LRIC Bottom-Up model for interconnection

Consultation Document 3.1 & Addenda

Summary of the comments
Decisions taken by the BIPT

Prepared by BIPT
In collaboration with Bureau van Dijk Management Consultants

September 10th, 2003

Bottom-up LRIC model – Consultation Document 3.1:
Summary of the comments and decisions taken by the BIPT

Table of Contents

0. INTRODUCTION

On April 27th and October 3rd, 2001, the BIPT issued the first and second consultation document with respect to the creation of a Bottom-Up model, in order to define the general methodology and the logical and physical network to be modelled. The summaries of these two consultation documents have been published by the BIPT on June 4th, 2001 and on March 29th of 2002. The decisions were commented in further detail to the market on June 24th, 2001 and April 9th, 2002 by the BIPT's consultant, *Bureau van Dijk Management Consultants.*

Subsequently, a third consultation document for the development of the first version of the Bottom-Up model was issued on April 23rd, 2002. During the technical meeting that followed upon the consultation document on May 21st, 2002, the present operators phrased some comments, which were translated in a first addendum to the third consultation document, issued on June 3rd, 2002. Finally, a second addendum was issued on July 15th, 2002, treating the modelling of Accommodation Costs, DWDM equipment and the signalling network.

In the third consultation document and its addenda, the BIPT invited the various telecom operators to submit information and phrase comments regarding the technical algorithms that will be used for the dimensioning of the network, costing information, the output of the model and reconciliation issues. We hereby would like to thank all operators who gave us their views on the various subjects. This present document gives a summary of the operators' comments on each question, followed by the decisions taken by the BIPT. The reasoning behind each decision is explained or can be found in the initial consultation document.

1. GENERAL ASPECTS OF THE BOTTOM-UP MODEL

In this first section, some general aspects concerning the Bottom-Up model will be presented that were decided upon in the first and the second consultation document. In that regard, firstly the scope of the model will be discussed. Secondly, the applied costing methodology will be dealt with and finally, the general structure of the modelled network and of the Bottom-Up model itself will be clarified.

1.1 The scope of the Bottom-Up model

Definition of the increment First and foremost, when developing a Bottom-Up model, one has to decide upon the definition of the increment, i.e. the group of telecommunication services that tariffs will be determined for.

In the first consultation document, it was decided that the increment will consist of *all* PSTN/ISDN-services[1] that are offered by the incumbent operator. The definition of this increment fully complies with the European Commission's Recommendation C(98)960 and ensures that a certain part of the incumbent's shared and common costs can be recovered, which tends to encourage network investments and reflect the real costs of new market entrants. Finally, for the sake of clarity, the BIPT remarks that leased lines and data services are *not* included in the increment.

The network to be modelled Once the increment has been defined, one should decide which parts of the network will be modelled. As the increment purely consists of PSTN/ISDN-services, it is clear that solely the *PSTN/ISDN*-network qualifies to be modelled and that e.g. the *data* network is not relevant.

Subsequently, one has to decide which parts of the PSTN/ISDN-network will be included. In that perspective, it was decided in the first consultation document that solely the *core PSTN/ISDN-network* will be modelled, which implies that the local access network will *not* be included in the first version of the Bottom-Up model.

As a consequence, a distinction has to be made between the local access and core PSTN/ISDN-network. In accordance with the European Commission's Recommendation C(98)960 and with other bottom-up models, network components that are not traffic sensitive and are dedicated to a particular customer, are said to be part of the local access network. These are all network components from the customer termination point, up to and including the line card. Network components that are traffic-sensitive on the other hand, belong to the core network.

1.2 The TELRAIC costing methodology

The BIPT's Bottom-Up model is a *Total Element Based Forward Looking Long Run Average Incremental Costing* (TELRAIC) model. In this paragraph, the concepts of this costing methodology will be expounded.

Element Based In an '*Element Based*' model, the network is considered as a collection of switching and transmission equipment that constitute the switching nodes and transmission links, also called the *elements* of the network. Consequently, the provision of a certain

[1] PSTN/ISDN-services are also called "switched services".

PSTN/ISDN-service invokes the usage of certain of these network elements, which is determined by the routing table.

In the Bottom-Up model, element usage costs will be calculated, based on the total cost of the network elements, the routing table and the traffic volumes of the services of the increment. This allows the calculation of the total cost of the provision of a given PSTN/ISDN-service as the sum of the costs of the network elements that are used by the service. Moreover, an 'element based' approach promotes the transparency of the cost structure and allows to acquire a profound insight in the impact of technical optimisation on the cost structure.

Long Run "*Long run*" refers to the time horizon within which all costs become variable and the firm can undertake all capital investments or desinvestments that it desires in order to increase or decrease the capacity of its different network service offerings. The long run horizon implies that the entire investment cost caused by interconnection can be avoided.

Forward looking: the valuation of assets and the use of Modern Equivalent Assets (MEA's) In the Bottom-Up model, the cost base will be *forward looking*. *Forward-looking* costs aim to look ahead and consider the costs that would be applicable when one would build a network, featuring the same functionality as the existing one, *at present*.

This implies that the historical costs of the assets cannot be used for the valuation of the operator's assets, since they do not reflect the current situation; as a consequence, application of a *Current Cost Accounting* (CCA) methodology, i.e. the revaluation of the operator's assets at current prices, is required.

As for some assets market prices no longer exist (e.g. due to technological obsolescence), the assets will be valued using the cost of replacement with their *Modern Equivalent Asset* (MEA). This replacement cost equals the lowest cost of an asset that provides at least an equivalent functionality and output as the asset being valued. In practice, this may be the latest available and proven technology, which is therefore the asset that a new entrant might be expected to employ.

Incremental Costing The increment is defined as "*all PSTN/ISDN-services*", which implies that the network modelled in the Bottom-Up model will be the efficient equivalent of the incumbent's *PSTN/ISDN-network*.

The choice of the increment has a direct influence on the dimensioning of the network and on the sharing of costs between various services. The paragraphs hereunder comment on how the choice of the increment influences the determination of the direct investment in network components in the Bottom-Up model.

Direct investment in switching equipment

Since all PSTN/ISDN-services (or "switched services") are part of the increment, a complete switching network will be dimensioned and taken into account when determining the cost of the PSTN/ISDN-network. After all, no other services than those included in the increment make use of this switching equipment.

Direct investment in transmission equipment

Unlike the switching components, transmission equipment (T-MUX, ADM,..) is not exclusively used by PSTN/ISDN-services, but also e.g. by leased lines. The algorithms presented in paragraph 2.3 aim at quantifying the transmission equipment components needed for the transmission of PSTN/ISDN-traffic. Regardless of the definition of the increment, some of these components will always be dedicated to PSTN/ISDN services (e.g. tributary cards), whereas other components (e.g. investments in the fixed parts of an ADM) could be shared with other services (e.g. leased lines).

The algorithms for the dimensioning of the transmission equipment in the Bottom-Up model only take into account the volumes of the services included in the increment (i.e. ISDN/PSTN traffic). This implies first of all that the Bottom-Up model will model a smaller amount of equipment than the amount that would be required for offering a complete range of telecommunications services. However, part of the required transmission equipment is determined by the transmission links on which the transmission nodes are located (e.g. fixed investment in ADMs). Therefore, the cost of these shared transmission components will be shared between PSTN/ISDN-services and other services. This approach is consistent with the one taken w.r.t. the sharing of direct investment in transmission links.

Direct investment in transmission links

The physical structure of each ring and point-to-point connection is based on the incumbent's network. For each '*Link LDC-host*' and for each '*Regional Ring*', the capacity modelled is based on the installed capacity in the incumbent's network. For the '*Core Links*', the modelled capacity is based on the capacity used. No sufficiently detailed information was available that allows the application of detailed algorithms for the dimensioning of the transmission links on the individual link or ring-basis.

However, in the Bottom-Up model the choice of the cable type, as well as the sharing of cables, ducts and trenches between different transmission layers is optimised. The cost of the transmission links is shared between PSTN/ISDN- and other services, based on the reality within the incumbent.

This is consistent with approaches taken in other bottom-up models. In the *Europe Economics* model the cost of the transmission links are attributed to each of the services using the transmission network on the basis of their share of capacity[2]. Also in the hybrid model of IT-og Telestyrelsen (Denmark), the transmission link costs are attributed based on the capacity of the different services that utilise the links[3].

Indirect Network Support CAPEX, Network OPEX and non-network related overhead costs

In order to determine the Indirect Network Support CAPEX, Network OPEX and non-network related overhead costs for the services that belong to the increment, firstly these costs for *all* services offered by the operator are identified and subsequently, an appropriate part of these costs is allocated to the PSTN/ISDN-services. A detailed description of the allocation process can be found in paragraph 3.4.

[2] Cfr. p. 37 of "Study on the preparation of an adaptable bottom-up costing model for interconnection and access pricing in European union countries – A final report for Information Society Directorate-General of the European Commission by Europe Economics" (April 2000).
[3] Cfr. p. 78 of "Report on the hybrid model" by IT-og Telestyrelsen (August 2000).

1.3 Modified scorched node approach

A LRAIC cost model calculates the cost of offering services by an operator that exploits an *efficient* network. However, with respect to the efficiency of the network, different approaches can be taken in a Bottom-Up model (e.g. scorched earth approach, scorched node approach or modified scorched node approach).

Since the topology and nodes of an incumbent's network cannot be altered readily, the BIPT decided to apply a *modified scorched node approach*. In such approach, the existing network nodes are considered to be fixed, but all other network elements can be optimised. The actual network is taken as the starting point for the optimizing process and optimisation algorithms will iterate the network structure until an efficient solution is obtained. However, based on the reactions of the sector, it was decided that, given the limited impact expected on the results of the model, no optimization will be considered in the first version of the Bottom-Up model.

1.4 General structure of the network modelled

During the presentation of the conclusions of the second consultation document (d.d. April 9th 2002), the following structure of the network to be modelled was presented:

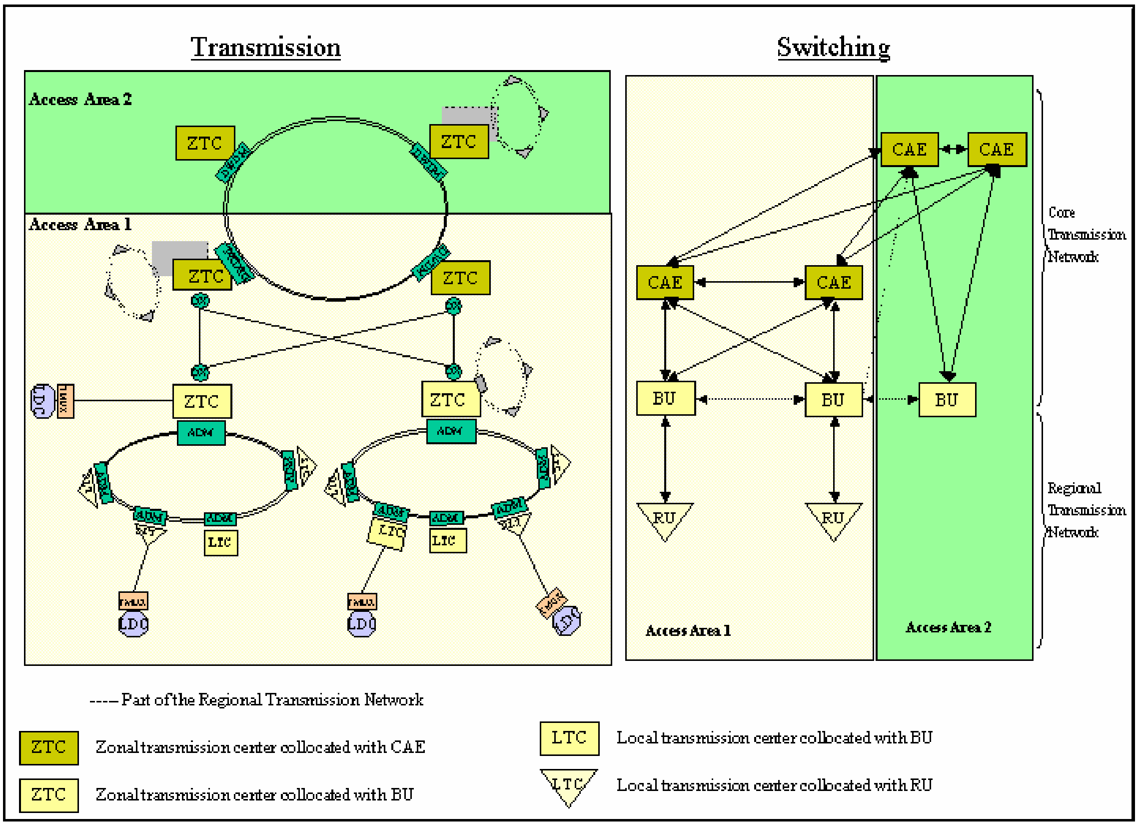


Figure 1: Overview of the logical and physical structure of the network modelled

In Figure 1, all main categories of network components and the terminology used are summarised. The technical algorithms for switching and transmission, presented in the third consultation document, were based on this structure.

1.5 General logical structure of the Bottom-Up model

The modelling of the network shown in Figure 1 by the Bottom-Up model is represented in Figure 2. First and foremost, technical formulae have to be derived that allow the dimensioning of the network, based on the demand volumes at the switching nodes. Once the switching equipment, transmission equipment and transmission infrastructure are dimensioned, various costing information is inserted into the model (regarding a.o. the remuneration of capital, mark-ups for overhead and OPEX costs etc.), which firstly allows the computation of the total investment costs of the various categories of network components and subsequently, the determination of total yearly costs related to the categories of network components, according to a certain depreciation method. In the model, the total yearly costs of the categories of network components are called *resource pools*. Resource pools can be considered to be cost pools that contain all direct and indirect CAPEX and OPEX costs that should be allocated to a certain set of network components, related to a given network functionality.

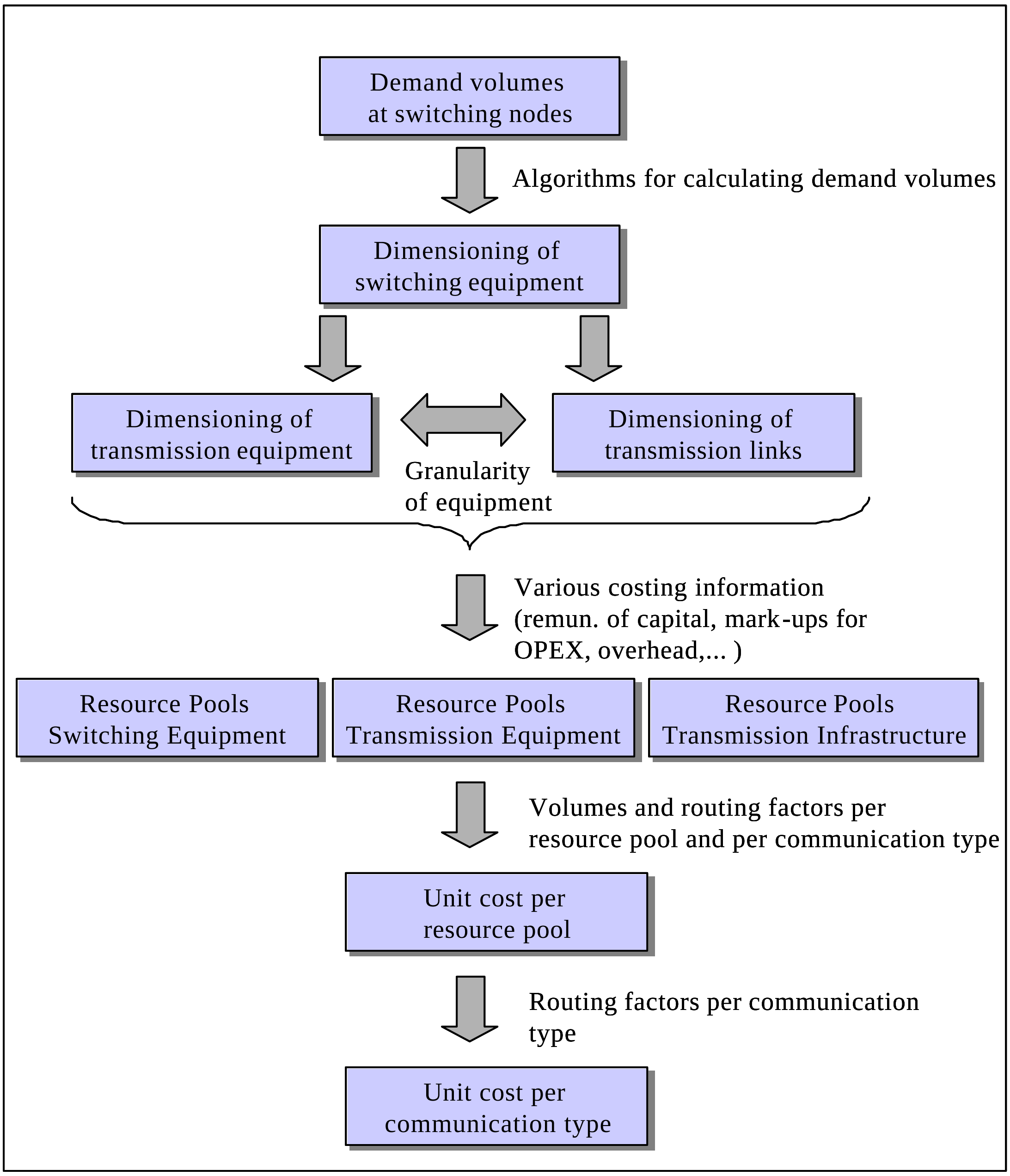


Figure 2: General structure of the Bottom-Up model

Please note that the sharing of the network components between the different services (e.g. PSTN/ISDN-services versus data services) and between the different parts of the network (e.g. local access network vs. core network) is considered in the dimensioning algorithms. This implies that the costs allocated to the resource pools of the Bottom-Up model are exclusively related to the PSTN/ISDN core network.

