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

Cable & Wireless Cayman Islands

Submitted 10 March 2006

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LRIC mobile Network model

1. Introduction

1. This document is the first part of a revised version of a draft LRIC costing manual, which C&W submitted on 14 December 2005 fulfilling 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. That draft and this revised LRIC costing manual, as required by the Authority, 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. The original draft costing manual also include two WACCs proposed for use in the fixed and mobile network models, respectively.

3. This revised version reflects the the Authority's revised process determination of 8 February 2006, which in addition to the above, requires C&W to file the costing models. With this additional requirement, C&W has had to expand its written submission to tie the documents more closely to the model. We have also used the intervening time to:

    a. gather more evidence with respect to expense factors,

    b. provide an alternative method of allocating fixed and common costs, and

c. correct a number of typographical errors and make a number of clarifications to the original text.

4. This revised submission is divided into five parts:

a. 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.

b. 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.

c. The Mobile Network Model Manual, which describes 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.

d. The cost separations methodology, which describes how the inputs to the expense factor analysis were developed.

e. The LRIC models themselves, which are comprised of four modules: i) bottom-up fixed network model; ii) the bottom-up mobile network model; and iii) a consolidation module. As explained below, C&W has generated two versions of the LRIC models—a confidential version that it has submitted to the authority and a non-confidential version that it has submitted to other interested parties in the proceeding.

5. 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.

6. The mobile service set is smaller than the fixed one. Mobile traffic services are split in a similar way to the fixed ones: retail and wholesale. 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.

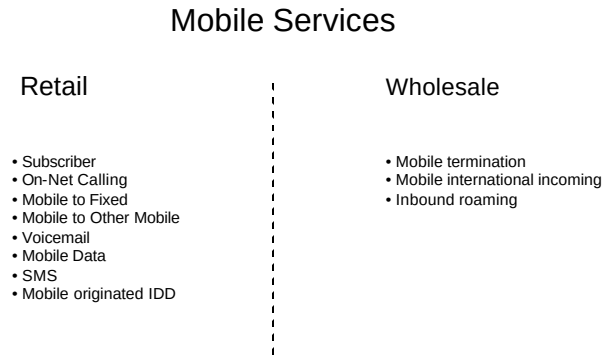


Figure 1 Mobile services in the LRIC model

2. Methodology

1. A GSM network consists of Cell Sites, BTSs, BSCs and MSCs. In addition to these basic network building blocks (shown below) there are several other pieces of equipment, including TCUs and VLR/HLRs, that require consideration in a comprehensive costing exercise.

GSM Mobile Network Diagram

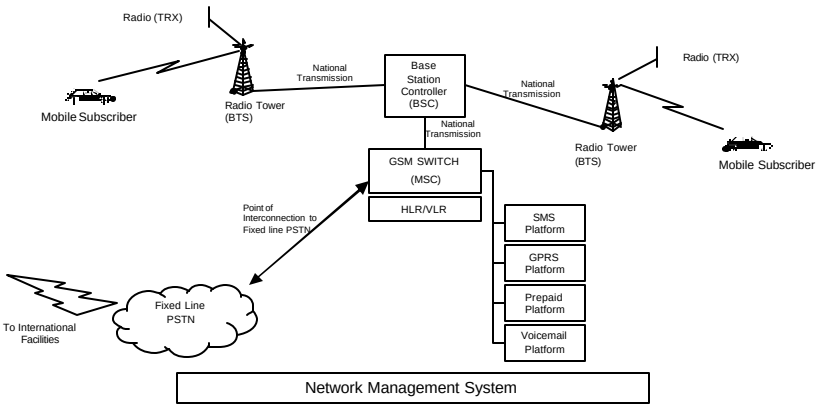


Figure 2 Mobile Network Architecture

Mobile Network - Radio

2. 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

3. 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

4. Fixed national 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 at market prices. The mobile network is thus assumed not to own any fixed transmission infrastructure.

Mobile Network - Switching

5. 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

6. 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 Cayman by land type	Splits the traffic into that carried in dense, medium and rural areas. 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

Key Assumption	Description
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

7. 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.

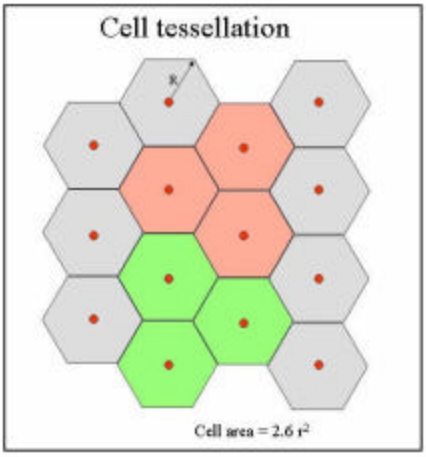


Figure 3 GSM Cell Tessellation

8. 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.

9. 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.

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

11. 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.

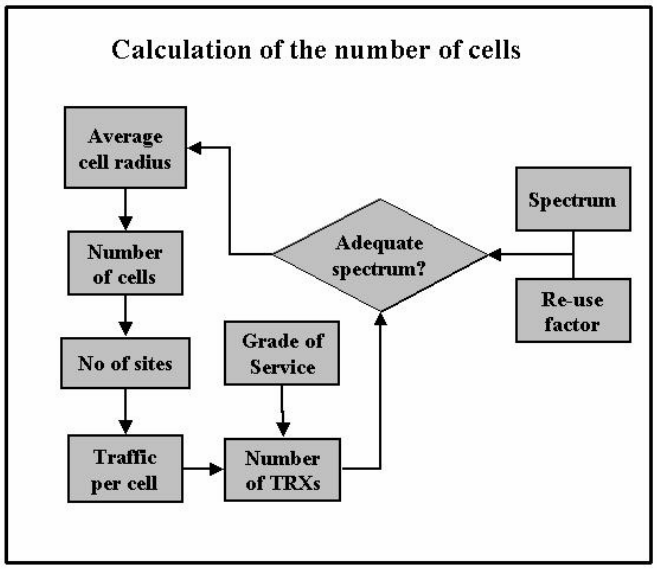


Figure 4 Calculating the number of GSM cells

12. 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	2
Rural	4

Figure 5 Maximum Cell Radius

13. 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.

14. 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.

15. 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

16. 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

17. 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.

18. 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.

19. 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

20. 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.

21. 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

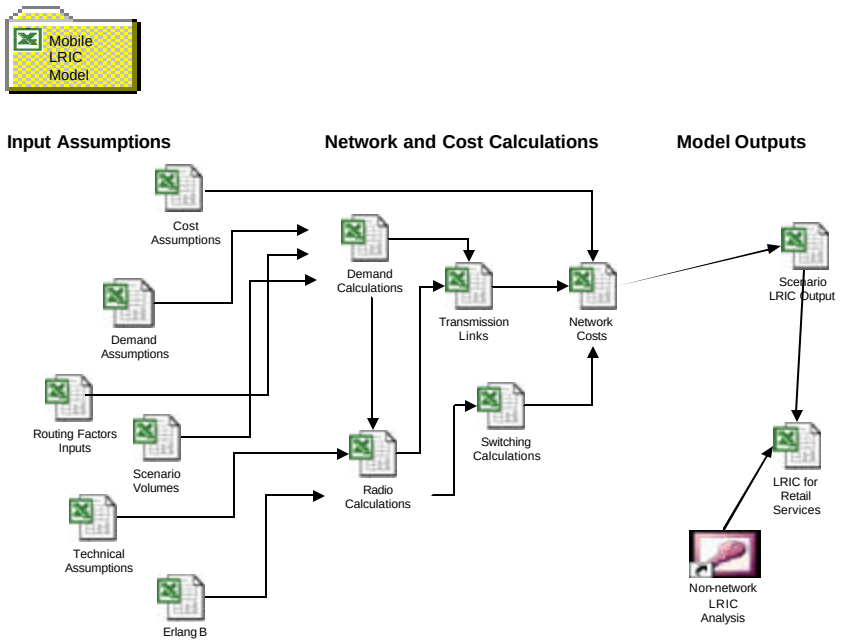
22. This section describes the various worksheets in the MS Excel Bottom-up model and provides and overview as to operating procedures.

