5. Loop Cost Studies

Description of Models

Q. Let's turn to the fifth major section of your testimony, concerning SWBT's loop cost studies. Earlier, you mentioned some difficulties you encountered during your investigation. Despite these problems, have you been able to gain an understanding of the Company's loop studies and study methodology?

A. Yes. Members of my firm and I have focused considerable attention on the loop studies, because these UNE rates are of great importance in moving towards a more competitive market. As a result of examining the electronic copies of SWBT's loop cost models and files, as well as hard copies of various workpapers and outputs from models that were not provided electronically, we gained a fairly detailed understanding of SWBT's loop cost estimating approach.

SWBT uses a series of unlinked database sample files and spreadsheets, along with some models that were not available to me, apparently because they operate on mainframe computers. I have attached a flow chart (Schedule 2) which represents my understanding of the linkages and flows of the sample data, input development spreadsheets, and mainframe models.

Q. Did the fact that the mainframe models (LPVST and ACES) were not electronically accessible prevent you from analyzing and simulating the SWBT loop modeling process?

A. No. Their inaccessibility slowed our review and forced us to spend more time than if they had been available for direct examination, but it did not prevent us from learning what was happening in the SWBT cost studies. Using the workpapers and output from these models, as well as responses to discovery (including copies of the electronic files that feed into these models), we were eventually able to understand what went on within this portion of the modeling process. It turns out that the algorithms within the LPVST model actually perform relatively simple multiplication functions that need not be performed on a mainframe computer. In fact, these computations could easily be accomplished in a spreadsheet.

In fact, once we understood what was happening within LPVST, we were able to simulate it within an electronic spreadsheet. We subsequently linked the simulated LPVST electronically to other components of SWBT's modeling process, thereby greatly simplifying and accelerating our overall analysis and allowing us to probe much deeper than if we had not taken this extra step. By integrating various aspects of the studies into a single system of linked files, we were able to examine relationships among various aspects of SWBT's cost modeling process.

It is my understanding that when other parties ask SWBT to run its loop cost models using alternative input assumptions, SWBT takes as much as two weeks to develop and provide new cost estimates. In contrast, using these linked spreadsheets, we were able to develop new estimates nearly instantaneously. This allowed us to analyze the effect of modifying the labor rates, fill factors, cable investments and other aspects of SWBT's cost studies, and to readily determine the corresponding changes in monthly loop costs.

Q. Before we get into specific input assumptions and problems you found in SWBT's loop cost modeling, can you explain in more detail the relationships among the many piece parts of the SWBT loop modeling process, starting with the input development files?

A. Yes. At its core, the SWBT loop modeling process has many similarities to other telecommunications cost models. For instance, it applies cable investments per foot to loop distance data. The investments vary by plant mix (aerial, underground or buried), by technology (copper or fiber) and by copper cable gauge (26, 24, 22 or 19). Unlike some other models (e.g. Hatfield and BCPM) the loop distances are derived from sample data descriptive of the existing network. Samples lengths are developed for the three geographic zones, but these data are not input directly to the LPVST model. Rather, LPVST uses the percentages of loops within standardized distance bands (e.g., from 2,500 to 3,500 feet). This is an aspect of the modeling process that we studied in considerable detail; a discussion of the banding process will follow later in my testimony.

The cable investments used in LPVST are developed primarily from two spreadsheets. The loop investment inputs to LPVST originate in the Broad Gauge Report, which is used to develop cable costs per foot, excluding contractor costs. The outputs of the Broad Gauge Report are comprised of material costs per foot plus splicing and placing; the results are sometimes referred to as *unit partial costs*. The splicing and placing costs are developed within the Broad Gauge development spreadsheet, based on estimates of the time it takes to splice and place cable multiplied by assumed hourly labor rates. These investments are developed by plant type (aerial, underground or buried), by technology (copper or fiber), by copper cable gauge (26, 24, 22 or 19) and by the various cable sizes. These unit partial costs (outputs from the Broad Gauge Report) are then input to an intermediate spreadsheet (GEOKS96forRFI.xls) which is used to determine cable costs per pair foot as well as plant mix.

This second spreadsheet GEOKS96forRFI.xls (Pre-LPVST spreadsheet) combines the Broad Gauge results with other data. Specifically, it uses an inventory of embedded cable sheath feet by geographic zone, plant type, cable gauge, and cable sheath size; it also uses an inventory of Feeder Distribution Interface (FDI) quantities and sizes by geographic zone. All these inventory data are descriptive of SWBT's existing network in Kansas. From these data, the Pre-LPVST spreadsheet computes FDI investment per pair and feeder cable investment per pair foot (including contractor costs) for each of the plant types and cable gauges. The analogous distribution cable investments per pair foot are then residually determined from the total sheath foot quantities, based upon some assumptions concerning the placement of FDIs. Plant mix by geographic zone is also derived from the embedded inventory of sheath feet. Therefore, the principal outputs from the Pre-LPVST spreadsheet are the FDI investment per pair, the feeder and distribution cable investments per pair foot by gauge and plant type, and the mix of aerial, buried, and underground plant. All these outputs vary by geographic zone and are used as inputs to LPVST.

Q. Are there other inputs used by LPVST?

A. Yes. Fill, pole, and conduit factors are inputs to the LPVST model. Also, as I mentioned earlier, the percentages for copper feeder, fiber feeder, and copper distribution within each loop length band are taken from the loop sample data for each of the geographic zones and input to LPVST.

Q. Can you describe the internal workings of SWBT's LPVST model?

A. Not exactly. Since the model resides on a mainframe computer, it was not accessible to me. However, by examining hard copies of inputs, printouts of internal engineering assumptions, and outputs of investment results, we were able to simulate the LPVST process to within pennies.

