Traffic distribution	
Dense	59.10%
Medium	32.10%
Rural	8.80%
Coverage area surface (km2)	
Dense	22
Medium	47
Rural	195
Cell sectorisation per area	
Dense	0%
Medium	0%
Rural	0%
Maximum cell radius:	
Dense	1.5
Medium	2
Rural	4
Subscriber capacities and increments for MSC, HLR	TBD
# cell sites per BTS	6 maximum
Grade of service	2%
% BTS served by radio	8%
% BTS served by cable	92%
% of co-located BTS	TBD
Average microwave hops per BTS	1
Number and type of any dedicated transmission links (eg, microwave backhaul)	Approx. 203, HDSL
Number of NMS	1
Capacity planning max load factor	80%
GPRS Design Factors	
TS data trans. rate (kbps) (inc. overhead)	13
Busy hour capacity per TS (Mbits)	48
Assumed traffic per 2Mbit/s E1 (E)	20.3
Network increments	
Mobile network	
MSC increment	125,000
HLR increment	250,000
Number of cell sites per BSC	20
PCU Capacity	270
GSN Complex	
SGSN capacity	30,000
GGSN capacity	90,000
Internet gateway	
Capacity increment	100,000

Extract 7

Erlang B Table Sheet

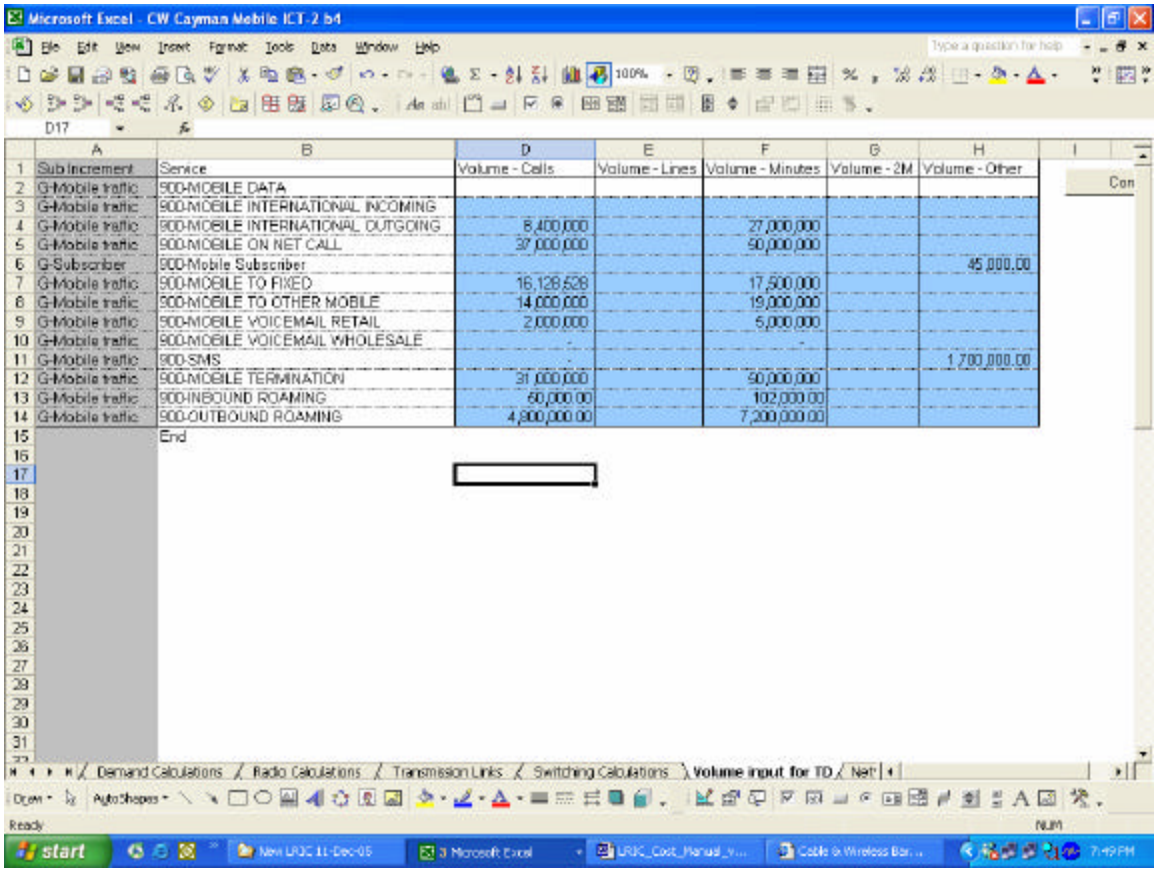
53. Extract 8 is part of the standard Erlang B table used in dimensioning mobile radio networks.



Extract 8

Input Usage Volume Assumptions

Volume Input Sheet



	A	B	D	E	F	G	H
1	SubIncrement	Service	Volume - Calls	Volume - Lines	Volume - Minutes	Volume - 2M	Volume - Other
2	G-Mobile traffic	900-MOBILE DATA					
3	G-Mobile traffic	900-MOBILE INTERNATIONAL INCOMING					
4	G-Mobile traffic	900-MOBILE INTERNATIONAL OUTGOING	8,400,000		27,000,000		
5	G-Mobile traffic	900-MOBILE ON NET CALL	37,000,000		50,000,000		
6	G-Subscriber	900-Mobile Subscriber					45,000.00
7	G-Mobile traffic	900-MOBILE TO FIXED	16,128,528		17,500,000		
8	G-Mobile traffic	900-MOBILE TO OTHER MOBILE	14,000,000		19,000,000		
9	G-Mobile traffic	900-MOBILE VOICEMAIL RETAIL	2,000,000		5,000,000		
10	G-Mobile traffic	900-MOBILE VOICEMAIL WHOLESALE	-		-		
11	G-Mobile traffic	900-SMS	-				1,700,000.00
12	G-Mobile traffic	900-MOBILE TERMINATION	31,000,000		90,000,000		
13	G-Mobile traffic	900-INBOUND ROAMING	60,000.00		102,000.00		
14	G-Mobile traffic	900-OUTBOUND ROAMING	4,800,000.00		7,200,000.00		
15		End					

Extract 9

54. Extract 9 above captures the assumed usage volumes of each service, this combined with the routing factors produces the demand volumes of each network component.

Demand Assumptions Sheet

55. Extract 10 below captures the demand assumptions such as the average conversation holding time, % traffic in busy hour and ratio of total calls to successful to calls.

Parameter	Value
Voice usage	
Avg non conversation holding time (minutes per call)	0.11
No of busy days in month	30
% of daily traffic in BH	10%
Proportion of mobile to mobile traffic	28%
Ratio of total/successful calls	1.24
Data usage	
Monthly usage per sub (kbits) (bothway)	25.00
Usage for each SMS (kbits) (bothway)	0.500

