

1 **6. *Models***

2

3 **Q. Please turn to the sixth section of your testimony. Earlier you explained why**
4 **embedded costs were not the ideal approach to use with the KUSE, and you**
5 **indicated that the FCC has endorsed forward looking economic costs. What**
6 **has the FCC decided concerning the specific methodology to use in calculating**
7 **forward looking costs?**

8 A. In its May 8, 1997 *Universal Service Order*, the FCC adopted a universal service
9 plan to replace longstanding federal subsidies to incumbent local telephone companies
10 with explicit, competitively neutral federal universal service support mechanisms. The
11 FCC also decided that an eligible carrier's level of universal service support should be
12 based upon the forward-looking economic cost of constructing and operating the
13 network facilities and functions used to provide the services supported by the federal
14 universal service support mechanisms. However, the FCC found various problems
15 with the models under consideration, and concluded that it could not use any of the
16 models as a means to calculate the forward-looking economic cost of the network on
17 which to base support for universal service in high cost areas [¶ 245]. The FCC
18 concluded that the HAI (sponsored by interexchange carriers) and BCPM (sponsored
19 by local exchange carriers) should continue to be considered and developed further,
20 and stated that it might also consider models or model components developed by FCC
21 staff.

1 After extensive additional fact gathering and analysis, the FCC concluded that
2 neither BCPM or HAI offered a high enough level of accuracy and geographic
3 precision, concluding that

4
5 Neither of these models... estimate the cost of building a
6 telephone network to the subscriber's actual geographic
7 location, taking into account the actual clustering of customers
8 groupings such as neighborhoods and towns. [FCC 98-279, ¶
9 3].
10

11 In an effort to overcome these problems, the FCC endorsed a synthesis approach,
12 relying primarily on the Hybrid Cost Proxy Model (HCPM), developed by members of
13 its Staff.
14

15 **Q. The Commission is already somewhat familiar with the HAI and BCPM**
16 **models, having considered and rejected their use in setting unbundled element**
17 **prices for SWBT. Could you elaborate upon the limitations of the HAI and**
18 **BCPM models?**

19 A. Both models were repeatedly refined and improved, but they both continued to display
20 serious weaknesses in the way they locate customers and deploy cable to reach those
21 locations. This is of crucial importance in estimating costs of a cable network serving
22 low density, rural areas, and thus it isn't surprising that these weaknesses were troubling
23 to the FCC.

24 Perhaps the most important, and most difficult problem in accurately calculating
25 economic costs for universal service funding purposes involves geography-- where are
26 the end-users, and how much cable and equipment is needed to reach them? Although
27 there have been substantial improvements in this regard, neither HAI nor BCPM is fully

1 up to the task, as demonstrated by a variety of different indicators that can be used to
2 gauge how well the models deal with geographic aspects of the modeling process. For
3 instance, a careful examination of the modeling results with actual network data
4 sometimes revealed very substantial discrepancies in two of the most important
5 indicators of modeling accuracy, loop lengths and line counts. While one would not
6 expect these data for the modeled network to precisely match the analogous statistics
7 for the embedded network, extremely large discrepancies sometimes existed,
8 suggesting significant flaws in the modeling process.

9 In this regard, it is important to realize that the error rates increase as the study
10 area shrinks. A model may be adequate to estimate costs on a statewide average
11 basis, but it may not be sufficiently accurate to reach precise conclusions concerning
12 relative levels of cost on a much more granular basis (e.g., specific wire centers or
13 areas within those wire centers). When costs are reported for large geographic areas,
14 errors tend to average out, and thus the geographic weaknesses of the modeling
15 process are of lesser concern. However, such gross analyses cannot pinpoint the true
16 high cost areas, nor can they be used to develop precise estimates of how much higher
17 than normal, costs are in areas that have costs that exceed a given benchmark. Thus,
18 these weaknesses are of crucial importance in calculating costs for universal service
19 funding purposes.

20 Weaknesses in this aspect of HAI and BCPM are compounded by the fact that
21 both models are limited in their ability to input and output geographically related data.
22 They offer a limited set of geographic inputs, and little or no geographic outputs, making
23 it quite difficult, or impossible, for regulators or other parties to analyze the geographic
24 aspects of the modeling process, or to improve upon the model results.

1 These weaknesses compound each other in one important respect: neither
2 model provides the analyst with the tools needed to reveal what is going wrong in the
3 geographic modeling process. They don't generate maps of the network, they don't
4 provide any convenient way to examine the engineering and geographic details of the
5 network, and they don't offer a simple way to compare the modeled network with
6 reality.