Three generic categories of resource pools can be distinguished in the model:

- Resource pools w.r.t. switching equipment:

1. *Remote Unit (RU)*: This resource pool contains all costs, both CAPEX and OPEX, related to the RUs (e.g. a part of the line cards for PSTN and ISDN-BA, concentrators, E1-ports, accommodation costs etc) and related to the core network;

2. *Base Unit (BU)*: This resource pool contains all costs, related to the BUs (e.g. a part of the line cards for PSTN, ISDN-BA and ISDN-PRA, concentrators, E1-ports, switching matrices, processors, accommodation costs etc) and related to the core network;

3. *Covering Area Exchange (CAE)*: This resource pool contains all cost, related to the CAEs (e.g. ports, switching matrices, processors, accommodation costs etc) and related to the core network.

- Resource pools w.r.t. transmission equipment

4. *Equipment LDC*: This resource pool contains all costs for the core PSTN/ISDN transmission equipment related to a LDC, e.g. tributary cards in the LDC, TMUXs, tributary cards in the LDC's host etc;

5. *Equipment LTC*: This resource pool contains all costs for the core PSTN/ISDN transmission equipment related to a LTC, e.g. ADMs, tributary cards, TMUXs etc. located in a LTC. Moreover, also the cost of the LTC-part of the ZTCs is included[4];

6. *Equipment ZTC*: This resource pool contains all costs for the core PSTN/ISDN transmission equipment constituting ZTC-functionality, e.g. Cross-Connects, tributary cards for core links etc.

4 In the Bottom-Up model, costs related to the ZTCs are split in the costs for the LTC-functionality of the ZTC on the one hand, and the costs for the Cross-Connects on the other hand. Costs for the LTC-functionality are included in the resource pool 'Equipment LTC', while costs for the Cross-Connects are included in the resource pool 'Equipment ZTC'. Conceptually, this is a very important choice, since it allows us to consider a ZTC as a LTC in the case where traffic just passes through the ZTC without leaving the regional ring.

- Resource pools w.r.t. transmission infrastructure:

7. *Links LDC-host*: This resource pool contains all costs for the core PSTN/ISDN transmission link between the LDCs and their hosts on the regional rings (cables, ducts and trenches);

8. *Regional Rings*: This resource pool contains all costs for the core PSTN/ISDN regional rings (cables, ducts and trenches);

9. *Core Links*: This resource pool contains all costs for the core transmission links (cables, ducts and trenches), related to the PSTN/ISDN-network.

Furthermore, once the various resource pools are quantified, information regarding the traffic volumes of the communication types and the routing factors for all resource pools and communication types have to be inserted into the model, which allows the calculation of unit costs per resource pool. Finally, based on the routing factors, unit costs per communication type can be determined.

Evidently, the determination of routing factors is a crucial step in the cost allocation process. Therefore, the BIPT elaborated a complete methodology for the definition and quantification of the routing factors, of which a brief motivation, featuring more details, can be found in Annex A.

2. TECHNICAL ALGORITHMS

The operators' comments regarding the switching and transmission dimensioning algorithms are presented in the next paragraphs, as well as the decisions taken by the BIPT.

2.1 Algorithms for calculating the demand volume

2.1.1 Conversion of the number of minutes and calls in Busy Hour Erlang (BHE) and Busy Hour Call Attempts (BHCA)

Determination of BHE

In respons to the third consultation document, the incumbent operator reported that information regarding total bi-directional BHE for all of the existing BUs and CAEs is available. However, no BHE information is measured for the RUs.

In order to obtain the information regarding the BHE per switching node, the incumbent applied the following methodology:

- During 7 successive days (medio 2002), the average number of Erlangs was measured for each quarter of an hour for each trunk;
- For each day, the maximum value of 4 successive measures is retained as the BHE of that day for a given trunk;
- The maximum value of the 7 BHE values for each day, is finally retained as the BHE of a given trunk;

- ✍ The BHE per switch is finally obtained by adding up all the BHEs of the trunks connected to that switching node.

The incumbent provided the BIPT with detailed information regarding the BHE for all the individual *directions* of a switching node. A direction can be defined as a direct physical connection between two switching nodes. In the incumbent's network, BUs and CAEs are generally connected to multiple switching nodes. BUs are always directly connected to at least 2 CAEs and often also to other BUs. Moreover, CAEs are connected to all other CAEs of the network, as well as to multiple BUs. Finally, it should be mentioned that within a given direction, traffic is uniformely distributed over the various trunks of the direction.

Furthermore, the fact that trunks are static implies that they always belong to the same direction and that the allocation of the trunks to the various directions of a switch cannot be altered dynamically in function of the traffic density at a given moment in time. This explains why the total BHE of a switching node is found by summing the BHE of the directions that leave from and arrive at the node. Indeed, even when the BHE of the different directions of a switching node occur at different moments, they still have to be added in order to find the BHE of the switching node since no re-allocation of the resources can be performed.

Taking these considerations into account, the BIPT decided to use the incumbent's information concerning the BHE as an input for the Bottom-Up model.

<u>Conversion of the volume of billed calls in BHCA</u>

Since no information regarding BHCA is available at node level at the incumbent operator, the BIPT decided to use the following method[5] to convert the volume of billed calls into BHCA:

The method boils down to the determination of the parameter *R* ('*Ratio*') in the following formula:

$$BHCA = (60*R) * BHE$$

An approximation of the parameter *R* can be derived from the following formula:

$$Total\ call\ demand = R * total\ \#\ minutes\ of\ network\ usage$$

From this formula, one can conclude that 1/R expresses the average length of network usage for a call (1/R is expressed in number of minutes).

The actual calculation of R is illustrated in Table 1:

[5] This method is based on the conversion of the volumes of billed calls and billed minutes in resp. BHCA and BHE, as presented in Figure 1 at page 6 of the third consultation document.

Determination of the parameter R			
Number of billed minutes	**1.000.000**	minutes	
Average duration per call	**3,2**	minutes	Assumption BIPT (cf. top-down model)
Average non-billed time for successful calls	**0,25**	minutes	Assumption Europe Economics (15 sec or 0,25 min)
Average non-billed time for unsuccessful calls	**0,50**	minutes	Assumption Europe Economics (30 sec or 0,5 min)
Number of billed calls	312.500	calls	
Assumption on % successful calls	**65,0%**		Assumption incumbent operator, approved by the BIPT
Total demand in number of calls	**480.769**	**calls**	
Number of unsuccessful calls	168.269	calls	
Total demand in number of minutes			
Related to billed calls	1.078.125	minutes	
Related to unbilled calls	84.135	minutes	
Total demand	**1.162.260**	**minutes**	
Total demand in number of minutes / Total demand in number of calls (1/R)			
	2,41750	minutes per call	

Table 1: Calculation of the parameter R

Firstly, in order to determine the value for 1/R, one has to convert the number of billed minutes into the number of billed calls. This can be achieved by dividing the number of billed minutes (for illustrative purposes, in Table 1 this number equals 1.000.000 minutes) by the average length of a call, i.e. 3,2 min per call (in Table 1, the value for the average length of a successful call as it was determined in the Top-Down model for interconnection is retained). Hence we find the number of billed calls to equal 312.500.

Secondly, the number of billed calls has to be converted into the total demand for calls, i.e. the sum of successful and unsuccessful calls. The total call demand can be found by dividing the number of billed calls (312.500) by the percentage of successful calls, which we assume to be 65% (30% of the calls aren't answered and in 5% of all call attempts, the line is busy). Hence we find total call demand to equal 480.769, which consists of 312.500 successful and 168.269 (= 480.769 – 312.500) unsuccessful calls.

Thirdly, once the total call demand expressed in number of *calls* is known, the total call demand expressed in number of *minutes* has to be determined. In that regard, the values for the average non-billed time for successful and unsuccessful calls have been adopted from the *Europe Economics* model, i.e. 0,25 and 0,50 minutes. These values allow the determination of the number of billed and unbilled calls, expressed in minutes. Indeed, the number of minutes related to billed calls is found by multiplying the number of billed calls by the sum of the billed and non-billed time for succesful times, i.e. 312.500 * (3,2+0,25) = 1.078.125, and the number of minutes related to unbilled calls is found by multiplying the number of unbilled calls by the time for unsuccesful times, i.e. 168.269 * 0,50 = 84.135.

Finally, 1/R is found by dividing the total demand volume (expressed in number of minutes) by the total call demand, i.e. (1.078.125 + 84.135)/480.769 = 2,4175. Hence, in order to obtain BHCA, one has to multiply BHE by:

R/60= 60/2,4175 = 24,81

2.1.2 Conversion of BHE in a number of E1's

Question 1.1: The BIPT invites the industry to comment on the formula presented above for the conversion of BHE in a number of E1s.

Summary of comments

Multiple operators indicated that it is difficult to determine a suitable value for the circuit efficiency ? (number of Erlang per circuit) that is applicable for a wide range of traffic densities and both for switching and transmission equipment. Moreover, they stated that the *Erlang B*-formula is widely recognised as being the most appropriate formula for the conversion of traffic density (BHE) into capacity (the number of E1s).

Decision taken by the BIPT

Given these remarks, the BIPT decided to adopt the Erlang B-formula in its Bottom-Up model.

For a certain *traffic density* (expressed in BHE) and a certain *blocking chance* P_b (i.e. the chance that there will be no lines available when somebody wants to initiate a call)[6], the *Erlang B*-formula computes the required capacity *N* (expressed in the number of PSTN-lines, i.e. 64 kbps-lines) in order to attain the specified blocking chance (quality of service)[7]:

$$P_b = \frac{\frac{BHE^N}{N!}}{\sum_{l=0}^{N} \frac{BHE^l}{l!}}$$

For illustrative purposes, one can state that in order to attain a blocking chance of 0,69% when the BHE=4,85 Erlang, 11 lines of 64 kbps will be required.

Once the parameter *N* is known, we apply the following formula to convert *N* into the number of E1s:

PSTN/ISDN-traffic in E1s = ? N / ? ?

[6] P_b being 1% means that on average, when a certain person tries to initiate 100 calls at *ad random* chosen moments in time, 99 calls will be successful and 1 won't (in this last case, all available lines will be busy).

[7] It is common to choose P_b=1%.

where ? represents the number of 64 kbps-lines per E1, i.e. 30. Since the number of E1s obviously should be a natural number, the result of the division should be rounded to the next natural number[8].

Remark on the application of the Erlang-B formula

As already mentioned in the previous paragraph, in the incumbent’s network BUs and CAEs generally feature multiple *directions* and the incumbent specified for every BU and CAE the BHE of all individual directions arriving and leaving the switching node.

With respect to the conversion of the BHE per switching node into a number of E1s by application of the Erlang B-formula, the Erlang B-formula should not be applied to the total number of BHE per switching node, but to the BHE of every individual direction, since[9]

$$ErlangB(x*BHE, P_b) < x * ErlangB(BHE, P_b) \quad for \quad x > 1$$

and

$$ErlangB(y+z, P_b) < ErlangB(y, P_b) + ErlangB(z, P_b) \; for \; y, z > 0$$

Hence the application of the formula on the total BHE would lead to an underestimation of the required number E1s. It is estimated that the underestimation would amount to at least 5% of the number of circuits per BU and per CAE.

Therefore, the BIPT decided to identify for every node the number of directions, represented by the symbol *D*, and to determine the required number of E1s as:

$$D * ErlangB(total\_BHE\_per\ node/D, P_b)$$

Please remark that this formula implies that one considers total traffic to be uniformly distributed over the various directions.

Finally, the BIPT also takes into account the fact per E1 ? 64kbps channels are available. Hence for every direction, the number of E1s is found as:

$$?\ ErlangB(BHE, P_b) \quad / ?\ ?$$

2.1.3 Demand volume for the dimensioning of the network

Question 1.2: The BIPT wishes to invite the industry to give its view on the future evolution of the terminating and originating services (expressed in a growth percentage for 2003 compared to 2002). It should be clearly motivated on what the forecasts are based.

---

[8] This is reflected by the mathematical symbol ?x?; e.g. ?3,56?=4

[9] In this formula, ‘*ErlangB(X, P_b)*’ indicates the required capacity, determined with the Erlang B-formula, for *X* Busy Hour Erlang and a blocking chance equal to P_b%.

Summary of comments

Most operators indicated that it is extremely difficult to forecast future demand, given the current market situation, and kept their selves from specifying actual estimates. However, some thought that demand evolution could be expected to feature flat growth or even a slight decline.

Decision taken by the BIPT

Given the fact that none of the operators submitted figures regarding estimated future demand, the BIPT decided not to apply a correction factor to the BHE-information obtained from the incumbent operator. Also the number of PSTN, ISDN-BA and ISDN-PRA user lines (determined in June 2002) has not been changed.

2.1.4 Demand volume for the calculation of the unit cost

The current version of the Bottom-Up model contains information on the actual volumes of 2002. However, this information will be replaced with so-called 'Outlook 2003' volumes (i.e. a forecast of traffic volumes for 2003 which was revised at the end of June 2003) in the Bottom-Up model to be used for setting bottom-up tariffs for 2004. The 'Outlook 2003' will be used as an estimate for the volumes of 2004, since the BIPT believes these figures to be the most realistic available approximation. Please note that this implies that the Institute assumes that traffic volumes will neither grow or decline in 2004 when compared to 2003.

Note however that the communication types for which the incumbent communicated the Actuals do not completely correspond to the communication types defined in the Bottom-Up model[10]. Although the regulated interconnection services obviously are the same, some communication types for e.g. 'Belgacom-to-Belgacom traffic' (i.e. traffic from a Belgacom subscriber to another Belgacom subscriber) differ. The BIPT developed a rigorous methodology, based on the physical structure of the network, for the conversion of the traffic volumes for the communicated communication types to the communication types of the Bottom-Up model.

2.2 Algorithms for modelling the switching equipment

2.2.1 Determining the cost drivers for the switching network

Question 1.3: The BIPT invites the industry to comment on the determining of the cost drivers of the switching network.

Summary of comments

Calculating the number of E1's

[10] An overview of the communication types, retained in the Bottom-Up model, can be found in Annex A.

Most operators indicated that the *Erlang B*-formula should be used for the determination of the number of E1s (cfr. question 1.1).

Decision taken by the BIPT

Calculating the number of E1's

The BIPT decided to adopt the *Erlang B*-formula for the determination of the number of E1s.

2.2.2 Determining the quantities of the switching components

Question 1.4: The BIPT invites the industry to comment on the determining of the quantities of switching components needed.

Summary of comments

Whereas most operators agreed on the reasoning applied to derive the presented formulae, they also stress the importance of the parameter ? (capacity utilization) and ask for a clear definition of this parameter. Some suggested that for PSTN/ISDN, even higher capacity utilization ratios should be applied than those proposed by the BIPT. Some believed that a capacity utilization rate in excess of 90% would not be unreasonable, given the relatively stable number of PSTN lines.

Moreover, multiple operators indicated the erroneous division by 2 (resp. 30) with respect to the inclusion of ISDN-BA (resp. ISDN-PRA) lines in some formulae.

Furthermore, the BIPT was asked to clarify why no concentrators are required for ISDN-PRA cards.

Finally, it was mentioned that a distinction should be made between the ports on the concentrators in the RUs and BUs, and the ports on the switching matrices in the BUs and CAEs.

Decision taken by the BIPT

Firstly, with respect to the capacity utilization, given the stable number of PSTN/ISDN lines, the BIPT has decided to retain a value of 90%.

Secondly, the BIPT confirms the erroneous division in some formulae and the fact that concentrators are indeed required for ISDN-PRA cards.