Q. Your spreadsheet simulation does not exactly replicate the LPVST results. Did this hinder your understanding and evaluation of the LPVST process?

A. Not to my knowledge. It seems likely that the remaining discrepancies are due to rounding errors, perhaps related to the fact that we relied upon hard copy printouts in developing our simulation. While it may not be a perfect replica of the mainframe LPVST model, our spreadsheet simulation of LPVST is completely auditable, traceable, and verifiable and it accomplishes essentially the same purpose as LPVST. Furthermore, our simulation has a very important advantage over the mainframe version: we were able to electronically link it to various other components of SWBT's cost modeling process, allowing us to gain a better understanding of the process and greatly reducing the amount of time and effort required to develop alternative results based upon alternative input assumptions.

Q. Can you describe the modeling process within your spreadsheet simulation of LPVST?

A. Yes. Since many calculations take place across many dimensions, in my description of the process I will narrow the focus specifically to geographic zone 1, 26-gauge buried distribution cable investment. Keep in mind that similar calculations take place for aerial and underground plant, copper and fiber feeder, other cable gauges (24, 22, and 19) and for the remaining two geographic zones (2 and 3).

A key input to LPVST is the relative percentage of buried plant in the distribution network. The embedded inventory is used in the Pre-LPVST spreadsheet to develop this percentage for Kansas. The output from the Pre-LPVST spreadsheet provides another key input to LPVST as well: the cost of cable. Continuing with this specific example, a per-pair-foot unit investment amount is used for 26-gauge buried distribution cable. These two inputs--the percentage of buried plant and the unit investment--are multiplied by each other, as well as by the relative percentage of 26-gauge cable in each distance band and a set of distances (referred to by statisticians as "class marks") which are assumed to be descriptive of the cable lengths within each band (1000, 2000, 3000, etc.). The relative percentages are based on engineering assumptions concerning the optimal distances that particular gauge cable may be deployed. (The thinnest cable, 26 gauge, is the least costly option for short distances. Heavier gauge cable is used when spanning longer distances, in order to maintain adequate quality). A fill factor is then applied to produce an estimate of the 26-gauge buried investment for each of the bands. The other gauges are similarly calculated and added to the 26-gauge investment amount. This total investment is then multiplied by the percentage of samples within each band and then summed for all bands, resulting in a buried distribution cable investment per loop for geographic zone 1.

Q. How are structure investments estimated in LPVST?

A. They are not really modeled. Instead, the cost of aerial and underground structures (poles and conduit) is estimated by applying ratios to the cable investment. Some weaknesses in this approach will be discussed later in my testimony.

Q. How does LPVST model the deployment of fiber?

A. For the feeder portion of LPVST, fiber feeder is assumed to be deployed when feeder distances are greater than 15,000 feet; copper feeder is assumed for lengths of 15,000 feet and under. A process similar to the one just described is used to develop copper and fiber feeder investments.

Q. Can you summarize the outputs of the LPVST model?

A. Yes. The principal outputs of the LPVST model are investments per loop for items such as aerial cable, underground cable, buried cable, poles, and conduit for copper feeder, fiber feeder, and copper distribution in each of the three geographic zones.

Q. Would you please explain what happens to the outputs of the LPVST model?

A. SWBT takes the LPVST outputs and inputs them to other spreadsheets, in order to develop monthly cost estimates. Specifically, the cable and structure investments per loop are input to the spreadsheet K8gp1.xls, which I will refer to as the Post-LPVST spreadsheet and aggregated into ARMIS type accounts, where there is no longer a distinction between feeder and distribution investments. Other investment components of the loop such as premise termination, Digital Loop Carrier (DLC), feeder stub and frame stringer are calculated in this spreadsheet. In addition, Feeder Distribution Interface (FDI) investment per pair is input directly to the Post-LPVST spreadsheet from the Pre-LPVST spreadsheet. As I indicated earlier, for purposes of our analysis, we electronically linked together the Pre-LPVST spreadsheet, our simulation of LPVST, and the Post-LPVST spreadsheet.

Q. Would you define feeder stub?

A. When digital electronics are used in the loop network (e.g. with fiber cable), a portion of the electronics is typically located at a *remote terminal* (RT) which sometimes serves not only its own distribution area, but also one or more additional areas. The FDI serving these other areas, lacking its own digital electronics, will be connected to the electronics at the remote terminal by copper feeder cable. This copper cable is called *feeder stub*.

Q. Would you further explain how the feeder stub investments are calculated by SWBT?

A. The average feeder stub length within each geographic zone is multiplied by the 24-gauge buried cost per pair foot and the percentage of fiber feeder. Some problems with this approach will be discussed in a later section.

Q. Would you now describe how monthly loop costs are derived from the loop investments developed so far?

A. Just as we simulated the LPVST mainframe model, we also simulated SWBTs Annual Cost Extraction System (ACES), since this was not provided to us in an electronic format. The resulting spreadsheet simply takes annual capital cost factors and maintenance factors and applies them to the investments developed in the LPVST process, resulting in annual cost estimates. The annual capital cost factors come from the CAPCOST model. These costs are then divided by 12 to arrive at the monthly TELRIC estimates filed by SWBT.

Loop Fill Factors

Q. Please turn your attention to the problems you have found with this process, beginning with the fill factor assumptions. How does SWBT compute fill factors?

A. The Company computes a fill factor for each geographic zone by dividing the number of working lines by the number of available lines. The number of available lines comprises the number of committed lines and **Begin proprietary *** *** End proprietary** of the number of uncommitted lines. This reduction in the number of uncommitted lines reduces the total number of available lines, thereby increasing the ratio of working lines to available lines, or calculated fill factor. For example, copper feeder in zone 1 has a fill factor of **Begin proprietary *** *** End proprietary** when 100% of uncommitted lines are taken into account. After making this adjustment, the fill factor jumps to ***** Begin proprietary . *** End proprietary** .