7 All forward looking cost models necessarily rely upon simplifying assumptions,
8 particularly with regard to distribution costs. These simplifying assumptions can
9 potentially result in substantial overstatement or understatement of the high cost problem
10 in particular areas. Ideally, model outputs should be carefully reviewed, to ensure that
11 simplifying assumptions aren't creating unacceptable distortions and to facilitate
12 refinement of the cost calculations. Neither HAI nor BCPM produces standard output
13 that can be reconciled back to maps of the roads, feeder routes, distribution areas and
14 other geographic features of each wire center. Were such output available, it would be
15 easier to understand and interpret the cost results, and to increase the accuracy of the
16 cost estimates by isolating and overcoming modeling errors.

17
18 **Q. Are there other aspects of the models' outputs that are more limited than would**
19 **be desirable?**

20 A. Yes. Both models can generate cost estimates for individual wire centers, and for
21 smaller geographic areas within wire centers. However, they do not provide the user
22 with any convenient way of organizing and grouping the areas within wire centers. Wire
23 centers can differ widely in the number of lines they serve and in the geographic areas
24 they cover. But analogous variations are also present within the individual wire centers.
25 Cost estimates that are developed for wire centers as a whole will fail to reveal whether

1 there are both low cost and high cost areas within some of the individual wire centers.
2 As I explained earlier in my testimony, a finer-grain approach can potentially be useful
3 in identifying which customers are most in need of high-cost support.

4
5 **Q. Does the FCC model suffer from some of these same weaknesses?**

6 A. Yes, but to a lesser degree. The FCC model offers some useful improvements over
7 HAI and BCPM, but it does not completely overcome the weaknesses I just
8 mentioned. For example, the geographic aspects of the modeling process are more
9 open to inspection and modification, and the model provides intermediate data files
10 containing customer location and other data which can be mapped using standard
11 mapping software. In this regard, as with other weaknesses in the HAI and BCPM
12 models, it is fair to say that the FCC model represents a substantial step forward,
13 although there remains room for further improvement.

14
15 **Q. One of the key differences between BCPM and HAI is the way they locate**
16 **customers to be served by the network. Is this an important aspect of the cost**
17 **modeling process?**

18 A. Yes. Perhaps the two most important drivers of per-line network costs are average
19 loop length and customer density per route mile, and both these drivers are functions of
20 customer location. Therefore, if one wants to accurately identify high cost areas, and
21 precisely measure how much higher than normal costs are in these particular geographic
22 areas, it is crucially important to accurately locate customers. In my opinion, both
23 models exhibit serious deficiencies in this respect, although later versions of the models
24 reflect significant improvements over earlier versions. In general, it would be fair to say
25 that the latest version of the HAI Model is superior to the latest version of BCPM,

1 because it relies upon geocoded customer location data, which is a fundamentally better
2 approach.

3

4 **Q. Let's begin with the BCPM customer location process. How does BCPM find**
5 **the network's customers?**

6 A. According to the *BCPM 3.1 Model Methodology*, the primary sources of raw data
7 for BCPM customer location are census block (CB) data for residential customers and
8 PNR Associates (PNR) data for business customers (mostly at the CB level). (BCPM
9 3.1 Model Methodology, p. 27.) Algorithms in the BCPM model use road data to
10 distribute these customers within the wire center. PNR is a Pennsylvania-based market
11 research and consulting firm that developed data used by both the HAI and BCPM
12 models for estimating customer locations. Although the basic network geographic unit
13 in BCPM is the "ultimate grid," also called a Carrier Serving Area (CSA), the entire
14 wire center is first partitioned into "microgrids," the smallest geographic unit in the
15 BCPM customer location process.

16

17 **Q. Let's now consider the HAI Model. How does HAI estimate customer lines**
18 **and locations?**

19 A. HAI relies upon PNR to estimate the number of telephone lines and their location,
20 including geocoding of customer addresses, in conjunction with various other data
21 sources concerning wire center, tandem, and STP locations, recent (1996) ARMIS
22 data, and user-adjusted inputs. To the extent it is available, HAI 5.0a uses geocoded
23 address data at the earliest stages of the cost modeling process, in assigning customers
24 to "clusters." Where actual geocode locations are unknown, it uses "surrogate"
25 locations, which are evenly spaced along the borders of census blocks. There are two

1 types of clusters, “main” and “outlier.” An outlier cluster has 1-5 lines; a main cluster
2 has 6 lines or more. According to the HAI model documentation:

3
4 In order to be considered members of a cluster, customer locations
5 must meet the following criteria:

- 6 * no point in a cluster may be more than 18,000 feet distant from the
7 cluster’s centroid (based on right angle routing);
- 8 * no cluster may exceed 1,800 lines in size;
- 9 * no point in the cluster may be farther than two miles from its nearest
10 neighbor in the cluster. (HAI Model, Release 5.0a, p. 32)

