Draft Manual for the LRIC Models of the Fixed and Mobile Telecommunications Networks for the ECTEL Member States

June 2008

Table of Contents

I. Background

A. Introduction

1. This draft manual accompanies the draft LRIC models for fixed and mobile telecommunications services in [insert ECTEL member nation here]. It describes the structure of the model, the various inputs required, proposed inputs for cost and technical assumptions and outputs.

2. The format and, in some instances, the text of this manual closely follows that of a submission by Cable & Wireless in the Cayman Islands to address requirements set out by that regulator's *Public Consultation on Costing Manual* (CD 2005-1), dated 27 October 2005. However, the models are significantly different from the models under consideration in that proceeding, and the manual therefore diverges in a number of important respects from that manual.

3. This manual is divided into three sections:

a. the Background Section, which

- describes the overall methodological approach
- discusses issues common to both the fixed and mobile models, including the cost of capital, expense factors, asset lives and treatment of retail costs;
- discusses the output reports in the models;
- explains additional calculations that are required to turn the LRIC results into the full range of rate elements for the reference interconnect offer; and

b. The Fixed Network Model Section, which describes the structure and functioning of the fixed network model.

c. The Mobile Network Model Section, which describes the structure and functioning of the mobile network model.

4. The LRIC models themselves are comprised of two workbooks: i) bottom-up fixed network model; and ii) the bottom-up mobile network model.

B. The LRIC Approach

Efficient networks and technology

5. The models assume an efficient network (or, more properly, networks, as both fixed and a mobile network costs are produced) which is deployed with the latest technology currently in use in the country and which is designed to provide service to a specified level of customer demand and amount of traffic at a required quality of service.

6. With respect to fixed network technology, incumbent and new entrant operators are currently moving towards an Internet Protocol (IP)-based network. Therefore, the LRIC methodology for the fixed network is based on an IP-based architecture as opposed to the traditional PSTN. The entire fixed network is located within national boundaries of each market.

7. For the mobile network, to date all operators have pursued GSM technologies. Therefore, only these technologies are included in the model. The entire mobile network infrastructure is located within the national boundaries of each market, except for the switch. Experience indicates that successful mobile operators in the region operate on multi-islands and share switching resources. However, each operator has different shared switch configurations. Therefore, in order to capture switch economies without choosing between existing configurations, the mobile model assumes that each island is sharing its switch with an aggregate subscriber base of 100,000. It is assumed further that this switch resides out-of-country for each island.

8. All equipment costs are based on current market prices. Where current market prices have not been available, the historic price has been adjusted by price trends.

Cost Causality and Increment definition

9. Incremental cost is generally defined as the cost of adding a product or service to a portfolio of existing products or services or, conversely, the cost avoided if production of a product or service is taken away from the list of existing products or services. For example, if the company currently produces two services (A and B) and then decides to stop producing service A, then the company's costs will decrease. The company will save the variable cost and any fixed costs specific to the production of this service.

10. Figure 1 (below) illustrates the definition of LRIC for a service (Service A). The LRIC approximates the slope of the cost curve, which is often referred to as the Cost-Volume Relation, or CVR.

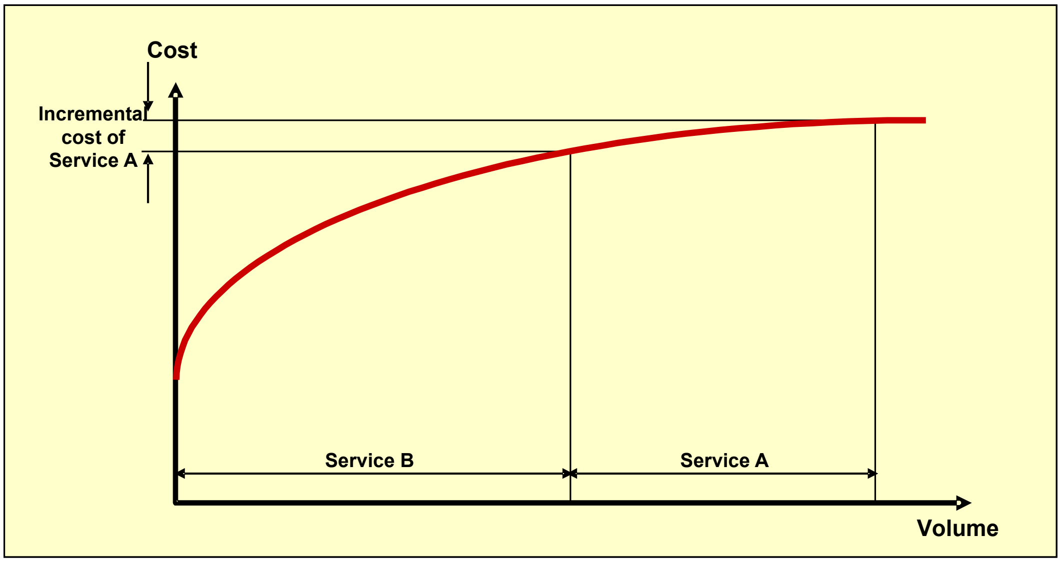

Figure 1. Illustration of Service Increments

11. An increment is the set of products or services over which the costs are being measured. The following increments are used in the LRIC models:

Fixed Line Network

- Access: contains all the Access services currently offered by the incumbent (PSTN Access, ISDN Access, ADSL).
- Transmission: includes all retail and wholesale traffic services, leased lines and data services currently offered by the incumbent.

Mobile Network

- Traffic: contains all mobile traffic services offered by the existing operators in the market
- Subscriber: contains all subscriber-related costs, such as handsets and customer care.

12. We note that site costs and costs of the network management system are considered a common cost to the two mobile increments. The cost of providing the mobile switching centre is treated as incremental to traffic services.

Common Costs

13. The models work on the principle that network costs and capital values are calculated for each network component according to the volume inputs given. If the volume input for a particular service is removed, then the reduction in costs shown by the model will indicate the LRIC value for that particular service. Similarly, volumes may be removed for a group of services which represent a high-level or service group increment.

14. Fixed common costs (FCC) are fixed costs associated with the production of the service increment that cannot be avoided unless production of all services to which they are common is stopped. FCCs are fixed with respect to volume. These FCCs are only avoided when the production of all services has ceased. Examples of FCCs are the network equipment required for mobile coverage (as opposed to the mobile network required for capacity or traffic) and the fixed and mobile license fees.

15. As the fixed and mobile networks are modeled as self-standing businesses, there are separate fixed and mobile FCCs.

16. There are also increment specific fixed costs, ISFCs, which are not incremental to the individual services, but can be avoided when the service group increment is ceased.

17. The model calculates FCCs and IFSCs for each cost category. There are a number of potential methodologies for allocating FCCs and IFSCs to services. The model employs the most widely accepted and used mark-up methodology, Equal Proportionate Mark-Up (EPMU), where the IFSCs are allocated to the "pure" LRIC values, and the FCCs are allocated to pure LRIC + IFSC mark-up values. The calculation process is discussed in further detail below.

18. This discussion of FCCs and ISFCs relates to the network-related costs. Non-network costs are treated separately and are discussed in section 1D below.

The Bottom-up Methodology

a. Logical Structure

19. There are four basic assumptions on the network design that must be emphasized before a fuller discussion of the modelling:

- the networks—fixed and mobile--are considered as separate entities, each with its own network and sites.
- the fixed network is assumed to be based entirely in the respective island; the mobile network in each island is assumed to share a common off-island switch.
- a scorched node approach is applied to both the fixed and mobile networks, i.e., the location of the modeled plant is assumed to be where the existing plan is currently.
- The bottom up model assumes “instantaneous build”: it takes specified traffic volumes and customer numbers as an input and constructs a theoretical network capable of handling these volumes, with due regard to a particular grade of service. The costs of all required network elements are then calculated and annualised. This annualised cost is then used to derive an in-year depreciation charge and gross replacement cost (GRC) per network element.

20. Figure 2 below provides a high-level illustration of the logical structure of the bottom-up model. We emphasize that Figure 2 is a *logical* structure of the model, not the physical structure of the model.

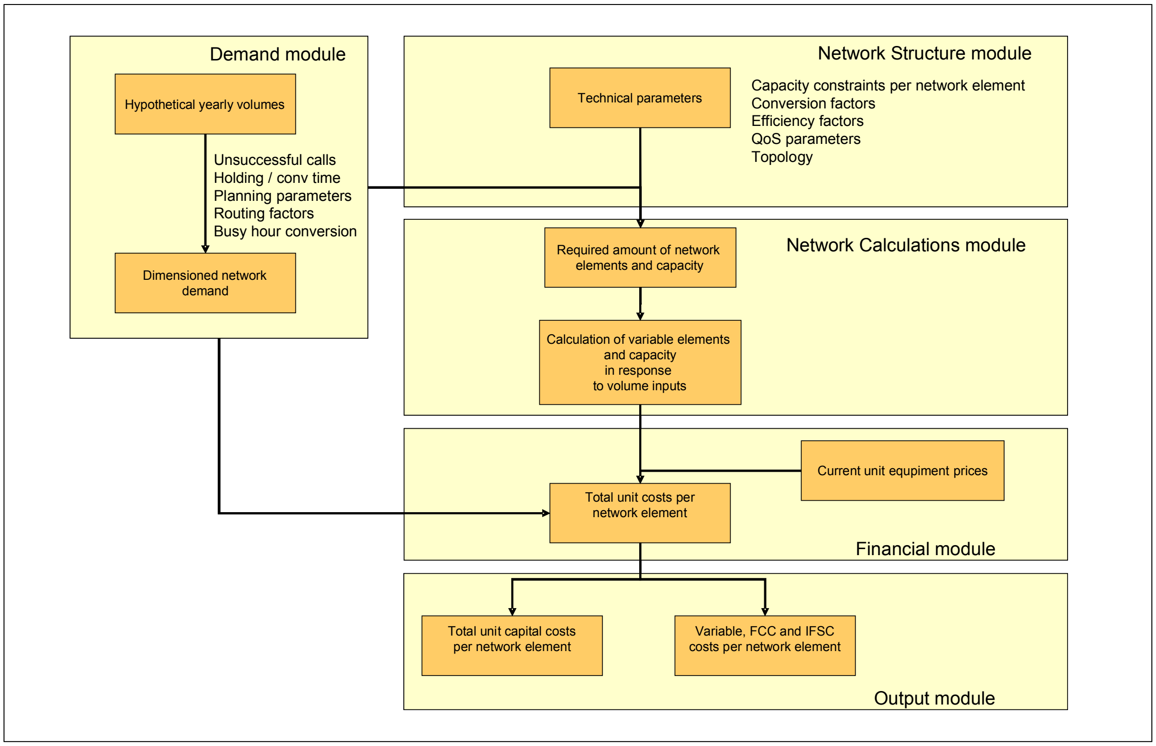

Figure 2. Logical Structure of the Bottom-Up LRIC model

21. In the demand **module**, the demand inputs for each service are collected. These include traffic per service and of the number of customers. These are all external inputs to the model. They are hypothetical volumes based on an estimated market volume. The fixed network is dimensioned to meet the entire market demand. The mobile network is dimensioned to meet one-third of the entire market demand under the assumption that there are three operators in each island. These volumes are then translated into dimensioning volumes, using parameters such as percentage of unsuccessful calls, planning parameters, routing factors and busy hour data. The output from the demand module serves as an input to the network structure module and is used later on to calculate unit costs for network equipment and, in turn, unit-costs of services.