Thirdly, the BIPT recognises that it is desirable to distinguish different dimensioning algorithms for the ports on the concentrators and the ports on the switching matrices.

For convenience and in order to present a comprehensible overview of the formulae that were applied for the dimensioning of various elements of the network modelled in the Bottom-Up model (i.e. switching equipment, transmission equipment and transmission infrastructure), the BIPT decided to bring all the formulae together in Annex B. As a consequence, all formulae w.r.t. the dimensioning of the RUs, BUs and CAEs can be found in paragraph 1 of this annex.

2.3 Algorithms for the modeling the transmission links

In this section, the operators' responses to questions 1.5 to 1.9 regarding the modeling of the different types of transmission links and the subsequent decisions taken by the BIPT are all integrated in one text. By doing so, the BIPT intends to optimize the transparency of the rational applied for the modeling of the transmission links.

Summary of comments

With respect to the *length* of the different types of links for which the costs are modelled in the Bottom-Up model, i.e. the links between the LDCs and the regional rings (since the investment costs of these links are solely contained in the resource pool '*Link LDC-host*', the links between the LDCs and the regional rings will hereafter be called '*Links LDC-host*'), the links constituting the regional rings (since the investment costs of these links are solely contained in the resource pool '*Regional Rings*', the links constituting the regional rings will hereafter be called '*Regional Rings*') and the links constituting the core transmission network (since the investment costs of these links are solely contained in the resource pool '*Core Links*', the links constituting the core transmission network will hereafter be called '*Core Links*'), the incumbent operator has provided the *actual* figures regarding the lengths of the links.

With respect to question 1.6b, it was reported that the formula for the determination of the required length of fiber & cable was not entirely clear and that the rules for choosing the right cable type are missing.

With respect to the formula for the determination of the required length of ducts & trenches, some operators reported that the treatment of spare capacity in ducts and trenches is not explicitly mentioned, and that one has to take into account the possibility of *sharing* the infrastructure. Indeed, cables, ducts and trenches can be shared between the different types of links themselves, but also between the local access network and the regional & core transmission network. Moreover, questions were raised concerning the number of ducts per trench.

Finally, with respect to the determination of the required capacity, various operators mentioned that the Erlang B-formula should be used to calculate the required capacity.

Decisions taken by the BIPT

Firstly, the BIPT would like to remark that its decisions regarding the transmission infrastructure issues are ordered *by topic*, rather than by the questions of the consultation document, since the BIPT is convinced that this structure will promote the clarity and the logic of the reasoning presented hereunder.

Moreover, please note that transmission links that are exclusively used for international traffic or for traffic to/from OLOs shall not be modelled in the Bottom-Up model and hence shall not be included in the transmission link resource pools (cfr. section 1 for the definition of the resource pools).

Determining the length of the transmission links

With respect to the length of the *Links LDC-host*, an average length was provided by the incumbent operator.

With respect to the length of the *Regional Rings* and the *Core Links*, the incumbent operator communicated the individual length of all *Regional Rings*, as well as the individual length of all *Core Links*. Evidently, total length for both types can be found by summing the length of all individual links. Table 2 shows the relative proportion of the *Regional Rings* and *Core Links* vis-a-vis the *Links LDC-host* with respect to the average length and the number of the links.

Link type	Relative Average length	Relative Number of links
Link LDC-host	1	1
Regional Ring	19,82	0,23
Core Link	8,40	0,16

Table 2: Relative proportion of the average length and number of the transmission links

After statistical verification by comparing these figures with the cartesian distance, based on the Lambert coordinates of the transmission nodes, the BIPT concluded that these values can be considered to be accurate and therefore, the Institute opts to use these figures in the Bottom-Up model. As a consequence, the determination of correction factors becomes obsolete.

Calculating the required capacity

With respect to the determination of the capacities of the transmission links, the BIPT has decided that in the first version of the Bottom-Up model, the capacities of the *Links LDC-host* and *Regional Rings* will be based on the capacities in the incumbent's network. Moreover, the determination of the capacities of the *Core Links* will be based on part of the number of active virtual containers (VCs) that are transported over the link.

In the model, the installed capacity of the *Links LDC-host* is known to be STM-1 (155 Mbps). Although the required capacity on these links is far less than 155Mbps, the BIPT opts to adopt the actual installed capacity since STM-1 is the lowest capacity that can be implemented on an optical fiber.

Most *Regional Rings* of the model feature STM-16 capacity, although in a limited number of cases, lower capacities are taken (STM-4 or 2xSTM-1).

Finally, in the model the capacities of the *Core Links* range from STM-4 to STM-64.

The following table summarises the capacities considered in the model for the three types of links:

Link type	Installed capacity
Links LDC-host	STM-1
Regional Rings	STM-1, STM-4, STM-16
Core Links	STM-4, STM-16, STM-64

Table 3: Capacities of the transmission links

Finally, the BIPT wants to remark that the issue of spare capacity will be treated further on in this paragraph.

Choosing the right cable type

When choosing the right type of cable for the *Links LDC-host*, *Regional Rings* and *Core Links*, one has to take into account the *number of fibers* that the cable contains. The standard number of fibres within one cable equals 12, 24, 48, or 96 and evidently, the price of the cable rises with the number of fibers that it contains.

Taking into account the definition of the increment being all PSTN/ISDN-services, the BIPT hereafter assumes that w.r.t. the *Links LDC-host*, only two fibers are required within the cable to transmit the traffic arising from the increment, since PSTN/ISDN-traffic densities on the *Links LDC-host* are known to be rather limited and are far less than the installed capacity (STM-1). Consequently, a single cable featuring the minimum number of fibers (i.e. 12) will be sufficient to realise the *Links LDC-host*. Logically, only one duct is required to protect the cable and one trench is required to contain the duct.

With respect to the required number of fibers in a cable for the *Regional Rings*, the BIPT assume once again that a single cable featuring 12 fibers suffices as most *Regional Rings* feature STM-16 capacity. Consequently, a *Regional Ring* requires only one trench and one duct as well.

As for the core links, the choice of the cable type depends on whether DWDM technology or 'classical' SDH transmission is used. In general, DWDM can be seen as a remedy for '*fiber exhaust*', i.e. the situation where in an actually existing network the installed number of fibers does no longer suffice for the transport of the traffic densities on the network by means of 'classical' SDH transmission. In such a case, DWDM equipment can be installed in order to enhance the capacity of the fibers.

Based on the information that was available, the BIPT executed a preliminary analysis in order to assess the cost efficiency of implementing DWDM technology in a network that is to be build at present (i.e. the Bottom-Up approach) and concludes that, given the fact that one assumes that the network is built at present and hence one can freely choose a number of fibers for the transmission links that is sufficient to transport the traffic densities on the network (including also non-PSTN/ISDN-network), it is not cost efficient to install DWDM technology. Indeed, the preliminary analysis showed that the cost of installing DWDM equipment does not offset the cost of the additional number of fibers required in the case when no DWDM is installed. Hence in the Bottom-Up model, transmission over the core links will be realised by 'classical' SDH technology[11]. Note however that the cost efficiency analysis will be subject of further discussions between the BIPT and the incumbent operator within the scope of the update of the Bottom-Up model.

[11] A brief summary of this analysis, indicating the applied methodology and the conclusions, can be obtained from the BIPT at request.

Assuming that STM-16 is the highest proven technology that can be used for classical transmission and two fibers are required to transmit a full-duplex signal, the maximum number of E1s that can be transported over a cable featuring 12 fibers is:

*#E1s/STM-1 * #STM-1s/STM-16 * 12/2 = 63 * 16 *12/2 = 6048*

Taking this number into account, we notice that for 2 core links of the network that is modelled, 12 fibers do not suffice for transmission of the traffic. Therefore, the BIPT decided to retain cables featuring 24 fibers for *all* core links, as this will guarantee the reliability of transmission and also allows for future growth.

Assumptions regarding the sharing of infrastructure

The BIPT acknowledges the comments of the operators with respect to the sharing of infrastructure. Therefore the BIPT elaborated an approach that will be presented in the remainder of this section, including formulae for the determination of appropriate quantities of cables, ducts and trenches for the 3 types of transmission links. Multiplication of these formulae with prices for cables, ducts and trenches, will allow to determine appropriate investment costs that are to be included in the resource pools for the 3 types of transmission links.

As already mentioned in the introduction, investments for transmission links include investment for cables, ducts and trenches. In order to determine accurate costs for the resource pools for the three types of transmission links, one has to take the following elements into account:

- Cables, ducts and trenches can be shared by multiple types of transmission links;
- Trenches that are modelled in the Bottom-Up model can not solely be used for the regional and core transmission network, but also for the local access network;
- Cables, ducts and trenches can be used to transport other traffic than just PSTN/ISDN-traffic (e.g. data traffic, leased lines).

Firstly, we will describe how these three elements are taken into account and quantify all relevant parameters. Subsequently, we will present formulae in order to determine the total investment costs for the different types of links.

✍ Sharing of cables, ducts and trenches between multiple types of transmission links

Consider the situation represented by Figure 3, which features 3 *Core Links* (named *CL1*, *CL2* and *CL3*), 2 *Regional Rings* (named *RR1* and *RR2*) and 1 *Link LDC-host* (named *L1*). In principle some or all of these links could be realised by the same cables, ducts and trenches, e.g. *Core Link CL3* could be realised through one or multiple pairs of fibers in a cable that also contains fibers that are used for *Regional Ring RR1*. These considerations have to be taken into account when determining an accurate investment cost for resource pools for the *Links LDC-host*, *Regional Rings* and *Core Links*.

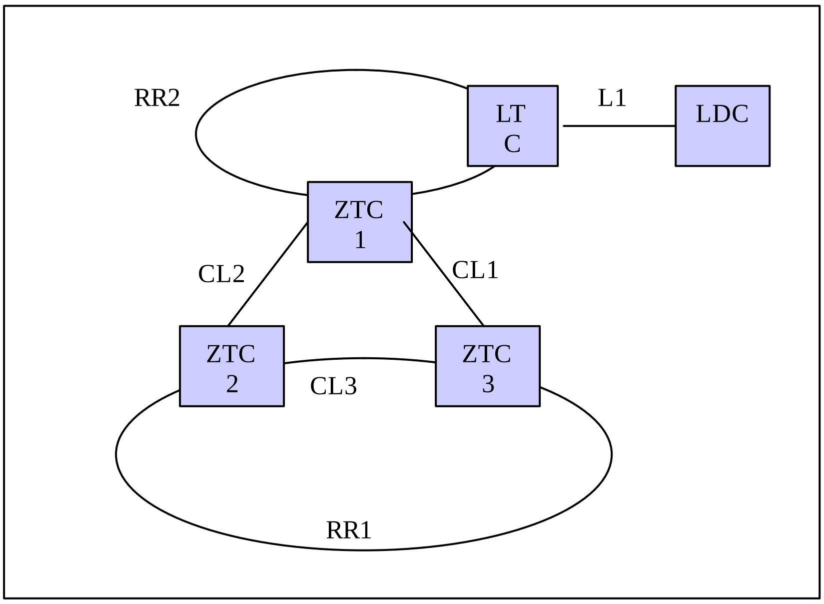


Figure 3: Sharing of cables, ducts and trenches between different types of transmission links

<u>Investment cost for the resource pool "Link LDC-host"</u>

In the Bottom-Up model, we assume that *Links LDC-host* will never be shared with *Core Links* and *Regional Rings*. We believe this to be very realistic, since LDCs are generally located on sites where it is not cost efficient to extend the regional ring in order to incorporate the LDC (e.g. regions featuring low population density) and therefore, a dedicated point-to-point connection is realised in order to include the LDC in the operator's network.

Formula As a consequence, the investment costs for *Links LDC-host* can be found as[12]:

$$Investment_{Link\ LDC\text{-}host} = \left(\sum_{i \in trench,duct,cable} unit\ price_i \right) * length_{Link\ LDC-host}$$

In this formula, unit prices are expressed in € per meter and the total length is expressed in meter. Note that these investment costs still include the costs that has to be allocated to the local access network, and the cost for the non-PSTN/ISDN-services.

<u>Investment cost for the resource pools "Regional Rings" and "Core Links"</u>

From Figure 3, it is clear that, as opposed to *Links LDC-host*, costs of cables, ducts and trenches can be shared between *Regional Rings* and *Core Links* (e.g. *CL3* and *RR1*). However, we want to note that w.r.t. the fibers, although different fibers of a given cable can be used for different types of links, a single given pair of fiber is dedicated to a sole transmission link.

Given these considerations, *Core Links* are realised in two distinct manners:

[12] For reasons of conciseness, in this formula investment costs for cables, ducts and trenches are summed. However, at the end of this paragraph, final formulae can be found for each investment cost separately.

- Cables, ducts and trenches for the *Core Links* are shared with the *Regional Rings* (e.g. *CL3*);
- Cables, ducts and trenches are completely dedicated to the *Core Link* (e.g. *CL1* and *CL2*).

In order to determine investment costs for the resource pools for both types, we define *?* as the ratio of the length of the *Core Links* that coincide with the *Regional Rings* and the total length of the all *Core Links*:

$$? \; ? \; \frac{length\ core\ links\ coinciding\ \ with\ regional\ \ ring\ \ links}{total\ length\ core\ links}$$

As a consequence, the cost of (*?*total_length* $_{core\ links}$) meters of cables, duct and trenches has to be allocated to the *Core Links* (*?* % of the costs) and to the *Regional Rings* (1-*?* % of the costs).

Formulae The definition of the variables *?* and *?* allows us to determine the investment costs for the *Core Links*:

$$Investment\ costs_{Core\ Link} =$$

$$(\underset{i?trench,duct,cable}{?} unit\ \ price_i) * (length_{corelink}\ ?\ (1 ? ?\ ) * ? * length_{corelink})\ ?$$

$$(\underset{i?trench,duct,cable}{?} unit\ \ price_i) * length_{core\,link} * (1 ? ? * (1 ? ?\ ))$$

whereas investment costs for the *Regional Rings* are:

$$Investment\ costs_{Regional\ Ring} =$$

$$(\underset{i?trench,duct,cable}{?} unit\ \ price_i) * length_{regional\,ring} * (1 ? ?\ \ * ? * \frac{total\_length_{corelinks}}{total\_length_{regional\,rings}})$$

With respect to the parameter ?, we believe it is reasonable to assume that ? equals *75%*, since most *Core Links* coincide with *Regional Rings*. For the realisation of the *Core Links*, one faces the trade-off between additional investment costs for trenches (when the *Core Links* are realised separately, i.e. not coinciding with the *Regional Rings*) and additional cable costs (when the *Core Links* coincide with the *Regional Rings*). Indeed, whereas one can expect that the length of a *Core Link* might be less when it is realised separately than when it has to follow the path of the *Regional Rings* and less line cards will be required, no dedicated trenches have to be digged when the *Core Link* is realised over the *Regional Rings*. Given the fact that trench costs by far exceed cable costs, one expects it to be preferable that a large share of the *Core Links* coincides with the *Regional Rings*.

Finally, one has to determine a value for *?*, the key that allocates costs of shared cables, ducts and trenches to the two types of links. In the Bottom-Up model, we opt to define *?* as:

? = number of fibres occupied by Core Links / total number of occupied fibres

Hence *(1-?)* is the ratio of the number of fibres occupied by *Regional Rings* and the total number of occupied fibres.

✍ Sharing of cables, ducts and trenches between the local access network and the regional & core transmission network

The cables, ducts and trenches of the network can be shared between the local access network and the regional & core transmission network. Evidently, only the share of the investment costs of the 3 link types for the regional & core transmission network will be taken into account into the Bottom-Up model. Therefore, the investment costs for each type of link have to be multiplied by certain parameters that represent the share of the cost for cables, ducts and trenches that should be allocated to these links. These parameters are called *'%Shared_[type of link]_cable'*, *'%Shared_[type of link]_duct'* and *'%Shared_[type of link]_trench'*.

As a consequence, in order to take into account the sharing of the cables, ducts and trenches with the local access network, the formulae for the investment costs for the 3 types of links have to be adapted as follows:

Investment costs$_{Link\ LDC\text{-}host}$, excl. share of Local Access =

$$\left(\sum_{i \in trench,duct,cable} unit\ price_i * \%Shared\_Link\ LDChost\_i\right) * length_{Link\ LDC-host}$$

Investment costs$_{Regional\ Ring}$, excl. share of Local Access =

$$\left(\sum_{i \in trench,duct,cable} unit\ price_i * \%Shared\_regional\ ring\_i\right) * length_{regional\ ring} * \left(1 - ? * ? * \frac{total\_length_{core\ links}}{total\_length_{regional\ ring}}\right)$$

Investment costs$_{Core\ Link}$, excl. share of Local Access =

$$\left(\sum_{i \in trench,duct,cable} unit\ price_i * \%Shared\_core\ links\_i\right) * length_{core\ links} * (1 - ? * (1 - ?))$$

The values of the parameters can vary according to the transmission link *component* (cable, duct and trench), as well as to the transmission link *type*. In the remainder of this paragraph, we will quantify these 9 parameters.