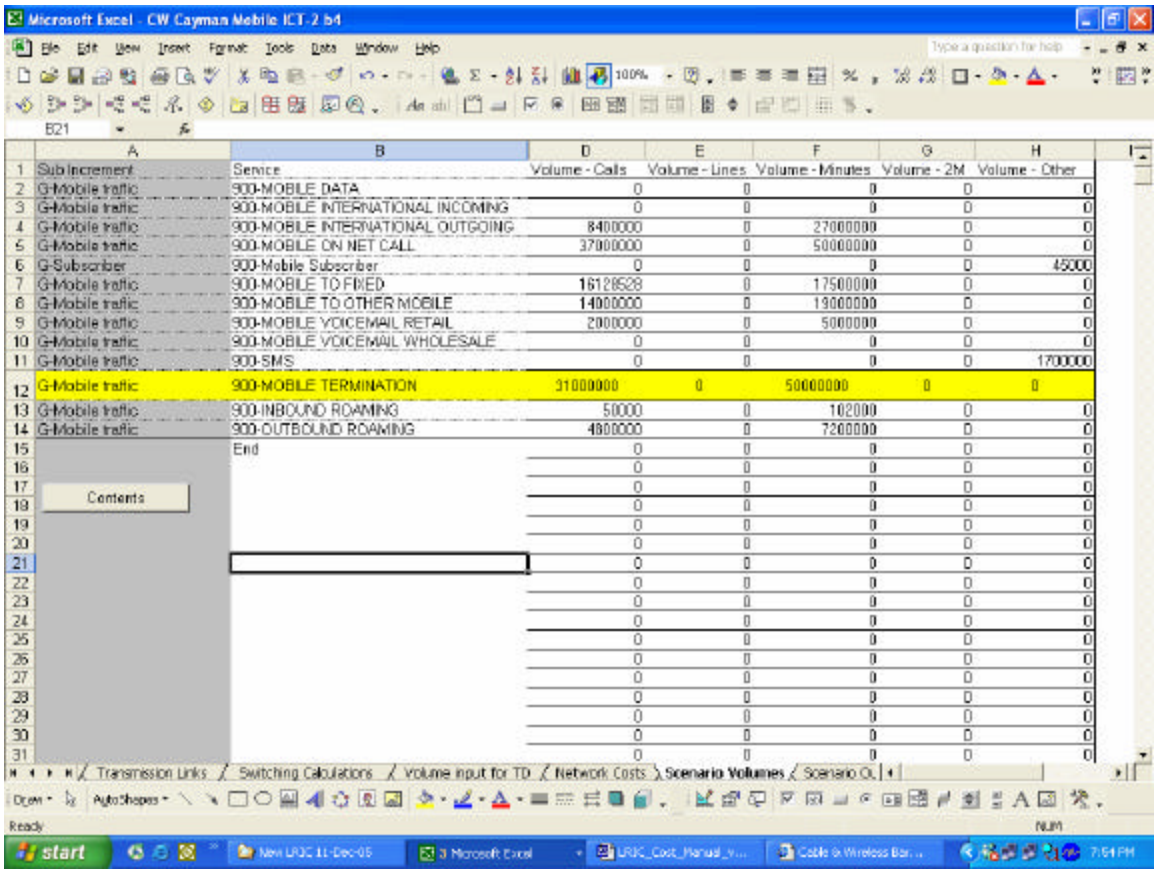
Extract 10

Calculating BU LRIC

56. The following manual steps describe the calculation process involved in computing the LRIC for the Mobile Termination service. This is done using only one network element, the BTS, and observing the change in cost of the BTS when the Mobile Termination service volumes are eliminated. Other network elements impacted by a change in mobile termination or the large increment (traffic) to which mobile termination belongs are the BSC, MSC, national transmission, HLR/VLR and prepaid platform. However, it order to ease the presentation will be showing the screen shot extracts only of the impacts on the BTS. Nevertheless, we will show the calculation of the comprehensive impacts at the end of the case study.

Step 1

In calculating the incremental cost of Mobile Termination the model sets the volumes (calls: 31,000,000 and minutes: 50,000,000) of the service 900-MOBILE TERMINATION to zero. This is done through the 'Scenario Volumes' sheet, an extraction of which is shown below.



	A	B	D	E	F	G	H
1	SubIncrement	Service	Volume - Calls	Volume - Lines	Volume - Minutes	Volume - 2M	Volume - Other
2	G-Mobile traffic	900-MOBILE DATA	0	0	0	0	0
3	G-Mobile traffic	900-MOBILE INTERNATIONAL INCOMING	0	0	0	0	0
4	G-Mobile traffic	900-MOBILE INTERNATIONAL OUTGOING	8400000	0	27000000	0	0
5	G-Mobile traffic	900-MOBILE ON NET CALL	37000000	0	50000000	0	0
6	G-Subscriber	900-Mobile Subscriber	0	0	0	0	45000
7	G-Mobile traffic	900-MOBILE TO FIXED	16128528	0	17500000	0	0
8	G-Mobile traffic	900-MOBILE TO OTHER MOBILE	14000000	0	19000000	0	0
9	G-Mobile traffic	900-MOBILE VOICEMAIL RETAIL	2000000	0	5000000	0	0
10	G-Mobile traffic	900-MOBILE VOICEMAIL WHOLESALE	0	0	0	0	0
11	G-Mobile traffic	900-SMS	0	0	0	0	1700000
12	G-Mobile traffic	900-MOBILE TERMINATION	31000000	0	50000000	0	0
13	G-Mobile traffic	900-INBOUND ROAMING	50000	0	102000	0	0
14	G-Mobile traffic	900-OUTBOUND ROAMING	4800000	0	7200000	0	0
15		End	0	0	0	0	0

Extract 11

Step 2

Demand Calculations Sheet

The objective of this sheet is to calculate the Demand Volumes for the various network elements.

Given the elimination of the Mobile Termination service volumes in step 1, the 'Total annual minutes (for network sizing)' is recalculated and is reduced, it moves from 253,283,951 minutes, as shown in Extract 12, **down to 197,198,542 minutes thereafter**.

Where:

2.1) 'Total annual minutes (for network sizing)' = Sum(Total minutes from Mobile + Total minutes to Mobile) x (1+ (% for non conversation holding time)

Demand Calculations

Usage Calculations

Voice Usage

	Minutes from mobile	Minutes to mobile
MOBILE DATA		
MOBILE INTERNATIONAL INCOMING	-	-
MOBILE INTERNATIONAL OUTGOING	27,000,000	-
MOBILE ON NET CALL	50,000,000	50,000,000
MOBILE TO FIXED	17,500,000	-
MOBILE TO OTHER MOBILE	19,000,000	-
MOBILE VOICEMAIL RETAIL		5,000,000
MOBILE VOICEMAIL WHOLESALE		-
MOBILE TERMINATION		50,000,000
INBOUND ROAMING		102,000
OUTBOUND ROAMING	7,200,000	
Total	120,700,000	105,102,000
% for non conversation holding time	12.17%	7.09%
Total annual minutes (for network sizing)	253,283,952	
Total busy hour erlangs	1173	
Voice BH traffic per subscriber (mE)	26	

Extract 12

Given the new 'Total annual minutes (for network sizing)' the 'Total Busy Hour Erlangs' and the 'Voice Busy Hour traffic per Subscriber (mE)' is recalculated, they are given by the following equations:

2.2) 'Total Busy hour Erlangs' = (Total Service Usage Volume/12)/ (No of busy days in month *from Extract 10*) x (% of daily traffic in BH *from Extract 10)/ 60* = 1172 **(new value = 913)**

2.3) 'BH Traffic per Subscriber' = ((Total Busy hour Erlangs) / (# Subscribers *from Extract 8*)) x 1000 = 26 **(new value = 20)**

After calculating eqns. 2.2 and 2.3 the Busy Hour Erlang required for Interconnect related traffic is computed. This is calculated using the following two equations and the values before reduction is shown in Extract 13 below:

2.4) 'Annual minutes for Interconnect Link Sizing' = Max(one-way interconnect traffic) x (1+ (% for non conversation holding time)) = 79,304,768 **(no change in value)**

2.5) 'Total Busy hour Erlangs' = (Sum Interconnect traffic *from Extract 12*)/12)/ (No of busy days in month *from Extract 10*) x (% of daily traffic in BH *from Extract 10)/ 60* = 367 **(no change in value)**

The results of eqns. 2.4 and 2.5 are subsequently used to dimension the MSC Trunk Controller Units (TCUs).

Interconnect traffic	
Total interconnect traffic o/g	70,700,000
Total interconnect traffic i/c	50,102,000
Maximum one-way interconnect traffic	70,700,000
Annual minutes for ic link sizing	79,304,769
BHE	367

Extract 13

After calculating the above the next step is to compute the demand volumes of the network elements. This step requires two key inputs, one is the actual usage demand (minutes and calls, obtained from the *Volume Input Sheet*) for all conveyance related services and the other is the Routing factors captured in the *Routing Factors Assumptions sheet*. These inputs are restated in this sheet (*Demand Calculations Sheet)* for ease of computation. See extracts 14 and 15 below.

Demand for conveyance services

Conveyance Services	Call conversation minutes (Actual Demand) (mins)	Successful calls (Actual Demand), (calls)
MOBILE INTERNATIONAL OUTGOING	27,000,000	8,400,000
MOBILE ON NET CALL	50,000,000	37,000,000
MOBILE TO FIXED	17,500,000	16,128,528
MOBILE TO OTHER MOBILE		

	19,000,000	14,000,000
MOBILE VOICEMAIL RETAIL	5,000,000	2,000,000
MOBILE TERMINATION	50,000,000	31,000,000
Total	168,500,000	108,528,528

Extract 14

Routing Factors

	GSM: BTS	GSM: BSC	GSM: MSC -call sensitive	GSM: MSC - duration sensitive
Conveyance Services				
MOBILE INTERNATIONAL OUTGOING	1.00	1.00	1.00	1.00
MOBILE ON NET CALL	2.00	2.00	3.60	1.00
MOBILE TO FIXED	1.00	1.00	1.00	1.00
MOBILE TO OTHER MOBILE	1.00	1.00	1.00	1.00
MOBILE VOICEMAIL RETAIL	0.00	0.00	1.00	1.00
MOBILE TERMINATION	1.00	1.00	2.60	1.00

Extract 15

Extracts 14 and 15 are combined in the following formula to calculate the Demand Volume of the network elements:

2.6) 'Demand (annual minutes)' = Sumproduct(Volumes of Extract 14 : GSM: NE values of Extract 15)

Using the BTS as an example network element, the computed 'Demand (annual minutes)' and corresponding Demand (BHE) are calculated as follows:

2.7) Before elimination of the Mobile Termination service volumes the: 'Demand (annual minutes)' = (1 x 27,000,000 + 2 x 50,000,000 + 1 x 17,500,000 + 1 x 19,000,000 + 0 x 5,000,000 + 1 x 50,000,000) = 213,500,000 (shown below in extract 16)

2.8) After reduction of the volumes, the new 'Demand (annual minutes)' for the GSM: BTS Network Element is:
= (1 x 27,000,000 + 2 x 50,000,000 + 1 x 17,500,000 + 1 x 19,000,000 + 0 x 5,000,000 + 0 x 50,000,000) = 163,500,000

Demand Measures by NE				
	GSM: BTS	GSM: BSC	GSM: MSC-call sensitive	GSM: MSC-duration sensitive
Driver	Minutes	Minutes	Calls	Minutes
Demand (annual minutes or calls)	213,500,000	213,500,000	254,328,528	168,500,000
Demand (BHE)	988	988		780

Extract 16

2.7 and 2.8 are repeated for each Network Element used in facilitating Mobile Termination service.