22. The network **structure module** describes the network topology. External inputs are technical information regarding network elements (element size and modularity, the logical structure of the network, and the area types (urban, suburban and rural) and their characteristics.

23. In the calculations **module**, the required number of each network element type is calculated. The inputs to this module are the required capacity per network element type (from the routing module), area type characteristics, radio and core blocking requirements, and a translation method to calculate

the required capacity from the amount of traffic or the number of subscribers (such as an Erlang formula). In this module the network elements and some of the other network related assets are split into common costs and non-common costs. The output of this module is the required quantity of each element type and the classification into common and specific costs, which is used in the financial module to calculate the costs incurred by each element type.

24. In the financial **module** the required network investments are determined for the relevant year. The required equipment quantities are multiplied by the current equipment prices. Depreciation is calculated on the basis described in section IC below.

25. In the **output module** the unit costs per network element and the network related fixed common costs are calculated using the network volumes. The result of this is a bottom-up of the costs per network element. The incremental costs per network element are obtained by setting the volume of each service to zero and identifying the difference in cost per element with and without the relevant service.

<u>b. Volumes and Routing Factors</u>

26. The model takes, as inputs, the hypothetical service volumes for the various services, which may be measured in minutes of duration, number of calls, number of lines or bandwidth requirement. These service volumes must be converted to a demand for the various network elements – the process for achieving this is:

- Volumes are scaled by factors to allow for such things as planning allowances.
- The scaled volumes are then multiplied by the related routing factors for each network element to calculate a volume demand by network element.
- In the case of traffic products, the resulting annual demand is converted to busy-hour demand, which is used to dimension the network.

27. Below this process is described in more detail for the different volume types.

Volume Scaling

Minutes

28. Call conversation minutes for each service (which are provided as an input to the model) are converted to network occupancy minutes via the following formula:

*Occupancy minutes = conversation minutes + number of successful calls *(ratio of total/successful calls) * non-conversation holding time per call*

where the ratio of total/successful calls and non-conversation holding time per call are inputs to the model

Calls

29. The number of calls for each service (provided as an input to the model) are converted to total calls (successful and unsuccessful) via the following formula:

*Total calls = successful calls * ratio of total/successful calls*

Lines

30. The number of lines for each service is converted to a demand volume via the following formula:

*Lines network demand = Lines * Annual growth rate for lines*

where the annual growth rate is a planning assumption to ensure that sufficient capacity is provided to cover projected growth.

Capacity

31. For certain products a simple line driver is not adequate for modeling, because the lines may have different capacities. This applies to leased lines, frame relay and direct Internet connections. In these cases, a capacity volume driver is derived from an analysis of the lines sold by capacity.

32. For each capacity of circuit, the capacity driver volume is calculated according to the following formula:

*Service capacity =Σ [line j * capacity of line j] /2 Mbit/s*

The service capacity is then summed for all the capacities sold to give the total capacity for each product.

33. Service capacities are then converted to network capacities via the following formula:

*Network capacity = Service capacity * (1 + transmission capacity allowance)*
where transmission capacity allowance is a planning benchmark

Routing Factors

34. Routing factors tell us how much each network component is used by each service. The routing factors can therefore be regarded as a set of weights which allow us to translate service demand into network element demand.

35. So for each network element, the routing factors are multiplied by the scaled service demands to arrive at the total demand for each network element. The formula is as follows:

$$\textit{Demand for NE1} = demand_{service\ 1} * RF_{service1,\ NE1} + demand_{service\ 2} * RF_{service2,\ NE1} + demand_{service\ 3} * RF_{service3,\ NE1}\ \textit{Etc}$$

36. The end result is a set of demand measures for each network element which can then be used to dimension the network.

C. Economic Asset lives and Depreciation

37. There are numerous LRIC studies that give economic asset lives for fixed network elements.[1] However, NGN components have considerably shorter economic lives relative to PSTN components. Public records of economic asset lives for mobile network equipment are more difficult to find. One source is the 2002 Ofcom's review for mobile termination.[2] There is evidence to suggest that some GSM network elements are shorter lived than those on the public record.

38. The assumptions on asset lives are found in the Asset Lives sheet of the fixed model and the Cost Assumptions sheet in the mobile model, and reproduced here for ease of reference.

[1] For example, Europe Economics (2000) and PTS (2003). See, respectively, "Study on the Preparation of an Adaptable Bottom-up Costing Model for Interconnection and Access Pricing in European Union Countries", Europe Economics, April 2000 and http://www.pts.se/Archive/Documents/SE/Model%20documentation%20-28%20mars%2003.pdf

[2] See, http://www.ofcom.org.uk/consult/condocs/mobile_call_termination/wmvct/annexc/?a=87101 It is worth noting that PTS in Sweden refer to largely the same lives in their 2003 proceeding. See "Mobile LRIC Model specification: Final version for the industry working group". PTS, 2003. .

Fixed Network Asset Lives

Mobile Network Asset Lives

Cell Site	10
TRX	5
BTS	5
BSC	5
MSC	5
TCU	5
HLR	5
SGSN	5
GGSN	5
PCU	5
Internet Gateway	5
Voicemail Platform	5
Network Management System	5

39. Depreciation is an important component of costs in any capital-intensive industry, such as telecommunications. The appropriate concept of depreciation for use in an economic cost study is "economic depreciation." Economic depreciation reflects the decline in the value of embedded plant and equipment during the year. This decline in value is an economic cost that the owner of the embedded plant incurs.

40. Economic depreciation obviously reflects physical wearing out of the plant and equipment. In telecommunications, however, the most important driver of economic depreciation is technological progress. Technological progress results in:

- The availability of new equipment whose cost is lower, in real terms, than the original cost of the embedded plant, but that has equivalent or greater functionality;
- The availability of new equipment that has greater functionality than embedded plant; *e.g.*, ability to generate additional revenue from new services and features, at the same or lower cost;

41. Both of the above drive down the value of embedded plant and equipment. Eventually, the plant becomes completely obsolete, and the economic value is then equal to the salvage value (which may be negative).

42. Economic depreciation is clearly illustrated in the choice between investing in new plant this year or delaying the investment for a year. If the investment is delayed, demand during the current year cannot be met. By delaying, however, the supplier may benefit from being able to purchase lower-priced equipment or equipment with greater functionality next year. The equipment purchased next year may also last longer before it becomes obsolete. These benefits of delay must be foregone if demand is to be met this year. The value of the foregone benefits is economic depreciation. It is part of the economic cost of meeting demand this year.

43. There are several types of depreciation approaches one could use in a costing study. An annuity approach derives the annualised capital costs, including the cost of capital. It smoothes annual capital costs over the life of the asset. A simple annuity represents the partial repayment of the capital invested and a return on the investment. The annual payment continues until the end of the investment term.

44. However, because of physical deterioration and technological progress, the economic value of capital services provided by plant declines over time. Economic depreciation is the decline in economic value of the plant during the year. That decline in value – not some levelised variant thereof – is the cost of economic depreciation that year.

45. Economic depreciation is calculated so that at the end of the year, embedded plant – valued at the new lower economic value – can compete on an even keel with new plant. Thus, costs in the next year do not depend on whether plant was used in the previous year. Production costs are the same using new plant as continuing to use embedded plant that has been properly depreciated.

46. For this reason, the approach taken here to reflect economic capital costs each year is not to levelise them over time as a straight-line depreciation or simple annuity approach would do. Here capital costs are calculated one year at a time. The capital costs each year include a return on the economic value of the plant that year and economic depreciation (decline in economic value) during that year.

47. Given that regulatory prices are based on economic values, the decline in the economic value of an asset each period must be recovered that period. There is no opportunity to recover that cost in later periods. Suppose, for example, that the economic value of the plant declines by 40% during an initial price-cap period. In setting the terms and conditions of the new plan, the regulators will allow the firm the opportunity to recover and earn a return on only the remaining 60%. The 40% loss of capital value can be recovered only during the initial period. "Smoothing" of capital recovery simply does not work in this context.

48. The formula for annualized capital costs (depreciation plus return on net capital) in this model is therefore specified as:

Purchase price = WACC*(1-1/asset life/2) + (1/asset life).[3]

[3] Derived more explicitly:
Total annualized capital cost=
return on net capital + depreciation=
(WACC*net capital value) + (equipment purchase price/economic asset life)=
WACC*(purchase price – purchase price/asset life/2) + (purchase price/ asset life)

D. Expense Factors

49. While a bottom-up methodology is universally recognized as being adequate to measure hypothetical network costs, there is much less consensus about how well it measures non-network costs. An ABC methodology was used to separate network, overhead and retail costs.