Q. Is this a reasonable procedure?

A. This adjustment is a reasonable step toward making the transition from embedded data to an appropriate factor for use in a long run cost study, but it is not sufficient, as I will discuss below.

Q. Were you able to replicate SWBT's results?

A. Not exactly. Using the underlying LEIS data received during the discovery process, we were unable to match the fill factors used by the Company in the LPVST model. However, our simulations were fairly close. For both feeder and distribution cable we were only about 3 percentage points off for geographic zone 1 and less than 1 percentage point off for geographic zones 2 and 3.

Q. Do you agree with the Company's cable fill factors?

A. No. A classic long run cost study optimizes the amount of plant investment to best match the volume of output. It is not intended to be a simulation of the real-world situation, in which the carrier has installed plant over a period of many decades and periodically comes in and overbuilds a particular route by adding additional cable, or replacing the older cable.

While the Company made a step towards adjusting its embedded data to account for this discrepancy, it did not go far enough. The Company has included an unnecessarily large amount of spare capacity in its studies. In particular, the Company has used unreasonably low fill factors for distribution cable **Begin proprietary***** *****End proprietary** thereby providing far more spare capacity than the minimum level that is necessary or appropriate for a long run cost study.

Q. You say the Company has used fill factors that are too low for a long run study. What might be the rationale for using such low fill factors?

A. The only plausible economic rationale for including so much spare cable would be in anticipation of potential growth in demand over the life cycle of the plant in question. Thus, for example, if one assumes the cable will be in use for 15 years, one might argue that large enough cables must be installed to ensure that the capacity of these cables won't be exceeded at any time within the entire 15 year life cycle.

However, even if one accepts this line of reasoning, it wouldn't be appropriate to look at the fill factor present at the very beginning of the entire 15-year period. This would create a clear distortion, since the fill factor will steadily increase over time, as growth occurs. If one is going to go beyond a classic "static" analysis which focuses on the volume of demand and required amount of spare capacity in a single year, then it is crucially important to accomplish this in a balanced and consistent manner.

If one is going to consider future growth as a rationale for extra spare capacity, then the appropriate calculations would need to look at the average level of spare capacity over the relevant period, not simply the amount of spare capacity at the very beginning of the growth cycle. The costs of the extra capacity installed to meet future growth should be offset by the additional revenues that will be received due to future growth in demand. In order to get a proper matching of costs and benefits, it wouldn't be appropriate to spread the entire cost of spare capacity needed for future years over the current volume of units.

Properly handled, the cost of extra capacity installed to serve future demand would not place a substantial burden on current ratepayers, because the calculations would recognize that this extra capacity will be paid for by future ratepayers. Rather than complicating the issue by moving from a single year study to an entire life cycle study, I would suggest simply using a fill factor that is reasonably representative of the minimum level of spare capacity that can be realistically achieved by firm operating at a minimum cost, long run equilibrium.

Q. Does SWBT's approach adequately match this benchmark?

A. No. The upward adjustment to embedded data made in SWBT's study is not adequate. As a result, there is a mismatch between the quantity of distribution cable that was modeled and the volume of demand (number of working loops) that was used in deriving the estimated cost per unbundled loop.

In effect, SWBT has included a high fraction of unused cable (presumably installed in anticipation of future growth), without giving any consideration to the larger volume of loops that will be provided from that spare capacity in future years. Stated differently, SWBT has priced out relatively large cables, then taken the resulting costs and spread them over a much smaller quantity of loops. The effect is to inflate the estimated cost per loop.

In the context of this proceeding, this overestimation would effectively force SWBT's competitors to pay for cable capacity that they won't be using, and which will actually be used and paid for by future customers. In effect, the potential exists for a "double dip" with the cost of this excess capacity being paid for once through higher than necessary unbundled loop rates and again through revenue increases which will occur as the spare capacity is absorbed through growth in demand which occurs over time. To be consistent with the long run economic costing approach, distribution fill factors should be higher than the overall average fill level typically present in SWBT's network, but no greater than the "target" levels used by network engineers in determining whether cable must be reinforced.

Q. Would you summarize your recommendations concerning the Company's fill factor inputs?

A. Yes. A long run cost study should use fill factors that are substantially higher than the average fill level typically present in an incumbent LEC's network, but less than the highest fill levels present in such a network. In any event, the fill factors should be no greater than the "target" levels used by network engineers to determine when relief is needed (more facilities must be installed).

I have developed alternative fill factors for distribution cable, as shown on Schedule 3. The approach I used was straightforward. I analyzed a wide variety of different scenarios, involving different growth rates, numbers of customer lines, cable sizes and other assumptions. With regard to distribution cable, I looked at the percentage of spare capacity (or fill factor) that was present at the time cable was installed, and at various years thereafter up to and including 17 years after installation. Depending upon the assumed growth rate and other factors, demand could potentially grow to the point where it exceeds the capacity of the originally installed cable. In the case of distribution cable, this is generally something to be avoided except under unusual circumstances (growth well in excess of the level that was forecast). To minimize the risk of exhausting the cable capacity within this 17-year period I have provided a safety margin of additional spare capacity in schedule 3. Even so, the average fill percentage tends to be much higher than the factor proposed by the Company in all but the very earliest years of the life cycle. I recommend looking to the midpoint of the 17 year period as a proxy for the equilibrium fill percentage that is appropriate for use in a long run cost study. Specifically, I recommend using a distribution fill factor of 53%, as shown on page 1 of schedule 3.