Mobile Model Structure

23. 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

24. 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.

25. As the cost model is now available for perusal. We do not include extracts from the model in this text.

26. Leased line costs are imputed from C&W tariff lists.

27. 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.
- *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.

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

28. 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. P

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

Network Calculations

29. 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.

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

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

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

Cost calculations

30. 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.

Model Outputs

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

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

4. CASE STUDY

Introduction

33. 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.

34. 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.

35. The following case study provides calculation steps, intermediate outputs and final outputs to demonstrate how the model determines the Pure LRIC for the Mobile termination service Building on the LRIC calculation, a summarised table of the Pure LRIC is presented to the end of the case study.

36. 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 GRC and annualized costs 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.

37. We produce the pure LRIC only in summary fashion as drilling down would require case studies of additional services.

38. This case study is for instructional purposes only and therefore costs and volume numbers presented in this case study may not be consistent with those submitted in the actual model and may not be representative of what C&W Cayman or other operators face.

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

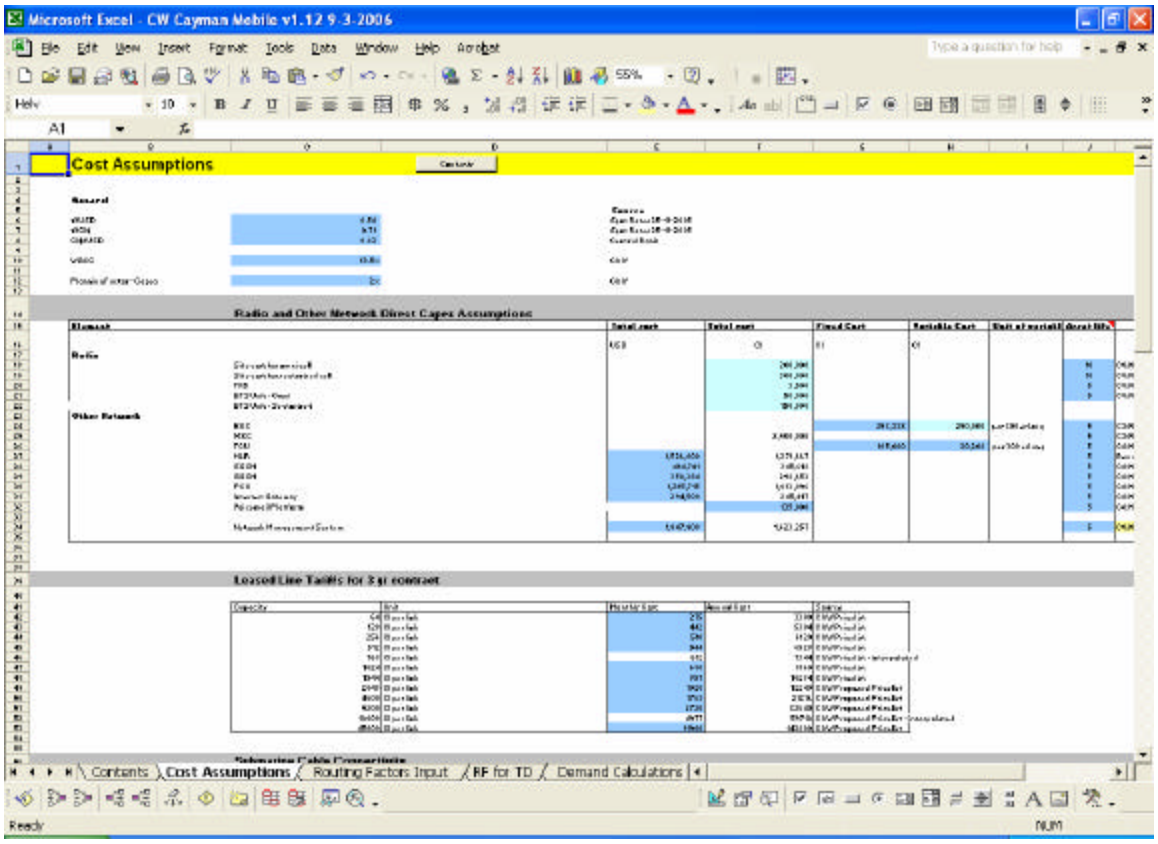
The Starting Point

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

Input Cost Assumptions

41. 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
- TCUs
- HLR
- SGSN
- GGSN
- PCU
- Internet gateway
- Voicemail
- Network Management System