50. The bottom-up modelling approach outlined in this manual directly derives all network capital costs. In addition, the expense factor components of the bottom-up models also generate the following categories of cost:

   - Network operating expenses
   - Annualised cost of support assets
   - Network recharges (assuming that any fixed and/or mobile operator in the relevant ECTEL member country modelled will be part of a larger group of companies, thus providing for economies of scale in relation to certain categories of costs that can be shared across other operating companies in the region)
   - Annualised cost of working capital balances

51. Non-network common operating and capital costs are calculated using a similar expense factored approach in the consolidation and reporting module. The categories of cost calculated in this way are:

   - Fixed and mobile network overheads
   - General overheads attributed to fixed and mobile networks using an Activity-based costing (ABC) allocation
   - Overhead recharges
   - Annualised cost of working capital balances

52. Note that retail expenses and capital costs relating to the retail part of the business, where relevant, are treated as a mark-up to the network operating costs and non-network common costs.

53. This section explains the expense factor approach used to calculate all non-retail operating expenses and capital costs.

54. The analysis of expense factors has been conducted using an existing ABC tool which has been updated for financial and, where available, operating data of the incumbent for the financial year ending 31st March 2006.

55. The ABC analysis calculates the cost of a series of activities performed by the business and provides for an activity-defined view of the cost of operating the business. Each cost centre in the business may perform several activities. Each cost centre/activity combination in the ABC analysis has been mapped to an expense factor for calculation in the LRIC model. A full list of expense factors is provided in Appendix I. The main groups of expense factors are as listed below. Where similar categories of expense factor appear in different parts of the model, this is based on the allocation of the base activities between the fixed and mobile networks and the retail part of the business.

Fixed Network Model (Expense factored)

- Distribution network operating expenses
- Core network operating expenses
- Other fixed network operating expenses
- International network operating expenses
- Interconnect specific operating expenses
- Fixed network recharges
- Fixed network specific costs
- Fixed network support expenses
- Annualised cost of fixed network working capital
- Annualised cost of fixed network support assets

Mobile Network Model (Expense factored)

- Mobile network operating expenses
- Mobile interconnect specific operating expenses
- Mobile network specific costs
- Mobile network support expenses
- Annualised cost of mobile network working capital
- Annualised cost of mobile network support assets

Business Common (Expense factored)

- Fixed & mobile network overhead expenses
- General overhead expenses – apportioned to networks
- Overhead recharges
- Overhead specific costs

Retail Expense Model (Equi-proportional mark-up)

- Retail expenses
- General overhead expenses – apportioned to retail
- Retail recharges
- Retail specific costs
- Annualised cost of retail working capital
- Annualised cost of retail support assets

56. The base operating costs data produced from the ABC analysis were reduced in two ways:

    - Any one-off expenses were either eliminated entirely or reduced to reflect activity that might occur episodically (e.g. redundancy costs);
    - Network opex associated with the fixed network were reduced by 25% to reflect cost efficiencies anticipated from the transition to an IP based network; and network opex associated with the mobile network were reduced by 15%.
    - The remaining operating cost was reduced by 5% to address any concerns about existing incumbent inefficiency.

Definition of Expense Factors

57. The expense factors are based on the definition and allocation of activities in the ABC analysis. The ABC analysis defines the activities performed by each cost centre, such that each cost centre is apportioned between the activities it performs.

58. Where necessary, an ABC activity may be mapped to more than one expense factor in order to reflect more precisely the sensitivity of that expense to particular parts of the business eg; fixed network, mobile network, retail.

59. The mapping exercise allows the calculation of a total value of each expense factor, which can be reconciled back to the total activity costs extracted from the ABC model.

Adjustment of Expense Factors

60. Facility is provided to adjust certain expense factors to take account of circumstances that are modelled in the bottom up models, but which vary from the actuality. For example, there are certain costs that are modelled

directly in the bottom up model and need therefore to be excluded from the expense factors in order to avoid the double counting of such costs. A rationale for each adjustment is documented in the working files.

Selection of Expense Factor drivers

61. In order to calculate each expense factor it is necessary to understand the cost driver of that expense factor. Each expense factor calculated in the bottom-up models is driven by the Gross Replacement Cost (GRC) of a network element or group of network elements. The selection of the driver element or group of elements is based on the way in which the associated activities are allocated in the ABC model. This means that when a service volume reduction in the bottom up model causes a reduction in the GRC of a network element, a corresponding reduction in the expense factor will be observed against that network element in respect of that service. This reduction will be the LRIC of that expense factor in respect of that network element for the service in question.

62. Driver groups are defined in the expense factor worksheets in the bottom up models. Once a group has been defined, it is possible to derive the appropriate percentage which should be applied to the GRC of the group in order to calculate an expense factor value.

63. For example:

    If Expense Factor A has an ABC-based value of $1,000,000, is driven by the GRC of a group of network elements called Driver Group 1, and the total GRC value of Driver Group 1 is $6,000,000, then the expense factor % would be $1,000,000 divided by $6,000,000 = 16.67%

Calculation of Overhead Expense Factors

64. Expense factors representing non-network and non-retail operating cost overheads are calculated in and shared across the Mobile and Fixed Model based on the GRC and Operating Cost of each Network Element as calculated by the bottom-up models.

Calculation of retail costs

65. The calculation of operating costs and annualised capital costs relating to the retail part of the business are not included as part of this model and

where they appear, i.e., as part of the local service service deficit calculation, appear as part of a simple mark-up.

66. The retail opex calculated off-model, as with opex in general, was adjusted downwards to capture efficiency gains and eliminate non-recurring costs.

E. Cost of Capital

General Approach

67. The cost of capital included in the LRIC represents the opportunity cost of funds invested in the businesses modeled. Companies raise funds in the form of equity or debt, and it is the weighted average of the costs of these forms of capital (WACC) that is the measure of the overall cost of capital in this exercise. The variables that go into the calculation of the WACC should, as much as possible, be forward-looking.

68. The WACC is defined as:

$$WACC = R_e W_e + R_d W_d$$

Where:

R_e = cost of equity capital

R_d = cost of debt capital

W_e = weight of equity capital (equity/(debt + equity)); and

W_d = weight of debt capital (debt/(debt + equity))

69. The approach taken for estimating the WACC for the fixed and mobile network models is the following. The WACC for peer companies are calculated on the basis of forward-looking variables then adjusted to reflect relevant East Caribbean risk and taxation. The results of those adjusted WACCs are then averaged.

70. The first step in the calculation is to identify comparable or peer companies. Given that a country-risk premium is to be added, the companies should be from countries that do not have significant country-risk premiums (to avoid double-counting). The companies should also be sufficiently large to be efficient participants in financial markets. Finally, the companies should be pure providers of fixed services or pure providers of mobile services as the modeled entities are pure providers.

Cost of Equity and Debt

71. For calculating the cost of equity, the standard the Capital Asset Pricing Model (CAPM) is adopted. The CAPM is generally specified as:

$$R_e = R_f + \beta \quad (R_m - R_f)$$

where

R_f = the estimated return available from risk free investment

R_m = the estimated returns available from risky investments in the market generally

β = the correlation between movements in the share price of the company concerned compared with movements in the market generally, a measure of its systematic risk.

72. To account explicitly for the country equity risk, R_m and R_f are measured in terms of a minimum risk, developed market. A separate country equity risk premium term, R_c, is added. As we are interested in the pre-tax cost of equity, we must also gross-up for corporate taxes, t.

$$R_e = R_f + \beta \quad (R_m - R_f) + R_c/(1-t)$$

73. The risk *free rate* is the return that can be earned on government securities that generally carry a negligible risk of default. US Treasury bonds are such a security. With respect to term, there is no internationally accepted yield period when selecting bonds for these purposes. The medium-term, 5 year Treasury note rate, is used.

74. The overall *market* return *to equity* is measured on the basis of discounted cash flow analysis of the US stock market. These analyses are publicly available, in this study, data from Bloomberg is used.

75. The *equity beta* measures the "covariance" of movements in a company's share price and movements in the market index and provides a measure of the specific risk associated with an individual company compared to the market. These measures are available from Bloomberg and Valueline.

76. For the country *risk premium*--to reflect the differential risk between investing in the United States and in the OECS—the *real* country risk is identified. For this the difference between the (nominal) equity risk premium

and the (nominal) debt risk premium is calculated. Nominal country risk premiums reflect both inflation risk and real risk. It is likely that the nominal country risk premiums for debt in the ECTEL states reflect primarily inflation risk. The difference between the two should act as a proxy for the real country equity risk premium.

77. The source used for country risk variables is Aswatch Damodaran's site (see Appendix IIA and IIB)

78. *Taxes* must be explicitly considered in the analysis, because return to equity (profit) is taxable. A simple average of tax rates across the OECS is assumed: 33.33%.

79. Turning to the cost of debt component of the WACC, the cost for the comparator companies is calculated by taking the interest expense over the total debt. Return to debt (interest expense) is not subject to tax and does not need to be adjusted. This base data is provided in Appendices IIA and IIB.

Weighted Average Cost of Capital

80. The final step to arrive at the real return to capital is to subtract out the *inflation*. The fixed exchange regime of the Eastern Caribbean dollar to the U.S. dollar suggests that inflation in the OECS will not diverge significantly from inflation in the United States. A consensus value for U.S. inflation over the next two to four years is used.

81. Calculations of the real pre-tax cost of capital are given in Appendix IV. It includes the estimated pre-tax real costs of capital for the comparator fixed and mobile operators, adjusted to reflect conditions in the ECTEL states.

F. Local Service Deficit Calculation

82. The LRIC-based costs are used to estimate a Local Service Deficit for the regulated incumbent's fixed network. In the calculation found in the "LSDC calc" sheet, unit LRIC average costs for local fixed services are multiplied by their corresponding forecasted incumbent volumes for total local service cost. Estimated revenue was derived by taking the average revenues for these services, based on the incumbent's actual unit 07/08 revenue modified in light of the volume assumptions, and multiplying by the same set of volumes as the costs. If the sum of the resulting differences is negative a local service deficit exists.

83. In order that the revenues are not understated, revenue items for regulated services that have not been modeled in LRIC, e.g., value-added services, were added.

84. In applying the local service deficit contribution to rates, the proposed rates had to conform to a number of constraints. Firstly, the per minute ADC could potentially be applied to mobile-to-fixed calls, fixed-to-mobile calls, transit, fixed originated international calls, DQ and emergency services and C&W fixed terminated IDD. We note that fixed-to-mobile call ADC would not find expression in the RIOs.. Secondly, the LSDC on any given traffic type should not exceed the overall unit Local service deficit, i.e., local service deficit over all LSD contributor traffic minutes. Thirdly, those LSDCs should be expected to generate no more recovery than under the ADC in force in the former agreement.