<u>Trenches</u>

Hypothesis Based on information derived from foreign Bottom-Up models, we adopt the hypothesis that 50% of the trenches are shared between the local access network and the regional & core transmission network. Subsequently, 50% of the cost of this shared infrastructure is allocated to the local access network; the remaining 50% is allocated to the regional & core transmission network.

Inclusion in the model This means that for all three link types, (50%+50%*50%)=75% of the costs for trenches are retained and the remaining 25% are omitted.

<u>Ducts</u>

Hypothesis In the Bottom-Up model the hypothesis is adopted that no ducts are shared between the local access network and the regional & core transmission network, since the local access network consists of twisted copper pairs, while the regional and core transmission network mainly consist of optical fiber.

Inclusion in the model This means that for all three link types, 100% of the costs for ducts are retained.

Cables

Hypothesis With respect to the cables, in the Bottom-Up model the hypothesis is adopted that no cables are shared between the local access network and the regional & core transmission network, since the local access network consists of twisted copper pairs, while the regional and core transmission network mainly consist of optical fiber.

Inclusion in the model This means that for all three link types, 100% of the costs for cables are retained.

Table 4 summarises the values of the parameters w.r.t. the sharing of transmission infrastructure with the local access network:

	Regional & Core Network	Local Access Network	Total
Link LDC-host			
Total cost ducts	100%	0%	100%
Total cost trenches	75%	25%	100%
Total cost cables	100%	0%	100%
Regional Ring			
Total cost ducts	100%	0%	100%
Total cost trenches	75%	25%	100%
Total cost cables	100%	0%	100%
Core Link			
Total cost ducts	100%	0%	100%
Total cost trenches	75%	25%	100%
Total cost cables	100%	0%	100%

Table 4: Sharing of transmission infrastructure with the local access network

✍ Sharing of cables, ducts and trenches between the PSTN/ISDN-services and other services

Introduction Once the costs that have to be allocated to the local access network are eliminated from the investment costs of the 3 link types, in a final phase one has to identify the share of the remaining costs that have to be allocated to PSTN/ISDN-services. Stated otherwise, the share of the remaining costs for other services such as leased lines, data traffic etc. have to be eliminated. As in the previous paragraph, this elimination is realised by multiplying the investment costs, excl. share for local access, for each type of link by certain parameters that represent the share of the cost for cables, ducts and trenches that should be allocated to PSTN/ISDN-services. These parameters are called *'%Switch_[type of link]_cable'*, *'%Switch_[type of link]_duct'* and *'%Switch_[type of link]_trench'*.

Hence the final formulae[13], representing the investment costs that have to be taken into account for the 3 resource pools, can be found as follows:

Links LDC-host

$Investment\ costs_{Link\ LDC\text{-}host}$ *for cables = unit* $price_{cable}$ ** %Shared_Links LDChost_cable * %Switch_Links LDChost_cable ** $length_{Link\ LDC\text{-}host}$

$Investment\ costs_{Link\ LDC\text{-}host}$ *for ducts = unit* $price_{duct}$ ** %Shared_Links LDChost_duct * %Switch_Links LDChost_duct ** $length_{Link\ LDC\text{-}host}$

$Investment\ costs_{Link\ LDC\text{-}host}$ *for trenches = unit* $price_{trench}$ ** %Shared_Links LDChost_trench * %Switch_Links LDChost_trench ** $length_{Link\ LDC\text{-}host}$

Regional Rings

$Investment\ costs_{Regional\ Rings}$ *for cables = unit* $price_{cable}$ ** %Shared_regional rings_cable * %Switch_regional rings_cable ** $length_{regional\ ring}$ ** (1 - ? * ? ** $total\_length_{core\ links}$ */* $total\_length_{regional\ rings}$*)*

$Investment\ costs_{Regional\ Rings}$ *for ducts = unit* $price_{ducts}$ ** %Shared_regional rings_duct * %Switch_regional rings_duct ** $length_{regional\ ring}$ ** (1 - ? * ? ** $total\_length_{core\ links}$ */* $total\_length_{regional\ rings}$*)*

$Investment\ costs_{Regional\ Rings}$ *for trenches = unit* $price_{trench}$ ** %Shared_regional rings_trench * %Switch_regional rings_trench ** $length_{regional\ ring}$ ** (1 - ? * ? ** $total\_length_{core\ links}$ */* $total\_length_{regional\ rings}$*)*

Core Links

$Investment\ costs_{Core\ Links}$ *for cables = unit* $price_{cables}$ ** %Shared_core links_cables * %Switch_core links_cables ** $length_{core\ link}$ ** (1 - ? * (1- ?))*

$Investment\ costs_{Core\ Links}$ *for ducts = unit* $price_{duct}$ ** %Shared_core links_duct * %Switch_core links_duct ** $length_{core\ link}$ ** (1 - ? * (1- ?))*

---

[13] These formulae can also be found in paragraph 3 of Annex B.

$$Investment\ costs_{Core\ Links}\ for\ trenches = unit\ price_{trench} * \%Shared\_core\ links\_trench * \%Switch\_core\ links\_trench * length_{core\ link} * (1 - ? * (1- ?))$$

Definition of allocation key Finally, we have to define an allocation key in order to quantify the share of the infrastructure costs that has to be allocated to PSTN/ISDN-services. We opted to define this key as follows:

Share for PSTN/ISDN-services =
capacity used for PSTN/ISDN-services / totally used capacity

Consequently, the share of the costs that is attributed to non-PSTN/ISDN-services equals the ratio of the capacity used by these other services and the totally used capacity.

Please note that that the adoption of this allocation key implies that the available capacity that is not used for the transmission of the traffic ("spare capacity"), is allocated proportionally to PSTN/ISDN-services on the one hand, and the other services on the other hand. This means that the same procentual spare capacity is assumed for the PSTN/ISDN-services and other services. Although one could argue that e.g. data services are expected to feature a higher growth than PSTN/ISDN-services, quantifying future growth rates for the various traffic types is very difficult. Therefore, we prefer at this stage not to introduce additional parameters featuring values that are to a large extent arbitrary. This approach is consistent with the approach taken in other Bottom-Up models (cfr. paragraph 1.2).

Quantification of allocation key For every single Regional Ring and Core Link of the incumbent's network, the percentage of the totally used capacity that is consumed by PSTN/ISDN-traffic is communicated by the incumbent operator. The average percentage for the Regional Rings of the Bottom-Up model equals 18,57%, while the average percentage for the Core Links of the Bottom-Up model is 45,02%.

Note that this parameter is not available for the Links LDC-host. Therefore, the hypothesis is taken that the overall share for PSTN/ISDN-services on the Links LDC-host equals the average percentage on the Regional Rings, i.e. 18,57%. We believe this assumption to be very realistic since one can expect the traffic characteristics on the Links LDC-host to be very similar to the traffic characteristics on the Regional Rings.

Table 5 summarises the values of the parameters w.r.t. the sharing of transmission infrastructure with the local access network and the parameters w.r.t. the share for PSTN/ISDN-services:

	Investment Cost	Share Non-Access Network	Share for PSTN/ISDN	Share to be retained in Bottom-Up model
Link LDC-host				
duct	100%	100%	18,57%	**18,57%**
trench	100%	75%	18,57%	**13,93%**
cable	100%	100%	18,57%	**18,57%**
Regional Ring				
duct	100%	100%	18,57%	**18,57%**
trench	100%	75%	18,57%	**13,93%**
cable	100%	100%	18,57%	**18,57%**
Core Link				
duct	100%	100%	45,02%	**45,02%**
trench	100%	75%	45,02%	**33,77%**
cable	100%	100%	45,02%	**45,02%**

Table 5: Summary of all parameters w.r.t. shared use of infrastructure

2.4 Algorithms for modeling the transmission equipment

As was the case for the formulae for the determination of the required switching equipment and transmission infrastructure, the BIPT took the comments made by the industry into account when reviewing the proposed formulae for the modeling of the transmission equipment and centralised the adapted formulae in paragraph 2 of Annex B. Therefore, in this section solely the comments made by the industry will be summarized (remarks concerning questions 1.10-1.13), while we will refer to Annex B for an overview of the formulae for the modelling of the transmission equipment in the LDCs, LTCs and ZTCs.

2.4.1 Modelling the transmission equipment in the LDCs, LTCs and ZTCs

Summary of comments

Firstly, some operators indicated that ? should be determined using the *Erlang B*-formula. Moreover, it was mentioned that the cost drivers for the transmission equipment in the core network cannot be the number of user lines and that costs should be traffic driven.

Decision taken by the BIPT

The BIPT recognises that the cost for the dimensioning of the transmission equipment in the transmission centres (LDCs, LTCs and ZTCs) should indeed be traffic driven and that the *Erlang B*-formula will be applied for the determination of the number of E1s.

As already mentioned, the BIPT opted to centralise all formulae regarding the dimensioning of the transmission equipment in paragraph 2 of Annex B.

2.5 Algorithms for dimensioning the signalling network

Summary of comments

One operator has provided detailed information on its signalling network. Moreover, some operators express their concern on the inclusion and treatment of signalling costs within the Bottom-Up LRIC-model.

Decision taken by the BIPT

The BIPT has extensively discussed the justification of specific signalling costs related to the new star topology signalling network during the verification of the BRIO 2003. As these discussions focused on the justification of these costs in relation to the interconnection tariffs based on a top-down model, it may be possible that the conclusions of these discussions are not automatically applicable in a bottom-up environment.

At this stage, no specific signalling costs are included in the bottom-up model. The BIPT has decided to evaluate the need to add additional signalling costs in the bottom-up model and the way in which this should be done, when updating this model for the BRIO 2004.

2.6 Routing rules

Summary of comments

Although most operators did not phrase remarks concerning the proposed routing rules, some clarifications were asked, concerning the routing factors and the determination of the BHE on the one hand (e.g. w.r.t. the period of measurement of the BHE), and the routing rules itself on the other hand (e.g. w.r.t. the rules for the installation of a direct trunk).

Decisions taken by the BIPT

Cost allocation method Firstly, the BIPT wants to make a general remark concerning the allocation of costs of the PSTN/ISDN-network to the various communication types. The BIPT believes that two approaches can be taken:

- for every communication type, one can determine its *traffic volume* (expressed in million of minutes) and an appropriate routing factor, and subsequently allocate costs based on the multiplication of both figures:

$$\textit{cost allocated to communication type}_i \ ? \ RF_i * volume_i$$

- for every communication type, one can determine the *traffic density*, provoked by the communication type during the busiest hour (expressed in Busy Hour Erlang), and an appropriate routing factor and subsequently allocate costs based on the multiplication of both figures:

$$\textit{cost allocated to communication type}_i \ ? \ RF_i * Erlang_i$$

Although one could argue that the BHE is an investment driver for the network and hence should also be a driver for the allocation of costs, the BIPT decided that the first approach will be retained in the Bottom-Up model, since:

- No information concerning the BHE *per communication type* is available, nor at node level, nor at aggregate level. Since this information is required in order to elaborate the second approach, one would have to introduce assumptions regarding the distribution of the total BHE per node over the different communication types. This would be arbitrary to a certain extent and is therefore not desirable;

- This approach is consistent with the one taken in the Top-Down model for the BRIO 2003.

Please note that this approach inherently entails that one assumes the distribution of traffic density of the communication types during the BHE to be equal to the relative ratio of the total traffic volumes of the various communication types.

The choice of this cost allocation method implies that the BHE does not intervene in the deduction of appropriate routing factors. For a description of the methodology and the hypotheses applied for the determination of the routing factors, we refer to Annex A.

Routing rules As already indicated in the third consultation document, the BIPT will apply the incumbent's routing rules in the Bottom-Up model. These rules were developed when the incumbent moved from its old 3-layer network architecture to the new 2-layer architecture. As the transformation of the architecture and the development of the new routing rules intended to simplify the network architecture, enhance traffic securisation and improve network management, the BIPT assumes that these standardised rules provide reasonable resilience and efficient routing.

In response to some questions that were raised, the BIPT can confirm that a direct E1-link between two BUs is created when traffic exceeds 20 BHE and that the same rule applies for the link between a BU and CAE. Moreover, regarding securisation, the architecture ensures that the zonal, interzonal, international and VAS traffic of 100% of the incumbent's customers is secured for at least 60% of the peak traffic.

2.7 Algorithms for dimensioning the accommodation requirements

Summary of comments

Almost all operators agreed that the most appropriate cost driver for the accommodation costs is the number of m^2. Some operators also mentioned fixed yearly costs per building.

Decision taken by the BIPT

<u>Calculating the surface requirements</u>

The BIPT has decided that the most appropriate cost driver for the accommodation costs is the number of m^2. An exception is made for specific fixed OPEX such as fixed fees covering the average electric power consumption, which are added as a fixed cost per building.

With regard to the number of m^2, a distinction has to be made between the footprint surface of the equipment and an amount of 'overhead' surface for corridors, stairs, sanitary equipment etc. As the prices that will be applied in the Bottom-Up model already take the space requirements for 'overhead' into account, only the footprint of the equipment should be considered in the Bottom-Up model. However, in order to promote the versatility of the model, the BIPT has chosen include a parameter for the 'overhead' surface by means of a separate 'multiplying ratio' that can vary for the different switching and transmission equipment.

The footprint surface of both switching and transmission equipment includes the space between rack rows in order to access the equipment.

2.7.1 Modelling the accommodation requirements for switching equipment

Dimensioning the accommodation requirements for switching equipment

The footprint surface of a standard configuration is determined for the whole of the switching equipment (concentrators, processor, switching matrices etc) in the RUs, BUs and CAEs. Based on the detailed demand information at the node level, the footprint surface of one or more complete RU, BU or CAE standard configuration will be taken into account.

The following surface requirements for RU, BU and CAE standard configurations are modelled:

	Capacity	Surface Requirements
RU	1.000 equivalent lines	0,85 m²
BU	7.000 equivalent lines	13,22 m²
CAE	5.50 E1s	14,55 m²

Table 6: Surface requirements of switching equipment

Determination of the overhead surface requirements for switching equipment

As already stated, since prices for accommodation take account of the space requirements for 'overhead', no separate 'multiplying ratio' has to be added:

	Ratio for overhead surface
RU	0%
BU	0%
CAE	0%

Table 7: Overhead space requirements for switching equipment

This information has to be interpreted as follows: if e.g. 10m² is needed for the switching equipment in a RU, an extra 10m² (i.e. 150% x 10m²) will be added as overhead surface.

Sharing of the accommodation requirements with the access network

The line cards are considered to be part of the access network. Therefore, a correction factor will be applied in order to eliminate all accommodation costs related to this non-traffic related part of the switching equipment.

	Correction factor for the elimination of line card surface requirements
RU	54%
BU	80%

Table 8: Sharing of accommodation with the access network

A correction factor of e.g. 54% for the RUs, means that 46% of the footprint surface requirement is related to the line cards.

Sharing of the accommodation requirements between PSTN/ISDN-services and other services

Since all switching equipment is exclusively used for PSTN-ISDN services, the sharing of the accommodations costs for switching equipment is not relevant.

In Annex B, detailed information regarding the individual formulae that were elaborated for the dimensioning of the accommodation costs of all types of switching nodes can be found.

2.7.2 Modelling the accommodation requirements for transmission equipment

Dimensioning the accommodation requirements for transmission equipment

The footprint surface of a standard configuration for all types of transmission equipment is determined. The number of each type of transmission equipment will be multiplied by these footprint surfaces in order to obtain the total accommodation requirements for each transmission node.

The following surface requirements for transmission equipment are modelled (incl. ODF and DDF):

	Surface Requirements
T-MUX	2,73m²
ADM	2,73m²
Cross Connect	2,73m²
SLT	2,73m²

Table 9: Surface requirements of transmission equipment

The possibility of sharing racks between different categories of transmission equipment has not been taken into account in the algorithms for dimensioning the accommodation requirements.

Determination of the overhead surface requirements for transmission equipment

As already stated, since prices for accommodation take account of the space requirements for 'overhead', no separate 'multiplying ratio' has to be added:

	Ratio for overhead surface
LDC	0%
LTC-RU	0%
LTC-BU	0%
ZTC-BU	0%
ZTC-CAE	0%

Table 10: Overhead space requirements for transmission equipment

This information has to be interpreted as follows: if e.g. 10m² is needed for the switching equipment in a LDC, an extra 10m² (i.e. 150% x 10m²) will be added as an overhead surface.