Step 3

Radio Calculations Sheet

After Step 2, the next important step takes place in the *Radio Calculations Sheet*. This step is key to the design of the radio network, in it the number of cell sites, the number of cells and the number of TRXs (Radio units) are calculated using inputs from the *Technical Assumptions Sheet* (Extract 7), Voice Usage in Erlangs calculated in the *Demand Calculations Sheet* (Extract 12) and the *Demand Assumptions Sheet* (Extract 10).

Radio Calculations

Inputs			
	Data and SMS subs	43,609	45,000
	Annual SMS	1,700,000	
	Data usage per sub	0.0833	
	SMS usage per sub	0.01	
	Data and SMS usage per sub (BH Mbits)	0.0001	
	Voice demand (E)	1173	
	Data-SMS demand BH Mbits	4	
	Cell tessellation factor	22.50%	

Extract 17

Extract 17 captures some key technical inputs, shown above in their pre-reduction values. These are required in the dimensioning of the radio network. They are:

3.1) 'Data and SMS subs' - Total # Mobile Subscribers, obtained ultimately from the *Volume Inputs Sheet*, Extract 9

3.2) 'Annual SMS' – SMS usage volume, obtained ultimately from the *Volume Inputs Sheet* Extract 9

3.3) 'Data usage per sub' – calculated figure using the formula:

((Monthly usage per sub (kbits) (bothway) *from Extract 10*) / (No of busy days in month *from Extract 10*)) x (% of daily traffic in BH *from Extract 10*)

3.4) 'SMS usage per sub' – calculated figure using the formula:

((Annual SMS *from 3.2*) / (Data and SMS subs *from 3.2*)) x (Usage for each SMS (kbits) (bothway) *from Extract 10*) / 12 / (No of busy days in month *from Extract 10*)) x (% of daily traffic in BH *from Extract 10*)

3.5) 'Data and SMS usage per sub (BH Mbits)' – calculated figure using the formula:
(Data usage per sub *from 3.3* + SMS usage per sub *from 3.4*) / 1024

3.6) 'Voice demand (E)' – linked directly to the *Demand Calculations Sheet* (Extract 12)

3.7) 'Data-SMS demand BH Mbits' – calculated figure obtained from the formula:

(Data and SMS subs *from Extract 16*) x (Data and SMS usage per sub (BH Mbits) *from 3.5*)

3.8) Cell tessellation factor – linked directly to the *Technical Assumptions Sheet* (Extract 7)

The removal of Mobile Termination volumes affects only the Voice Demand (E) parameter above, which reduces from 1172 down to 913. This has been explained in Step 2 above.

Extracts 18 and 19 together capture results of the algorithm used in calculating the dimensions of the radio network the results of which are shown in Extract 20 below:

Calculations

	Max carriers per sector 850	8.00			
	Max carriers per sector 1900	11.00			
		Dense Urban	Urban	Rural	
	Area (sq km)	22	47	195	264

Calculations					
	Percentage Traffic	59%	32%	9%	
	Voice demand	693	376	103	
Checks	Max cell radius	1.5	2	4	
	Max cell area	5.85	10.4	41.6	
	Min number of sites	5.00	6.00	6.00	17.00
		Dense Urban	Urban	Rural	
	Average cell radius	1.5	2.00	4.00	
	Number of cells (omni and sectorised)	15	18	18	
	% of omni cells	0%	0%	0%	
	% of sectorised cells	100%	100%	100%	
	Number of sites	5	6	6	
	Effective Voice Traffic per cell (E)	57.75	26.14	7.17	
	Effective data and sms traffic per cell (Mbits)	0.19	0.08	0.02	
	850MHz effective Voice Traffic per cell (E)	23.10	10.46	2.87	
	850MHz effective data and sms traffic per cell (Mbits)	0.07	0.03	0.01	
	1900MHz effective Voice Traffic per cell (E)	34.65	15.68	4.30	
	1900MHz effective data and sms traffic per cell (Mbits)	0.11	0.05	0.01	
	Radio path Grade of Service	2.0%	Erlang table column	4	
	850MHz: Required number of timeslots for voice per cell	31	16	6	

Calculations					
	850MHz: Required number of timeslots for data and sms per cell	1	1	1	
	850MHz: Total number of timeslots per cell	32	17	7	
	850MHz: Timeslots per carrier (TRX)	8	8	8	
	850MHz: Required number of TRXs per cell (sector)	4	3	1	
	850MHz: Voice erlangs per TRX	5.78	3.49	2.87	
	1900MHz: Required number of timeslots for voice	43	22	8	
	1900MHz: Required number of timeslots for data and sms	1	1	1	
	1900MHz: Total number of timeslots	44	23	9	
	1900MHz: Timeslots per carrier	8	8	8	
	1900MHz: Required number of TRXs per cell	6	3	2	
	1900MHz: Voice erlangs per TRX	5.78	5.23	2.15	
	850MHz	Dense Urban	Urban	Rural	Total
	Number of omni-sites	0	0	0	0
	Number of sectorised sites	5	6	6	17
	Total number of sites	5	6	6	17
	Number of omni-cells	0	0	0	0
	Number of sectorised cells	15	18	18	51

Calculations					
	Total number of cells	15	18	18	51
	Number of TRXs	60	54	18	132
	1900MHz				
	Number of omni-sites	0	0	0	0
	Number of sectorised sites	5	6	6	17
	Total number of sites	5	6	6	17
	Number of omni-cells	0	0	0	0
	Number of sectorised cells	15	18	18	51
	Total number of cells	15	18	18	51
	Number of TRXs	90	54	36	180

Extract 18

1					1	1	1	1	1	1
2	Dense Urban	Urban	Rural		Dense Urban	Dense Urban	Dense Urban	Dense Urban	Dense Urban	Dense Urban
3	22	47	195		22	22	22	22	22	22
4	59%	32%	9%		59%	59%	59%	59%	59%	59%
5										
6	722.21	392.27	107.54		722.2143	722.2143	722.2143	722.2143	722.2143	722.2143
7										
8										
9										
10										
11										
12										
13	Dense Urban	Urban	Rural							
14	1.50	4.25	11.95		0.05	0.075	0.1	0.125	0.15	0.175
15										
16	12.00	6.00	3.00		10155	4515	2541	1626	1131	831
17										
18	-	-	-		0%	0%	0%	0%	0%	0%
19	1.00	1.00	1.00		100%	100%	100%	100%	100%	100%
20										
21	4.00	2.00	1.00		3385	1505	847	542	377	277
22										

Extract 19

Sections 6. through to 19 of the Manual provide a comprehensive description on the function and reasons for the underlying algorithm employed in determining the results below in Extract 20. For the sake of not being overly burdensome, that section is not repeated here. However, after having an understanding of the fundamental operation of the algorithm, it remains to determine how the results of the algorithm are affected when Mobile Termination volumes are eliminated. Before doing so however, the other inputs to the algorithm must be explained, they are:

3.9) 'Max carriers per sector 850' – This calculates the maximum number of radios (limiting factor) required for the 850 MHz spectrum. It is calculated using the formula:

((Available GSM 850 spectrum *from Extract 7*) / (GSM Carrier bandwidth *from Extract 7*) / (Re-use factor GSM 850 *from Extract 7*)) x 1000 and rounded up to the nearest whole number.

3.10) 'Max carriers per sector 1900' - This calculates the maximum number of radios (limiting factor) required for the 1900 MHz spectrum. It is calculated using the formula:

((Available GSM 1900 spectrum *from Extract 7*) / (GSM Carrier bandwidth *from Extract 7*) / (Re-use factor GSM 1900 *from Extract 7*)) x 1000 and rounded up to the nearest whole number.

3.11) 'Area (sq km)' – This is the assumed coverage areas for Dense Urban; Urban; and Rural areas. These are obtained directly from Extract 7 of the *Technical Assumptions Sheet.*

3.12) 'Percentage Traffic' – This captures directly from Extract 7 of the *Technical Assumptions Sheet*, the assumed percentage of traffic expected in the three geographic design areas.