II. LRIC Fixed Network Model

A. Introduction

85. This section describes the structure and function of the LRIC Fixed Network model. The services, assumptions and calculations are identified.

86. In the figure below we have grouped the fixed services in the model into different groups, retail and wholesale.

- Retail services are offered to end users, and can be grouped into access, domestic and international voice, domestic and international data and other.
- Wholesale services are offered by the modeled network operator to other operators and resellers.

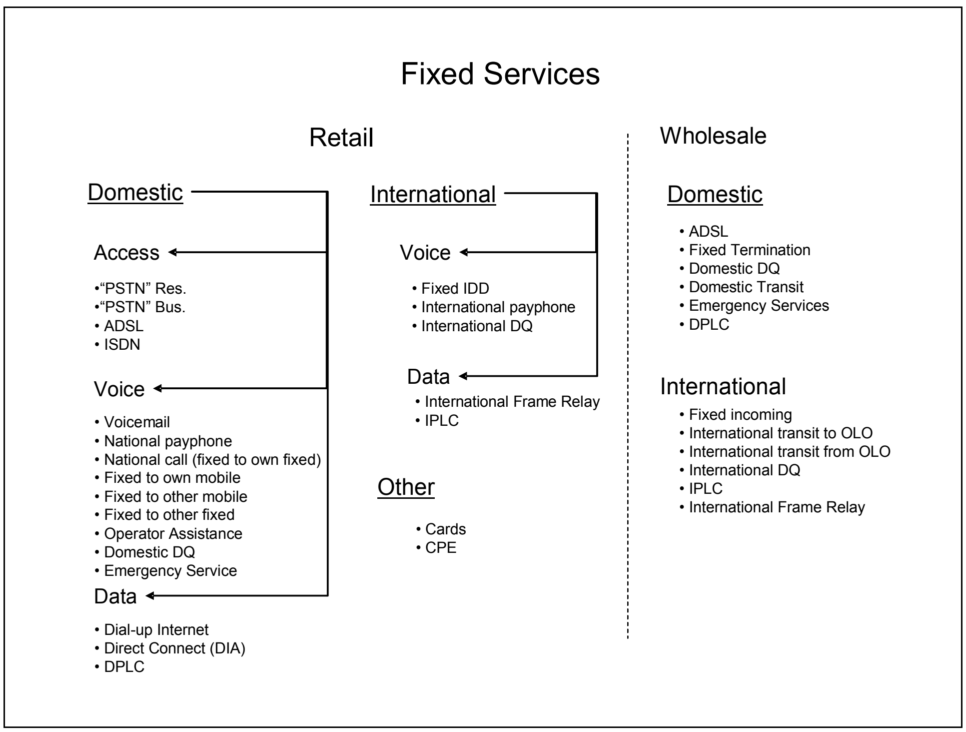

Figure 3. Fixed services in the LRIC model

B. Methodology

87. The fixed network that existed in the OECS member countries until recently was based on traditional technology, with a division into a core network and an access network (see figure 1 below, please note that this is a simplified structural representation and that the number of switches may not correspond to any actual network in the OECS islands). The core network was based on circuit-switched technology, incorporating digital host switches and remote switching units and SDH transmission links. Originating and terminating internet traffic has been routed through a broadband access server (BRAS). DSLAMs are located at the remote switching units.

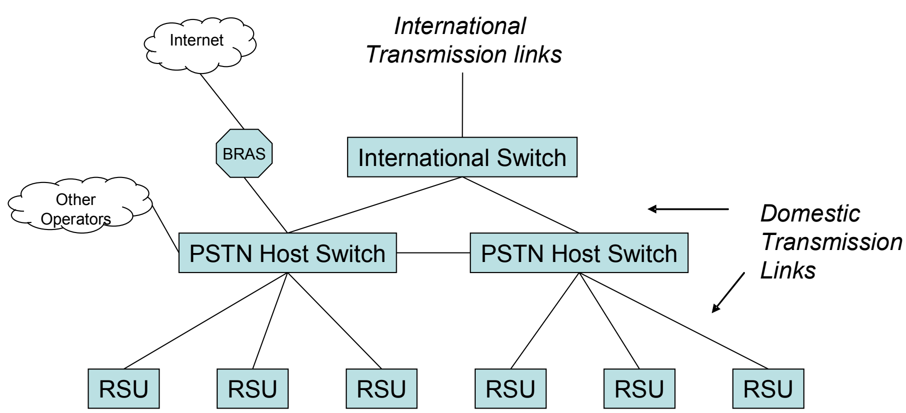

Figure 4. Network Architecture - Traditional Network

88. The access network is based on copper multi-pair cables, both aerial and underground.

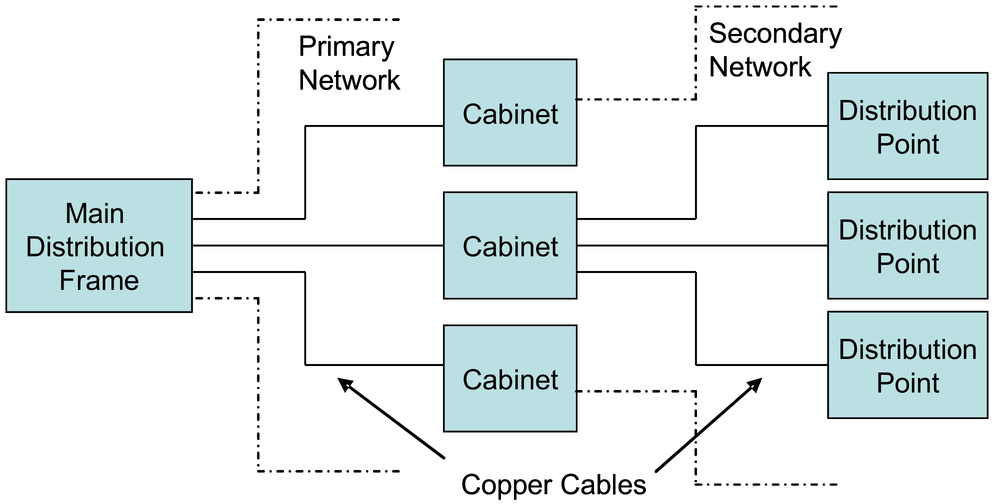

Figure 5. Access Network Architecture

89. The traditional network is now transitioning to next generation technology. Furthermore, the forward-looking approach adopted in the LRIC exercise requires that the bottom-up model be constructed using the technology that an efficient operator would employ today. This means that there are some fundamental differences in the modelled approach when compared with the existing network in the OECS. The key difference is next generation switching equipment is employed to provide a multi-service platform based in IP technology.

90. The implication of this in terms of equipment are that:

- existing PSTN remotes are replaced with voice/broadband-enabled IP concentrators supporting the existing range of services. These will be referred to Media Gateways (MGs) in this text;
- the access network includes of DSLAMs at the Media Gateways;
- existing hosts switches are replaced with Mutltiservice Edge/Softswitch technology. Packet Voice Gateways are installed to allow interface with circuit-switched external networks; and,
- the core transmission network uses SDH Rings.

91. The structure of the modelled core network is shown in the diagram below.

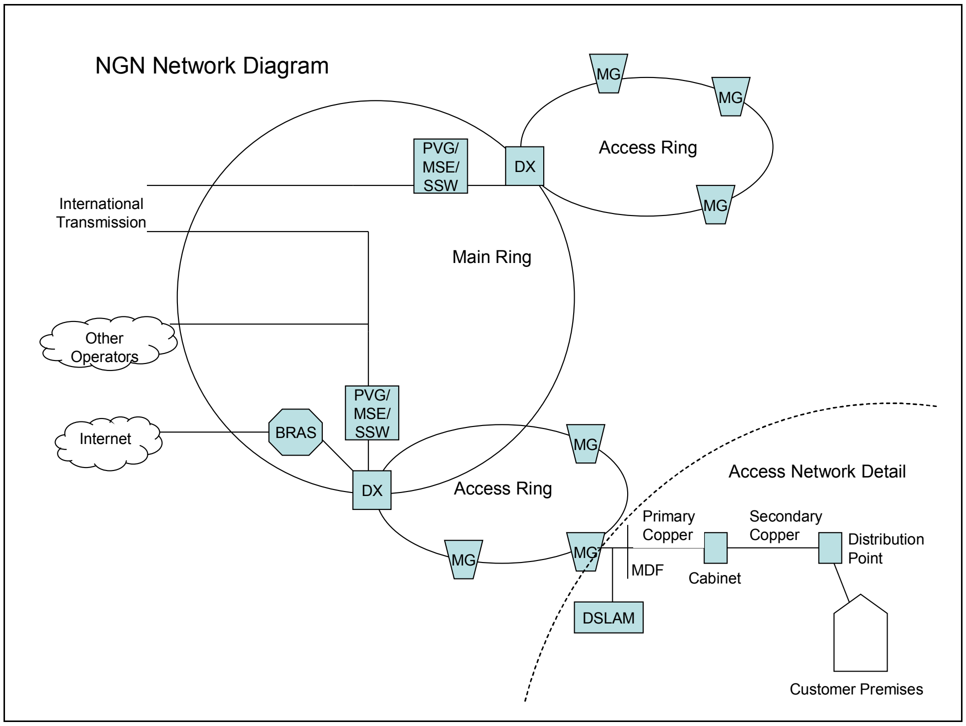

Figure 6. Core Network Architecture - Modelled Network

92. Although the IP technology is radically different to the traditional circuit switches, incumbent plans indicate that the topological structure of the network in the islands are likely to remain as it is today, with changes only in the type of equipment deployed at each node. As a result, the same approach to modelling the fixed network is taken– which is also consistent with the scorched-node assumption that underpins the costing methodology.