I used a similar approach in the analysis of feeder cable. However, I used a slightly higher growth rate for feeder cable than for distribution cable. Some of the growth in the network results from the addition of distribution cables to new subdivisions and along new roads. Hence, the growth experienced along a typical distribution cable route will tend to be lower than the growth experienced on a typical feeder route, which must accommodate growth over a much broader area. Also, I looked at the average fill rate over a much shorter period, recognizing that it isn't economically efficient to install feeder cables that are large enough to accommodate many years worth of growth. Typically, feeder cables are engineered to be "relieved" within 5 to 7 years. The results of my feeder cable fill analysis indicates a 73% fill factor is reasonable (as shown on page 3 of schedule 3) for input into LPVST. This is roughly equivalent to the feeder fill factors used by the Company in its studies, indicating there is no need to modify its feeder fill factors.

Pole Factors

Q. Let's turn to SWBT's cable structure assumptions. The parties have raised various concerns regarding aerial structure costs [CA-0006]. Before addressing your concerns can you describe how SWBT estimated aerial structure investments?

A. With regard to aerial structures (poles), SWBT simply applies a uniform factor of **Begin proprietary*** ***End proprietary** to aerial cable investment. That is to say for every dollar invested in aerial cable plant, SWBT assumes **Begin proprietary*** ***End proprietary** is invested in poles. This uniform factor is the statewide embedded ratio of pole investment adjusted for inflation to aerial cable investment adjusted for inflation.

Q. What is your response to this approach?

A. The value of the input **Begin proprietary*** ***End proprietary** does not seem excessive. If anything, this factor might be somewhat below a perfectly accurate measure of the current relationship between aerial structure investment and cable investment. This is a rather simplified approach, and it won't necessarily yield accurate results. For example, a simplistic ratio approach won't necessarily provide reliable indications of the relative levels of aerial structure investment in rural versus urban areas.

Q. What is the effect of applying a uniform factor to the average cost per pair foot of aerial cable investment in rural and urban areas?

A. This procedure is the equivalent of modeling aerial structure costs as a linear function of cable investment. This can be demonstrated with a simple hypothetical example. Assume a pole factor of 0.7 is used. This factor translates into $2.80 per foot if it is applied to a 200 pair cable that costs $4 per foot (installed). This same factor of 0.7 translates into just $1.40 per foot if it is applied to a 50-pair cable that costs $2 per foot (installed). However, there is no reason to assume that the poles will cost twice as much if the 200 pair cable instead of 50 pair cable.

In reality the installed cost of a pole is relatively constant regardless of whether a 50-pair cable or a 200-pair cable is hung on the pole. For example, assume poles cost $400 and are spaced every 200 feet, or the equivalent of $2 per route foot. Continuing with the previous example, the .07 factor understates pole costs by $0.60 ($2.00 - $1.40) per foot wherever the small cable size is used and it overstates pole costs by $0.80 ($2.80 - $2.00) wherever the larger cable size is used.

Q. How can this problem be solved?

A. Ideally, SWBT would revise their entire procedure to more directly and accurately estimate pole costs. Short of a complete overhaul of this part of their studies, at least one minor improvement is feasible: The pole factor can be adjusted upward in areas where cable sizes tend to be smaller (such as the rural areas in geographic zone 1) and the factor can be adjusted downward in areas where the average cable sizes are larger (such as the urban areas in geographic zone 3).

Q. What is your recommendation concerning the pole factor inputs?

A. I recommend slightly different factors be used for the three geographic zones. I've left the overall level of SWBT's pole factor unchanged, but modified it to vary across zones, as shown in schedule 4. In this schedule, I first estimate the number of poles in each of the three geographic zones. I developed this estimate by taking the actual number of poles in Kansas of 129,025 [FCC 1996 ARMIS Report 43-08, Sub. 2, Table 1.A, p. 3] and allocated them based on aerial sheath feet in each of the geographic zones (extracted from the GEOKS96forRFI.xls spreadsheet) assuming uniform pole spacing. Aerial structure investment is computed by multiplying the SWBT pole factor **Begin proprietary*** ***End proprietary** by the estimated aerial cable investment. This aerial structure investment is then spread across the geographic zones in proportion to the number of poles in each area.

To simplify the analysis, aerial cable investment is estimated in this schedule by applying Broad Gauge aerial cable investments to the average cable size in each zone and multiplying this result by the zone's actual total aerial sheath feet. The average aerial cable size is computed by dividing aerial sheath pair feet by aerial sheath feet. As expected, the average cable sheath size increases as you go from rural areas to more densely populated areas (**Begin proprietary *** *** End proprietary**). The estimated cable investments are consistent with this pattern. The aerial structure investments are then divided by the estimated aerial cable investments to estimate the pole factors. The resulting derived pole factors (0.82 in rural zone 1, 0.68 in suburban zone 2 and 0.60 in urban zone 3) are more representative of what one would expect considering the different cable sizes that are typically present in different zones.

Contractor/Trenching Assumptions

Q. Let's now turn to SWBT's contractor/trenching input assumptions (Issue CA-0021). Does SWBT use appropriate assumptions regarding these inputs?

A. No. In its loop cost studies SWBT assumes contractor costs for trenching that do not vary by geographic zone. This is incorrect; the cost of trenching varies between downtown, suburban and rural areas due to differences in the frequency of encountering man-made obstacles. For example, in downtown urban areas additional costs are incurred because a relatively large percentage of the trenching effort will involve tunneling under or around sidewalks, streets, and other utility lines. To fully understand this statement, consider the situation where distribution cable runs alongside the street (this is typically, but not invariably the case). At every street crossing, the trench will necessarily need to pass under a street at the intersection. Similarly, where sidewalks and water and sanitary sewer mains are located under or alongside a street that must be crossed, it will be necessary to tunnel under, over or around these manmade obstacles. One cannot simply terminate the trench every time an obstacle is encountered. The relative presence or absence of sidewalks and street crossings can be readily observed when driving through urban and rural areas. For example, in an urban area, a street crossing might be encountered every 1,200 feet or so, whereas in a less congested rural area a crossroad might be encountered every two or three miles.