Sharing of the accommodation requirements between PSTN/ISDN-services and other services

The transmission equipment modelled is not exclusively used by PSTN/ISDN-services. The shared use of the transmission equipment is modelled by taking into account the correction factors presented in the table below. These correction factors are also used when determining the investment costs in the transmission equipment.

	Correction factor for sharing between PSTN/ISDN and other telephony services
T-MUX	No sharing of T-MUX equipment is modelled
ADM	$Perc_{switch}$ = % of the ADM used for PSTN/ISDN services The % is determined for each ADM individually
Cross Connect	CC_{pstn} = % of the cross-connect used for PSTN/ISDN services The % is determined for each Cross Connect individually
SLT	$VC4_{pstn}$ = % of the links used for PSTN/ISDN services The % is determined for each SLT individually

Table 11: Sharing of accommodation with the other services

3. COSTING INFORMATION

3.1 Investment costs of the switching and transmission equipment

Summary of comments

Several operators have provided detailed information for the switching and transmission components as distinguished in the 3rd consultation document. Comments were made regarding the differences in the commercial agreements that some operators have with their suppliers (e.g. more service driven) and the technology driven switching and transmission components that are presented in the 3rd consultation document. In order to compensate these differences, some operators have proposed a mapping between the cost components in their contracts and the cost components for the Bottom-Up model.

Decisions taken by the BIPT

With regard to the *structure* of the components, the BIPT has decided to maintain the way in which the switching and transmission nodes have been broken down in components.

With regard to the *level* of the costing parameters, a simple comparison *at the component level* was not possible given the variations in cost component structure (e.g. split between concentrator and switching matrix). Therefore, based on the algorithms presented in paragraphs 2.2 and 2.4 and implemented in the Bottom-Up model, a comparison of the costing information *at the network level* was made for both the transmission network (equipment) and the switching network. By doing so, the BIPT was able to obtain a first indication of the degree of consistency of the costing information parameters of different operators.

The Institute has concluded that, in general, the costing information of different operators is largely consistent at the network level, which means that this input allows the BIPT to decide on the *level* of the costing parameters that should be implemented.

The following paragraphs present the investment cost of switching and transmission equipment, retained as input parameters in the Bottom-Up model. Please note that these costing parameters are the result of the structure of breakdown of the switching and transmission costs of one specific set of input data, corrected to the level of other sets of input data.

3.1.1 Switching equipment

The following tables present the investment cost for the switching equipment of the various types of switching nodes (RUs, BUs and CAEs).

✍ **RUs**

PSTN card (1 user)	37,5 €
ISDN-BA card (1 user)	107,5 €
Concentrator (1 E1)	4.800 €

✍ **BUs**

PSTN card (1 user)	37,5 €
ISDN-BA card (1 user)	107,5 €
ISDN-PRA card (1 user)	2.272,40 €
Concentrator (1 E1)	4.800 €
Switching matrix port (1 E1)	2.272,40 €
Switching matrix (1 E1)	2.716,18 €

✍ **CAEs**

Switching matrix port (1 E1)	2.272,40 €
Switching matrix (1 E1)	2.716,18 €

Remarks:

The input parameters for the costing of the switching equipment result in switching cost per equivalent line of ? 100 €, i.e. consistent with the costing information used in the CCA-TAM exercise in the bottom-up model.

The total amount of equivalent lines is determined as:

- 1 PSTN end user line = 1 equivalent line;
- 1 ISDN-BA end user line = 2 equivalent lines;
- 1 ISDN-PRA end user line = 30 equivalent lines;
- 1 E1-trunk card in a BU / CAE = 30 equivalent lines.

Moreover, the presented structure of the cost components provides a total switching cost which is for ? 40% related to the local access network and for ? 60% related to the regional and core network. This is also consistent with the top-down model for interconnection.

In order to allow the operators to evaluate the reasonableness of the cost levels, in the following table, per type of switching node (RU, BU and CAE), the average investment in switching equipment per node is given, as well as the average number of equivalent lines (for the RUs) and the average number of BHE (for the BUs and CAEs, as in the RUs no BHE is measured).

Please note that the investment figures solely include *direct* investments in switching equipment: costs for Indirect Network CAPEX, overhead, accommodation or OPEX are not included.

Switching node	Average investment per node	Average BHE or eq. lines per node	Average investment per BHE/eq. line
RU	55.547,44 €	2.175 eq. lines	25,54 €/eq. line
BU	1.618.520,37 €	916,17 BHE	1.766,62 €/BHE
CAE	2.033.781,69 €	9.141,75 BHE	222,47 €/BHE

3.1.2 Transmission equipment

The following tables present the investment cost for the transmission equipment of the various types of transmission nodes (LDCs, LTCs and ZTCs).

✍ **LDCs**

TMUX tributary card (21 E1s)	1.368,37 €
TMUX Equipment (excl. STM1 line card)	4.961,50 €
STM-1 line card on TMUX	550,44 €

✍ **LTCs**

E1 tributary card on ADM (16 E1s)	1.368,37 €
STM-1 tributary card on ADM (1 STM-1)	606,17 €
ADM for STM-1 ring (incl. line cards)	7.255,13 €
ADM for STM-4 ring (incl. line cards)	13.196,00 €
ADM for STM-16 ring (incl. line cards)	33.241,66 €
ADM for STM-64 ring (incl. line cards)	98.076,52 €

✍ **ZTCs**

STM-1 port in Cross Connect	1.003,80 €
Fixed cost of Cross-Connect	289.905,60 €
SLT with STM-4 capacity (excl. line cards)	9.667,93 €
SLT with STM-16 capacity (excl. line cards)	27.241,66 €
SLT with STM-64 capacity (excl. line cards)	89.076,52 €
STM-1 tributary cards in the SLTs	606,17 €
STM-4 line cards in the SLTs	3.528,47 €
STM-16 line cards in the SLTs	6.000,00 €
STM-64 line cards in the SLTs	9.000,00 €

In order to allow the operators to evaluate the reasonableness of the cost levels, in the following table, per type of transmission node (LDCs, LTCs and ZTCs), the average investment in transmission equipment per node is given.

Please note that the investment figures solely include *direct* investments in transmission equipment: costs for Indirect Network CAPEX, overhead, accommodation or OPEX are not included.

Transmission node	Average investment per node
LDC	7.336,54 €
LTC	11.670,06 €
ZTC	391.936,96 €

3.2 Investment costs of the transmission infrastructure

Summary of comments

Various operators submitted information regarding the cost of transmission infrastructure. Some operators noted that the communicated costs for ducts and trenches are country-specific and hence are only valid for Belgium.

Decisions taken by the BIPT

The BIPT was delighted to notice that multiple operators submitted price information for the different transmission infrastructure elements (cables, ducts and trenches). In order to allow a qualitative comparison of the information provided by the various operators, the BIPT performed a simulation, whereby the total investment costs of all transmission links in the regional and core transmission network were calculated, based on the formulae derived in section 2.3 and applying the prices for trenches, ducts and cables provided by the operators.

From this simulation, the BIPT concludes that, although prices for individual cost elements (i.e. cables, ducts and trenches) might differ to a limited extend, the total investment for the three transmission infrastructure resource pools (i.e. Links LDC-host, Regional Rings and Core Links) is very similar when applying the price information of the various operators. Stated otherwise, although unit prices for cables, ducts and trenches might differ *separately* between the operators, the *sum* of the three cost elements is almost the same for the various operators.

In that regard, one could argue that, given the fact that for no link in the network that is modelled, more than one cable, featuring 12 or 24 fibers is required, it could be advisable to solely consider *aggregates* of transmission infrastructure prices, e.g. the unit price (expressed in Euro per meter) for 1 trench, containing 1duct and 1 fiber featuring 12 fibers, or the unit price of 1 trench, containing 1duct and 1 fiber featuring 24 fibers.

However, for the sake of clarity and transparency, we hereby specify the unit prices that are used in the Bottom-Up model individually. When determining these prices, the BIPT explicitly paid attention to reflecting the relative proportion of the different price elements and to ensuring that the total investment cost of the network as calculated by the Bottom-Up model, corresponds to the total investment costs, based on the price information supplied by the various operators.

3.2.1 Investment costs for cable

Prices are only specified for cables featuring 12 and 24 fibers, since in the network that is modelled, there is no need for cables containing more fibers.

Retained price for 12 fiber cable (€/meter)	7
Retained price for 24 fiber cable (€/meter)	7,5
Supplier list price for 48 fiber cable (€/meter)	Not applicable in the network modelled
Supplier list price for 96 fiber cable (€/meter)	Not applicable in the network modelled

3.2.2 Investment costs for ducts and trenches

No operator distinguished separate unit prices for duct in a metropolitan, urban or rural area and only one operator distinguished separate prices for trenches. Moreover, since the Bottom-Up model does not take into account geotypes, both for ducts and trenches an *average* unit price is retained.

Average price for duct/meter (€/meter)	5

Average price for trench (€/meter)	28

3.3 Investment costs in the signalling network

Summary of the comments

Two operators have provided costing information for the signalling equipment in the signalling nodes.

Decisions taken by the BIPT

As the BIPT has not yet decided how to treat the signalling costs in the bottom-up model, the quantification of the costing parameters for signalling equipment has been considered as not relevant at this moment.

3.4 Indirect network costs and non-network related overhead costs for the PSTN/ISDN-network

Summary of comments

With respect to the indirect network and non-network related overhead costs, the BIPT noticed that almost all operators reported that it is extremely difficult, if not impossible, to submit qualitative responses to the questions posed in the third consultation document. Moreover, some stated that it is advisable to take into account cost data from other Bottom-Up models and foreign operators. Finally, the remark was made that the BIPT must ensure that, when determining indirect network costs and non-network related overhead costs for PSTN/ISDN-services, costs for wholesale and retail services are clearly distinguished, in order to prevent that cost that are to be allocated to retail services are recovered via wholesale services.

Decisions taken by the BIPT

In the third consultation document, a primal proposition was presented on how indirect network costs could be incorporated in the Bottom-Up model. However, since most operators were unable to submit qualitative responses concerning the indirect network costs and the BIPT suspects that confusion might exist concerning the exact definition of the various indirect network cost elements, the BIPT believes that this first approach could be improved significantly and hence should be altered.

Therefore, the BIPT hereafter wishes to present a new, tailored framework, featuring unambiguous definitions of all indirect network cost elements and a suitable level of abstraction[14]. Once the approach is presented, the BIPT will indicate how the defined parameters are quantified.

Methodology for the inclusion of indirect network costs and non-network related overhead costs in the Bottom-Up model

The following tables illustrate the different indirect network costs and non-network related overhead cost parameters, as they will be retained in the Bottom-Up model:

Switching	*Local*	*Transit*
Total Network OPEX	…	…
Direct Network OPEX Indirect Network OPEX	… …	… …
Indirect Network Support CAPEX	…	…
Non-network related overhead	…	…

Transmission	*Equipment*	*Infrastructure*
Total Network OPEX		
Direct Network OPEX Indirect Network OPEX	… …	… …
Indirect Network Support CAPEX	…	…
Non-network related overhead	…	…

Table 12: Inclusion of indirect network costs and overhead costs in the Bottom-Up model

From these tables, one can derive that the following cost categories are defined:

- Indirect Network Support CAPEX;
- Direct Network OPEX;
- Indirect Network OPEX;
- Non-network related overhead.

For all of these cost categories, an appropriate value will be determined for the following network element categories:

- Local switching (gathering the resource pools '*RU*' and '*BU*');
- Transit switching (resource pool '*CAE*');
- Transmission equipment (gathering the resource pools '*Equipment LDC*', '*Equipment LTC*' and '*Equipment ZTC*');
- Transmission infrastructure (gathering the resource pools '*Links LDC-host*', '*Regional Rings*' and '*Core Links*').

This structure allows the BIPT to quantify all parameters in a qualitative manner since information can be obtained from multiple sources:

- The incumbent operator;
- Other Bottom-Up models;
- Other licensed operators.

[14] It showed that the information that was requested in the third consultation document was too detailed in order to allow a qualitative quantification.

The determination of the parameters as presented in Table 12 is mainly based on information from the incumbent. The consistency of this information was checked with the values of parameters in both the Top-Down model for interconnection and the model for Accounting Separation. However, the fact that other sources are available for the determination of the indirect network costs, allows the BIPT to verify the reasonabless of its results.

In the following part, the different indirect network costs and non-network related overhead cost categories will be defined and one will explain how they are incorporated in the Bottom-Up model.

Indirect network support CAPEX

Definition One defines the *'Indirect network support CAPEX'* as the total of all capital expenditure costs that cannot be directly attributed to specific network components that are dimensioned in the Bottom-Up algorithms, but that are indispensable for providing PSTN/ISDN-services. These include e.g. CAPEX costs for network management systems.

As a consequence, this cost category contains all CAPEX costs relevant for PSTN/ISDN-services, excluding 'Direct investment CAPEX' (i.e. all direct investments in switching equipment, transmission equipment, transmission infrastructure and technical buildings) and 'Non-network related overhead CAPEX' (e.g. building costs for the corporate headquarters).

Inclusion in the Bottom-Up model The indirect network support CAPEX will be included in the Bottom-Up model as a *mark-up percentage,* namely as a percentage of the gross replacement cost of the direct network investments:

Mark-up for Indirect Network Support CAPEX =
GRC Indirect Network Support CAPEX / GRC Direct Investment CAPEX

Direct network OPEX

Definition One defines the *'Direct network OPEX'* as the total of all direct operational expenditure costs that are required to guarantee the continuity of the network components' functioning. These include a.o. maintenance costs of switches.

As a consequence, this cost category contains all OPEX costs relevant for PSTN/ISDN-services, excluding 'Non-network related overhead OPEX' and 'Indirect Network OPEX' (defined hereafter).

Inclusion in the Bottom-Up model The direct network OPEX will be included in the Bottom-Up model as a *mark-up percentage,* namely as a percentage of the gross replacement cost of the direct network investments:

Mark-up for Direct Network OPEX =
Direct Network OPEX / GRC Direct Investment CAPEX

Indirect network OPEX

Definition One defines the *'Indirect network OPEX'* as the total of all direct operational expenditure costs that are required to guarantee the continuity of the *indirect* network investments' functioning. These include a.o. maintenance costs of the network management systems.

As a consequence, this cost category contains all OPEX costs relevant for PSTN/ISDN-services, excluding 'Non-network related overhead OPEX' and 'Direct Network OPEX'.

Inclusion in the Bottom-Up model The direct network OPEX will be included in the Bottom-Up model as a *mark-up percentage,* namely as a percentage of the gross replacement cost of the indirect network investments:

Mark-up for Indirect Network OPEX =
Indirect Network OPEX / GRC Indirect Network Support CAPEX

Non-network related overhead costs

Definition *'Non-network related overhead costs'* can be defined as the total of all costs related to general support services, that cannot be attributed to the exploitation of the network.

Consequently, this cost category contains all costs relevant for PSTN/ISDN-services, excluding 'Direct Investment CAPEX', 'Indirect Network Support CAPEX', 'Direct Network OPEX' and 'Indirect Network OPEX'.

Inclusion in the Bottom-Up model Non-network related overhead costs will be included in the Bottom-Up model as an absolute amount.

Quantification of the indirect network cost mark-ups

Indirect network support CAPEX

In order to determine the mark-up for 'Indirect Network Support CAPEX', one has to quantify both the nominator (i.e. the Gross Replacement Cost (GRC) of all investments in indirect network support items) and the denominator (i.e. the GRC of all investments in direct network elements, i.e. switching equipment, transmission equipment, transmission infrastructure and technical buildings).

The calculation of the mark-up in the current version of the Bottom-Up model is mainly based on the information that was collected within the framework of the Top-Down model for the BRIO 2003. This means that actual, ex post audited network costing information of 2001 is considered. The calculation of the mark-up will be updated for the Bottom-Up model that will be used for setting bottom-up tariffs for 2004.

Determination of the nominator With respect to the Indirect Network Support CAPEX, one has to make a distinction between two categories of Indirect Network Support CAPEX:

- Indirect Network Support CAPEX that is allocated to the various ONP-blocks in the Top-Down model and emerges almost exclusively from the incumbent's division '*Advanced Network Services*'[15];
- Indirect Network Support CAPEX emerging from the incumbent's general support divisions '*Facilities and Business Services*' (FBS) and '*Information Technology Group*' (ITG).