93. There is therefore an equivalence in terms of location and sites of some of the network components of the existing network, and network components in the modelled IP network as shown in the table below[4]:

Traditional Component	NGN Component
Access network cable and duct	No change
Core network fibre and duct	No change
Remote switching units	Media Gateways (MG) with DSLAMs
Host Switch with DSLAMs	IP Softswitch(SSW)/Multi-service Edge (MSE)/Packet Voice Gateway

4 Indeed, the model uses the component categories may use the term RSU and MG, and MSE and Host switch interchangeably.

International Switch	None

Description of Network Components

Fixed Model - Access Network

94. The access network is based around a copper cable infrastructure and contains the following components:

- Copper multi-pair cables – these are used in a variety of sizes ranging from 6-pairs to 2000 pairs. Some of the cable is underground, either in ducts or directly buried, and some is aerial, mounted on poles.
- Joints – which provide the connections between the cables – they come in varying sizes according to the cable size.
- Manholes – these are used to provide access to cables joints for installation and maintenance purposes.
- Poles – these may be dedicated to the telecoms network, or may be shared with other utilities such as electricity.
- Duct – this provides an underground conduit for the cable. Some duct may be shared between the access and core networks.
- Distribution Points (DPs), Dropwires and Network Interface Devices – these provide the final link to the customer premises.

Fixed Model - Core Transmission

95. The core transmission network is based around optical fibre cables which may be either underground in ducts or aerial, supported on poles. The following components are used:

- Fibre Cables – these are provided in sizes ranging from 6 to 24 pairs.
- Fibre Joints – these provide the connections between separate lengths of fibre cable, and vary according to the size of cable jointed.
- Ducts, poles and manholes – these are shared with the access network.

96. It should be noted that the transmission network is based on traditional SDH equipment, in a resilient ring configuration. This provides a minimum of 1 STM1 link to each MG. While in the future it may be possible to move to an optical Ethernet technology, giving greater circuit efficiency. However, the incumbent's plans involve the continued investment in SDH as a tried and tested approach which can be relied upon to give carrier-class quality of service.

Fixed Model - Switching

97. Media Gateway (MG) – this equipment connects to the copper access network, and provides the functionality for provision of voice and ISDN calls. ADSL services are provided via a collocated DSLAM unit.

98. Softswitch/Multi-Service Edge and Voice Packet Gateway – this equipment collocated and route calls between MGs, and provides the link between the IP infrastructure of the OECS national network and outside networks.

Network dimensioning rules and assumptions

99. This section describes the rules and assumptions that underpin the dimensioning of the fixed and mobile networks.

Fixed Network - Access

100. For the access network, the cost driver is subscriber lines. By applying the scorched node assumption, all existing nodes in the access network are assumed to remain regardless of the driver volume. At the minimum point, when the driver volume is zero, we assume that there is a capability to provide a line to every customer via normal provisioning procedures. This implies the following at the minimum point:

- At least two pairs are provided to connect each distribution point.
- At least two pairs are provided to connect each cabinet (jumpering at the cabinet can then allow connection to the relevant DP).
- The ratio of aerial to underground cable is kept constant, as it is assumed that the geographical mix of customers does not change with changing volume.
- The total numbers of DPs and cabinets remains the same (scorched node assumption)

101. At the maximum point (i.e., where the volume driver is at the current levels of demand in the network, it is assumed that:

- The current lengths and sizes (i.e. pairs) of cable are appropriate to service the demand, including appropriate allowances for spare capacity.
- The current numbers of cabinets and poles are appropriate to service the demand.

102. In order to calculate the quantities of cables and joints to provide for particular levels of demand, the model interpolates between the minimum and maximum points, using the following method:

- Km length for each cable type remains the same (scorched node assumption)
- The size of each cable (ie number of pairs) is scaled according to the following formula: *Cable size = maximum point cable size * volume / max_volume*
- This size is then rounded up to the nearest standard cable size

Volume at Maximum	146,860	Volume Driver	50,000

Aerial Direct Feed	Pairs provided at maximum	km	Scaled pairs	Rounded pairs	Pair km at max point	Pair km at current volume
	6	6	2	6	34	34
	12	21	4	6	256	128
	18	36	6	12	656	437
	25	98	9	12	2,461	1181
	30	7	10	12	207	83
	37	15	13	18	571	278
	50	82	17	18	4,097	1475
	75	20	26	30	1,523	609
	100	90	34	37	8,974	3320
	150	34	51	75	5,055	2528
	200	129	68	75	25,790	9671
	300	83	102	150	24,915	12457
	400	44	136	150	17,787	6670

Figure 7 Access Dimensions Extract

103. The model extract above (from the "access calculations" sheet) gives an example illustrating how this works:

- In this example, the volume is set to 50,000 lines, compared with a maximum of 146,860 lines
- The first column shows the different sizes of cable at the maximum point
- The second column shows the km of each type
- The "scaled pairs" shows the new size of cable required when the volume is reduced to 50,000 lines
- The "rounded pairs" column shows the requirements using standard cable sizes
- The "pair km at maximum point" shows the pairs multiplied by km at the maximum point
- The "Pair km at current volume" shows the pairs multiplied by km at the volume of 50,000 lines.

104. So, at the volume of 50,000 the same overall km of cable are installed (as the same coverage to the cabinets and DPs must be provided), but the number of pairs in each cable length is reduced to service the reduced demand.

105. The same approach is used to dimension cables of the E-side and D-side, both for aerial and underground.

106. For cable joints, incumbent data on the average separation of joints in a cable run is used to estimate the required number of joints of each type.

The formula used is:
Number of joints = cable km / average separation

107. For manholes and poles, the quantities are assumed to remain constant as they will be needed to provide coverage, regardless of the volume demand.

<u>Fixed Network - Transmission</u>

108. For the core transmission network, the quantities of fibre cable and associated joints are assumed to remain constant, as all the cable will be needed to provide connectivity regardless of the traffic demand.

109. The dimensions are therefore built up from incumbent data, which breaks down the cables by type (i.e. number of pairs and underground/overhead) and gives the km length of each type.

110. The fixed network ratio of km length of aerial fibre to km length underground fibre has been adjusted where necessary to reflect a aerial proportion of 64% of the overall share. This assumption reflects the view that a new build would most likely have a greater proportion of aerial cables to underground cables than the existing incumbent has in practice.

<u>Fixed Network – Submarine Transmission</u>

111. The OECS currently makes use of a variety of submarine cable systems to provide international connectivity for voice and data. In order to model this, using current costs, an analysis is performed from recent capacity purchases.

112. A unit cost per STM-1 capacity is thus derived representative of the current costs involved in procuring the required connectivity. The international capacity required in the OECS is calculated from the “Demand Calculations” sheet, and this demand is used to drive the required number of STM-1s.

<u>Fixed Network - Switching</u>

113. The switching equipment is dimensioned according to recent supplier network design specific to the incumbent’s Caribbean businesses. We note that, as is so often the case for smaller markets, the switching equipment purchased is the minimum configuration produced by the vendor.

<u>Fixed Network - MG Dimensions</u>

114. The starting point for determining the costs of the media gateways (MGs) is a list of all the incumbent’s current RSUs and the installed line capacity.

115. The dimensioned demand column is calculated by scaling the current installed lines for each RSU by the lines volume driver using the following formula:

*Dimensioned demand = total lines * volume driver / total lines max point*
The MG cost for each node is then calculated in the total cost per MG column via the following formula:
*Cost = dimensioned demand * (1+voice/dsl provisioning ratio) / MG fill ratio * MG cost per port*

116. Although most of the MG costs comprise the costs of the access line interface, there remain some costs which relate to handling traffic. The above dimensioning formula does not allow for this distinction, so it is next necessary to calculate the split between traffic-related and line related costs.

117. This is done in the “MG analysis” sheet. Here, using data provided by a well-known vendor relating to the replacement of certain RSUs by MG equipment, it is possible to derive the relationship between line-driven costs and the remaining fixed cost.

118. The resulting ratio of fixed costs as a % of total is then used to split the MG costs in the MG dimensions sheet into fixed (traffic related) and variable (line related) costs.

Fixed Network - Softswitch Dimensions

119. A softswitch is located at the existing host switch sites (this implies that in the St. Lucia and Grenada versions of this model there are two, in the other Member States only one). Each softswitch node consists of the following components:

- Softswitch hardware
- Softswitch software
- Gateway controller
- C7 Interface
- Central Office LAN

120. These quantities for these components represent a minimum configuration, yet are capable of supporting the entire voice and data requirements for a market the size of an OECS member country. As such, the equipment costs for the softswitches are fixed and do not vary with volume (just as the traditional switches were).

121. It should be noted that the softswitches are capable of handling all the international traffic, as well as national, and so there is no separate international switching element.

C. Model Structure & Operation

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

Fixed Model Structure

123. The structure of fixed model set out in the "Contents" tab of the workbook. They can be roughly grouped into five types of sheets:

- Model Inputs
- Network Structure
- Network Calculations
- Cost Calculations
- Top-down Interface (for volumes and Route factors)
- Model Outputs

124. A pop-up "menu" is incorporated into each of the sheets to explain the function of the sheet and assist in navigation around the model.

125. In addition to these worksheets, there is a "Definitions" sheet, which contains a glossary of terms and concepts used in the model; and a worksheet "LSDC Gen calc" related to the calculation of the Local Service Deficit described below.

Model Inputs

126. There are ten sheets constituting the model inputs: List of Services, List of Network Elements, Cost Assumptions, Technical Assumptions, Demand Assumptions, Routing Factors, Asset lives and Expense Factors. The Expense factor sheet is derived from two sub input sheets Adjusted Expense Factors and consol Expense factors. The sheets contain the following information:

- *List of Services* and *List of Network Elements* are self-explanatory.
- *Cost assumptions* – the unit cost assumptions used for the duct, access, transmission and NGN parts of the network
- *Technical assumptions* – the engineering assumptions that are used to dimension the network.

- *Demand assumptions* – the assumptions regarding traffic, used to dimension the network.
- *Routing Factors* – the source for the routing factors for all the services. We note that we use traditional notation for the network elements here, so “PSTN Host Switch” is used for the MSE/Softswitch/PVG element, “RSU” is used for the MG element.
- *Asset lives* –the asset lives used in the model to calculate the annualised costs.
- *Expense factor sheets* – these were described in Section ID.