Q. Do other cost models allow for degrees of difficulty in trenching?

A. Yes. Variation in trenching costs is consistent with the input assumptions used in the Benchmark Cost Proxy Model (BCPM) which is currently sponsored by U S WEST, BellSouth, and the local exchange operations of Sprint. It is also consistent with the input assumptions of the HAI model, which is often sponsored by AT&T and MCI, as well as the

Telecom Economic Cost Model, developed by our firm, which has been used in a variety of different state jurisdictions.

Q. Do you have a recommendation for adjusting the values of the contractor/trenching cost inputs?

A. No. In the discovery phase of the proceeding we asked SWBT to provide source documents and workpapers for their contractor cost inputs. The materials provided did not show a straightforward explanation of how they developed their contractor cost factor. In response to discovery, they did provide copies of various contracts which clearly confirm that the cost per foot varies widely, depending upon the extent of man made obstacles encountered, and other factors. However, it was unclear how these contracts and other supporting documents related to the input values used in SWBT's studies. Besides, the changes we would contemplate would adjust costs only from one zone to another. Given the time constraints and difficulties we encountered, we did not develop an alternative approach, and thus I do not recommend any changes to the contractor/trenching cost input values.

FDI Assumptions

Q. Let's turn to SWBT's assumptions regarding loop feeder/distribution interfaces, an area in which the parties involved have raised various concerns [CA-0016]. What exactly is at issue here?

A. In SWBT's current network, FDIs are deployed **Begin proprietary***   ***End proprietary** of the time. Hence, AT&T submits that SWBT's FDI investment should be reduced by **Begin proprietary ***   *** End proprietary** because, by SWBT's own admission, **Begin proprietary ***** ***** End proprietary** of its distribution pairs do not use FDIs (they are directly spliced to feeder cables).

Q. Is this an approach you endorse?

A. No. As I discussed earlier, the placement of an FDI is an efficient forward-looking network configuration, since it simplifies and speeds the process of assigning distribution pairs and connecting them to feeder cable. SWBT's cost studies assume FDIs are ubiquitously deployed, increasing FDI investment. If this is the minimum cost forward-looking configuration as SWBT apparently contends, one can logically infer that the corresponding reductions in maintenance and operations costs more than offset the carrying costs on the extra investment. Accordingly, I recommend that plant expense factors be reduced by at least as much as the cost of the extra FDIs (a reduction of approximately 0.001), thereby reflecting the net savings achieved through the forward-looking, least-cost network configuration.

Loop Banding

Q. Would you next describe the LPVST model's banding process?

A. Certainly. In its LPVST program, the Company uses a banding method in which sample loop length data are grouped into class intervals, or distance bands. All bands are 1,000 feet in range with the exception of the first bands for distribution, copper feeder, and fiber feeder loops, and the last band for copper feeder. The range of the first band for fiber feeder loops is 15,000-15,499 feet, and the range of the first band for distribution and copper feeder loops is 0-1,499 feet. The range of the last band of copper feeder is 14,500-14,999 feet. In calculating investments, the LPVST model assigns to a band a *class mark*, typically the midpoint of the band's range. That is, the model assumes that all members of the class are at the midpoint--in effect, that the midpoint is the mean, or the total length of all loops, divided by the number of loops. For example, the class mark of the band 1,500-2,499 feet is 2,000 feet. Consequently, the LPVST model assumes that all loops between 1,500 feet and 2,499 feet are 2,000 feet in length; then a total loop length can be calculated by multiplying the class mark of a band by the frequency of loops that lie within that band. So, if 50 loops in a data set fall into the 1,500-2,499 band, then the total loop length in this band is 2,000 feet multiplied by 50, or 100,000 feet.

There is a controversial exception to this method in a few cases, where SWBT assigned class marks that were not at the midpoint of the band. Specifically, loops in the 0-1,499 foot band are assigned a length of 1,000 feet rather than the midpoint length of 750 feet. The Company's basis for this treatment is that there are relatively few short loops (SBWT's response to Issue CA-0001 submitted by AT&T), and thus the class mark can appropriately be assigned on the basis of the upper end of the overall band of 500-1,499 feet.

Q. What are the issues concerning the LPVST model's banding process?

A. In Issue CA-0001, AT&T argues that the Company's LPVST program uses "flawed loop length averaging" which results in overstated costs. Specifically, AT&T claims that the total loop length calculated using the banding method **Begin proprietary *** *** End proprietary** , overstates the total actual loop length, which it claims is actually just **Begin proprietary *** *** End proprietary** feet. Due to this 6% discrepancy, AT&T suggests using actual loop lengths rather than banded loop lengths in determining loop investment costs. This line of reasoning was apparently persuasive in Missouri, where the commission substituted the average loop length within each band, rather than using the class mark.

Q. Did you analyze the statistical validity of SWBT's banding process?

A. Yes. We performed an extensive analysis of the data in an effort to determine whether SWBT's method was valid, whether AT&T's alternative was appropriate, or whether some other alternative was preferable. Our conclusions were mixed.