3.13) Voice demand by Geographic Area – This calculates the voice demand for each of the three geographic areas by multiplying the 'Voice Demand (E)' captured in Extract 17 above by the percentage Traffic of each area: = (Voice Demand (E) *from Extract 17*) x (Percentage Traffic *from Extract 18*)

Removing Mobile Termination volumes changes the 'Voice Demand by Geographic area', this is because the 'Voice demand(E)' parameter reduces from 1172 down to 913 as explained for Extract 17 in Step 2 above.

This reduction subsequently affects the calculated values of the following parameters of Extracts 18 and 19; example below is cited for the dense urban geographic area. Note however, that the same changes apply to the other two geographic areas.

3.14) 'Effective Voice Traffic per cell (E)' = (Voice demand (E) *from Extract 18*) / (Number of cells (omni and sectorised) *from Extract 18*) /(Capacity planning max load factor *from Extract 7*).

3.15) 'The Number of cells (omni and sectorised)' *from Extract 18* in the formula above is the sum of the number of omni cells plus the number of sectored cells. The formula in the model is given as: = (% omni cells *from extract 7*) x (Number of sites *from extract 18*) + (% sectorised cells *from*

extract 7) x (Number of sites *from extract 18*) rounded up to the nearest whole number.
Where:
3.15.1) 'Number of sites' *from extract 18* = (Coverage Area (sq km) for Dense Urban) / (Max cell area which is approximated using the formula 2.6 x Average cell radius raised to the power of 2). Extract 19 uses a special algorithm matching cell capacity to radii in order to find the optimum radii for the required capacity.

After calculating the Effective Voice Traffic per cell (E), this is then used to calculate the allocation of voice traffic for each of the two spectrum categories, the 850MHz and the 1900 MHz. These are calculated as follows:

3.16) '850MHz effective Voice Traffic per cell (E)' = ((Available GSM 1900 spectrum *from extract 7*) / (Available GSM 1900 spectrum + Available GSM 850 spectrum)) x (Effective Voice Traffic per cell (E))

3.17) '1900MHz effective Voice Traffic per cell (E)' = (Effective Voice Traffic per cell (E)) – (850MHz effective Voice Traffic per cell (E))

Given the 1900MHz effective Voice Traffic per cell (E) and 850MHz effective Voice Traffic per cell (E) calculated above, the '850MHz: Required number of timeslots for voice per cell' and '1900MHz: Required number of timeslots for voice per cell' are calculated. For example, the required number of timeslots for voice per cell for the 850 MHz spectrum is dependent on the radio path grade of service, assumed to be 2.0% and the calculated voice traffic per Erlang. Thus looking up the Erlang B table from Extract 8 produces the required number of circuits, in this case 32 before removal of Mobile Termination volumes. **Removing Mobile Termination volumes reduces this to 26**.

Similarly the '850 MHz required number of timeslots for data and SMS' is calculated, this works out to be 1. **The removal of Mobile Termination volumes have no effect on the timeslots required for data and SMS**.

Ultimately given the required number of timeslots for voice, data and SMS the required number of radios (TRXs) is calculated using the following formula:

3.18) 'Number of TRXs for 850 MHz' = (850MHz: Required number of TRXs per cell (sector)) x (Total number of cells)

Where:
3.18.1) '850MHz: Required number of TRXs per cell (sector)' = (850MHz: Total number of timeslots per cell) / (850MHz: Timeslots per carrier (TRX) *from Extract 7*)

and

3.18.2) 'Total number of cells' = sum of the number of omni cells plus the number of sectored cells. The formula in the model is given as: = (% omni cells *from extract 7*) x (Number of sites *from extract 18*) + (% sectorised cells *from extract 7*) x (Number of sites *from extract 18*) rounded up to the nearest whole number

Removing Mobile Termination volumes reduces the calculated required number of TRXs for 1900 MHz from 90 down to 75, no change is experienced for the 850 MHz TRXs, the required number remains the same at 60.

The pre-reduction results are captured in Extract 20 below. That is, the total 'Number of TRXs' for Dense Urban reduces from 150 down to 135 after removal of Mobile Termination volumes.

The number of TRXs for the two other geographic areas is similarly affected.

Overall, the total number of TRXs reduces from 312 as shown in Extract 20 down to 261.

Results				
Number of omni-sites	0	0	0	0
Number of sectorised sites	5	6	6	17
Total number of sites	5	6	6	17
Number of omni-cells	0	0	0	0
Number of sectorised cells	15	18	18	51
Total number of cells	15	18	18	51
Number of TRXs	150	108	54	312
Total voice timeslots				2046
Total data and sms timeslots				102

Extract 20

Step 4

Transmission Links Sheet

The objective of the *Transmission Links Sheet* is to calculate the number and capacity of transmission links required between the BTSs and BSCs. The two key inputs into this sstep are:

- Number of TRXs required from the *Radio Calculations Sheet*, Extract 20, Step 3.
- Capacity per TRX kbit/s from the *Technical Assumptions Sheet*, Extract 7.

Removing Mobile Termination volumes ultimately affect the required capacity of transmission links between BTSs and BSCs. **For example when Mobile termination volumes are removed the required capacity for sectored sites drops from 768 kbps down to 512 kbps**

Extract 21 captures the pre-reduction results

Transmission Links

Dimensions

BSC-BTS links

	Dense Urban	Urban	Rural	total
Number of omni-sites	0	0	0	0
Number of sectorised sites	5	6	6	17
Total number of sites	5	6	6	17
Number of omni-cells	0	0	0	0
Number of sectorised cells	15	18	18	51
Total number of cells	15	18	18	51
Number of TRXs	150	108	54	312
TRXs per cell	10	6	3	6.12
TRXs per site - omni	10	6	3	6.12
TRXs per site - sectorised	30	18	9	18.35
Capacity per TRX kbit/s	25	25	25	25
Dimensioned capacity per TRX kbit/s	31	31	31	31
Total LL capacity required - omni	313	188	94	191
Total LL capacity required - sectored	938	563	281	574
LL product required - omni	**512**	**256**	**128**	**256**
LL Product required - sectored	**1024**	**768**	**512**	**768**
Number required - omni	**0**	**0**	**0**	**0**
Number required - sectored	**5**	**6**	**6**	**17**

LL Capacities Available - kbit/s
45000
18000
12000
9000
6000
1544
1024
768
512
256
128
64

Extract 21

Step 5

Switching Calculations Sheet

The objective of the Switching Calculations sheet is to calculate the following:

- Number of MSCs
- Number of BSCs
- Erlang per BSC
- Number of TCUs
- Erlangs per TCU
- Number of HLRs
- Number of SGSNs
- Number of GGSNs

Removing the volumes of Mobile Termination affects the Erlangs per BSC and Erlangs per TCU.

The Erlang per BSC reduces from 1236 down to 946.

The Erlangs per TCU does not change in this case since it is dependent on the maximum of the inflow traffic vs. outflow traffic as demonstrated in equations 2.4 and 2.5 of Step 2 above. In this case the assumed volume of outflow traffic is greater than the inflow volume assumed, therefore reducing Mobile termination volumes to zero, which reduces the inflow volumes even more. Thus, based on the eqns. 2.4 and 2.5 the max volume remains unchanged, therefore, not affecting the required TCU capacity in Erlangs.

The pre-reduction results of switching calculations are shown in Extracts 22 and 23 below.

Switching Calculations

Inputs	
Voice subscribers	45,000
data and sms subscribers	45,000
Capacity planning max load factor	80%
Assumed traffic per 2Mbit/s E1 (E)	20.3
Total number of sites	17.00
MSC	
MSC increment	125,000.00
Number of MSCs	1.00
BSC	
Number of cell sites per BSC	20
Number of BSCs	1.00
Number of Erlangs per BSC	988
Erlangs per BSC including capacity planning allowance	1,236
TCU	
Number of TCUs	1
Number of Erlangs per TCU	367
Erlangs per TCU including capacity planning allowance	459
HLR	
HLR increment	250,000.00
Number of HLRs	1.00

Extract 22

Data and sms system infrastructure calculations	
PCU	
PCU Increment	270.00
Capacity required (time slots)	102.00
Number of PCUs	1.00
GSN Complex	
SGSN capacity	30,000.00
GGSN capacity	90,000.00
Number of SGSNs	1.00
Number of GGSNs	1.00
Internet gateway	
Capacity increment	100,000.00
Number of units	1.00

Extract 23

Step 6

Network Cost Sheet

This step brings together the results of all the previous steps and sheets and calculates the Capital and Operating costs for each network component. It is in this step that the ultimate cost impact of removing Mobile Termination volumes is realized.