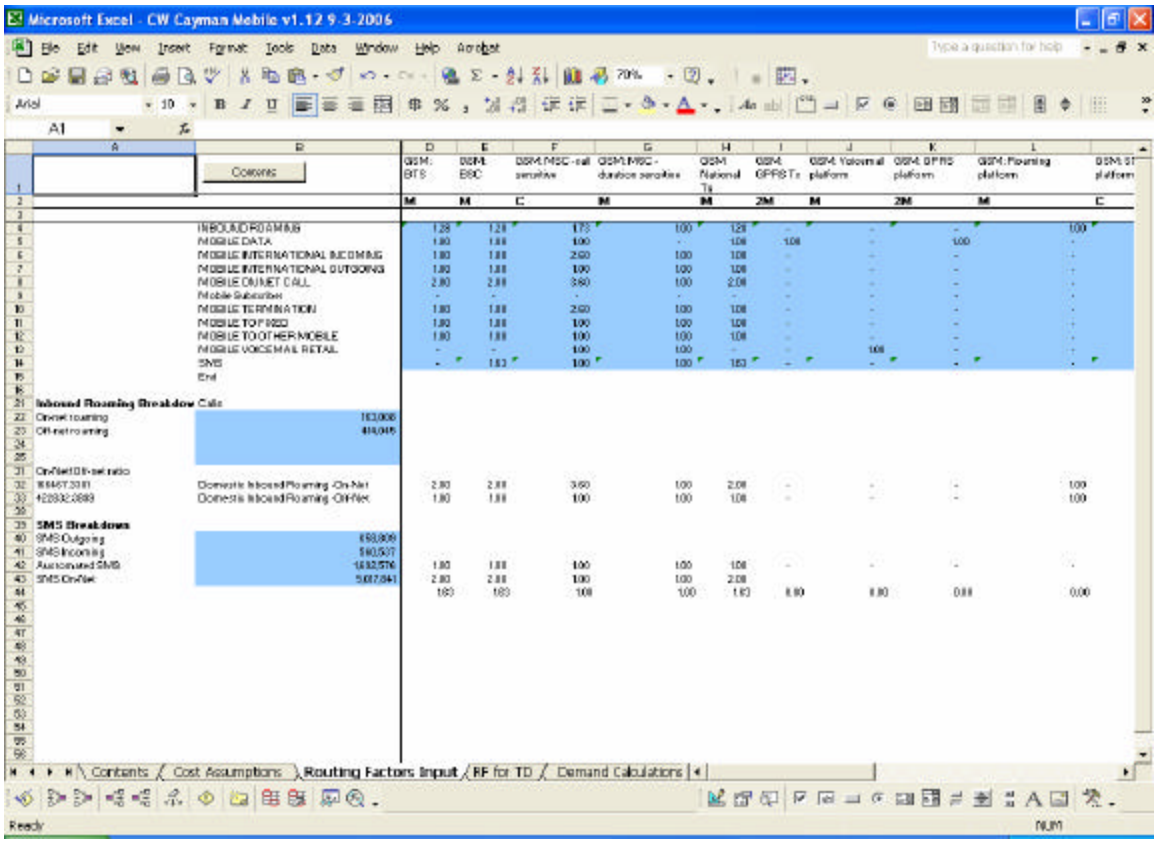
Extract 1

42. Please note that for the purposes of this case study we have assumed a WACC of 11.65%.

Input Technical Assumptions

Routing Factors Input Sheet

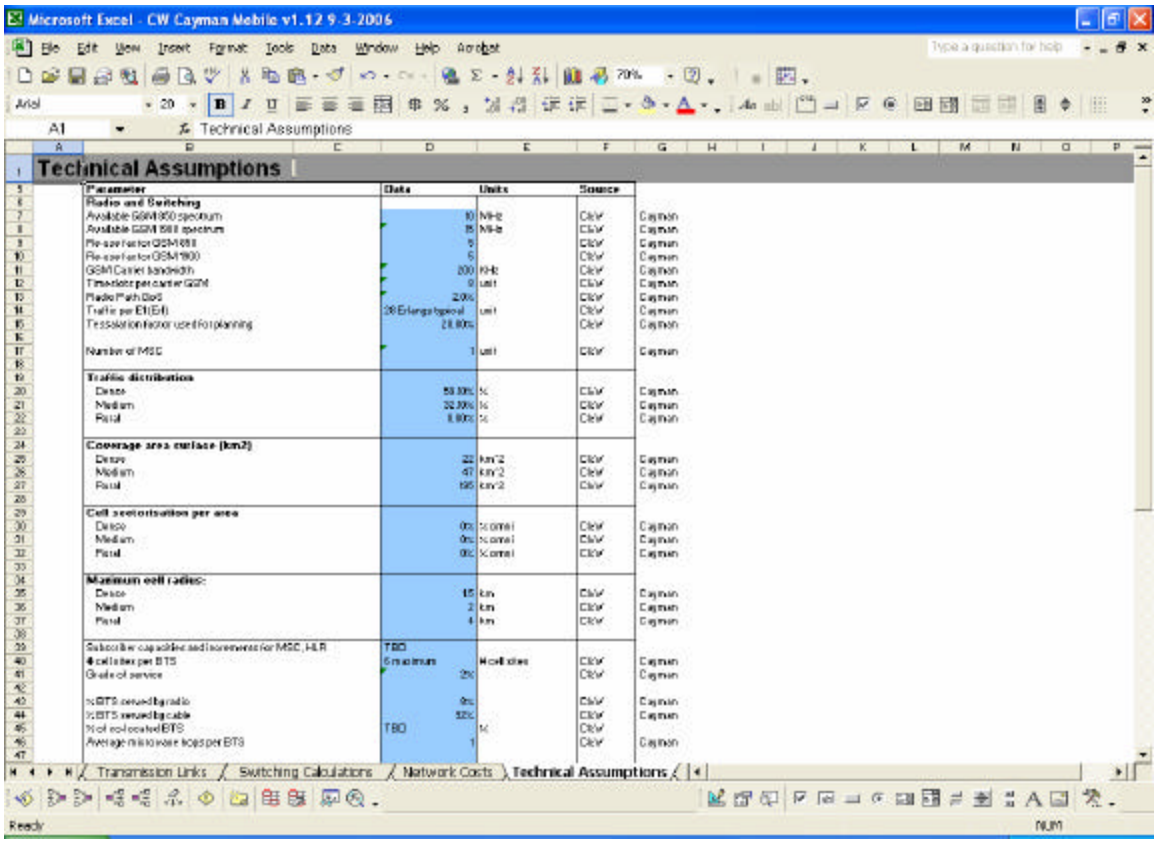
43. This sheet captures the routing factors (Extract 2) used in calculating the demand volumes for each network component. For a given service, routing factors reflect the level of usage of each network component by that service.



Extract 2

Technical Assumptions Sheet

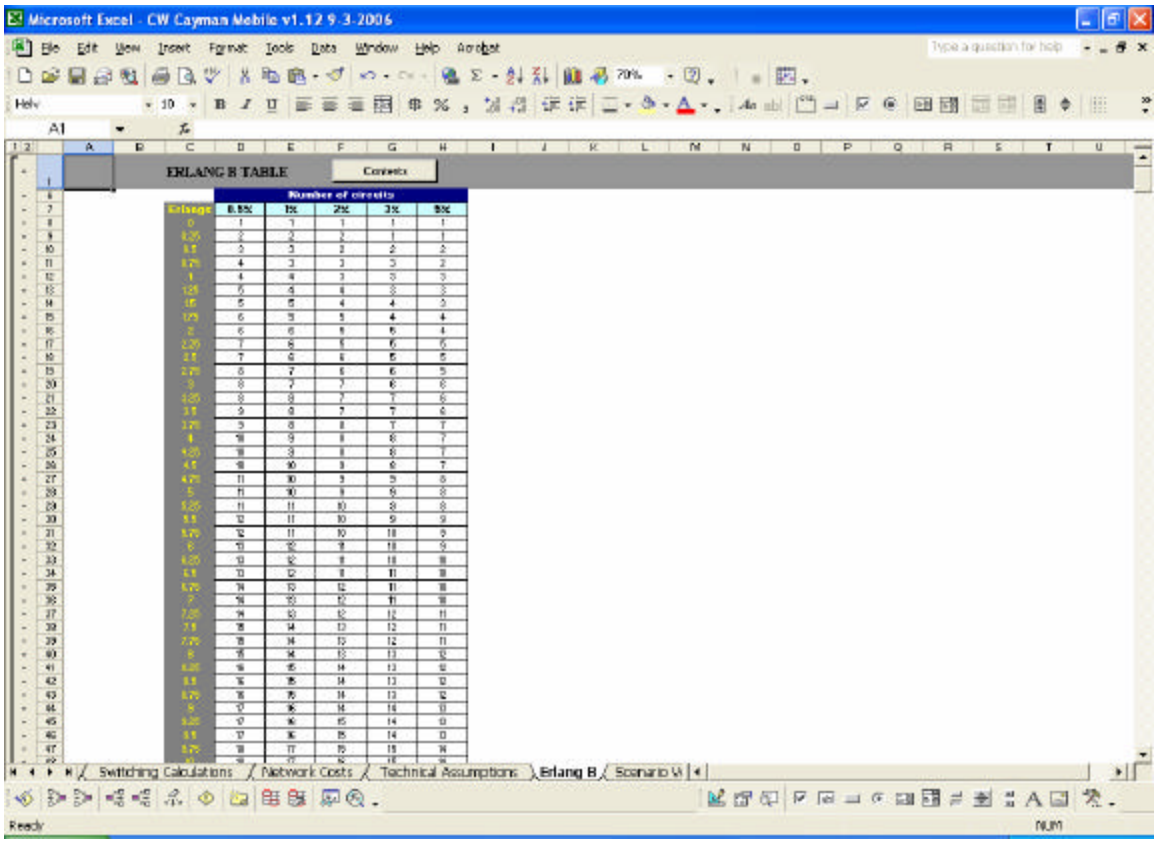
44. Extract 3 captures the key technical assumptions employed in dimensioning the mobile network.