To begin with, we concluded that the banding method generally is an appropriate and valid method of dealing with data of this type, and we found it has some important advantages over AT&T's alternative, which has a potential for downward bias. Mathematically speaking, there are two ways of calculating the average loop length. While it is possible to take the average of all lengths, this can be cumbersome and unnecessary in some situations. As Freund and Williams state,

> If the numbers are unwieldy or a set of data is very large, it may be advantageous to group the data first and then obtain the mean from the resulting distribution....In connection with this, it must be pointed out that when a set of data is grouped each item, so to speak, loses its identity, we know only how many items fall into the various classes, and the actual mean of the data cannot be obtained. However, we can get a good approximation by assigning the value of the class mark to each item falling into a given class...This kind of approximation is usually excellent, since the errors that are introduced will more or less 'average out.'"
> John E. Freund and Frank J. Williams, *Elementary Business Statistics: The Modern Approach.* Prentice-Hall: Englewood Cliffs, NJ, 1964, pp. 35-6.

An advantage of using the banding method is the class mark's lack of susceptibility to extreme, or nonsensical, values in the sample of loop lengths. Since a straightforward average takes into account every loop length, it is susceptible to error where problems exist in the underlying data. In this case, we found that AT&T's recommended averaging approach is susceptible to a downward bias, because the underlying data set includes some questionable data points that unduly influence the average. Most notably, the data for copper feeder loop lengths contain 101 measurements of 1 foot. Needless to say, these are not reliable figures, and they should be given little, if any, weight. For instance, this nominal value may have been assigned in the data base whenever the actual length was unknown. While AT&T claims that SWBT's banding method results in an overstatement in total loop length of 6%, that claim is based in part on average calculations that are unduly influenced by this nonsensical or flawed data.

Q. Does the presence of these data anomalies present any serious drawbacks to the LPVST model's banding process?

A. No. Keeping in mind that the objective is to estimate the average loop length of the underlying population from which the sample data are randomly selected, we want to use an estimator that will not be affected by nonsensical sample data. The banding method is generally consistent with this objective.

Q. Did you find any problems with SWBT's banding process?

A. Yes. The class mark, or estimate of central tendency, for the band that ranges from 0 feet to 1,499 feet was not estimated in a manner consistent with the subsequent bands. As I noted earlier, rather than assigning a class mark value of 750 feet to each loop falling into the first band, SWBT assigns a class mark of 1,000 feet to the first band. SWBT argues this is appropriate, on the basis that the actual range of the data is centered towards the upper end of this range. We performed several analyses, in an effort to sort out the competing claims of SWBT and AT&T in this regard.

Q. Would you please describe the analysis you performed to evaluate whether or not it was appropriate to use a class mark of 1,000 feet for bands that ranged from 0 to 1,500 feet?

A. Yes. In order to address this area of concern, we first analyzed the averages both with and without any nonsensical or extreme data values. Next, we compared these averages to the class marks assigned by SWBT and the alternative option of using the midpoint of the overall band. Finally, we conducted a statistical procedure known as a sign test to determine which class mark, 750 feet or 1,000 feet, is a better estimate in calculating the central tendency of the data. Schedule 5 first shows the average of all loop lengths falling within the first band's range of 0 to 1,499 feet. The schedule also shows the average without taking into account any extreme values (e.g., removing the 101 loops at 1 foot).

Q. What were the results of this analysis?

A. Schedule 5 summarizes our results. In particular, it shows a comparison of the first band's average loop length and the average loop length less any outliers, or extreme data. It also shows my recommended class mark to be assigned to each band. These recommendations are based upon the results of the statistical sign tests. SWBT assigned a 1,000-foot class mark to both distribution and copper feeder data falling into the first band of loops ranging from 0 feet to 1,499 feet. Supported by the statistical test, I recommend a 1,000-foot class mark for first band distribution loops and a 750-foot class mark for first band copper feeder loops. The differences between my recommended class marks and the actual loop length averages are also shown in Schedule 5. The recommended class marks, on average, are a mere 5 feet less than the actual average loop lengths.

Q. Did you perform any other statistical sign tests on the band data?

A. Yes. We also attempted to perform a sign test for the first band of fiber feeder loops, to determine whether a class mark of 15,250 is appropriate to use. However, we found that there were only four sample loop lengths in band 1 fiber feeder data--three are 15,003 feet and one is 15,006 feet. This data set was too small to allow a valid sign test. Consequently, the schedule shows a difference of 246 feet, or 1.6%, between the recommended class mark of 15,250 feet and the sample average of 15,004 feet for fiber feeder loops in band 1.

Q. What are your conclusions concerning the LPVST model's banding process?

A. Having compared both options–using the ordinary mean or using a system of class mark averaging, I have concluded that the banding method used by the Company is generally appropriate and valid with two minor exceptions. Regarding the first band data, the use of a 1,000-foot class mark is consistent with the underlying sample data for distribution loops. However, I recommend that 750 feet be used as the class mark for copper feeder loops and 15,250 feet (instead of the company's assigned class mark of 15,000 feet) be used as the class mark for fiber feeder loops.

Fiber Feeder and Feeder Stub Assumptions

Q. Regarding Issue CA-0022, do you have concerns with the way SWBT is modeling fiber feeder and the feeder stub?

A. Yes. As described in detail above, SWBT uses loop sample distance data which are input to the LPVST model. The loop sample lengths are organized into feeder, DLC, feeder stub, distribution, and total lengths. DLC and feeder stub are subparts of the feeder segment (i.e. the sum of the DLC and feeder stub lengths always equals the feeder length). However, the feeder stub segment is not necessarily present in every sample. In these instances, the DLC distance is equal to the feeder portion and the feeder stub segment distance is 0 feet.