The capital cost of the BTS is computed according to the following:

6.1) 'No of TRXs per BTS' = (Number of TRXs *from Step 3, eqn 3.18*) / (Total number of sites *from Step 3, eqn 3.15.1*) **= 312 / 18 = 18 Pre-reduction value**

6.2) calculate the 'Average TRX cost for a BTS'. This is = (TRX unit cost *from*
Extract 1, Cost Assumptions Sheet) x (No of TRXs per BTS' *from eqn 6.1*) **= 45,000 x 18** = **825,882 Pre-reduction value**

6.3) Then the Total Unit Cost of a BTS complete with TRXs = Sum(Average TRX cost for a BTS' *from eqn 6.2* + BTS unit (less the TRXs) *from Extract 1, Cost Assumptions Sheet*) **= 825,882 + 175,000 = 1,000,882 Pre-reduction value**

6.4) Therefore the 'Total Capital Cost of a complete BTS excluding spares' is = (Unit Cost of a BTS complete TRXs *from 6.3*) x (Total number of sites *from Step 3, eqn 3.15.1*) **= 1,000,882 x 17 = 17,015,000 Pre-reduction value**

6.5) Adding for spares and planning produces 'Total capital cost (incl spares and planning)'= (Total capital cost (excl spares) *from eqn 6.4*) x (1 + Spares - % of total capex *from Extract 4, Cost Assumptions Sheet*) x (1 + Planning factor - % capex *from Extract 1*) = **17,015,000 x (1 + 5%) x (1 + 2%) = 18,223,065 Pre-reduction value**

6.6) Adding for the Network Management System which is spread across Network Elements on an equi-proportionate basis, this is = (Total capital cost (incl spares and planning) *from eqn 6.5*) + 255,918 = **(18,223,065 + 255,918 = 18,478,983) Pre-reduction Total Capital Cost of BTS or Effective NRC**

Extract 24 captures the pre-reduction results, they are for the BTS:

Effective NRC = 18,478,983
Depreciation = 2,986,718
BTS-BSC links = 195,075

After reducing Mobile Termination volumes to zero the above values reduces to:

Effective NRC = 16,021,038
Depreciation = 2,589,446
BTS-BSC links = 181,305

Network Costs

Contents

Direct Capex

Calculation of BTS Unit Cost

BTS Calculations

	Number	Unit Cost	Asset Life	
Site and Cell Costs				
Omni Sector BTS	0	450,000	5	
Sectorised BTS	17	500,000	5	
Average cell cost for a BTS		500,000	5	
TRX Costs	Number	Unit Cost	Asset Life	No of TRX per BTS
TRX	312	45,000	5	18
Average TRX cost for a BTS		825,882	5	

BTS Cost	Total Cost	Asset Life
Site and Cell	500,000	5
TRX	825,882	5
BTS Unit	175,000.00	5
Total	1,500,882.35	5

Inputs

Asset Life

	BTS	BSC	MSC		TCU
Unit Equipment	5	5	5		5

Allocation

	BTS	BSC	MSC		TCU
Call Attempts	0%	0%	50%		0%
Minutes	100%	100%	50%		100%
Subscribers	0%	0%	0%		0%

Volume

		BTS	BSC	MSC		TCU
Number of nodes		17	1	1		1
Number of sites		15	1	1		1
Number of network management sys	1					

Unit Cost

		BTS	BSC	MSC		TCU
Unit Equipment		1,000,882	675,000	3,541,667		450,600
Network Management system	375000					

Capital Costs

	BTS	BSC	MSC		TCU
Total capital cost (excl spares)	17,015,000	675,000	3,541,667		450,600
	17,015,000	675,000	3,541,667		450,600
Total capital cost	17,015,000	675,000	3,541,667		450,600
Total capital cost (incl spares and planning)	18,223,065	722,925	3,793,125		482,593

	Minutes related			
	BTS	BSC	MSC	TCU
Total capital cost	18,223,065	722,925	1,896,563	482,593
Total capital cost including Network Management System	18,478,983	733,078	1,923,197	489,370
Annualised Capex Cost (Simple Annuity)	4,958,426	196,705	516,047	131,312
Depreciation	2,986,718	118,486	310,842	79,096
Cost of Capital	1,971,708	78,219	205,205	52,216
Effective NRC	18,478,983	733,078	1,923,197	489,370

Operating Costs

Annual opex

Transmission Links

	Dense Urban	Urban	Rural	Total
LL product requir	512	256	128	
LL Product requir	1,024	768	512	
Number required	-	-	-	
Number required	5	6	6	
Unit Cost - omni	11,475	9,180	4,590	
Unit Cost - secto	11,475	11,475	11,475	
Total opex	57,375	68,850	68,850	**195,075**

Cell Site Rental

	Annual Unit Cost	Number of Sites	Opex
Dense Urban	12,106	5	60,529
Urban	12,106	6	72,635
Rural	5,128	6	30,769
Total		**17**	**163,934**

Extract 24

Step 7

Scenario Output Sheet

This is where the before and after scenario is played out to calculate the Incremental cost of Mobile Termination which is finally output to the model's *BU Output Sheet* shown in Extract 27.

The cost impact of removing Mobile Termination volumes equates to its Incremental cost. The results of the *Network Cost Sheet* are posted to the Scenario Output sheet where the differences between the network elements' calculated total costs of the pre-reduction and post-reduction scenarios are calculated and stored. These differences generate the BU LRIC values for Mobile Termination.

Scenario Output Before Removal of Mobile Termination Volumes

Entity	NRC	Depreciation	Opex
400-GSM: BTS	18,478,983	2,986,718	-
400-GSM: BSC	733,078	118,486	-
400-GSM: MSC -call sensitive	1,923,197	310,842	-
400-GSM: MSC -duration sensitive	2,412,567	389,938	-
400-GSM: MSC - MSC Tx Link	-	-	-
400-GSM Int'l Tx	-	-	-
400-GSM National Tx	-	-	195,075
400-GSM: Interconnect Link Fixed - Voice	-	-	-
400-GSM: GPRS Tx	-	-	-
400-GSM: Voicemail platform	-	-	-
400-GSM: GPRS platform	1,991,075	321,813	-
400-GSM: Roaming platform	-	-	-
400-GSM: SMS platform	-	-	-
400-GSM: Prepaid platform	-	-	-
400-GSM: HLR/VLR - traffic sensitive	769,279	124,337	-
400-Cellsite land & masts	9,103,500	553,117	163,934
400-GSM: Handsets and SIM card/activation platform	-	-	-
400-GSM: HLR/VLR - subscriber sensitive	769,279	124,337	-
End			
Total	36,180,958	4,929,588	359,009

Extract 25

Scenario Output After Removal of Mobile Termination Volumes

Entity	NRC	Depreciation	Opex
400-GSM: BTS	16,021,038	2,589,446	-
400-GSM: BSC	652,753	105,503	-
400-GSM: MSC -call sensitive	1,923,197	310,842	-
400-GSM: MSC -duration sensitive	2,412,567	389,938	-
400-GSM: MSC - MSC Tx Link	-	-	-
400-GSM Int'l Tx	-	-	-
400-GSM National Tx	-	-	181,305
400-GSM: Interconnect Link Fixed - Voice	-	-	-
400-GSM: GPRS Tx	-	-	-
400-GSM: Voicemail platform	-	-	-
400-GSM: GPRS platform	1,991,075	321,813	-
400-GSM: Roaming platform	-	-	-
400-GSM: SMS platform	-	-	-
400-GSM: Prepaid platform	-	-	-
400-GSM: HLR/VLR - traffic sensitive	769,279	124,337	-
400-Cellsite land & masts	9,103,500	553,117	163,934
400-GSM: Handsets and SIM card/activation platform	-	-	-
400-GSM: HLR/VLR - subscriber sensitive	769,279	124,337	-
End			
Total	33,642,688	4,519,333	345,239
Difference: (Before Reduction Total minus After Reduction Total)	**2,538,270**	**410,255**	**13,770**

Extract 26

Subtracting the NRC, Depreciation and Opex totals of Extract 26 from Extract 25 produces the following Incremental values for Mobile Termination. These are shown in the last row of Extract 26 above