Extract 3

Erlang B Table Sheet

45. Extract 4 is part of the standard Erlang B table used in dimensioning mobile radio networks.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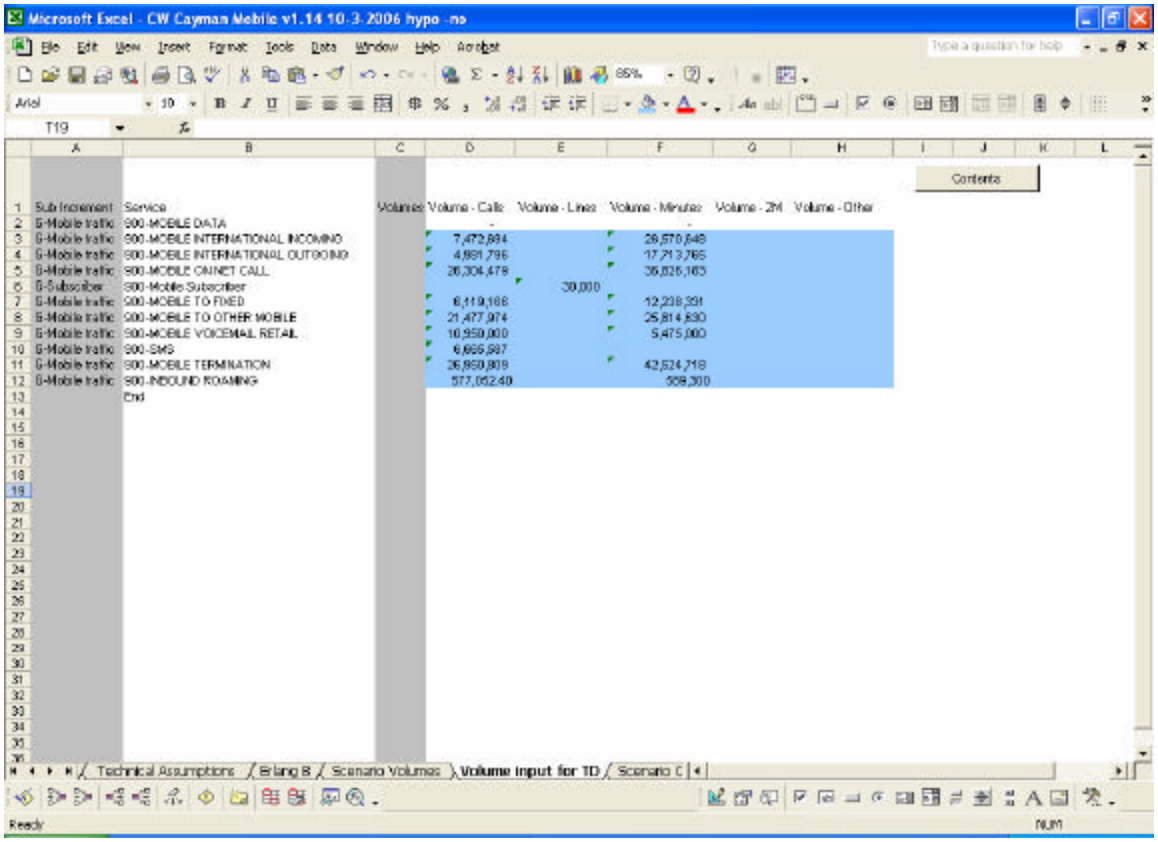
ERLANG B TABLE
Switching Calculations
Network Costs
Technical Assumptions
Erlang B
Scenario Vi
Ready
NUM
Extract 4