Top-down Interface

- *Volume inputs (Scenario Volumes and TD Volume Inputs)* – these are the sources for the volumes by service. It also includes leased lines, frame relay and direct internet connection –it is used to calculate the bandwidth required for these services.
- *RF for TD* – This sheet, an intermediate sheet, captures the routing factors assigned to network elements in columnar form for subsequent use in the Vol Net Elem sheet.
- *Vol Net Elem* –. This sheet brings together the TD Volume Inputs sheet and the RF for TD sheet through a series of pivot tables employed in deriving the demand volume of each network element.

Network Structure

127. There are five worksheets containing the data which defines the structure of the network. The worksheets contain the following information:

- *Access Dimensions* – the quantity of various types of cable, and other information such as the spacing of joints and the number of manholes and poles.
- *Transmission Equipment Dimensions* – the quantity of different types of optical cable.
- *Duct Dimensions* – the quantity of different categories of duct.

- *MG Dimensions* – the MG sites, and the number of lines installed at each site.

- *Core Fibre Dimensions*– the quantity and length of fibre in the core network.

Network Calculations

128. There are six working composed of the algorithms used to calculate the quantities of network equipment required to meet the service demand. The contain the following information:

- *Demand Calculations* – taking the volume inputs by service and scaling up to allow for such thing as future growth, this sheet uses the routing factors to calculate the demand placed on each network element. This demand is then expressed both as an annual measure and a busy-hour measure.

- *Access Calculations* – the calculation of the access network required to meet the demand.

- *MG Calculations* – the calculation of the MG lines needed to meet the demand.

- *Duct and Core Fibre Calculations* – (two sheets) the derivation of the dollar amount of duct and core fibre needed to meet demand.

- *International Transmission Costs* – the calculation of the amount of submarine cable capacity needed to meet service demand.

Cost Calculations

129. There are five sheets composed of the calculations of total costs for the main network components. The contain the following calculations:

- *Access costs* – using the calculated dimensions of the access network, along with the unit prices, this sheet calculates the total access network costs split by the various components.

- *Core fibre costs* – using the core fibre dimensions, total costs for fibre in the core network are calculated.

- *Transmission equipment costs* –using the transmission dimensions, this sheet calculates total costs for the core transmission network.

- *NGN costs* – this sheet calculates the costs of the NGN components, based on the dimensions, the traffic demand and the unit costs.

- *Other Costs* – this sheet prices out the total number of payphone and DSLAM units.

130. Please note that it is in these Costs sheets that any mark-up for indirect capex is added.

Model Outputs

131. There are seven individual worksheets in each which a) pull together the output of the bottom-up network costs and expense factored opex and b) summarize the LRIC results by service.

- *Cost Summary and Mapping* summarises the costs for the network components, and provides splits where needed (e.g., to split duct between access and core, and to split the core transmission between voice, data and internet).

- *Scenario Output*. *BU Output and BU Output(2) (three sheets)* provides bottom-up LRIC results in tabular form

- *FAC output* contains imported values from the bottom-up models showing the full costs of each Network Element per Cost Type.

- *Fixed Network Costs* contains a report describing total and unit cost of individual Fixed Network Elements.

- *Fixed Service Costs* contains a report describing the total and unit costs of individual Fixed Services by Network Element.

132. There is one aspect to the Fixed Service Cost sheet that requires additional explanation: the interconnection specific costs. These costs are estimated as being composed of:

- *The portion of the annual budget of the* Carrier *Services Division* for the incumbent that only deals with interconnection and wholesale matters reflecting the resources of the Division that would be spent on interconnection and related activities in the member country modelled *as well as any activities undertaken by local business unit staff on* *such matters*. This is *a variable cost* as, if no operator were sending traffic, the incumbent would not have employed these resources.

- *The cost of the trib* cards *in the transmission core.* These are specific to a given operator and would not be incurred if traffic was not passed. These also are therefore *variable costs*.

- The relevant share for each business of *the costs of interconnection billing system* purchased for the purposes of interconnection. This considered a *fixed cost* because—whether traffic were being conveyed or not, the incumbent would still require the billing system to be in place and operable. These costs are excluded from the wholesale service costing.

133. The interconnection specific variable costs are disaggregated from the total call duration charge, making use of the route factors.

III. LRIC Mobile Network model

A. Introduction

134. This section describes the structure and function of the mobile LRIC model. The services, assumptions and calculations are identified.

135. Mobile services represent a smaller set than fixed services do. 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.

Mobile Services	
Retail	Wholesale
• Subscriber • On-net calling • Mobile to Fixed Calling • Mobile to Other Mobile Calling • Voicemail • Mobile Data • SMS • Mobile Originated International calling	• Mobile termination • Mobile incoming International calling • Inbound roaming

Figure 8 Mobile services in the LRIC model

B. Methodology

136. A GSM network consists of cell sites, BTS, BSC and MSC switches[5]. 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.

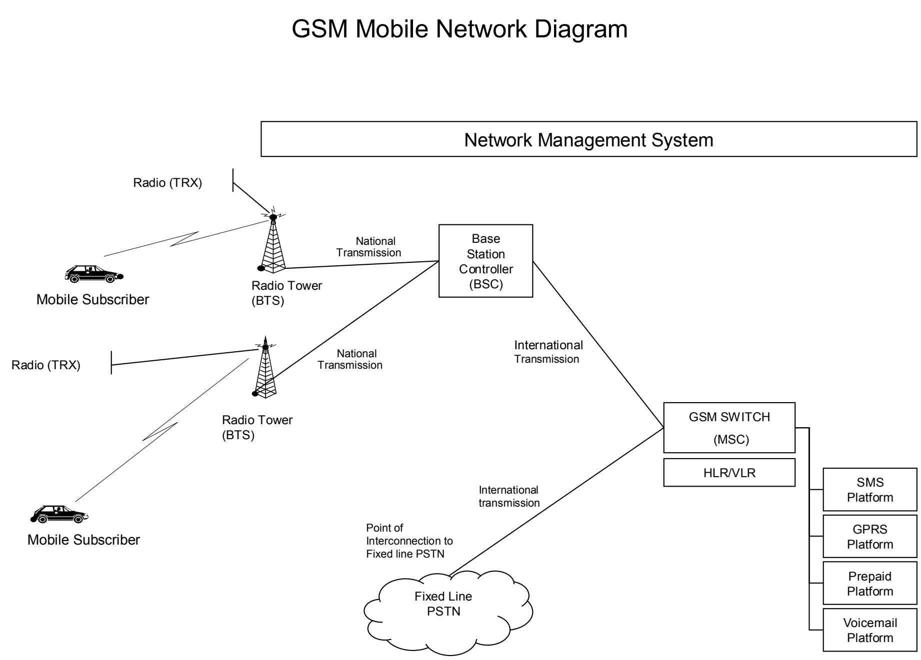

Figure 9 Mobile Network Architecture

Mobile Network - Radio

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

- Antennas
- Towers

[5] Please note that in this model assumes that a single switch serves more than one market.

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

138. 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

139. Fixed transmission connections are needed to connect the BTS units to the Base Station Controllers (BSC), and the BSC units to the switches. It is assumed that the mobile network uses leased line obtained at commercial rates from a fixed network operator to provide backhaul connectivity. The mobile network is, thus, assumed not to own any fixed transmission infrastructure.

140. 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 (i.e, where the BTS and BSC are not collocated).

Mobile Network – Switching

141. There are two main segments of the mobile switching equipment:

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

142. A single MSC is assumed to reside off-shore serving a total subscriber base of 100,000 subscribers. In all versions, the BSCs, as per the scorched node assumption, are assumed to be located where they are currently in the incumbent's network.

Mobile Network - Radio and Switching

143. 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 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.
Capacity Planning Maximum Load Factor	The maximum capacity used, before new capacity is added to the network. The higher the loading factor, the larger the capacity of each TRX and the lower the number of required components
Coverage areas (square km)	Splits the geographic area into dense, medium and rural. Used to calculate the capacity 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
Number of Cell Sites	This input is used to define the number of dense, medium and rural cell sites used in the model.
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
Network Increments	Details the number of subscribers that each unit of equipment can cater for

Radio Nodes

144. The GSM network consists of a number of cell sites. Each site is assumed to provide omni directional coverage (i.e. 360° coverage around the cell centre) or sectorised coverage (i.e. 3 x 120° 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.

145. The number and size of the equipment depends on the coverage area of the cell, which drives the amount of traffic that it is required to handle (also depending on whether the cell is rural, medium or dense). 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 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.

146. The number of cell sites in the networks is determined according to the scorched node assumption, and hence is simply an input to the model.

147. Using the numbers of cells for each segment, the traffic per cell is determined. 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.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 calculation is performed separately for voice and data.

Switching Nodes

148. MSC is assumed to be able to cater for 125,000 subscribers (equivalent to a traffic load of approximately 3000E of busy hour traffic). Actual subscribership is assumed to be 100,000 subscribers, including the subscribers in the modeled mobile operator.

149. As mentioned, the MSC and associated components such as the HLR are assumed to be located off-island and shared; the cost is split between the modelled island and the region, based on a split of mobile subscribers entered into the “Demand Assumptions” sheet.

Sizing the nodes

150. 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 is defined as a BTS, an omni cell is one antenna and a sectorised cell is 3 antennas.

151. 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.

C. Model Structure & Operation

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

Mobile Model Structure

153. The mobile model can be thought of as divided into the following modules:

- Model Inputs
- TD Interfaces
- Network Calculations
- Cost Calculations
- Model Outputs

Model Inputs

154. This module contains all the data inputs needed to run the model. Please note that in Appendix VI we present a comprehensive list of inputs required. The sheets contain the following information.

- *Services*
- *Cost Assumptions* – this contains all the unit cost data. Please note that 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* –the demand assumptions needed to dimension the network.
- *Technical assumptions* – the engineering assumptions needed to dimension the radio and switching networks.
- *Routing Factor inputs* – the source for the routing factors used for all services. Again, routing factors Indicate how often a particular network element is used in providing a given service and are used

to calculate the demand volumes of each network element. For example, a routing factor of 2 for a BTS supporting the service Mobile on-net calls, indicates 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.

- *Erlang B* – this contains a standard Erlang B lookup table.
- *Expense factor sheets (three)* – these were described in Section ID.