LPVST assumes that fiber is deployed in the feeder whenever the feeder lengths (i.e., DLC plus feeder stub lengths) are greater than 15,000 feet. LPVST does this by taking this sample and placing it in the appropriate distance band and costing it out as fiber. The cost of the feeder stub segments is later added by taking the average feeder stub distance for the entire sample, costing it out as 24-gauge copper cable, and multiplying this product by the percentage of samples assumed to be fiber. This method is inappropriate, since it sometimes overstates the feeder costs.

Q. Can you elaborate on this problem?

A. A modeling error occurs in certain instances when the feeder lengths (including the feeder stub) are greater than 15,000 feet. The feeder stub is effectively double-counted in these situations because the total feeder length, not just the DLC portion, is costed as fiber, and then an additional lengths of copper feeder stub is added at a later stage in the calculations.

Q. Can you give a specific example of this double-counting phenomenon?

A. Yes. I have provided an attachment which will graphically explain this modeling error. LPVST models three distinct scenarios: an all-copper scenario in which feeder lengths are less than 15,000 feet; a DLC-fiber scenario in which the digital electronics remote terminal is located at the FDI (i.e., no feeder stub); and a DLC-fiber scenario which includes a feeder stub. These three scenarios are shown in Schedule 6 from top to bottom.

I have provided a simple description using hypothetical feeder and distribution lengths. For example, the first hypothetical scenario assumes a sample loop containing a feeder distance of 12,000 feet and a distribution distance of 6,000 feet. This is not an actual example from the sample data, but instead describes the problem using round numbers. For costing purposes, this sample loop will be placed in the 12,000 foot copper feeder band and in the 6,000 foot distribution band. The next example depicts a scenario in which the feeder length is greater than 15,000 feet (19,000 feet) and the distribution length is again 6,000 feet. There is no feeder stub and the remote terminal is assumed to be co-located with the FDI. For costing purposes, this second sample is placed in the 19,000 foot fiber feeder band and in the 6,000 foot distribution band.

The modeling error occurs in the third scenario, in which the feeder length is again 19,000 feet. In this instance the feeder includes 12,000 feet of DLC feeder and a copper feeder stub of 7,000 feet, with a distribution length of 6,000 feet. LPVST places this sample in the19,000 feet fiber feeder band and costs it out as such. In effect, this loop is treated by LPVST as being exactly analogous to the much longer fiber feeder route (19,000 feet), yet it actually involves just 12,000 feet of fiber, with the remainder being copper feeder stub.

Q. What is the impact of this modeling error?

A. In the example above, the fiber feeder investments have clearly been overstated by placing the loop in the 19,000 foot band instead of the 12,000 foot band. SWBT has apparently tried to make an offsetting downward adjustment to the feeder stub costs, but was unable to confirm that this adjustment adequately defrayed the impact of this error.

Q. Can you offer a solution which avoids the fiber feeder overstatement and the potential feeder stub double-counting phenomenon?

A. Yes. The simplest way would be to remove the additional feeder stub costs. This effectively assumes that the remote terminal is located at the FDI. For each sample with a feeder distance greater than 15,000 feet, fiber feeder will then be assumed over the entire distance to the DLC as well as the feeder stub portion.

Q. Are there other solutions to this problem?

A. Yes. Instead of eliminating the feeder stub investment, the fiber cable calculations could be modified to eliminate the overlap. Using the example described above, LPVST should place the sample loop in the 12,000 foot band based on the DLC distance rather than placing it in the 19,000 band based on the total feeder distance.

Q. Is the LPVST flexible enough to make this adjustment?

A. It is unclear whether the mainframe version of LPVST is capable of making this adjustment. However, the LPVST simulation we developed is capable of implementing either solution.

Cable Investments

Q. SWBT's estimates of loop costs in zone 1 are very high relative to costs in other zones and in comparable areas in other SWBT states (Issue AC-0004). Have you investigated this issue?

A. Yes. Once we finally received an electronic copy of GEOKS96forRFI.xls, we were able to trace the logic and verify inputs from the 1996 Broad Gauge Report and outputs to the LPVST model. While auditing this Pre-LPVST model we found that some of the internal algorithms use inconsistent logic in their assumptions concerning the weighting of embedded sheath feet by gauge.

GEOKS96forRFI.xls combines Broad Gauge cable investments per foot with embedded sheath feet data to estimate cable investments per pair foot by gauge. When determining 26- and 24-gauge cable costs per pair foot, the costs are weighted by the sum of the sheath feet for all gauges. However, when 22- and 19-gauge cable investments are developed, they are weighted by the sheath feet associated with their respective gauge. This inconsistency introduces a serious problem of double counting. In other words, the 22- and 19-gauge cable data are used twice–once with reference to their own gauges and once with reference to the 26- and 24 gauge cable investments.

Q. What do you recommend concerning this inconsistency?

A. The Pre-LPVST spreadsheet should be revised to consistently use the gauge-specific weights, thereby eliminating this double counting. Stated differently, I recommend that the 26- and 24-gauge cable be treated in the same manner as the 22- and 19- gauge cable, thereby applying 26 gauge weights to the 26 gauge cable investment and the 24 gauge weights to the 24 gauge cable investment.

More specifically, on the worksheet “SHTHFT” Columns C, E, and G have lookup formulas displaying the relevant sheath feet data. The formulas in rows 4-42 are designed to display the total sheath feet (i.e. the sum of all gauges). The formulas currently in rows 48-86 are designed to display the sheath feet associated with that particular gauge (i.e., 22- and 19-gauge). I recommend changing the formulas in Rows 4-42 (cells related to 26- and 24-gauge) to display the sheath feet associated with those respective gauges.