Input Usage Volume Assumptions

Volume Input Sheet

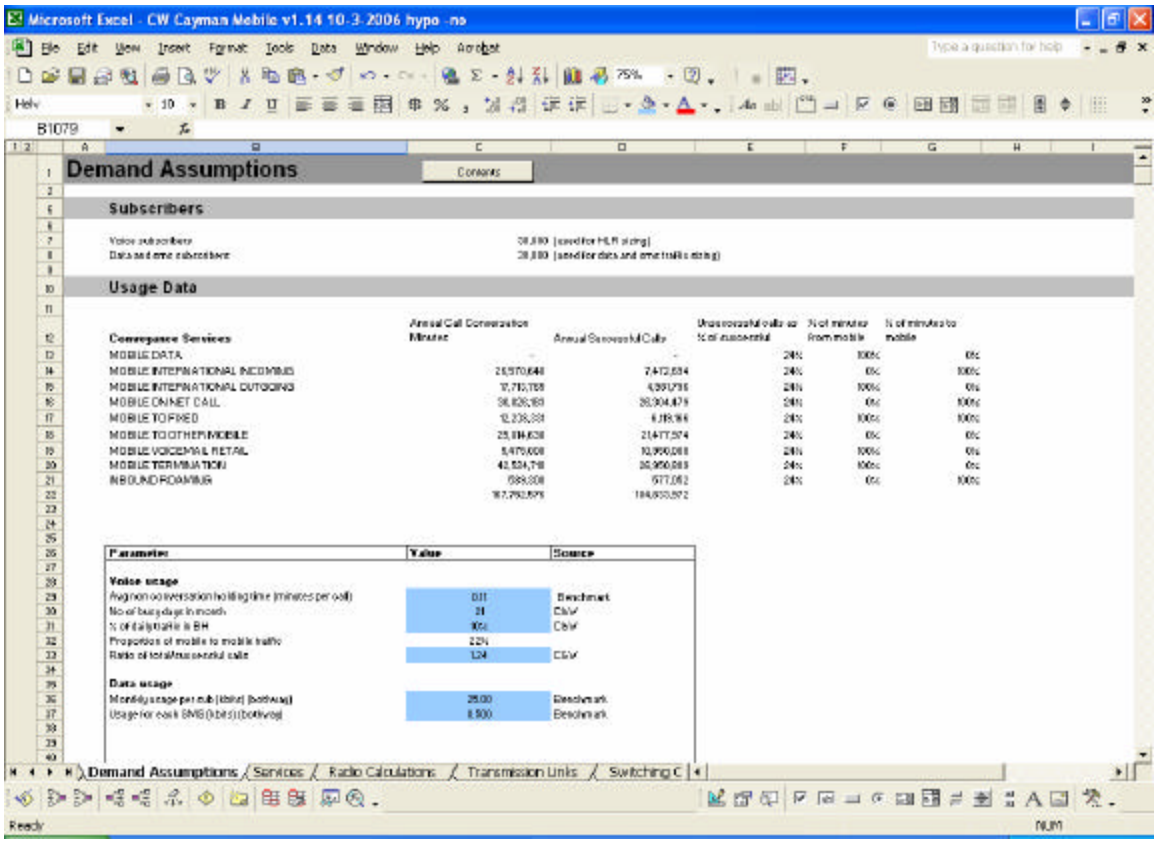


Extract 5

46. Extract 5 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

47. Extract 6 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.



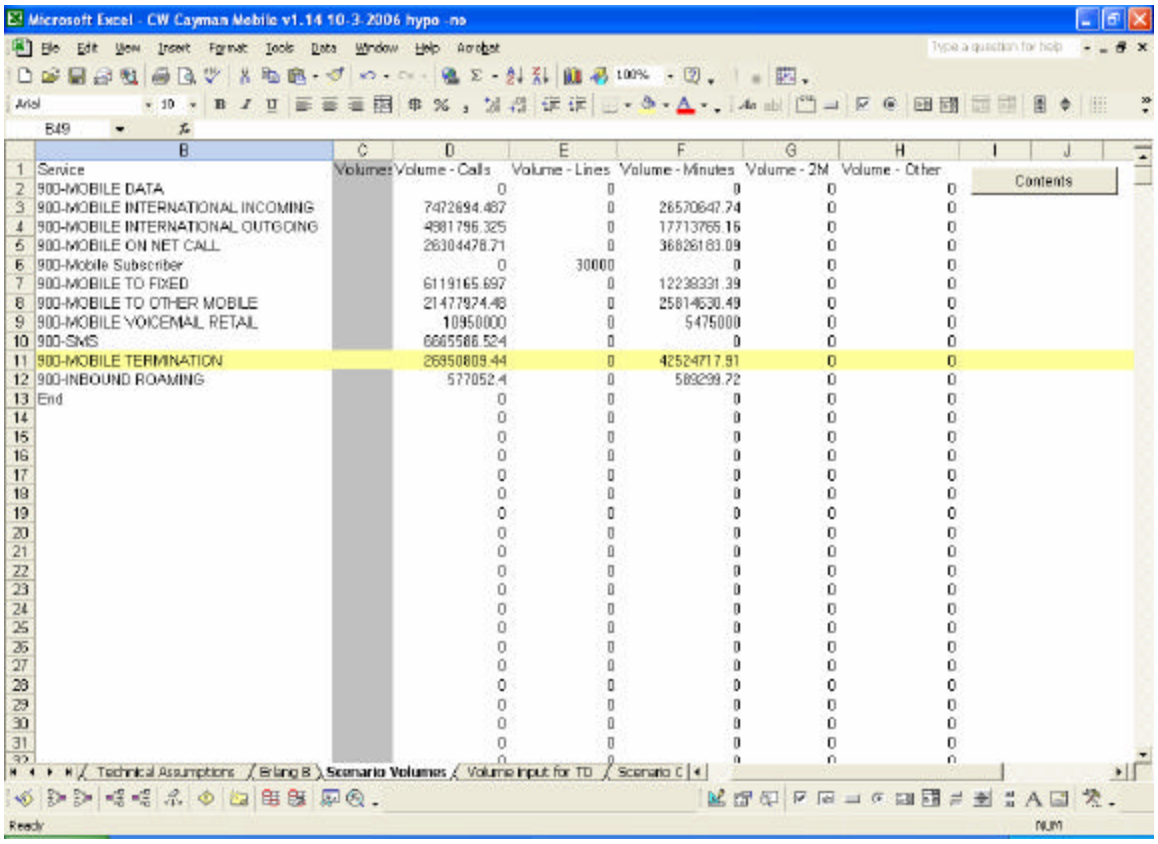
Extract 6

Calculating BU LRIC

48. 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 results 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: 26,950,809 and minutes: 42,524,718) of the service 900-MOBILE TERMINATION to zero. This is done through the 'Scenario Volumes' sheet, an extraction of which is shown below.



	B	C	D	E	F	G	H	I	J
1	Service	Volumes	Volume - Calls	Volume - Lines	Volume - Minutes	Volume - 2M	Volume - Other		
2	900-MOBILE DATA		0	0	0	0	0		
3	900-MOBILE INTERNATIONAL INCOMING		7472694.487	0	26570647.74	0	0		
4	900-MOBILE INTERNATIONAL OUTGOING		4881796.325	0	17713765.16	0	0		
5	900-MOBILE ON NET CALL		26304478.71	0	36826183.09	0	0		
6	900-Mobile Subscriber		0	30000	0	0	0		
7	900-MOBILE TO FIXED		6119165.697	0	12239331.39	0	0		
8	900-MOBILE TO OTHER MOBILE		21477974.48	0	25814630.49	0	0		
9	900-MOBILE VOICEMAIL RETAIL		10950000	0	5475000	0	0		
10	900-SMS		6665586.524	0	0	0	0		
11	900-MOBILE TERMINATION		26850809.44	0	42524717.91	0	0		
12	900-INBOUND ROAMING		577052.4	0	589299.72	0	0		
13	End		0	0	0	0	0		
14			0	0	0	0	0		
15			0	0	0	0	0		
16			0	0	0	0	0		
17			0	0	0	0	0		
18			0	0	0	0	0		
19			0	0	0	0	0		
20			0	0	0	0	0		
21			0	0	0	0	0		
22			0	0	0	0	0		
23			0	0	0	0	0		
24			0	0	0	0	0		
25			0	0	0	0	0		
26			0	0	0	0	0		
27			0	0	0	0	0		
28			0	0	0	0	0		
29			0	0	0	0	0		
30			0	0	0	0	0		
31			0	0	0	0	0		