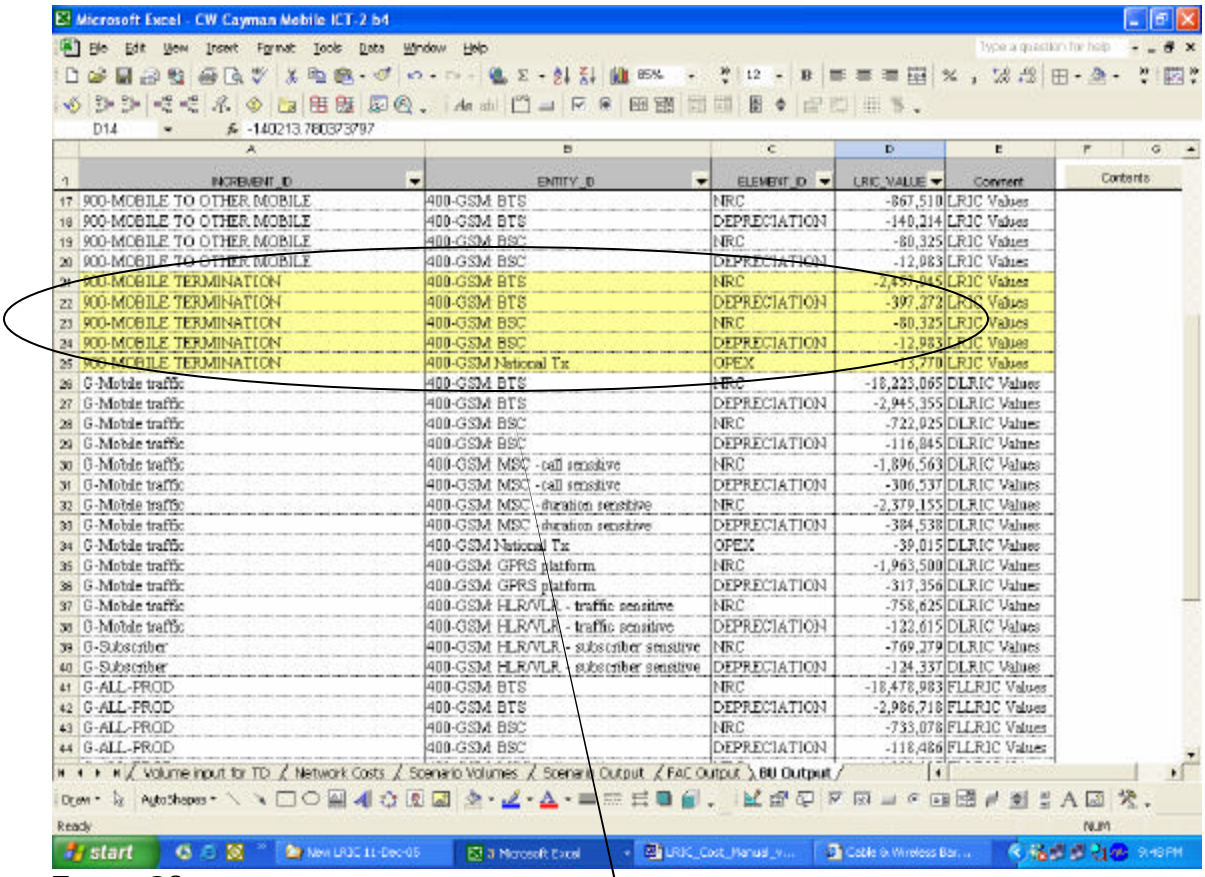
Step 8

BU Output Sheet

This is the final step where the results of the *Scenario Output Sheet* are posted, as shown below in Extract 26.

The Model in an iterative manner simulates the removal of the volumes of each service and calculates the associated LRIC values of NRC, Depreciation and Opex. These values are finally posted to the *BU Output Sheet*. Again the BU LRIC values associated with the Mobile Termination service are highlighted.

LRIC values with Mobile Termination shaded as reported in the *BU Output Sheet*



Extract 26

900-MOBILE TERMINATION	400-GSM: BTS	NRC	-2,457,945
900-MOBILE TERMINATION	400-GSM: BSC	NRC	-80,325
900-MOBILE TERMINATION	400-GSM: BTS	DEPRECIATION	-397,272
900-MOBILE TERMINATION	400-GSM: BSC	DEPRECIATION	-12,983
900-MOBILE TERMINATION	400-GSM National Tx	OPEX	-13,770

The model also calculates Bottom-up Joint (Increment Specific Fixed Costs) and Common costs which are reported in the *BU Output Sheet*. See section 3 of the Manual for a detail explanation of Joint and Common costs.

Joint costs or Increment Specific Fixed Costs (ISFCs) that are common to more than one Network Element are labeled in the BU model as G-Mobile Traffic, G-Subscriber or G-ALL-PROD. The addition of the Joint costs to the BU LRIC produces the BU Distributed LRIC (BU-DLRIC). These are allocated to services on the basis of each service BU LRIC value. See extracts 27 and 28 for more detail on the derivation of the BU-DLRIC amounts as they apply to Mobile Termination.

Common Costs are costs that are common to all services. The addition of Common costs to DLRIC will produce what is called BU Fully Distributed LRIC (BU-FLLRIC).

The summary that follows captures the BU-LRIC, BUDLRIC and BU-FLLRIC values for Mobile Termination and calculates the unit cost for all three values.

Scenario Output before removal of all traffic related service volumes

	Entity	NRC	Depreciation	Opex
	400-GSM: BTS	18,478,983	2,986,718	-
	400-GSM: BSC	733,078	118,486	-
	400-GSM: MSC -call sensitive	1,923,197	310,842	-
	400-GSM: MSC -duration sensitive	2,412,567	389,938	-
	400-GSM: MSC - MSC Tx Link	-	-	-
	400-GSM Int'l Tx	-	-	-
	400-GSM National Tx	-	-	195,075
	400-GSM: Interconnect Link Fixed - Voice	-	-	-
	400-GSM: GPRS Tx	-	-	-
	400-GSM: Voicemail platform	-	-	-
	400-GSM: GPRS platform	1,991,075	321,813	-
	400-GSM: Roaming platform	-	-	-
	400-GSM: SMS platform	-	-	-
	400-GSM: Prepaid platform	-	-	-
	400-GSM: HLR/VLR - traffic sensitive	769,279	124,337	-
	400-Cellsite land & masts	9,103,500	553,117	163,934
	400-GSM: Handsets and SIM card/activation platform	-	-	-
	400-GSM: HLR/VLR - subscriber sensitive	769,279	124,337	-
	End			
	Total	36,180,958	4,929,588	359,009
1	Difference: (Before Reduction of all Traffic related Volumes minus After Reduction of all Traffic related Volumes, Extract 27 - Extract 28)	25,943,833	4,193,246	39,015
2	Total BU LRIC from BU Output Sheet for Traffic Related Services	11,036,655.00	1,783,830.87	27,540.00
3	Therefore: Actual DLRIC Markup = 1 - 2	14,907,177.60	2,409,415.14	11,475.00
4	BU-DLRIC Markup % = 3 / 2	135%	135%	42%
5	Mobile Termination BU LRIC (from Total BU LRIC summary table below)	2,538,270.00	410,255.14	13,770.00
6	Mobile Termination BU LRIC as %age of of Total Traffic Related BU LRIC = 5 / 2	23%	23%	23%
8	**DLRIC Amount Allocated to Mobile Termination is therefore as shown in the summary table below (BU Joint Cost) = 6 x 3**	**3,465,520.99**	**560,125.00**	**2,667.63**

Extract 27

Scenario Output after removal of all traffic related service volumes

Entity	NRC	Depreciation	Opex
400-GSM: BTS	255,918	41,364	-
400-GSM: BSC	10,153	1,641	-
400-GSM: MSC -call sensitive	26,635	4,305	-
400-GSM: MSC -duration sensitive	33,412	5,400	-
400-GSM: MSC - MSC Tx Link	-	-	-
400-GSM Int'l Tx	-	-	-
400-GSM National Tx	-	-	156,060
400-GSM: Interconnect Link Fixed - Voice	-	-	-
400-GSM: GPRS Tx	-	-	-
400-GSM: Voicemail platform	-	-	-
400-GSM: GPRS platform	27,575	4,457	-
400-GSM: Roaming platform	-	-	-
400-GSM: SMS platform	-	-	-
400-GSM: Prepaid platform	-	-	-
400-GSM: HLR/VLR - traffic sensitive	10,654	1,722	-
400-Cellsite land & masts	9,103,500	553,117	163,934
400-GSM: Handsets and SIM card/activation platfo	-	-	-
400-GSM: HLR/VLR - subscriber sensitive	769,279	124,337	-
End			
Total	10,237,125	736,342	319,994

Extract 28

Summary BU LRIC, DLRIC and FLLRIC results for Mobile Termination service

Assuming:
WACC = 10.67%
Volumes (minutes) = 50,000,000

Then:
BU LRIC for Mobile Termination service (derived using the concepts outlined in Steps 1 – 8)

A	B	C	D	E	F	G
Network Element	**LRIC value – NRC**	**LRIC value - Depreciation**	**LRIC value -Opex**	**Cost of Capital = B x WAC**	**Total Economic Cost = C+D+E**	**Unit Cost = F / Volumes**
400 GSM BTS	$ 2,457,945.00	$ 397,272.38		$262,262.73	$ 659,535.11	
400 GSM BSC	$ 80,325.00	$ 12,982.76		$ 8,570.68	$ 21,553.43	
400 GSM National. Tx			$ 13,770.00			$ 13,770.00
TOTAL BU-LRIC	$ 2,538,270.00	$ 410,255.14	$ 13,770.00	$270,833.41	$ 694,858.54	**$ 0.014**