In order to determine the yearly depreciation cost of the assets of the first category, the incumbent communicated a list of so-called '*Asset Classes*' (ACs) that are relevant for the PSTN/ISDN-services. An AC comprises one or more assets related to a certain function and for all asset classes, the GRC is known. In a second step, in this list a distinction was made between an ACs that contain Direct Network CAPEX and those that contain Indirect Network Support CAPEX. Both types were further split up in ACs for 'Local Switching', 'Transit Switching', 'Transmission Equipment' and 'Transmission Infrastructure'. For each of these categories, the sum of the GRCs of the ACs that belong to the particular category is determined. This process is represented by the following figure:

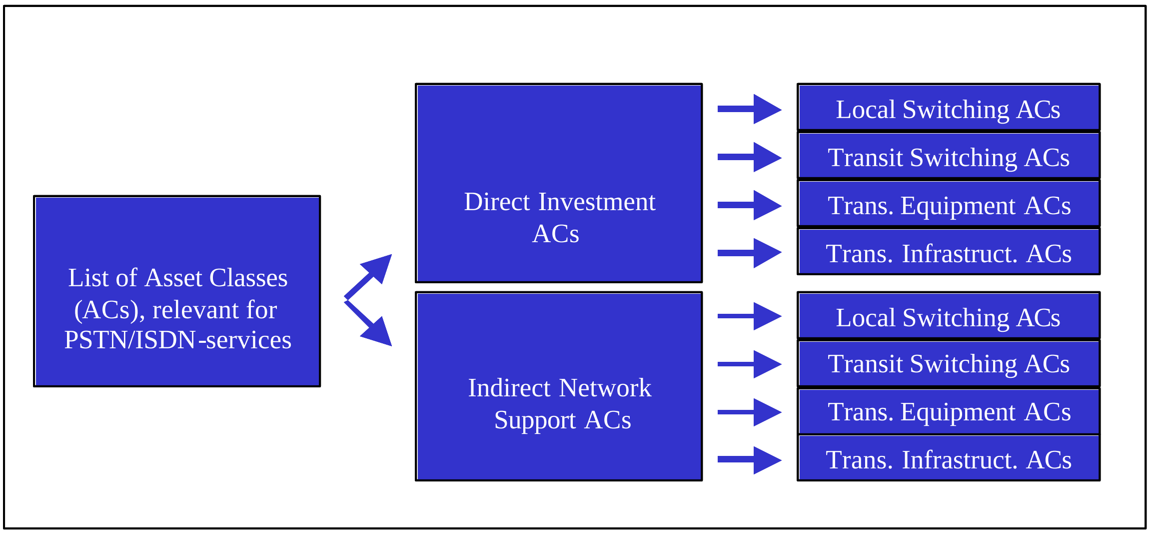


Figure 4: Determination of the GRC for the Indirect Network CAPEX – mark-up

With respect to the GRC of the Indirect Network Support CAPEX of FBS & ITG, one has to ensure that the CAPEX for buildings is eliminated from the CAPEX of FBS (as accommodation costs are directly determined in the Bottom-Up model). The incumbent reported that no detailed information regarding the GRC of the assets of FBS&ITG is available; hence the following approximation was retained:

GRC Asset$_i$ *FBS&ITG ? Net Book Value Asset*$_i$ *FBS&ITG + Depreciation Asset*$_i$ *FBS&ITG*

As the GRC of the Indirect Network Support CAPEX from FBS&ITG is far less than the GRC of the CAPEX that is allocated to the ONP-blocks, the impact of this approximation is rather small.

[15] A small share of the Indirect Network Support CAPEX that is allocated to the ONP-blocks emerges from the division '*Carrier & Wholesale Business*' (2,67%) or other divisions (3,51%).

Determination of the denominator As already mentioned, within the framework of the Top-Down model, all ACs that contain direct network CAPEX for 'Local Switching', 'Transit Switching', 'Transmission Equipment' and 'Transmission Infrastructure' are identified and their GRC quantified. For each of these categories, the sum of the GRCs of the ACs that belong to the particular category is determined.

Results The following table shows the resulting mark-ups:

Mark-up for Indirect Network Support CAPEX	
Switching - Local	**30,70%**
Switching - Transit	**26,76%**
Transmission Equipment	**6,23%**
Transmission Infrastructure	**0,00%**

Please note that, as already stated, the determination of these percentages was based on detailed information provided by the incumbent. In that regard, the BIPT wishes to make two remarks:

- Assets Under Construction were not retained for the determination of the GRC of Indirect Network Support CAPEX;
- With respect to the Indirect Network Support CAPEX, the so-called *sustenance fee* (i.e. a kind of maintenance contract that was concluded between the incumbent and its suppliers of switching equipment in order to maintain the switches, both w.r.t. software as w.r.t. hardware) and the updates of the software releases for the switching equipment are not considered as Indirect Network Support CAPEX, but rather as Direct Network OPEX. Consequently, no renumeration of capital for these expenditures in retained in the Bottom-Up model, which is in concordance with the Top-Down model.

Comparison with other sources The BIPT compared the ratios, based on information from the incumbent, with information from other bottom-up models. Although it was rather difficult to evaluate the mapping of this information with the definition of the cost categories in the BIPT's Bottom-Up model, the Institute believes that the obtained results are not unreasonable. As the information of other licensed operators was largely incomplete, it was not appropriate to use this information for other purposes than for verifying the order of magnitude.

__Direct & Indirect Network OPEX__

The mark-ups for Direct & Indirect Network OPEX in the current version of the Bottom-Up model are determined, based on actual audited figures for 2001 as structured in the model for Accounting Separation. In this model, the same allocation methodology for the Network OPEX is applied as in the Top-Down model for interconnection. The calculation of the mark-up will be updated for the Bottom-Up model that will be used for setting bottom-up tariffs for 2004.

Firstly, the *stage in the cost allocation process* that allows the most detailed but feasible allocation of OPEX to the categories 'Direct Network OPEX' and 'Indirect Network OPEX' has to be identified. This level is called the '*cost pool*'-level.

Secondly, for each of these cost pools, the incumbent examined to which ONP-block the OPEX should be allocated, i.e. whether they should be allocated to the ONP-blocks for switching (ONP_LOCAL SWITCH, ONP_TRANSIT SWITCH or ONP_SWITCHING NETWORK ALL) or to the ONP-blocks for transmission equipment & infrastructure (ONP_2MBITS/S PSTN LOCAL, ONP_2MBITS/S PSTN ZONAL or ONP_2MBITS/S PSTN INTERZONAL)[16].

Network OPEX for Switching With respect to the OPEX for *switching*, subsequently the following steps are taken:

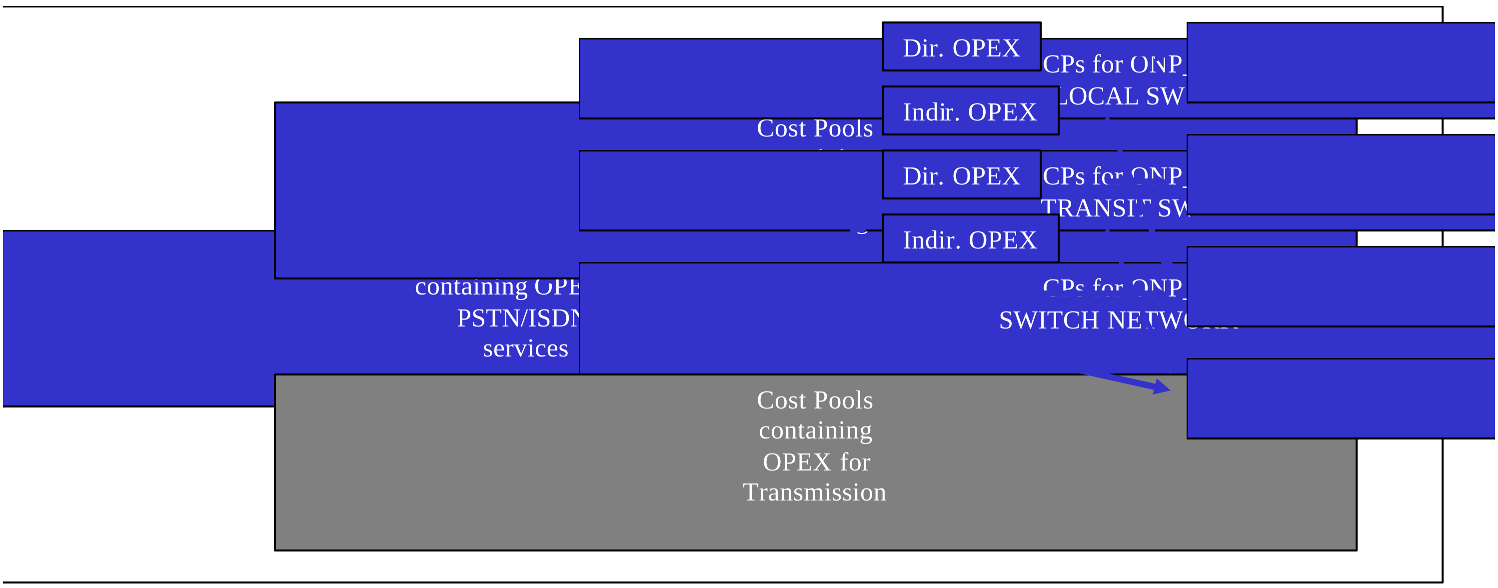
- Within the OPEX that should be allocated to the ONP-blocks 'ONP_LOCAL SWITCH' and 'ONP_TRANSIT SWITCH', a distinction is made between Direct Network OPEX and Indirect Network OPEX. This distinction is based on the examination of the nature of the OPEX contained in the cost pools;
- As OPEX for the ONP-block 'ONP_SWITCHING NETWORK ALL' solely concerns Indirect Network OPEX, this OPEX is to be added to the Indirect Network OPEX for Local Switching and Transit Switching. Based on the distribution of the number of equivalent lines in the existing network of the incumbent, 87,5% of the OPEX for 'ONP_SWITCHING NETWORK ALL' is allocated to Local Switching and 12,5% to Transit Switching.

Hence the following results are obtained:

Indirect Network OPEX for Local Switching =
*Indirect Network OPEX for 'ONP_LOCAL SWITCH' + 87,5% * Indirect Network OPEX for 'ONP_SWITCHING NETWORK ALL'*

Indirect Network OPEX for Transit Switching =
*Indirect Network OPEX for 'ONP_TRANSIT SWITCH' + 12,5% * Indirect Network OPEX for 'ONP_SWITCHING NETWORK ALL'*

This process is represented by the following figure:



[16] A description of the ONP-blocks, as defined by the incumbent operator, can be found on the BIPT's website (www.bipt.be), cfr. the description of the Top-Down model for interconnection (d.d. 01/12/2002).

Figure 5: Determination of Network OPEX for switching

Finally, one has to add the cost for the sustenance fee and the updates of the software releases for the switching equipment to the Direct Network OPEX for Local and Transit Switching. The allocation of these two cost categories also is based on the number of equivalent lines in Local Switches (RUs and BUs, 87,5%) and Transit Switches (CAEs, 12,5%).

Network OPEX for Transmission Within the cost pools that should be allocated to the ONP-blocks for the whole of transmission equipment & infrastructure (ONP_2MBITS/S PSTN LOCAL, ONP_2MBITS/S PSTN ZONAL or ONP_2MBITS/S PSTN INTERZONAL), the examination of the nature of the OPEX allows directly distinguishing between OPEX for 'Transmission Equipment' and 'Transmission Infrastructure'. Moreover, the examination allows also determining which OPEX costs concern 'Direct Network OPEX' and which concern 'Indirect Network OPEX'. This process is illustrated by the following figure:

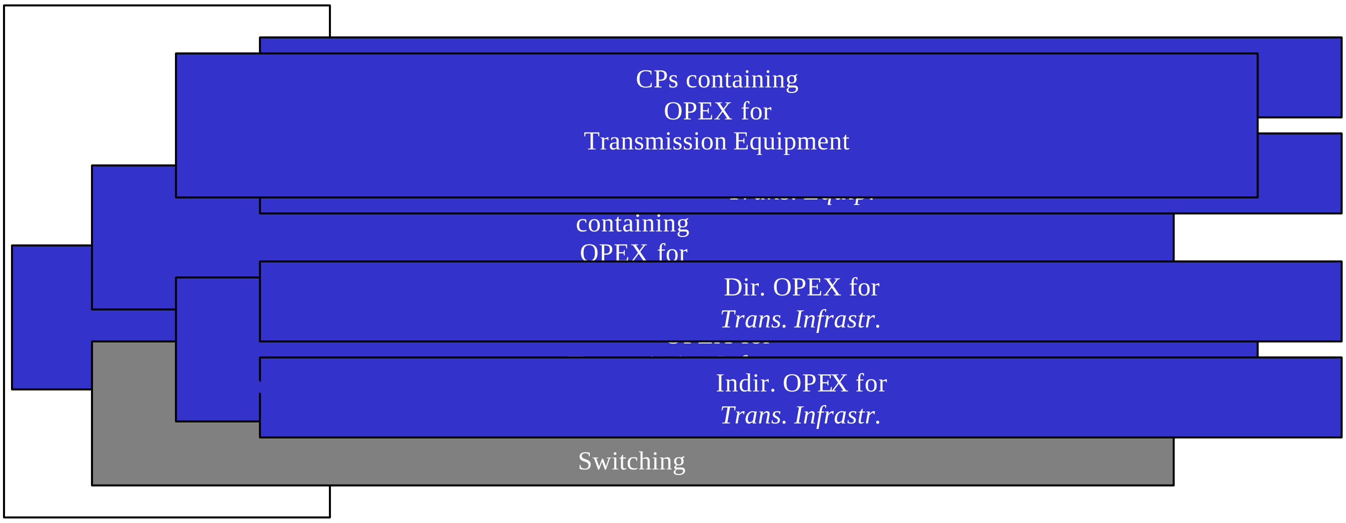


Figure 6: Determination of Network OPEX for transmission

Results The following table shows the results for Direct and Indirect Network OPEX:

	Mark-up for Direct Network OPEX	Mark-up for Indirect Network OPEX
Switching - Local	6,59%	7,27%
Switching - Transit	6,59%	7,60%
Transmission Equipment	1,82%	127,48%
Transmission Infrastructure	3,22%	0,00%

One notices that the mark-ups for Direct Network OPEX for 'Local Switching' and 'Transit Switching' are identical, which implies that the ratio of the GRC of the direct network CAPEX of 'Local Switching' and 'Transit Switching' equals the ratio of the absolute amount of Direct Network OPEX for both categories. Since this ratio is based on the number of equivalent lines of the local and transit switches, we can conclude that, according to the information provided by the incumbent, Direct Network OPEX per equivalent line does not differ between local and transit switches.

Comparison with other sources Although most operators were unable to specify values for the mark-up, comparison with data from other models shows that the obtained results are not unreasonable.

Non-network related overhead costs

Finally, also the non-network related overhead costs for the current version of Bottom-Up model are determined based on the Top-Down model for interconnection (budget 2002). The calculation of the non-network related overhead costs will be updated for the Bottom-Up model that will be used for setting bottom-up tariffs for 2004.

All overhead costs w.r.t. human resources management, finance, legal services, regulatory and public affairs, strategy and development and CEO support, are concentrated at the incumbent operator in so-called "*Management Groups*". Evidently, only a given share of the total of these overhead costs should be allocated to PSTN/ISDN-services. Therefore, the non-network related overhead costs can be found by firstly identifying the share of the *Management Groups* costs that are allocated to ANS (Advanced Network Services, i.e. the incumbent's network department) and secondly identifying the share of these costs that are allocated to the PSTN/ISDN-services. The allocation process is illustrated by the following figure:

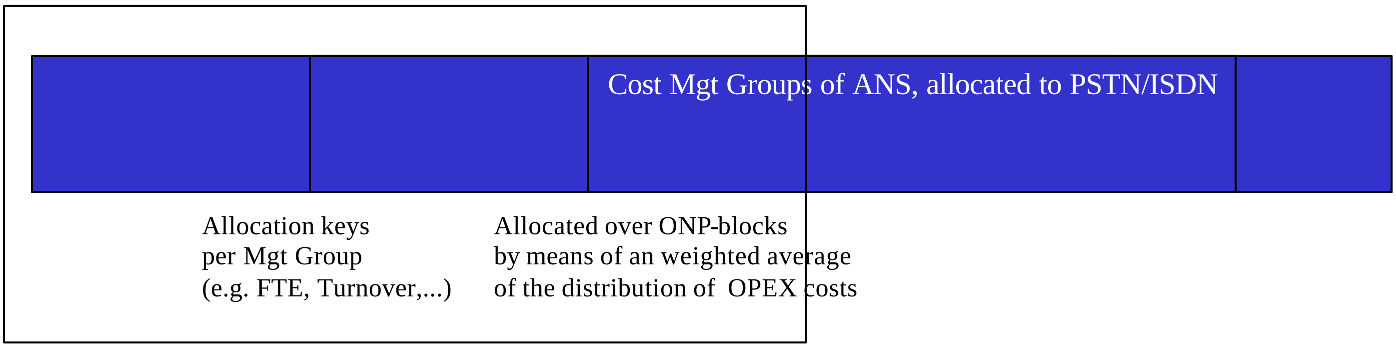


Figure 7: Determination of Non-network related overhead costs

Subsequently, the overhead costs for PSTN/ISDN-services have to be distributed over '*Local Switching*', '*Transit Switching*', '*Transmission Equipment*' and '*Transmission Infrastructure*'. The overhead costs for '*Local Switching*' and '*Transit Switching*' can readily and directly be derived from the Top-Down model (i.e. from the corresponding ONP-blocks for switching). The remaining overhead costs, i.e. those for '*Transmission Equipment*' and '*Transmission Infrastructure*' however, cannot be distributed based on the Top-Down model. Therefore, the BIPT decided to distribute these costs based on the relative proportion of Total Network OPEX costs.