Q. **Regarding Issue AC-0004, have you estimated the impact of eliminating this inconsistency, using your simulation of the LPVST process?**

A. Yes. Correcting this inconsistency reduces all of the cable cost estimates, but the impact is greatest in the rural areas. I estimate that the monthly loop cost estimate for zone 1 are reduced from more than **Begin proprietary ***** ***** End proprietary** to approximately $45. In other words, correction of this one modeling error alone reduces the zone 1 loop cost estimate by roughly 25% and it greatly narrows the discrepancy between the rural loop costs in Kansas and those in neighboring states.

When the spreadsheet is set to model geographic zone 2, the loop costs are reduced from **Begin proprietary *** *** End proprietary** The least significant impact occurs in zone 3, where the costs drop from **Begin proprietary *** *** End proprietary**

Q. Why does the adjustment have less of an impact on loop costs in geographic zone 3?

A. The thicker cables (22- and 19-gauge) are most often deployed in areas with longer loop lengths and lower density. In the more urban areas, the thicker cables (which were being double counted) are not deployed as frequently as in the more rural areas. The double counting involves the thicker gauge cables, and thus correcting the formulas as described above has the greatest impact in the rural areas where these cables are most common.

Q. Are there other problems inherent in using embedded sheath feet data estimating cable costs?

A. Yes. As I mentioned earlier in my testimony, SWBT failed to adjust its embedded mix of sheath sizes to reflect true long run optimization. It would be appropriate to modify the embedded sheath data to reflect a shift away from multiple sheaths of smaller sizes, towards single sheaths of larger sizes. An appropriate adjustment of this type would somewhat reduce both feeder and distribution costs, due to elimination of multiple smaller cables where a single larger cable would be less costly.

Also, SWBT fails to consider tapering of feeder cables. Schedule 7 depicts this "multisheath" problem. As shown, an efficient plant configuration uses a relatively large cable sheath initially leaving the central office, which then branches off and tapers down to smaller sheath sizes. This more efficient arrangement is not adequately reflected in SWBT's cost study. Again, this is an area where SWBT's cost modeling efforts fall short of the current state of the art. Other available models, including our firm's Telecom Economic Cost Model, do take into account these tapering and branching efficiencies. Modifying SWBT's cost studies to correct for this weakness would potentially reduce feeder costs, because greater emphasis would be given to the lower per-pair costs associated with larger cable sheath sizes. However, this reduction in cost would not necessarily have a significant impact on SWBT's final loop cost estimates, because there could be an offsetting change in the distribution costs (which are residually determined).

Q. You indicate that SWBT backs into distribution costs on a residual basis (Issue CA-0023). Is this a reliable method in determining investments?

A. No. Errors in the feeder cable analysis can potentially have ripple effects through the distribution cost estimates. In turn, modifications to the feeder estimates can potentially result in offsetting changes to the distribution estimates which are not necessarily valid.

Q. Have you developed any recommendations to correct for the multisheath and tapering problems, or the potential problems with residually determining distribution costs?

A. No. While there are certainly advantages to using embedded network data in modeling forward looking long run costs, there are also some inherent limitations to this approach, and these limitations are exacerbated by weaknesses in SWBT's models. Unlike the Telecom Economic Cost Model, for example, SWBT's models do not provide a clear picture of where the various cables are located, where tapering can and does occur, or where multi-sheath inefficiencies exist that could potentially be eliminated in a long run planning horizon. After giving the tapering and multi-sheath issues considerable thought, I was unable to develop a solution that I was confident would correct the problem without potentially introducing a new set of problems, or requiring massive modifications to SWBT's models. Perhaps with additional time and effort, a solution can be found which doesn't require a complete overhaul of the models. More likely, however, it will require a fairly drastic revamping of SWBT's loop cost modeling approach.

Miscellaneous Loop Issues

Q. Are there other problems concerning SWBT's loop modeling process that you would like to discuss?

A. Yes. We found some patterns in the Broad Gauge unit costs that seem questionable. For instance, Aerial cable material costs are much higher than Underground and Buried cable for large sheath sizes, but not for small sheath sizes. Also, the Aerial material costs display diseconomies of scale (4200 pair cable costs more per pair than smaller sheath sizes). Neither of these patterns is intuitively obvious, nor are they consistent with analogous data I have reviewed on other occasions. However, based upon SWBT's responses to our discovery requests, these patterns are apparently due to quirks in the Broad Gauge calculations. For instance, the Company assigns “miscellaneous” materials (e.g., splicing cases) in proportion to labor costs, which has the effect of slightly distorting the pattern of material costs per pair foot. However, this distortion does not appear to be significant, and thus I do not recommend making any changes in these inputs.

Q. **Can you summarize your recommendations regarding the loop studies submitted by SWBT?**

A. Yes. I recommend that the Commission require SWBT to reduce its labor rates, correct the gauge weights in the GEOKS96forRFI.xls spreadsheet as described in my testimony, correct the feeder stub double counting problem, use my recommended class marks in conjunction with SWBT’s banding approach, adjust the pole and fill factors as described in my testimony, and reduce the maintenance factor for buried copper cable to reflect the increased efficiencies associated with ubiquitous FDI deployment.

Q. **Did you estimate the impact of your recommendations concerning the loop costs filed by SWBT?**

A. Yes. I estimated the impact of making all of these adjustments within our simulation of the LPVST process. Schedule 8 pages 1-3 compare the monthly 8db loop costs filed by SWBT with the results of this simulation for each geographic zone, before common costs. The most notable discrepancies occur in rural zone 1 where loop costs drop nearly 50%, from **Begin proprietary ***** . *** **End proprietary** However, there also is a substantial drop in the more densely populated zones, As shown in Schedule 8 pages 2-3, the suburban zone 2 loop costs decreased from **Begin proprietary ***** *** **End proprietary** The smallest decrease (absolutely and relatively) occurred in urban zone 3, where monthly loop costs decreased from **Begin proprietary ***** ***** End proprietary**