BU Distributed LRIC (DLRIC) for Mobile Termination Service = LRIC + Joint Cost

A	B	C	D	E	F	G
Cost Type	**BU DLRIC - NRC**	**BU DLRIC - Depreciation**	**BU DLRIC value - Opex**	**Cost of Capital = B x WAC**	**Total Economic Cost = C+D+E**	**Unit Cost = F / Volumes**
BU LRIC	$ 2,538,270.00	$ 410,255.14	$ 13,770.00	$270,833.41	$ 694,858.54	
BU Joint Cost	$ 3,465,520.99	$560,125	$ 2,667.63	$369,771.09	$ 932,563.44	
TOTAL BU-DLRIC	$ 6,003,790.99	$ 970,379.86	$ 16,437.63	$640,604.50	$ 1,627,421.99	**$ 0.033**

BU Fully Loaded LRIC (FLLRIC) for Mobile Termination Service = LRIC + Joint Cost + Common Cost

A	B	C	D	E	F	G
Cost Type	**BU FLLRIC – NRC**	**BU FLLRIC - Depreciation**	**BU FLLRIC value - Opex**	**Cost of Capital = B x WAC**	**Total Economic Cost = C+D+E**	**Unit Cost = F / Volumes**
DLRIC	$ 6,003,790.99	$ 970,379.86	$ 16,437.63	$640,604.50	$ 1,627,421.99	
BU Common Cost	$ 2,137,980.13	$ 138,199.94	$ 72,259.42	$228,122.48	$ 438,581.84	
TOTAL BU-FLLRIC	$ 8,141,771.12	$1,108,579.80	$ 88,697.05	$868,726.98	$ 2,066,003.83	**$ 0.041**

Appendices

Appendix IA. Demand Calculations (Minutes and BH Erlang equivalents)

Demand Calculations

Usage Calculations

Voice Usage

	Minutes from mobile	Minutes to mobile
MOBILE DATA		
MOBILE INTERNATIONAL INCOMING	-	
MOBILE INTERNATIONAL OUTGOING		
MOBILE ON NET CALL		
MOBILE TO FIXED		
MOBILE TO OTHER MOBILE		
MOBILE VOICEMAIL RETAIL		
MOBILE VOICEMAIL WHOLESALE		
MOBILE TERMINATION		
Total		

			Source
% for non conversation holding time			Demand Assumptions
Total annual minutes (for network sizing)			=Total minutes to/from * (1+ % non conv holding time)

Total busy hour erlangs	
Voice BH traffic per subscriber (mE)	

Interconnect traffic

Total interconnect traffic o/g		(International o/g + MTF + MTOM minutes)
Total interconnect traffic i/c		(International i/c + FTM + OMTM minutes)
Maximum one-way interconnect traffic		(max of interconnect o/g or i/c)
Annual minutes for ic link sizing		(max of interconnect o/g or i/c) * (1 + % non-conv holding time)
Busy Hour Erlang equivalent		

Appendix IB. Demand Calculations (Demand by Network Element)

=

Demand Measures by Network Element

Element:	GSM: BTS	GSM: BSC	GSM: MSC - call sensitive	GSM: MSC - duration sensitive	GSM National Tx	GSM: Interconnect Link Fixed - Voice	GSM: GPRS Tx	GSM: Voicemail platform	GSM: GPRS platform	GSM: Roaming platform	GSM: SMS platform	GSM: Prepaid platform	GSM: HLR/VLR traffic sensitive	Cellsite land & masts	GSM: Handsets and SIM card/activation platform	GSM: HLR/VLR - subscriber sensitive
Driver:	Minutes	Minutes	Calls	Minutes	Minutes	Minutes	Minutes	Minutes	Minutes	Minutes	Minutes	Minutes	Minutes	Minutes	Minutes	Minutes
Demand (annual minutes or calls)																
Demand (BHE)																

Appendix II: Radio Calculations

Radio Calculations

Inputs

			Source
Data and SMS subs		A	Demand Assumptions
Annual SMS	-	B	Demand Assumptions
Data usage per sub		C	Demand Assumptions
SMS usage per sub		D	Demand Assumptions
Data and SMS usage per sub (BH Mbits)		E	Demand Assumptions
Voice demand (E)		F	Demand Calculations
Data-SMS demand BH Mbits	-	G	=E*A
Cell tessellation factor		H	Technical Assumptions

Calculations

Max carriers per sector 850			Technical Assumptions (Available spectrum/Carrier Bandwidth/Reuse factor)
Max carriers per sector 1900			Technical Assumptions (as above)

	Dense Urban	Urban	Rural	Total	
Area (sq km)					Technical Assumptions
Percentage Traffic					Technical Assumptions
Voice demand					=F*Percentage Traffic

	Dense Urban	Urban	Rural	
Average cell radius				Technical Assumptions
Number of sites				Derived from average Cell radius given Area and tessellation factor
% of omni cells				Technical Assumptions
% of sectorised cells				Technical Assumptions
Number of cells (omni and sectorised)				Weighted average
Effective Voice Traffic per cell (E)				Voice demand/# of Cells/Capacity load factor (Technical Assumptions)
Effective data and sms traffic per cell (Mbits)				G/#of cells*Percentage traffic/capacity load factor
850MHz effective Voice Traffic per cell (E)				Voice traffic per cell*percentage 850Mhz
850MHz effective data and sms traffic per cell (Mbits)				Data traffic per cell*percentage 850Mhz
1900MHz effective Voice Traffic per cell (E)				Voice traffic per cell*percentage 1900Mhz
1900MHz effective data and sms traffic per cell (Mbits)				Data traffic per cell*percentage 1900Mhz
Radio path Grade of Service				Technical Assumptions
850MHz: Required number of timeslots for voice per cell				Technical Assumptions (Grade of service, for data traffic per cell)
850MHz: Required number of timeslots for data and sms per cell				Technical Assumptions (Grade of service, for voice traffic per cell)
850MHz: Timeslots per carrier (TRX)				Technical Assumptions
850MHz: Required number of TRXs per cell				Total number of timeslots per cell/timeslots per carrier (TRX)
1900MHz: Required number of timeslots for voice				Technical Assumptions (Grade of service, for data traffic per cell)
1900MHz: Required number of timeslots for data and sms				Technical Assumptions (Grade of service, for voice traffic per cell)
1900MHz: Total number of timeslots				
1900MHz: Timeslots per carrier				Technical Assumptions
1900MHz: Required number of TRXs per cell				Total number of timeslots per cell/timeslots per carrier (TRX)

850MHz	Dense Urban	Urban	Rural	
Number of omni-sites				Number of sites*% omni cells
Number of sectorised sites				Number of sites*% sectorized cells
Total number of sites				
Number of omni-cells				Number of sites*% omni cells
Number of sectorised cells (tri-sectorized)				Number of sites*% sectorized cells*3
Total number of cells				
Total Number of TRXs (850Mhz)				Required number of TRXs per cell* total number of cells
1900MHz				
Number of omni-sites				Number of sites*% omni cells
Number of sectorised sites				Number of sites*% sectorized cells
Total number of sites				
Number of omni-cells				Number of sites*% omni cells
Number of sectorised cells (trisectorized)				Number of sites*% sectorized cells*3
Total number of cells				
Total Number of TRXs (1900Mhz)				Required number of TRXs per cell* total number of cells
Total Number of TRXs (850Mhz+1900Mhz)				
850MHz: Voice erlangs per TRX				Voice traffic by cell*number of cells/total number of TRXs
1900MHz: Voice erlangs per TRX				Voice traffic by cell*number of cells/total number of TRXs

Total voice timeslots	
Total data and sms timeslots	

Appendix III. Switching Calculations

Switching Calculations

		Source
Inputs		
Voice subscribers		Demand Assumptions
data and sms subscribers		Demand Assumptions
Capacity planning max load factor		Technical Assumptions
Assumed traffic per 2Mbit/s E1 (E)		Technical Assumptions
Total number of sites		Radio Calculations
MSC		
MSC increment		Technical Assumptions
Number of MSCs		=Voice Subscribers/MSC increment
BSC		
Number of cell sites per BSC		Technical Assumptions
Number of BSCs		=Total number of sites/number of sites per BSC
Number of Erlangs per BSC		=Total number of Erlangs (from Demand Calcs)/number of BSCs
Erlangs per BSC including capacity planning allowance		Adjusted for capacity load factor
TCU		
Number of TCUs		=number of MSCs
Number of Erlangs per TCU		from Demand Calculations
Erlangs per TCU including capacity planning allowance		Adjusted for capacity load factor
HLR		
HLR increment		Technical Assumptions
Number of HLRs		=Voice subscribers/HLR increment
Data and sms system infrastructure calculations		
PCU		
PCU Increment		Technical Assumptons
Capacity required (time slots)		Radio Calculations
Number of PCUs		Number of PCU given capacity required
GSN Complex		
SGSN capacity		Technical Assumptions
GGSN capacity		Technical Assumptions
Number of SGSNs		Required Capacity given # of Data Subscribers
Number of GGSNs		Required Capacity given # of Data Subscribers
Internet gateway		
Capacity increment		Technical Assumptions
Number of units		Required Capacity given # of Data Subscribers