Please note that for the determination of the overhead costs, no restructuring costs can be taken into account since in the Bottom-Up model, the operator is considered to function in a fully efficient way.

3.5 Interconnection specific costs

Question 2.9: The BIPT invites the industry to list all interconnection specific costs, if any, that have not been treated yet. Moreover, the BIPT welcomes all input on the cost drivers that should be used to allocate these costs to all of the interconnection services (traffic and non-traffic related).

Summary of comments

With respect to the interconnection specific costs, solely one operator responded to the question posed. The operator stated that the information provided within the framework of the Top-Down model should be used as input for the determination of the interconnection specific costs.

Decisions taken by the BIPT

The Bottom-Up model foresees the inclusion of interconnection specific costs as a fixed cost per minute for each of the interconnection services. However, the total amount of interconnection specific costs that should be allocated to the interconnection services hasn't been determined yet as these costs will be subjected to a detailed analysis during the BRIO 2004 discussions.

3.6 Remuneration of capital

Question 2.10: The BIPT invites the operators to comment on the use of the WACC formula.

For convenience, we repeat the WACC-formula:

$$WACC_{pré ? tax} \; ? \; (\frac{r_e}{1 \; ? \; t_c} \; ? \; \frac{E}{E \; ? \; D}) \; ? \; (r_d \; ? \; \frac{D}{E \; ? \; D})$$

whereas

r_e : Cost of equity (after taxes),
r_d : Cost of debt (before taxes),
t_c : Corporate tax rate,
E : Market value of equity,
D : Market value of debt.

and

$$R_e = R_f + ?_{equity} * [\, E(r_m) - R_f \,]$$

$$R_d = R_f + risk\ premium$$

R_f : Risk free interest rate,
$E(r_m)$: Expected return of a well diversified investment portfolio,
$E(r_m)-r_f$: Market risk premium,
$ß_{equity}$: Systematic risk a a specific company or activity.

Summary of comments

All operators supported the use of the WACC for the determination of the renumeration of capital.

Decisions taken by the BIPT

The Institute has decided to retain the WACC-formula for the determination of the renumeration of capital. The WACC included in the Bottom-Up model equals 12,88%. For the quantification of the parameters in the WACC-formula, the BIPT refers to the elaborate research that was carried out by the Institute and its consultant within the framework of the update of the Top-Down model for the BRIO 2003. Details of the calculation of the WACC can be found on the BIPT's website (www.bipt.be), in the document called '*Description of the top-down cost model of the BIPT for the determination of the interconnection tariffs for the BRIO 2003*'.

3.7 Calculating annualisations

The investment costs determined in the Bottom-Up model have to be annualised in order to calculate the relevant costs for a particular year. Besides the purchase price of the assets, this requires information on asset lives, price trends of each asset, as well as on the residual value of the asset at the end of its economic life. Moreover, the cost of capital needs to be determined. This cost consists of the multiplication of the mean capital employed by the Weighted Average Cost of Capital (WACC) and was treated in more detail in the previous paragraph. The annualised investment cost and the cost of capital combined determine the capital charge in the relevant period.

In this paragraph, firstly the various depreciation methodologies will be repeated for convenience, secondly the comments made by the operators will be summarized and finally the decisions taken by the BIPT will be specified.

3.7.1 Depreciation methodologies

An accurate annualisation charge should preferably have a depreciation profile that reflects economic reality, but, at the same time, it should allow an efficient operator to recover costs. Different depreciation rules can have a significantly different impact on the costs estimated for a particular year. The most commonly theoretically accepted depreciation method to calculate tariffs is the economic depreciation.[17] It measures the change in an asset's economic value. This value is the maximum of either the resale value or the value of the asset to the business measured by the (discounted) cash flow that the asset will generate in the future. The economic depreciation is calculated then as the difference between the value of the asset at the start and the end of a year. In a regulatory setting however, there is

[17] Economic depreciation is also the preferred approach of the IRG (independent regulators group).

the difficulty that the decisions of the regulator may affect the cash flow, hence influence the asset's value and the level of economic depreciation.

Economic depreciation is in practice very difficult to calculate. One of the main problems of the economic depreciation approach is that it is very information intensive. It requires future insight in asset values in relation to technological advances. Moreover, when calculating the net present value of the asset (NPV), difficult choices regarding revenue allocation have to be made. In practice, many operators have little idea of how the value evolution of a given asset actually looks like.

Because of these practical difficulties when calculating economic depreciation, more straightforward approaches are often preferred. Most of these approaches focus on recovering the replacement cost of a specific asset during its life. The appropriate depreciation profile may differ for each asset category. The goal however is to come as close as possible to the theoretically correct measure of depreciation (economic depreciation).

- **Straight-line depreciation**

The first alternative approach to calculate depreciation charges is the straight-line depreciation. Straight-line depreciation divides the asset's price by the asset's life to produce an annual depreciation charge. To this annual charge, a capital cost is added in order to obtain the annualisation charge. The straight-line depreciation approach is simple and may be appropriate for assets where technological progress is not very likely. Charges will be slightly higher in the first years (because of the higher capital costs) than in later years. The formula below calculates the annualisation factor for the straight-line depreciation methodology.

$$\left(1/asset\ life + cost\ of\ capital\right) * asset\ value$$

The goal of each alternative depreciation method is to provide an accurate estimate for the economic depreciation. In order to obtain this, the technical asset life should be taken into account, since the straight-line depreciation formula assumes the resale value of the asset of the end of the period to be zero.

- **Tilted straight line**

Some assets have prices that are expected to fall or to increase. For these assets, tilted straight-line depreciation might be more appropriate. When prices are expected to fall, the use of tilted straight-line depreciation will result in a steeper depreciation profile when compared to the unadjusted straight-line depreciation. The formula below describes this approach mathematically and calculates the depreciation values.

$$\frac{\left(asset\ price(i-1) + annual\ \%\ price\ change(i) \times remaining\ asset\ life(i) \times asset\ price(i)\right)}{Asset\ life}$$

1 ? i ? asset life
Asset price(i) = price of the asset at the beginning of the year i
Remaining asset life (i) = remaining asset life with year i included

The cost of capital has to be added to the above formula to obtain the annualisation values. Note that for declining prices, the annual % price change factor will be negative. This implies that when prices decrease, depreciation will be higher in the first years than in later years. For increasing prices, the opposite is true. Tilted straight-line depreciation also implies the use of technical asset lifes.

✍ Sum of digits

The sum of digits is a crude method for generating a front loaded depreciation schedule. This method may be useful whenever the asset's operating costs are expected to rise or when its price or the revenue it generates is expected to fall. The formula below describes the depreciation value when the sum of digits methodology is used.

$$\frac{?n ? 1 ? i?}{?n ? (n ? 1) ? (n ? 2) ? ... ? 1?} ? \ asset \quad price$$

1 ? i ? asset life
n= asset life

To obtain the annualisation values, a cost of capital should be added.

✍ Annuities

The annuities approach calculates both the depreciation charge and the cost of capital, but results in stable annualisation charges, provided the correct adjustments are made to capture the possibility of price changes. The balance between depreciation and the cost of capital within the constant payment however would vary: depreciation will be typically low at the start of the asset life, a higher proportion being used to cover the return on capital employed. Depreciation charges would be correspondingly higher towards the end of the asset life, since a lower proportion would be used to cover the interest charges on debt. The annualisation factor is calculated as follows.

$$\cos t\ of\ capital / ?1 ? ?1/(1 ? \cos t\ of\ capital ?^{asset\ life} ?$$

Note that sometimes, a tilted annuity may be calculated when the price of the asset is expected to change over time.

3.7.2 Depreciation periods

Question 2.12, 2.14, 2.16, 2.18 and 2.20: The BIPT invites the operators to express their view on the depreciation methodology that should be used for all switching equipment components, transmission equipment components and transmission infrastructure components (straight-line, tilted straight-line, sum of digits, annuities). If tilted straight-line depreciation should be used, please do not forget to mention the estimated annual price increase/decrease of the asset.

Questions 2.11, 2.13, 2.15, 2.17 and 2.19: The BIPT invites the operators to comment upon the proposed values for the asset lives of the switching equipment components, transmission equipment components and transmission infrastructure components.

Summary of comments

With respect to the *depreciation method* to be used in the Bottom-Up model, no consensus could be concluded from the answers of the different operators. While some operators suggested linear depreciation, other tended to prefer an annualisation approach, although most operators did not provide an answer to this question.

With respect to the *asset lives*, multiple operators communicated the depreciation periods that they apply. In general, these periods did not deviate greatly for the BIPT's proposal.

Finally, with respect to *price changes* of the various network elements (when tilted straight-line or tilted annuities would be used), the BIPT notices that very few information was provided by the operators. Some argued that their depreciation methods did not take into account price changes, while others specified values under reserve.

Decisions taken by the BIPT

Depreciation method Since the BIPT believes that the depreciation methodology that is retained in the Bottom-Up model should approximate the economic reality as close as possible and ideally, economic depreciations should be applied, the Institute decided to apply the Tilted Annuity Method (TAM). This method is generally considered to be one of the best approximations of economic depreciation and allows taking into account price evolutions of the various equipment.

The TAM-method ensures the recuperation of the investment cost and the remuneration of the invested capital by means of an annual annuity. The formula yielding the annual capital expenditure of asset *i*, according to the TAM-method, can be found as follows:

$$Annual\ Capital\ Cost_i \ ?\ F_{i,1} \ ?\ F_{i,2} \ ?\ F_{i,3}$$

with:

$$F_{i,1} \ ?\ \frac{GRC_{i,begin} \ ?\ GRC_{i,end}}{2}$$

$$F_{i,2} ? \sqrt{\frac{1 ? WACC}{1 ? MEA\ price\ increase}}$$

$$F_{i,3} ? \frac{1 ? \frac{1 ? MEA\ price\ increase}{1 ? WACC}}{1 ? ?\frac{1 ? MEA\ price\ increase}{1 ? WACC}?^{N}}$$

and

$GRC_{i,begin}$ = gross replacement cost of asset *i* at the beginning of the year
$GRC_{i,end}$ = gross replacement cost of asset *i* at the end of the year
WACC = weighted average cost of capital
N = expected technical lifetime of the MEA of asset *i*

Depreciation periods In order to establish the depreciation periods for the Bottom-Up model, several sources of information were used: the operators' answers to the consultation document, the incumbent's historic network data, the Europe Economics adaptable bottom-up model and international benchmarks provided by other regulators.

Analysis of the data shows that there is not much diversion on the different data sources. Moreover, in the answers of the consultation document, it is made clear that there is no real motivation for taking different lifetimes for the different *switching or transmission equipment*, as far as this equipment is provided together. This has resulted in minor differences between the initial BIPT proposal (based on Europe Economics data) and the final decisions that are summarized in the tables below:

Switching equipment	***Asset life (years)***
Line cards	15
Concentrator	15
Ports	15
Switch matrix	15
Processor	15

Transmission equipment	***Asset life (years)***
E1 Tributary cards	10
TMUX	10
STM-x cards	10
ADM-x	10
Cross Connects	10

The above assumptions have been double-checked with the incumbent's historic network data and seem to be a realistic estimate of the actual lifetimes of the various equipment. No lifetime will however be determined for accommodation since these costs will be modelled by rental fees.

With regard to the estimated lifetime of *transmission infrastructure*, the process of establishing asset lives is less straightforward. Concerning cable investment, there is a general consensus that lifetime of cable is 20 to 24 years. However, concerning duct and trenches, data shows that this can vary from 20 to 40 years.

Different factors influence the expected lifetime of duct and trenches. In the past, copper cable was often buried without any duct. As a result, the lifetime of the trench was the same as the lifetime of the cable, since replacement of the cable necessitates opening the trench. Moreover, different duct techniques have different lifetimes (e.g. the lifetime of a concrete duct can be expected to be much higher than the lifetime of a polymer duct).

However, the Bottom-Up model should look at technologies that are used today and hence look at the expected lifetime of duct and trenches as of today. Consistency should be guaranteed between the technology modelled and the lifetime expected. The BIPT has decided to use a single cable polymer duct and to take an average lifetime for duct and trenches of 30 years into account, which is considerably longer than the answers of some operators, but still shorter than the 40 years that can be expected when using concrete duct.

Transmission infrastructure	***Asset life (years)***
Cable	24
Duct & Trench	30

Please note that the asset lives as presented above were already applied for the implementation of the TAM-methodology in the Top-Down model for the BRIO 2003.

Price changes Since the operators provided only little information concerning the price changes, the BIPT decided to compare the available operators' information with information from other European Bottom-Up models and from the Top-Down model. After comparing these different sources, the BIPT decided to apply following values:

<u>Switching equipment:</u>

Comparison of information from operators, other Bottom-Up models and the Top-Down model shows that the specified price changes for the various switching equipment range from -8% to +1%. However, taking all input information into account and given the detailed information that could be retrieved from the Top-Down model, the BIPT believes that a price change of -2% for all switching equipment can be considered as a good approximation of reality.

Price changes for accommodation range from 0% to +1%. The BIPT retains a value of 0%.

Switching equipment	***Price change***
Line cards	-2%
Concentrator	-2%
Ports	-2%
Switch matrix	-2%
Processor	-2%
Accommodation	0%

Transmission equipment:

Comparison of information from operators, other Bottom-Up models and the Top-Down model shows that the specified price changes for transmission equipment range from -8% to 0%. Moreover, the BIPT noticed that price decreases for transmission equipment tend to be higher than for switching equipment. Therefore, taking all input information into account, the BIPT believes that a price change of -4% for all transmission equipment can be considered as a good approximation of reality.

Transmission equipment	*Price change*
E1 Tributary cards	-4%
TMUX	-4%
STM-x cards	-4%
ADM-x	-4%
Cross Connects	-4%

Transmission infrastructure:

Price changes range from -5% to +3,5% for cables and from +2% to +3% for duct and trenches. The BIPT retained a price change of -2% for the cables and +3% for duct and trenches.

Transmission infrastructure	*Price change*
Cable	-2%
Duct & Trench	+3%

Indirect Network Support CAPEX:

With respect to the Indirect Network Support CAPEX, price changes have to be determined for the categories 'Local Switching', 'Transit Switching', 'Transmission Equipment' and 'Transmission Infrastructure'. Since the Indirect Network Support CAPEX contains a variety of investment items that in principle can feature different annual price changes, this is not a straightforward job. Therefore, a weighted average was computed, taking into account the estimated annual price change and GRC of the various investment items. Taking these results into account, the BIPT decided to retain the following price changes:

Indirect Network Support CAPEX	*Price change*
Outside Plant	0%
Switching Local	0%
Switching Transit	0%
Transmission Equipment	0%

3.8 Working capital

3.8.1 Introduction

Working capital can be roughly defined as current assets less current liabilities. It is the amount of capital that is tied up in the business to keep the company running. Working capital is often used to build a 'bridge' between the moment that money flows out of the company and the time that the money from the sales of the goods or services flows in.

3.8.2 Calculating working capital

The following (simplified) formula gives a better view on the different components that have an impact on the working capital in a company:

$$\textit{Working capital} = \textit{stock} + \textit{debtors} + \textit{cash} - \textit{creditors}$$

The cost of working capital can be calculated as follows:

$$\textit{Cost of working capital} = \textit{working capital} \times \textit{financing cost}$$

In practice however, it is not always very straightforward to calculate the amount of working capital in a bottom-up exercise that models the costs of an efficient operator. The approach that the BIPT wants to propose in order to take into account the cost of working capital was initially presented by Oftel and later refined by Europe Economics.[18] For further details on this approach, we refer to the Europe Economics documents. The formula to calculate the tariff surcharge[19] is as follows:

$$\frac{\underline{\textit{Debtor days} - (\textit{Creditor days} \times (a/b))} \times r}{365}$$

a = total cost relating to the creditors
b = total economic cost
r = cost of capital

To calculate the total capital cost in use, the total capital equipment cost has to be multiplied by the cost of capital (r). The surcharge calculated by the above formula has to be applied to the total cost excluding working capital to produce a total cost including working capital. This surcharge, which is a percentage, should be applied to all investment categories such as RU, BU, CAE etc.