TD Interface

- *Volumes Inputs (Scenario Volumes and TD Volume Inputs)* — these are the sources for the volumes by service. These are the volumes that will be zeroed out to determine incremental costs.
- *RF for TD – This sheet, an intermediate sheet, captures the routing factors assigned to network elements in columnar form for subsequent use in the Vol Net Elem sheet.*
- Vol Net Elem –. This sheet brings together the TD Volume Inputs sheet and the RF for TD sheet through a series of pivot tables employed in deriving the demand volume of each network element.

Network Calculations

155. This module contains the algorithms used to dimension the network. The four sheets making up this module contain the following information.

- *Demand calculations* –taking the service demand from the Demand Assumptions and using the routing factors, it calculates demand by network element.
- *Radio calculations* – the calculations needed for dimensioning of the cell-sites.

- *Switching calculations* – the calculation of the size and quantities of equipment required for switching.
- *Transmission Links* – the calculation of the number and sizes of links needed to connect base stations to the switching network.

Cost calculations

156. *Network Costs* sheet 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

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

- *Scenario Output*. *BU Output and BU Output(2) (three sheets)* provides bottom-up LRIC results in tabular form
- *FAC output* contains imported values from the bottom-up models showing the full costs of each Network Element per Cost Type.
- The *Mobile Network Cost* worksheet contains a report describing total and unit cost of individual Mobile Network Elements.
- The *Mobile Service Cost* worksheet contains a report describing the total and unit costs of individual Mobile Services by Network Element.

158. One result in the Mobile Service Costs sheet warrants further discussion: the "fully loaded termination rate". This term simply refers to the mobile termination cost plus an add-on for interconnect specific costs. The interconnect specific costs for mobile are derived in the following manner. The variable interconnect specific cost is assumed to be commensurate to that for the fixed network. The derivation of that cost is found in section IG. To this are added proxy infrastructure costs. The proxy infrastructure costs are based on fixed network DPLC (and, if the mobile switch is located off island, IPLC) components. The capacity of both DPLC and IPLC components are assumed to be an STM-1. The total cost of non-infrastructure and infrastructure costs are divided by the relevant interconnect volumes to arrive at the mobile interconnect specific cost.

Appendices

Appendix I. List of Expense Factors

Fixed Network expenses

- Access Line Installations - Service Contract
- External Network Maintenance - Civil Works
- External Network Maintenance - Monitor Network Performance
- External Network Maintenance - Reconcentrate Cables
- External Network Maintenance - Repair Overhead Cables
- External Network Maintenance - Repair Underground Cables
- External Network Maintenance - Routine & Corrective Maintenance
- External Network Maintenance - Verify & Upgrade Plant
- Install Central Office Facilities - Business Access
- Install Central Office Facilities - Residential Access
- Maintain & Repair Distribution Network
- Network Planning - Access Network
- Provide Aerial Distribution Network Cabling
- Provide Underground Distribution Network Cabling
- External Network Maintenance - Repair & Replace Cables
- Maintain Core Network Infrastructure
- Maintain Data and IP Network Platforms
- Maintain National Switching Equipment
- Maintain National Transmission Cables
- Maintain National Transmission Infrastructure
- Monitor & Maintain Core Network
- Network Engineering - Fixed Network
- Network Planning - Fixed Network
- Provide National Switching Equipment
- Fixed Billing: System Integrity
- Maintain Internet Services Equipment
- Perform Repair of Faults Reported by Customers
- Provide & Maintain ADSL Services
- Provide & Maintain Other Service Platforms

- Provide & Maintain Payphone Services
- Provide & Maintain VAS
- Provide Dedicated Internet Access Services
- Provide Dial Up Internet Services
- Provide Domestic Frame Relay
- Provide Domestic Leased Lines
- Provide Fixed Network Prepaid Calling Card Services
- Regional Recharge - Internet Technical Centre
- Regional Recharge IN - Broadband
- Regional Recharge IN - Provide Internet Services
- Maintain International Transmission
- Provide International Leased Lines
- Regional Recharge IN - Maintain International Transmission
- ECFS Recharge
- Collate and analyse interconnect specific cost information
- Interpret Regulations into Interconnect Operating Policies and Compliance
- Manage Regulatory Policy
- Provide Regulatory Affairs Support
- Regional Recharge IN - Carrier Sales & Operations
- Regional Recharge IN - Carrier Services Billing
- NDM Networks Operations
- Provide Engineering Management
- Regional Recharge IN - Regional Facilities
- Regional Recharge IN - Regional Network Management Centre
- Asset Sales - Fixed Network
- Capital Accruals - Fixed Network
- Insurance - Fixed Network
- Leased Circuit Debtors - Fixed Network
- Wholesale Debtors - Fixed Network
- Royalty Fees - Fixed Network
- Staff Debtors - Networks - Fixed
- Costs Recoverable - Networks - Fixed

- Prepayments - Networks - Fixed
- Operational Provisions - Networks - Fixed
- Trade Creditors - Networks - Fixed
- Stock - Networks - Fixed
- Intercompany - Networks - Fixed
- Cash - Networks - Fixed
- Freehold Technical Infrastructure - Fixed Network
- Furniture and Fittings - Fixed Network
- Computers - Fixed Network
- Customer Apparatus - Fixed Network
- Building Infrastructure - Fixed Network
- Vehicles - Fixed Network

Mobile Network expenses

- Activate Cellular Service
- Install, Monitor & Maintain Mobile Network
- Maintain Mobile Network
- Maintain Radio Frequency
- Manage Handset Repair Strategy
- Monitor Mobile Network
- Plan Mobile Network
- Provide Mobile Network Services
- Regional Recharge - Mobile Other Operating
- Regional Recharge OUT - Mobile
- Manage Mobile Operations
- Asset Sales - Mobile Network
- Capital Accruals - Mobile Network
- Staff Debtors - Networks - Mobile
- Costs Recoverable - Networks - Mobile
- Prepayments - Networks - Mobile

- Operational Provisions - Networks - Mobile
- Trade Creditors - Networks - Mobile
- Stock - Networks - Mobile
- Intercompany - Networks - Mobile
- Cash - Networks - Mobile
- Mobile Staff Creditors
- Mobile Trade Debtors
- Mobile Wholesale Creditor
- Mobile Wholesale Debtors
- Freehold Technical Infrastructure - Mobile Network
- Furniture and Fittings - Mobile Network
- Computers - Mobile Network
- Building Infrastructure - Mobile Network
- Vehicles - Mobile Network

Fixed & Mobile Network Overheads

- Manage Disaster Recovery Process
- Manage Network Buildings
- Networks - General Management
- Manage Insurance Premium & Claims
- Power Plant Repairs
- Provide Operational Support Systems
- C&W Group Management Fee - Networks
- Finance, accounting and budgeting - Networks
- Human Resources - Networks
- Manage Admin Buildings - Networks
- Manage Corporate Affairs - Networks
- Procurement & Stores - Networks
- Manage Operations - Networks
- Property Rentals - Networks
- Operate Fleet - Networks
- Provide Business Support Systems - Networks
- Provide Legal Services - Networks
- Provide Project Management - Networks
- Regional Recharge IN - Provide IT Services - Networks
- Regional Recharge IN - Provide Legal Services - Networks
- Regional Recharge IN - Provide Tax Services - Networks
- Sundry Financial Charges - Networks

Appendix IIA. WACC Calculation- Fixed Network

Company	Country	Unlevered Beta[1]	Total Shareholders Equity ($M)	Pre-tax Cost of Equity	Equity Ratio	Interest Expense ($M)	Total Debt ($M)[2]	Cost of Debt	Adjusted CoC
Citizens Communications	USA	0.25	$ 998	15%	17%	$ 381	$ 4,739	12.27%	12.7%
CenturyTel Inc.	USA	0.53	$ 3,409	19%	55%	$ 213	$ 2,734	12.03%	16.1%
Iowa Telecom	USA	0.39	$ 243	17%	31%	$ 32	$ 546	10.08%	12.2%

Averaged Adjusted Real CoC	11.26%

Parameters for adjustments for OECS-5 states	
(Nominal) Country risk premium for debt [2]	4.24%
(Nominal) Country risk premium for equity	6.36%
Average Corporate tax rate in OECS-5	33.67%

Aggregate U.S. data (2008)		
Equity yield	13.88%	
T bill yield	2.66%	Federal Reserve Economic Data, April 14, 2008.
Inflation	2.40%	http://www.imf.org/external/pubs/ft/scr/2008/cr0894.pdf
Dividend Yield S&P 500 [4]	2.17%	
Growth Rate S&P 500 [5]	11.46%	

Notes and Sources:
- Accounting cost of debt financials from Fiscal Year End 2007 financial reports

[1] Levered data from Bloomberg

[2] Moody's Government Bond Ratings, as of April 10, 2008.

[3] Based on Aswatch Damodaran's Average Equity Market to Debt Market Volatility of 1.5

[4] Standard & Poors S&P 500 Earnings and Estimate Report, April 14, 2008.