Extract 7

Step 2

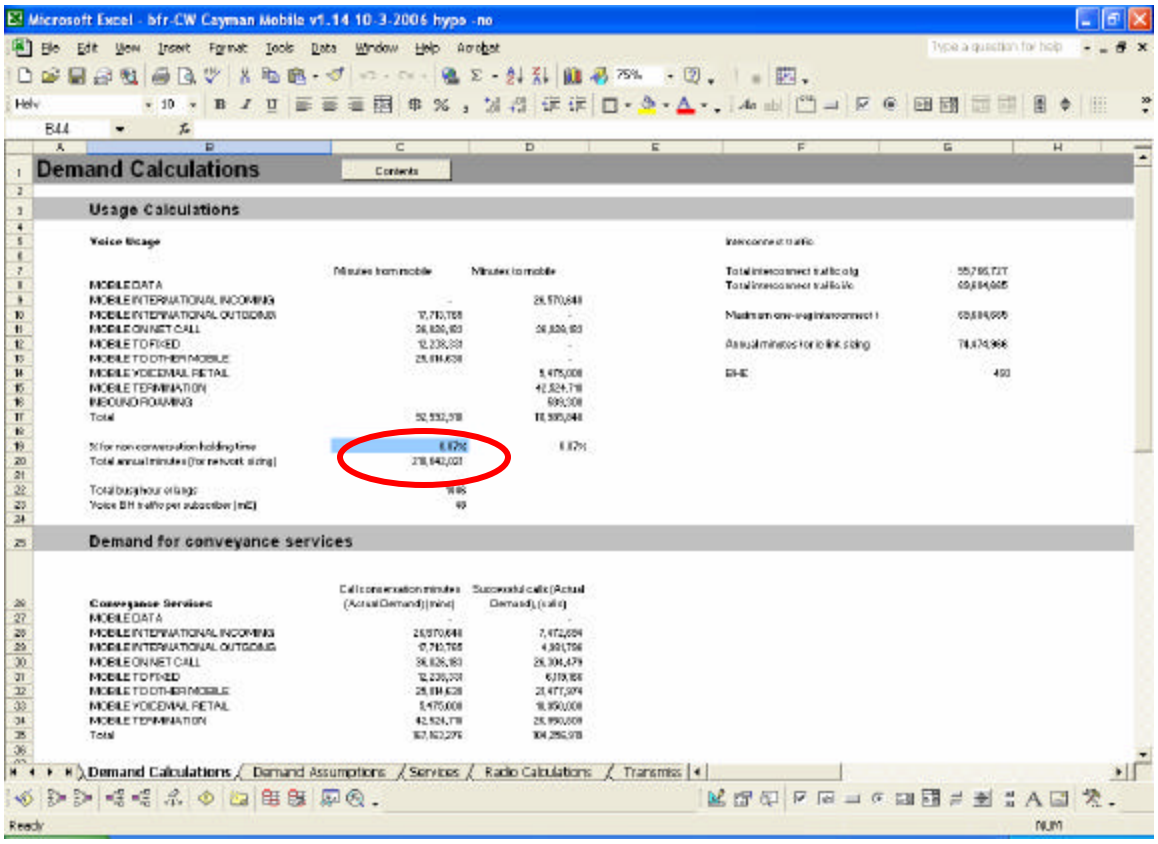
Demand Calculations Sheet

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 218,642,021 minutes, as shown in Extract 8, **down to 173,140,559 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)



Extract 8

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 6*) x (% of daily traffic in BH *from Extract 8)/ 60* = 1446 **(new value = 1145)**

2.3) 'BH Traffic per Subscriber' = ((Total Busy hour Erlangs) / (# Subscribers *from Extract 7*)) x 1000 = 48 **(new value = 38)**

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.:

2.4) 'Annual minutes for Interconnect Link Sizing' = Max(one-way interconnect traffic) x (1+ (% for non conversation holding time)) = 74,474,966 before and **59,581,867** after.

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 8) / 60* = 493 before and **394 after**.

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

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

2.6) 'Demand (annual minutes)' = Sumproduct(Volumes GSM: NE values)

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 26,570,648 + 1 x 17,713,765 + 2 x 36,826,183 + 1 x 12,238,331 + 1 x 25,814,630 + 0 x 5,475,000 + 1 x 42,524,718) = 198,514,459 (*Demand Calculations Sheet*)

2.8) After reduction of the volumes, the new 'Demand (annual minutes)' for the GSM: BTS Network Element is: 155,989,741

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

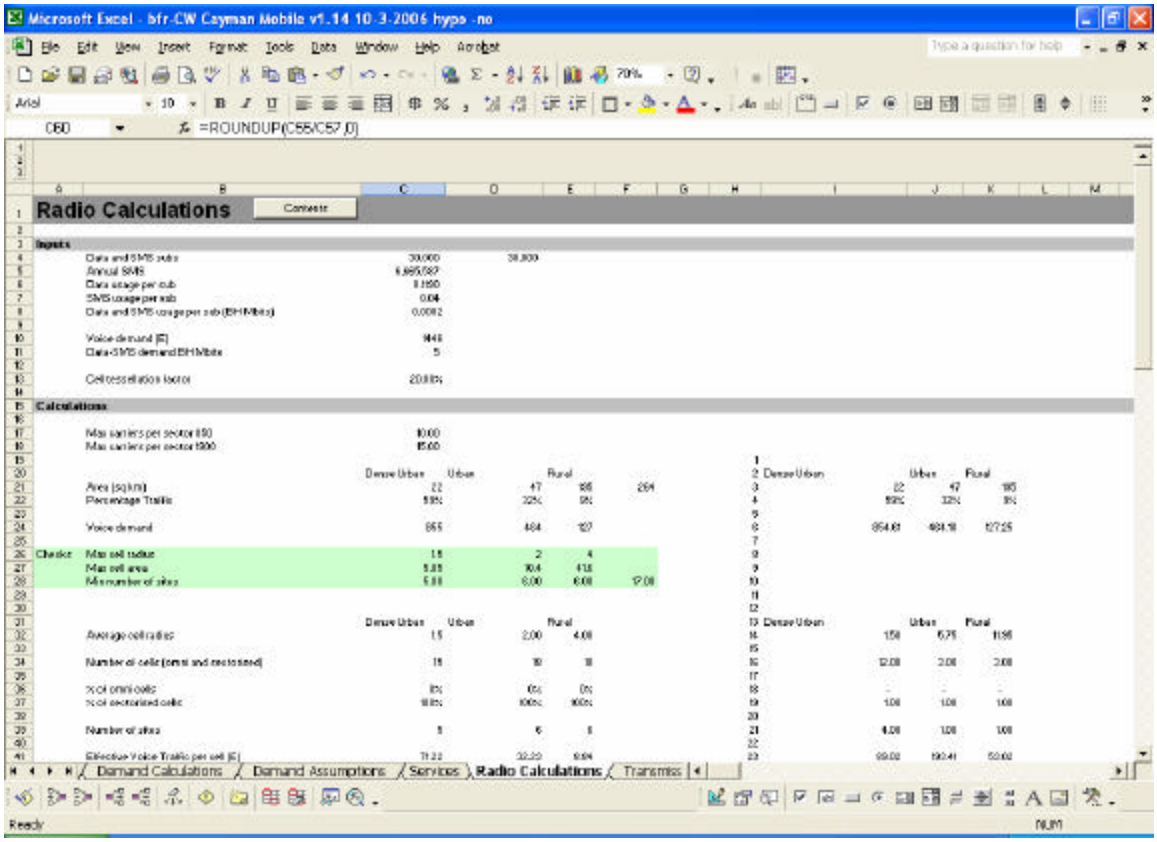
Step 3

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 3), Voice Usage in Erlangs calculated in the *Demand Calculations Sheet* (Extract 8) and the *Demand Assumptions Sheet* (Extract 6).

The removal of Mobile Termination volumes affects the Voice Demand (E) parameter, which reduces from 1446 down to 1145. This has been explained in Step 2 above.

Extract 9, *Radio Calculations Sheet*, captures the results of the algorithm used in calculating the dimensions of the radio network.



Extract 9

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 of the *Radio Calculations Sheet*. 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:

3.1) '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 Technical Assumptions Sheet) / (GSM Carrier bandwidth from Extract 7) / (Re-use factor GSM 850 from Extract 7)) x 1000 and rounded up to the nearest whole number.

3.2) '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 Technical Assumptions Sheet) / (GSM Carrier bandwidth) / (Re-use factor GSM 1900)) x 1000 and rounded up to the nearest whole number.

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

3.4) '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.

3.5) 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 *Radio Calculations Sheet* above by the percentage Traffic of each area: = (Voice Demand (E) *from Radio Calculations Sheet*) x (Percentage Traffic *from Radio Calculations Sheet*)

Removing Mobile Termination volumes changes the 'Voice Demand by Geographic area', this is because the 'Voice demand(E)' parameter reduces from 1446 down to 1145 as explained for in Step 2 above.

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

3.6) 'Effective Voice Traffic per cell (E)' = (Voice demand (E)) / (Number of cells (omni and sectorised)) /(Capacity planning max load factor *from Technical Assumptions Sheet*).