Appendix IV. Transmission Links

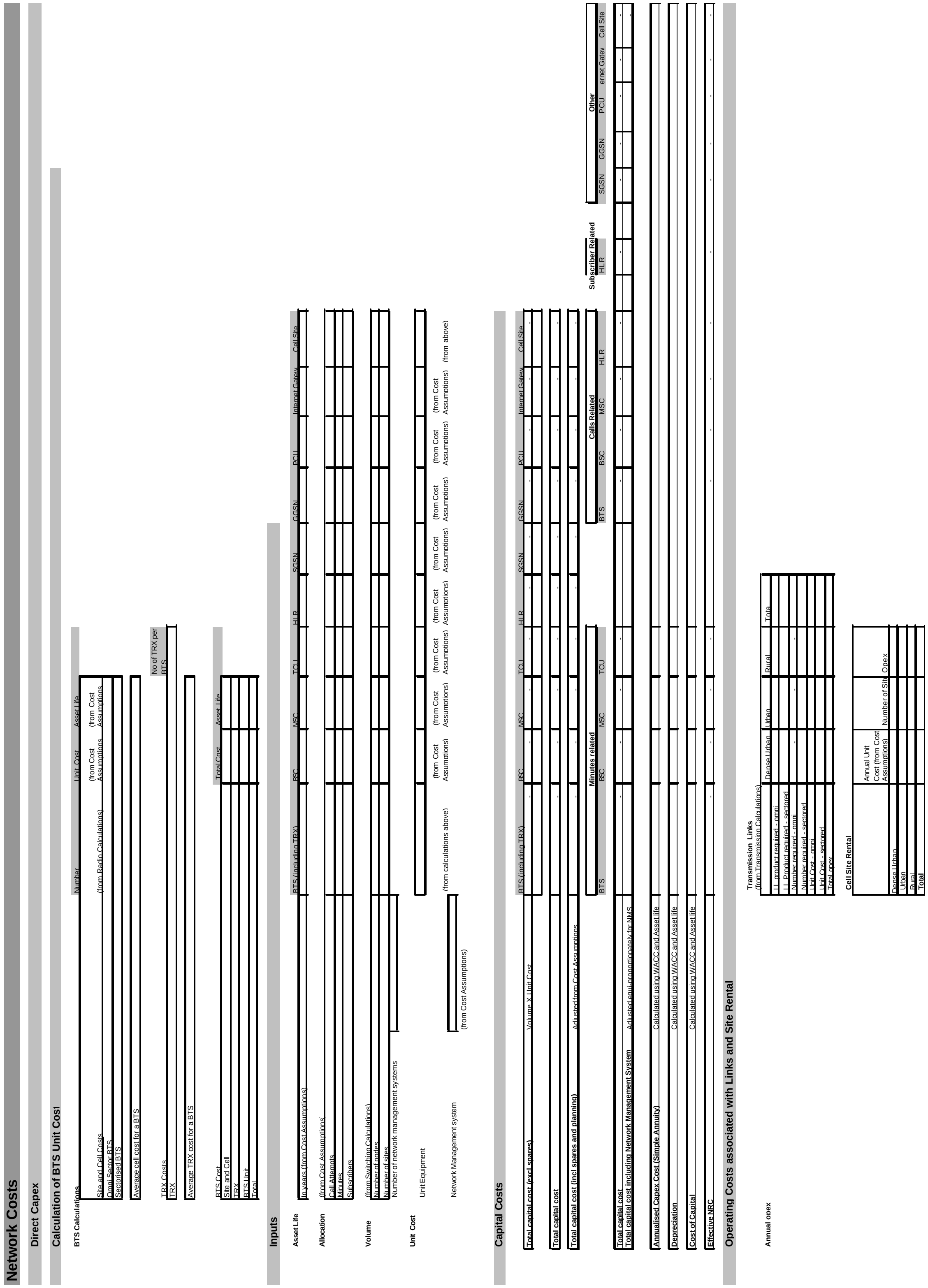
Transmission Links

BSC-BTS links

	Dense Urban	Urban	Rural	Total	Source
Number of omni-cells					A (from Radio Calculations)
Number of sectorised cells					B (from Radio Calculations)
Total number of cells					C (from Radio Calculations)
Number of omni-cells					D (from Radio Calculations)
Number of sectorised cells (trisectorized)					E (from Radio Calculations)
Total number of cells					F (from Radio Calculations)
Number of TRXs					G (from Radio Calculations)
TRXs per cell					H=G/F
TRXs per site - omni					I=H
TRXs per site - sectorised (tri-sectorised)					J=H*3
Capacity per TRX kbit/s					K=Carrier bandwidth/timeslot per carrier (from Technical Assumptions)
Dimensioned capacity per TRX kbit/s					L=H adjusted for capacity load factor (from Technical Assumptions)
Total LL capacity required - omni					M=L*I
Total LL capacity required - sectored (tri-sectorised)					N=L*J
LL product required - omni					Closest purchaseable capacity available
LL Product required - sectored					Closest purchaseable capacity available
Number required - omni					O=B
Number required - sectored					P=C

LL Capacities Available - kbit/s
45000
18000
9200
4600
2048
1544
1024
768
512
256
128
64

Appendix V. Network Costs.



Appendix VI. List of Inputs

Cost Assumption Inputs:

- Exchange Rates
- Weighted Average Cost of Capital (WACC)
- Planning Factor

Network Costs

- Radio and Other Network Direct Capex Assumptions
    - ♦ Radio
        - o Site cost for omni cell
        - o Site cost for sectorised cell
        - o TRX
        - o BTS Unit
    - ♦ Other Network Equipment
        - o BSC
        - o MSC
        - o VAS
        - o TCU
        - o HLR
        - o SGSN
        - o GGSN
        - o PCU
        - o Internet Gateway
        - o Network Management System
- Cost Allocation to Call Attempts (%), by network element
- Cost Allocation to Minutes (%), by network element
- Cost Allocation to Subscriber (%), by network element

Other

- Leased Line/Microwave Tariffs for 3 yr contract
- Spares - % of total Capex
- Cell Site Rental Charges

Technical Inputs

- Radio and Switching
    - o Available GSM 850 or 900 spectrum
    - o Available GSM 1900 or 1800 spectrum
    - o Re-use factor GSM 850 or 900
    - o Re-use factor GSM 1900 or 1800
    - o GSM Carrier bandwidth
    - o Timeslots per carrier GSM

    - Radio Path GoS
    - Traffic per T1 (Erl)
    - Tessellation factor used for planning
    - Number of MSC
- Traffic distribution
    - Dense (%)
    - Medium (%)
    - Rural (%)
- Coverage area surface (km2)
    - Dense
    - Medium
    - Rural
- Cell sectorisation per area
    - Dense (%)
    - Medium (%)
    - Rural (%)
- Maximum cell radius:
    - Dense (km)
    - Medium (km)
    - Rural (km)
- # cell sites per BTS
- Grade of service
- % BTS served by Micro Radio
- % BTS served by Fibre Cable
- % of BSC co-located with BTS
- Average microwave hops per BTS
- Number and type of any dedicated transmission links (eg, microwave backhaul)
- Number of NMS
- Capacity planning max load factor
- GPRS Design Factors
    - TS data trans. rate (kbps) (inc. overhead)
    - Busy hour capacity per TS (Mbits)
    - Assumed traffic per 2Mbit/s E1 (E)
- Network increments (To calculate the number of increments required)
    - MSC
    - HLR increment
    - Number of cell sites per BSC
    - PCU Capacity
    - GSN Complex
    - SGSN capacity
    - GGSN capacity
    - Internet Gateway Capacity increment
- Erlang b table

Demand Assumptions

Voice Usage

- Average non conversation holding time (minutes per call)
- No of busy days in month
- % of daily traffic in BH
- Proportion of mobile to mobile traffic
- Ratio of total/successful calls

Data Usage

- Monthly usage per sub (kbits) (bothway)
- Usage for each SMS (kbits) (bothway)

Asset Lives

- BTS (including TRX)
- BSC
- MSC
- TCU
- HLR
- SGSN
- GGSN
- PCU
- Internet Gateway
- Cell Site

Routing Factors

Volume Inputs

- Mobile Data (# Circuits & Mbits)
- Mobile International Incoming (Minutes & # Calls)
- Mobile International Outgoing (Minutes & # Calls)
- Mobile On Net Call (Minutes & # Calls)
- Mobile Subscriber (# Subscribers)
- Mobile To Fixed (Minutes & # Calls)
- Mobile To Other Mobile (Minutes & # Calls)
- Mobile Voicemail Retail (Minutes & # Calls)
- Mobile Voicemail Wholesale (Minutes & # Calls)
- Sms (# Calls)
- Mobile Termination (Minutes & # Calls)
- Inbound Roaming (Minutes & # Calls)
- Outbound Roaming (Minutes & # Calls)