[5] Data from Vanguard, April 23, 2008

Appendix IIB. WACC Calculation- Mobile Network

Company	Country	Unlevered Beta[1]	Total Shareholders Equity ($M)	Pre-tax Cost of Equity	Equity Ratio	Interest Expense ($M)	Total Debt ($M)[2]	Cost of Debt	Adjusted CoC
U.S. Cellular	USA	0.70	$ 3,196	22.3%	76%	$ 85	$ 1,002	12.69%	20.0%
NTT Docomo Inc	JAP	0.66	$ 35,397	21.6%	87%	$ 49	$ 5,128	5.19%	19.5%
LEAP Wireless International	USA	0.82	$ 1,724	24.3%	46%	$ 121	$ 2,044	10.17%	16.6%

Averaged Adjusted Real CoC	**16.32%**

Parameters for adjustments for OECS-5 states

(Nominal) Country risk premium for debt [2]	4.24%
(Nominal) Country risk premium for equity [3]	6.36%
Average Corporate tax rate in OECS-5	33.67%

Aggregate U.S. data (2008)

Equity yield	13.88%	
T bill yield	2.66%	Federal Reserve Economic Data, April 14, 2008.
Inflation	2.40%	http://www.imf.org/external/pubs/ft/scr/2008/cr0894.pdf
Dividend Yield S&P 500 [4]	2.17%	
Growth Rate S&P 500 [5]	11.46%	

Notes and Sources:
- Accounting cost of debt financials from Fiscal Year End 2007 financial reports
[1] Beta data from Bloomberg
[2] Moody's Government Bond Ratings, as of April 10, 2008.
[3] Based on Aswatch Damodaran's Average Equity Market to Debt Market Volatility of 1.5
[4] Standard & Poors S&P 500 Earnings and Estimate Report, April 14, 2008.
[5] Data from Vanguard, April 23, 2008

Appendix III. Fixed Network Model: List of Inputs

Cost Assumption Inputs:-

- **General Assumptions:**
  - Exchange rates
  - WACC
  - Planning cost as % of Capex

- **Duct Costs:**
  - Exclusive duct (ie, single bore)
  - Shared duct
  - Sub Duct

- **Access Network Costs:**
  - Copper (e.g. 100 pair, 500 pair, dropwire etc)
    - Aerial
    - NID
    - Underground
    - Other Information
    - Cabinets/Copper Cross connect
    - Poles
    - Islandwide Media mix
    - Media Mix (Entrant specific)
    - Manholes (list by type e.g. concrete, steel)
    - Costs for Asphalt/Concrete version
    - Distribution Points

- **Transmission Direct Capex Cost:**
  - Cable
  - Optical fiber joint

- **NGN Direct Capex Cost:**
  - MG, Per Port
  - SOFTSWITCH Node - Base, Per Node, 4 Port Access, Per 4 Port
  - Softswitch Per Port, Per Line/Trunk
  - Voice Migration Per Port, Per Line/Trunk
  - Voice Migration Planning, Per Line/Trunk
  - BRAS, Per DSL User
  - Network Management hardware, Per system
  - Network Management software, Per system
  - MG network interface card, Per card

- Voicemail Platform, Per platform

Technical Assumptions:-

- **Engineering Assumptions:**
  - Conversion factor for minutes to erlangs
  - # of 64kbps channels in a 2 Mbps link
  - NGN Assumptions
    - Planning ratio
    - MG Fill Ratio
    - ADSL average bandwidth per line Mbit/s
    - ADSL Service Contention Ratio
    - SOFTSWITCH ratio of call-sensitive/duration-sensitive
    - Number of Core NGN Sites
    - Max capacity for Softswitch – minutes
    - Line/Trunk Ratio

Demand Assumptions:-

- **Traffic Data:**
  - % of traffic in busy hours
  - # of busy hours
  - Transmission capacity allowance
  - Provisioning Allowance
  - Annual growth rate for lines
  - Avg non conversation holding time for successful calls (minutes per call)
  - Ratio of total/successful calls

Asset Lives:-

- NGN Equipment
- Duct
- Fibre Cable
- Fibre Joints
- Poles
- Management Systems
- Manholes
- Copper Cable
- Copper Joints
- DPs, Dropwire, NID

Routing Factors

Volume Inputs by # Calls, # Lines, Minutes, 2M, Other for:-

- ADSL RETAIL
- ADSL WHOLESALE
- CARDS
- DIAL UP INTERNET USAGE
- DIRECT CONNECT
- DOMESTIC DQ RETAIL
- DOMESTIC DQ WHOLESALE
- DOMESTIC LEASED CIRCUITS RETAIL
- DOMESTIC LEASED CIRCUITS WHOLESALE
- DOMESTIC TRANSIT
- EMERGENCY SERVICES RETAIL
- EMERGENCY SERVICES WHOLESALE
- FIXED CALL TO C&W MOBILE
- FIXED CALL TO OTHER MOBILE
- FIXED INTERNATIONAL INCOMING
- FIXED INTERNATIONAL OUTGOING
- FIXED VOICEMAIL RETAIL
- INTERNATIONAL DQ RETAIL
- INTERNATIONAL DQ WHOLESALE
- INTERNATIONAL FRAME RELAY RETAIL
- INTERNATIONAL FRAME RELAY WHOLESALE
- INTERNATIONAL LEASED CIRCUITS RETAIL
- INTERNATIONAL LEASED CIRCUITS WHOLESALE
- INTERNATIONAL PAYPHONE
- ISDN ACCESS RETAIL
- NATIONAL PAYPHONE
- OPERATOR ASSISTANCE
- PSTN ACCESS BUS
- PSTN ACCESS RES
- FIXED CALL to OLO
- PSTN TERMINATION
- NATIONAL CALL RETAIL
- INTERNATIONAL TRANSIT from OLO
- INTERNATIONAL TRANSIT to OLO

Network Structure Dimension Inputs:-

- **Duct dimensions:**
    - Exclusive duct (ie, single bore) lengths
    - Shared duct distance lengths
    - sub-duct lengths

- **Access Dimensions:**
    - Copper pair cable by type and length(e.g. 100 pair, 500 pair, dropwire etc)
        - Aerial Direct Feed
        - Aerial D-side
        - Aerial E-side
        - NID
        - Underground Direct Feed
        - Underground D-side
        - Underground E-side
    - Other Information
        - Average separation of jointing boxes by length
        - Average separation of fibre splices – underground by length
        - Average underground length of transmission between concentrator and distribution point
        - Average aerial length of transmission between cross connect cabinet and furthest distribution point
        - Average UG length of transmission between Exchange and the cross connect cabinet
    - Cabinets/Copper Cross connection points, units
    - Poles, units
    - Manholes (list by type e.g. concrete, steel)
    - DP's, units

- **MG Dimensions:**
    - Existing Concentrator Locations
    - Number of subscribers

- **Transmission Dimensions:**
    - Transmission type – aerial/underground
    - Lengths
    - Run
    - Sections
    - Fibre

- **Data Volume Inputs:**
  - Retail Domestic LL Capacity (2M)
  - Retail Domestic LL No. of Lines
  - Wholesale Domestic LL Capacity (2M)
  - Wholesale Domestic LL No. of Lines
  - Retail IPLC Capacity (2M)
  - Retail IPLC No. of Lines
  - Wholesale IPLC Capacity (2M)
  - Wholesale IPLC No. of Lines

Appendix IV. Mobile Network Model: 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
        - Site cost for omni cell
        - Site cost for sectorised cell
        - TRX
        - BTS Unit
    - ♦ Other Network Equipment
        - BSC
        - MSC
        - VAS
        - TCU
        - HLR
        - SGSN
        - GGSN
        - PCU
        - Internet Gateway
        - 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
    - Available GSM 850 or 900 spectrum
    - Available GSM 1900 or 1800 spectrum
    - Re-use factor GSM 850 or 900

    - Re-use factor GSM 1900 or 1800
    - GSM Carrier bandwidth
    - Timeslots per carrier GSM
    - Radio Path GoS
    - Traffic per T1 (Erl)
- Traffic distribution
    - Dense (%)
    - Medium (%)
    - Rural (%)
- Coverage area surface (km2)
    - Dense
    - Medium
    - Rural
- Cell sectorisation per area
    - Dense (%)
    - Medium (%)
    - Rural (%)
- # cell sites per BTS
- Grade of service
- 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)

Appendix V: Glossary

Common Cost - LRIC costs calculated as a consequence of volume reduction of all Products that are not pure and joint LRIC. They are calculated technically as LRIC cost of Total Increment (i.e. G-ALL-PROD - contains all products) minus sum of LRIC costs of all Sub Increments.

Element ID - Types of Cost, e.g. Annualized Cost, GRC, Opex and Overhead Opex.

Entity ID - Cost Object, e.g. level Cost Categories, 400-level Network Elements and 900-level Products.

EPMU – Equal Proportionate Mark-Up

FCC – Fixed Common Cost

GRP - Field GRP is defined only for individual Product Increments (GRP is defined as zero for Sub Increments and Total Increment). It defines the Group of Products that is also definition of Sub Increments.

Increment: The output over which costs are being measured.

Incremental costs: The additional costs that would result from a defined increment to demand.

Increment ID, Sub Increments, Total Increment - ID of Cost Object whose volumes where reduced to zero – individual Products (for calculation of pure LRIC), Sub Increments – groups of products (for calculation of Joint Cost) and Total Increment – all Products (for calculation of Common Cost).

ISFC – Increment-Specific Fixed Costs – those costs which do not vary with a particular driver volume, but which can be attributed entirely to a single increment.

Joint Cost: LRIC costs calculated as a consequence of a reduction in volume of a Group of Products that are not pure LRIC costs. They are calculated as the LRIC of a Sub-Increment (e.g. Mobile Traffic) minus the sum of the LRIC of individual Product Increments that belong to specified Group of Products.

Long run: The period over which all factors of production, including capital, are variable.

Long Run Incremental Costs (LRIC): The incremental costs that would arise in the long run with a defined increment to demand.

Markup Type: Type of LRIC values:

- LRIC without Markup - LRIC values of Product Increments (also known as pure LRIC),
- G-Fixed Access, G-Fixed Traffic, G-Mobile Traffic… - Joint Costs (these costs are removed only when all volumes of specified products are removed)

- BU-F: Common - Variable, BU-F: Mobile – Variable, BU-F: Common - Fixed, BU-F: Mobile – Fixed are Common Costs (these costs are removed only when all volumes of all products (group G-ALL-PROD) are removed).

MG – Media gateway

MSE- Multi-Service Edge

Network Component – a group of costs which relate to a particular, identifiable part of the network infrastructure (e.g., a local switch), loaded with all the related direct and indirect costs.

OLO – Other Licensed Operators – telecommunications network or service providers other than C&W.

Operating Cost-Values of LRIC Operating Costs, i.e. values of Opex and Overhead Opex Elements.

Routing Factor, Allocated Volume - Routing Factor defines, how many times a specific Network Element is used by a specific Product. The same mechanism allows also backward allocation of volume from Products to Network Elements.

RSU – Remote Switching Unit.

Scenario Values, LRIC Values. Scenario Values are calculated as the costs when volumes of selected Products are reduced from full volume to zero. LRIC values are calculated as the difference between Scenario Values and FAC Values.

TD – Top Down

WACC – Weighted Average Cost of Capital