[18] Study on the preparation of an adaptable bottom-up costing model for interconnection and access pricing in European Union countries, Europe Economics, April 2000
[19] This surcharge can be negative when there is a negative working capital.

Question 2.21: The BIPT invites the operators to comment on the proposed approach to take into account the cost of working capital in the bottom-up model.

Summary of comments

The operators believe that in principle, the secondly proposed formula is preferrable over the first one, but it was also mentioned that no priority should be given to the inclusion of a cost of working capital in the first version of the Bottom-Up model, since it is believed that the impact on the results would be very small.

Decisions taken by the BIPT

Given the fact that one can assume the impact of the inclusion of the cost of working capital on the results to be very small and the fact that also in the Top-Down model, no such cost is included, the BIPT decided to not include a cost for working capital in the first version of the Bottom-up model.

3.9 Yearly accommodation costs

Summary of comments

Only a few operators have provided an indication of the accommodation costs per m², as several argue that their internal costing information is not relevant for the Bottom-Up exercises as their network nodes are mainly situated in metropolitan areas. By consequence, their accommodations cost levels are not representative for the whole Belgian territory.

Decisions taken by the BIPT

As the BIPT wants to ensure that the determination of the accommodation costs in the Bottom-Up model is consistent with the costs for accommodation in the colocation offer, the BIPT decided to retain the following structure for the accommodation costs in the Bottom-Up model:

- an annual CAPEX cost per m² to cover the cost of the floorspace;
- an annual OPEX cost that covers the cost of electric power consumption.

The annual CAPEX cost per m² as retained in the Bottom-Up model covers the yearly depreciation cost of the building and of the electrical installations (a.o. airco). This cost includes the cost of the space requirements of 'overhead' such as corridors, stairs, sanitary equipment etc. Therefore, in order to determine the accommodation cost of switching or transmission equipment, only the footprint surface of the equipment has to be taken into account.

With respect to the OPEX cost, the BIPT decided to retain a *fixed* annual OPEX cost, which represents the *average* cost of electric power consumption of a technical building. As in the network modelled, one assumes the switching and transmission rooms to be physically colocated in the same technical building, fixed OPEX costs should be added, or to the switching equipment, or to the transmission equipment. In the Bottom-Up model, the BIPT opted to add the fixed OPEX costs to the switching equipment.

The following table presents the actual costs that were into account:

Annual CAPEX cost for floorspace	185,92 €/m²
Annual OPEX cost for electric power consumption	2.107 €

Please note that the cost for floorspace is consistent with the corresponding cost in the colocation offer and that the OPEX cost is based on the price per Ampère (86,01 €/Ampère) and the price per Kwh (0,124 €/Kwh).

4. OUTPUT OF THE MODEL

The output of the cost model will consist of separate costs for individual network components, as well as aggregated tariffs for the interconnection services.

4.1 Separate costs for individual network components

Question 3.1: The BIPT wishes to invite the industry to give its view on the list of network components for which total and average per minute costs will be provided as an output of the model.

Summary of comments

Firstly, it was stated that, when outlining the list of network components for which costs are specified, the BIPT should try to maximise the comparability with other data sources (e.g. other Bottom-Up models). In that regard, it was suggested that, besides the proposed format, the costs for transmission might also be specified in terms of links types like 'Link RU to BU', 'Link BU to BU', 'Link BU to CAE' etc.

Secondly, most operators agreed that the proposed list provides the required information in order to understand the resulting tariffs. However, some asked to add the cost of *switch ports*.

Decisions taken by the BIPT

The BIPT retains the following list of network components. Annual costs and costs/minute are calculated according to the TAM-methodology.

	Costs/min	*Total annual cost*
1. SWITCHING Equipment		
1.1 Remote Units		
1.2 Base Units		
1.3 Covering Area Exchanges		
2. TRANSMISSION Equipment		
2.1 Local Distribution Center		
2.2 Local Transmission Center		
2.3 Zonal Transmission Center		
3. TRANSMISSION Infrastructure		
3.1 Link LDC-host		
3.2 Regional Rings		
3.3 Core Links		
TOTAL		

Table 13: Cost for network components

Question 3.2: The BIPT invites the industry to comment on the categorisation of costs that will be distinguished for each network component.

Summary of comments

No objections were raised against the proposed categorisation.

Decisions taken by the BIPT

For each network component, the following total costs will be identified separately:

- *CAPEX (Capital Expenses)*
  - Direct network costs (resulting of the dimensioning formulae)
  - Indirect network support costs (calculated as a percentage of the GRC of the direct investment costs)
- *OPEX (Operating Expenses)*
  - Direct Network operating costs
  - Indirect Network operating costs
- *NON-NETWORK RELATED OVERHEAD COSTS*

4.2 Tariffs for interconnection services

Question 3.3: The BIPT invites the industry to comment on the list of interconnection services for which tariffs will be calculated and on the methodology of calculating the tariff for the local interconnection service.

Summary of comments

Opinions vary regarding the interconnection services for which tariffs will be calculated. Some argue that the Bottom-Up model should be used for the determination of the tariffs for a wider range of services (e.g. including collecting services), while another operator argues that LRAIC is no appropriate method for determining tariffs for non-bottleneck services, e.g. collecting services, since:

- an operator can choose to use another network than the incumbent's, or build his own network;
- If tariffs for non-bottleneck services are set at a level assuming fully efficient operation, there is no incentive for the operator using the collecting service to develop his own network infrastructure.

Decisions taken by the BIPT

The BIPT decided that the first version of the Bottom-Up model will yield tariffs for the following interconnection services:

- Local terminating service;
- Intra Access Area (IAA) terminating service;
- Extra Access Area (EAA) terminating service;
- Local collecting service;
- Intra Access Area (IAA) collecting service.

Note however that the reconciliation with the results of the Top-Down model for interconnection will impact the setting of the final interconnection tariffs.

4.2.1 Tariff structure

Question 3.4: The BIPT invites the industry to give its opinion on the proposal to derive a two-part charging structure for the interconnection services and asks to provide more information on the split of costs driven by the number of lines.

Question 3.5: The BIPT invites the industry to provide information on the average call set-up time in their networks and on the percentage of successful calls.

Summary of comments

The operators did not consider the proposed structure to be unreasonable. One operator suggested that in the Bottom-Up model, a differentiation between costs related to setup and those related to call duration might be pursued.

Decisions taken by the BIPT

Due to the important differences in the cost structure for switching and transmission equipment of the individual operators (and suppliers), the BIPT believes that it is not opportune to introduce a distinction between call-related costs and usage-related costs. By consequence, the BIPT decided that in the Bottom-Up model, no cost-based distinction can be made between a charge for call set-up and duration. The output therefore consists of an average tariff. If required, at any time this average tariff can be split up in between a charge for call set-up and duration based on tariff gradients, as is also the case in the Top-Down model.

5. RECONCILIATION ISSUES

5.1 Aim of the reconciliation

The aim of the reconciliation is to identify and to understand the differences between the results of the bottom-up and the top-down model. The analysis of the differences between the two models will provide a better understanding in the cost structure of incumbent operator and will enable the regulator to evaluate and to take into account the impact of inefficiencies. It should be clear that the aim of the reconciliation process is not to come to equal outputs of the top-down and the bottom-up model.

5.2 Areas of reconciliation

Question 4.1: The BIPT invites the industry to give its opinion on the proposed areas of reconciliation and on the level of aggregation at which the analyses will be made.

Summary of comments

The reactions of the operators on the areas of reconciliation were rather limited. In general, the proposed areas and level aggregation appeared to be reasonable to the operators, although it was mentioned that e.g. interconnection specific costs were not mentioned and that also demand volumes for non-interconnection PSTN/ISDN-services should be reconciled.

Some operators explicitly mentioned the need for a flexible approach with focus on the most important differences. Therefore, it is considered to be unnecessary to define the precise details of the reconciliation in advance.

Decisions taken by the BIPT

At this moment, no *explicit* reconciliation was performed by the BIPT. However, as the incumbent operator has been closely involved in the implementation of the Bottom-Up model during the last few months, the reconciliation has already been prepared in an *implicit* way. How this has been done, will be commented for each of the relevant areas of reconciliation:

- Capital expenses (CAPEX);
- Operating expenses (OPEX) and company overhead;
- Demand volumes;
- Routing factors;
- Miscellaneous items.

5.2.1 Capital expenses (CAPEX)

<u>**Network-related CAPEX**</u>

As described in the paragraph 3.4, the determination of the mark-ups of a.o. the Indirect network CAPEX has required a mapping of the direct network related asset categories in the incumbents costing systems, with the resource pools as defined for the development of the Bottom-Up model. This means that a comparison of the level of network CAPEX is possible for each resource pool. A more detailed analysis (e.g. at the level of network components) will require first of all the finalisation of the costing parameters for switching and transmission *equipment* in the Bottom-Up model. The results of these *costing parameters*, combined with the *volumes* dimensioned by means of the algorithms presented in chapter 2, will subsequently be compared with the detailed TAM-calculations on which the network CAPEX in the Top-Down model was based.

Non-network related CAPEX

The non-network related CAPEX mainly consists out of accommodation costs and some other non-building support CAPEX. Since the accommodation costs are modelled in the Bottom-Up model by means of specific algorithms, a detailed node-based analysis can be performed.

5.2.2 Operating expenses (OPEX) and company overhead

Both mark-ups for direct and non-direct network OPEX, as well as the absolute values for the company overhead are determined based on detailed information from the incumbent. This approach enables a straightforward reconciliation.

5.2.3 Demand volumes

Communication types

Some specific ‘technical’ non-interconnection communication types have been defined, inspired by the architecture of the network modelled in the Bottom-Up model for interconnection (cf. Annex A). These communication types do not correspond exactly with the technical and commercial communication types that are used in the Top-Down model. The interconnection services however are defined exactly as in the reference offer of the incumbent operator.

Volume per communication type

The Top-Down model for the BRIO 2003 uses the ‘Outlook 2002’ volumes for the determination of the unit costs. The current version of the Bottom-Up model however uses actual volumes for the year 2002.

The information on the actual 2002-volumes was communicated in the format as used for the Top-Down model. A mapping with the communication types defined in Annex A has been done.

The reconciliation of the demand volumes will mainly focus on differences between outlook and actual volume information. If relevant, the impact of some parameters for the mapping of the Top-Down and Bottom-Up communication types can be evaluated.

5.2.4 Routing factors

The theoretical routing factors for the Bottom-Up model have been determined by following largely the same approach as for the theoretical routing factors for the Top-Down model. This means o.a. that the network architecture plays a crucial role, much more that the actual demand volumes in each node of the network. Since the resource pools for which the routing factors have been defined are not the same as the ONP-block in the Top-Down model, reconciliation will not be straightforward. Especially for the transmission components, the reconciliation will need to be performed in a rather general way.

5.2.5 Miscellaneous items

At least three miscellaneous items will be dealt with during the reconciliation:

- *Cost for the signalling network:* cf. paragraph 2.5;
- *Interconnection specific costs:* cf. paragraph 3.5;
- *Restructuring costs:* the Top-Down model takes into account a part of the contributions of the incumbent operator for its *'Pension BackService Fund'* (PBS), as well as some cost related to specific restructuring programs (e.g. BEST). These cost are not considered in the Bottom-Up model, since abstraction is made of the history of the network modelled and of the operator that exploits the network.

5.3 Level of aggregation of the reconciliation

The tables below visualise the level of detail that at least will be analysed during the explicit reconciliation. They are sometimes more aggregated (e.g. transmission equipment) or more detailed (e.g. non-network related overhead) than the tables presented in the 3rd consultation document.

5.3.1 Capital expenses (CAPEX)

Costs/min	***Direct network CAPEX***		***Indirect network support CAPEX***		***TOTAL CAPEX***	
	BU	TD	BU	TD	BU	TD
1. SWITCHING Equipment						
1.1 Remote and Base Units						
1.2Covering Area Exchanges						
2. TRANSMISSION Equipment						
3. TRANSMISSION Infrastructure						
TOTAL						

Table 14:Aggregated comparison of the CAPEX

5.3.2 Operating expenses (OPEX) and non-network related overhead

Costs/min	*Direct Network OPEX*		*Indirect Network OPEX*		*Overhead*	
	BU	TD	BU	TD	BU	TD
1. SWITCHING Equipment						
1.1 Remote and Base Units						
1.2 Covering Area Exchanges						
2. TRANSMISSION Equipment						
3. TRANSMISSION Infrastructure						
TOTAL						

Table 15: Aggregated comparison of the OPEX

5.3.3 Demand volumes

Traffic types	*% Variance between volumes in BU and TD*
1. INTERCONNECTION services	
1.1 Terminating Local	
1.2 Terminating IAA	
1.3 Terminating EAA	
1.4 Collecting Local	
1.5 Collecting IAA	
1.6 Transit IAA	
1.7 Transit EAA	
1.8 Other IC: BGC to Fixed OLO	
1.9 Other IC: BGC to Mobile OLO	
1.10 International Transit	
1.11 International Traffic (Incoming & Outgoing)	
2. Non-IC PSTN/ISDN-services	
3. TOTAL PSTN/ISDN-traffic	

Table 16: Comparison of the Demand Volume

6. NEXT STEPS

The next paragraphs outline the detailed planning for the period of the finalisation of the bottom-up model to its reconciliation with the top-down model. This planning concentrates around two aspects, i.e. the communication towards the sector with regard to the bottom-up model and the way in which the sector will be able to provide its input in the process of reconciling the bottom-up and the top-down model for interconnection for the BRIO 2004.

6.1 Communication towards the sector with regard to the bottom-up model

A general presentation and a detailed demonstration on the bottom-up model of the bottom-up was organised on the 8th of September 2003.

On the 15th and 16th of September 2003, the sector will be able to consult a complete version of the bottom-up model, in which dummy values will be introduced for replacing all parameters that are considered to be confidential. Interested operators are invited to make a reservation at the BIPT for a specific time slot during these two days.

At the end of the week of October 6th 2003, another meeting with the sector will be organised. During this meeting, all written remarks and questions, submitted to the BIPT before September 30th, 2003, concerning the summary of the third consultation document, the consultation on the reconciliation and the access-tool in which the bottom-up model is developed, will be dealt with.

6.2 Input from the sector in relation to the reconciliation of the results of the bottom-up model with the results of the top-down model

The decisions outlined in the present document were taken into account in the finalisation of the first release of the bottom-up model that provides a provisional result for 2003. These results are considered as 'interim results' as the decisions of the BIPT on which they are based are not yet validated by the sector.

Moreover, as the BIPT has decided to use the outcome of the bottom-up model in the process of setting the BRIO 2004 tariffs, this validation of decisions of the BIPT by the sector should indicate whether or not these are suitable for determining bottom-up interconnection tariffs for 2004.

The BIPT therefore explicitly invites the sector to provide its comments on any topic dealt with in the summary of the third consultation document and in specific to verify the applicability of all decisions and parameters for the interconnection tariffs 2004. The comments should be provided to the BIPT. in writing before September 30th 2003.

In the week of September 8th, a fourth consultation document on reconciliation issues will be communicated to the sector. In this document, the methodology for the reconciliation will be outlined and the opinion of the sector on specific choices to be made will be asked for. The reactions on this consultation should also be provided to the BIPT in writing before September 30th 2003.

6.3 Overview of planning

Description	Date
General presentation and demonstration of bottom-up model	September 8th, 2003
Communication of summary of 3rd consultation document	September 10th, 2003
Communication of consultation document on reconciliation	September 12th, 2003
Consultation of bottom-up model by sector (after reservation)	September 15th and 16th, 2003 September 22nd and 23rd, 2003
Final date for submitting written reactions to BIPT. on: - Summary of the 3rd consultation document; - Access-tool in which BU-model is developed; - Consultation document on reconciliation.	September 30th, 2003
Meeting on bottom-up model, in which all questions communicated in writing before September 30th, 2003, will be dealt with.	October 8th, 2003

6.4 Contact information

Comments on the summary of the 3rd consultation document and on the bottom-up model developed in Access should be submitted in writing before September 30, 2003, to Ms. Hilde Verdickt (BIPT).

For any further information on the contents of this document or on the further planning outlined above, please contact Ms. Hilde Verdickt (BIPT) or Ms. Tine Debusschere (Bureau van Dijk).

BIPT **Ms. Hilde Verdickt** Sterrenkundelaan 14/21 1210 BRUSSELS Tel: + 32 2 226 87 34 Fax: + 32 2 226 88 04 Email: hilde.verdickt@bipt.be	***Bureau van Dijk, Management Consultants*** **Ms. Tine Debusschere** Avenue Louise 250/14 1050 BRUSSELS Tel: + 32 2 639 06 06 Fax: + 32 2 648 82 30 Email: tine.debusschere@bvdmc.com