3.7) 'The Number of cells (omni and sectorised)' 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 Technical Assumptions Sheet*) x (Number of sites *Radio Calculations Sheet*) + (% sectorised cells) x (Number of sites) rounded up to the nearest whole number.
Where:

3.7.1) 'Number of sites' = (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). The *Radio Calculations Sheet* 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:

3.8) '850MHz effective Voice Traffic per cell (E)' = ((Available GSM 1900 spectrum *from Technical Assumptions Sheet*) / (Available GSM 1900 spectrum + Available GSM 850 spectrum)) x (Effective Voice Traffic per cell (E))

3.9) '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 (28.49). Thus looking up the Erlang B table produces the required number of circuits, in this case 36 before removal of Mobile Termination volumes. **Removing Mobile Termination volumes reduces this to 30**.

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:

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

Where:
3.10.1) '850MHz: Required number of TRXs per cell (sector)' = (850MHz: Total number of timeslots per cell) / (850MHz: Timeslots per carrier (TRX) *from Technical Assumptions Sheet*)

and

3.10.2) '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 Technical Assumptions Sheet*) x (Number of sites) + (% sectorised cells) x (Number of sites) rounded up to the nearest whole number

Removing Mobile Termination volumes reduces the calculated required number of TRXs for 1900 MHz from 105 down to 90, no change is experienced for the 850 MHz TRXs, the required number changed from 75 down to 60.

The total 'Number of TRXs' for Dense Urban reduces from 180 down to 150 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 360 down to 312 as captured in the *Radio Calculations Sheet*.

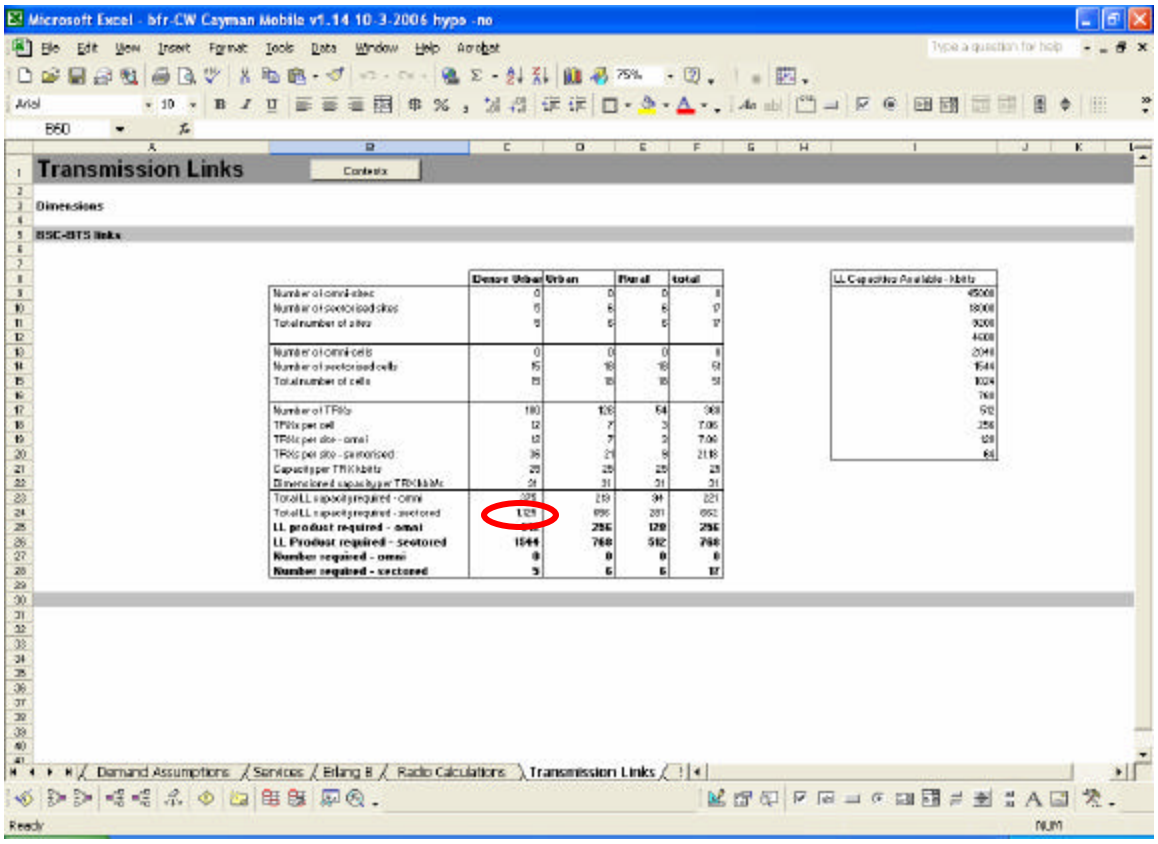
Step 4

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 in this step are:

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

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 1125 kbps down to 938 kbps, the results of which are captured in the** *Transmission Links Sheet*, and shown in Extract 10 below**.**



Extract 10

Step 5

Switching Calculations Sheet

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

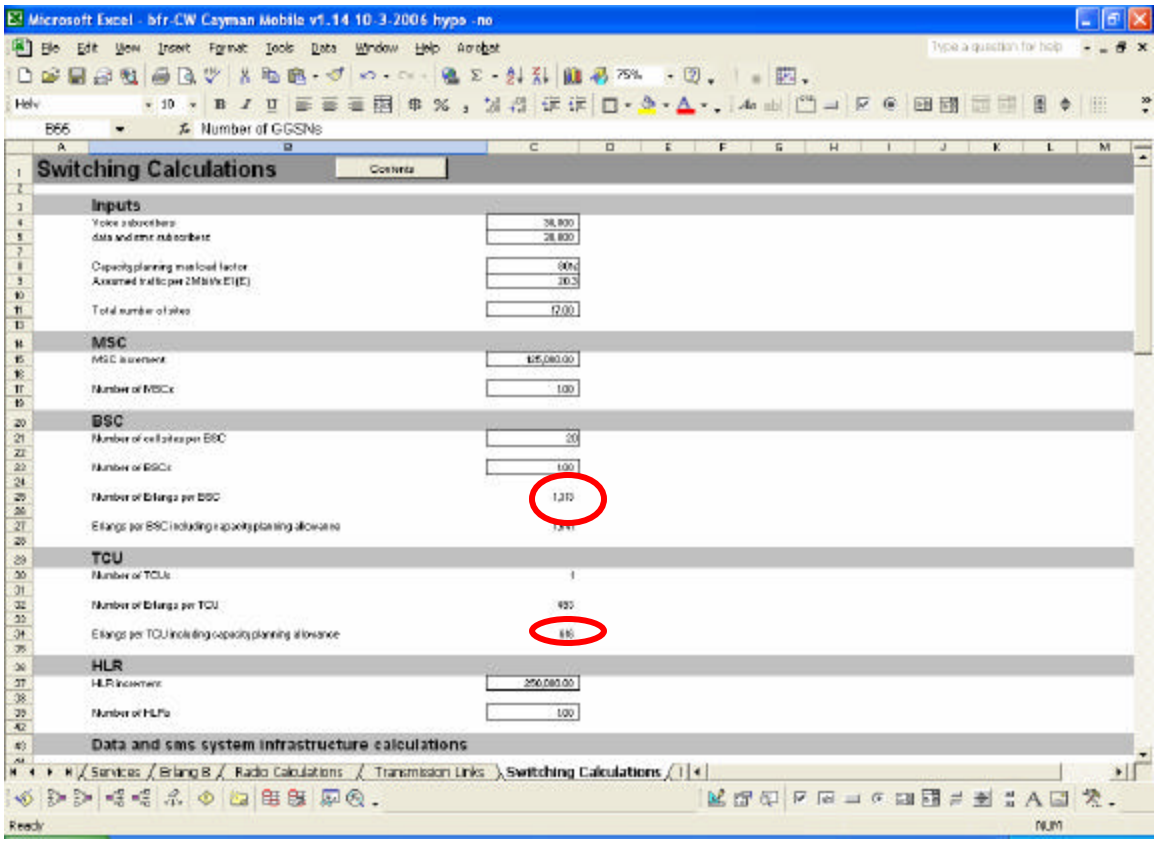
- Number of MSCs
- Number of BSCs
- Erlang per BSC
- Number of TCUs
- Erlangs per TCU
- Number of HLRs
- Number of SGSNs
- Number of GGSNs

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

The Erlang per BSC reduces from 1313 down to 1032.

The Erlangs per TCU changes 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 incoming traffic is greater than the outgoing volume, therefore reducing Mobile termination volumes to zero, reduces the incoming volumes. Thus, based on eqns. 2.4 and 2.5, the max volume changes, resulting in the required TCU capacity moving from 616 down to 493 Erlangs.

The results of switching calculations are captured in the *Switching calculations Sheet*, and shown in Extract 11 below.



Extract 11

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 3.10*) / (Total number of sites *from Step 3, eqn 3.7.1*) **= 360 / 17 = 22 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*) **= 3,500 x 22** = **77,000 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*) **= 77,000 + 150,000 = 227,000 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 3.7.1*) **= 227,000 x 17 = 3,859,000 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 Cost Assumptions Sheet*) x (1 + Planning factor - % capex) = **3,859,000 x (1 + 5%) x (1 + 2%) = 4,132,989 Pre-reduction value**

6.6) Adding for the Network Management System which is spread across Network Elements on an equi-proportionate basis: = (Total capital cost (incl spares and planning) *from eqn 6.5*) + 528,290 = **(4,132,989 + 528,290 = 4,661,279) Pre-reduction Total Capital Cost of BTS or Effective NRC**

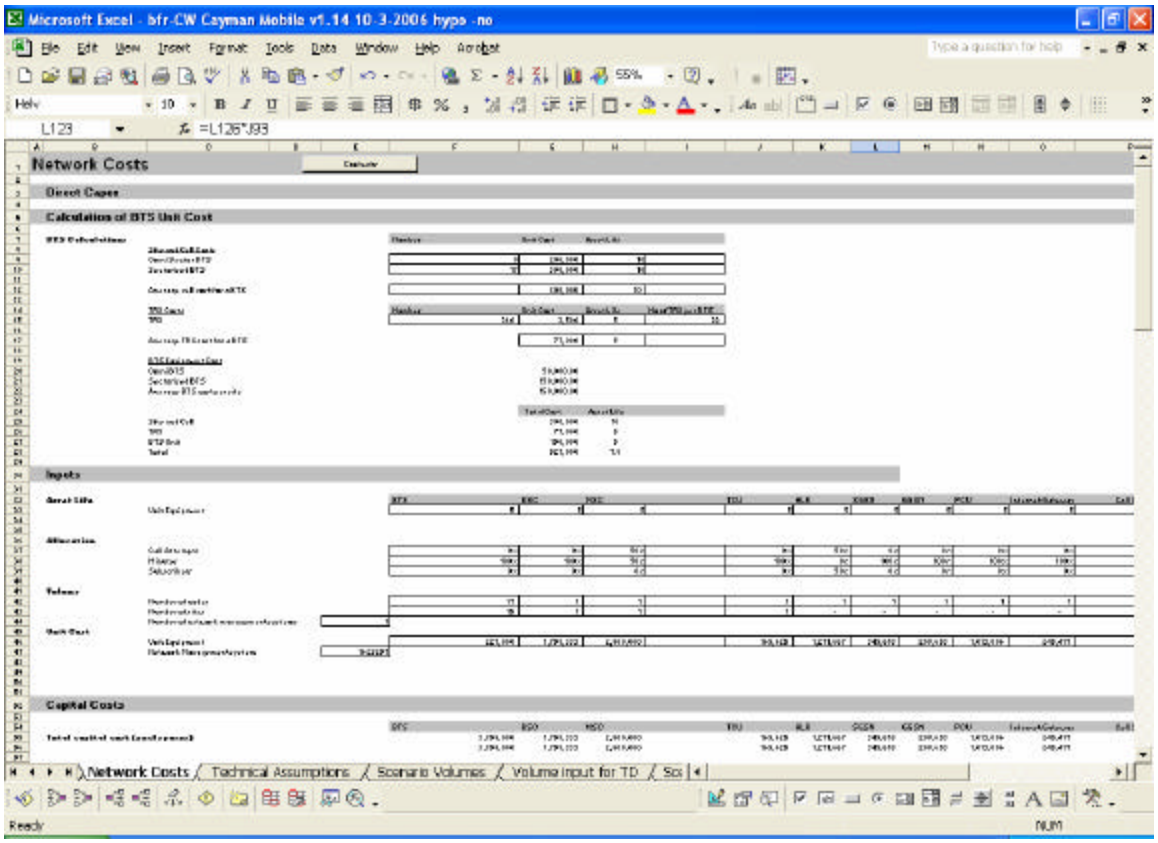
Extract 12 captures the pre-reduction results, they are for the BTS:

Effective NRC = **4,661,279**
Depreciation = **738,925**

Cost of BTS-BSC links = 184,652

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

Effective NRC = 4,465,486
Depreciation = 707,887
Cost of BTS-BSC links = 174,032



Extract 12

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 outputted to the model's *BU Output Sheet*.

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.

Before removal of volumes:

Entity	GRC	Annualised Cost
400-GSM: BTS	4,661,279	1,281,731
400-GSM: BSC	2,123,887	584,014
400-GSM: MSC -duration sensitive	1,951,510	536,615
Total	8,736,677	2,402,361

After removal of Volumes:

Entity	GRC	Annualised Cost
400-GSM: BTS	4,465,486	1,227,893
400-GSM: BSC	1,830,034	503,212
400-GSM: MSC -duration sensitive	1,935,691	532,265
Total	8,231,211	2,263,371

Step 8

BU Output Sheet

This is the final step where the results of the *Scenario Output Sheet* are posted to the BU Output Sheet.

The Model in an iterative manner simulates the removal of the volumes of each service and calculates the associated LRIC values of GRC, Annualised Costs and Opex. These values are finally posted to the *BU Output Sheet*.

Pulling all these elements together, we get the total bottom-up pure LRIC for the Mobile Termination service.

Summary BU pure LRIC results for Mobile Termination service

WACC 11.65%
Volume - Minutes 42,524,718

A	B	C
Network Element	**LRIC value – GRC**	**LRIC value – Annualised Costs**
400-GSM: BTS	$195,793	$ 53,838
400-GSM: BSC	$293,853	$ 80,802
400-GSM: MSC - duration sensitive	$15,819	$ 4,350
TOTAL PURE LRIC	**$505,466**	**$ 138,990**

Appendices

Appendix I. 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)