11
12 While the gathering of customers into “clusters” is a key step in the HAI 5.0a
13 cost modeling process, the HAI model does not use the shape of each cluster, nor does
14 it consider the actual location of customers within each cluster. Instead, in a step similar
15 to the BCPM establishment of distribution areas, the HAI Distribution Module
16 substitutes a simplified rectangular grid of equivalent size for each of the main clusters,
17 and an algorithm assigns end-users to hypothetical rectangular lots within the overall
18 rectangle. “The aspect ratio (height-to-width) of this rectangle is determined by the
19 data input development process for each cluster, and distribution cable is laid out in a
20 fashion that reflects this ratio” (HAI Model, Release 5.0a, p. 6)

21 In other words, the HAI model starts with detailed customer location data, but
22 it subsequently discards most of that information. The geocoded data are merely used
23 to define clusters of customers; the detailed information concerning customer locations
24 within these cluster areas is not retained. Instead, the clusters are converted into simple
25 geometric shapes, and the customers are assumed to be evenly spaced on rectangular
26 lots. The geocoded data are never used to locate customers within clusters, or to
27 determine how much cable would be needed to reach all of these customers (which

1 depends upon the pattern in which they are arranged, the location and shape of rights of
2 way, and other factors).

3

4 **Q. What is the consequence of this simplification?**

5 A. This simplified approach potentially results in an understatement of distribution cable
6 lengths, and thus loop costs. Essentially, geocoding is used in HAI only to group
7 customers into clusters, to define the size of the clusters, and to define the “aspect ratio”
8 of the clusters.

9 Thus, although the HAI model starts with precise information concerning many
10 customer locations within each wire center, it fails to fully utilize this information. It
11 simplifies away or ignores important aspects of the geographic data that are potentially
12 usable in the cost modeling process. For instance, the HAI model makes no direct use
13 of road data, despite the fact that distribution cable generally is located along road
14 rights of way, and it assumes customers are neatly arranged on rectangular lots,
15 regardless of whether or not this is actually the case. The effect of these simplifications
16 is to reduce the reliability of the HAI model in estimating distribution costs. In some
17 cases the HAI model may overestimate and in some cases it may underestimate the
18 amount of distribution cable required to reach customers.

19

20 **Q. Has the HAI clustering approach been criticized on other grounds as well?**

21 A. Yes. Critics have expressed concern that the clustering approach tends to understate
22 the amount of distribution cable needed. The fundamental problem is that irregularly
23 shaped clusters are converted into rectangles of the same area, and the customers are
24 evenly spaced on lots within that rectangle. Under this configuration, the cable
25 requirements can be substantially less than the cable required to serve the actual

1 locations in the irregularly shaped clusters.

2

3 **Q. Do you approve of the HAI practice of locating all surrogate geocodes to the**
4 **CB borders?**

5 A. No. The HAI approach can introduce bias into the cost estimating process, since it
6 assumes all such customers are clustered along the edges of the census block (CB).
7 This is unfortunate, since the edge clustering assumption will understate the actual
8 amount of cable required to reach customers in situations where they are actually
9 dispersed throughout the CB. The HAI approach simplistically locates ungeocoded
10 customers on the perimeter of the CB, even if the CB is bounded by something like a
11 river, rather than a road. A much better approach is to place “surrogate” locations
12 along roads, since most customers are located on roads, and most telephone cable is
13 placed along road rights of way.

14

15 **Q. The HAI model relies upon PNR data, which fails to accurately geocode a**
16 **sizeable portion of the customer locations. Can this problem be overcome?**

17 A. Yes. Every phone that is connected to the wired network has a location, and that
18 location can potentially be identified and mapped. The geocoding “failure” rate can
19 most easily be reduced by using additional data sources, such as the LEC’s customer
20 billing records, and/or the data base used in providing E911 service. If those data
21 sources prove inadequate in certain areas, the next best alternative would be to gather
22 additional data. For instance, global positioning system (GPS) satellite technology can
23 be used to identify actual customer locations in sparsely populated rural areas.

24

1 **Q. Does the FCC model solve the problems you have identified?**

2 A. It solves some of them, and takes major steps towards solving others. In developing its
3 synthesis, the FCC selected some of the strongest features of HAI and BCPM, as well
4 as the FCC staff model. In designing the customer location and outside plant portion of
5 its model, the FCC effectively endorsed HAI's use of geocoded customer location
6 data, and BCPM's use of roads to estimate the location of customers for whom precise
7 geocode data is not available. The FCC also endorsed its staff's approach to
8 identifying customer serving areas based on natural clusters of customers, sending cable
9 directly to the specific customer locations within each serving area. All of these
10 decisions are sound, and reflect clear progress over HAI and BCPM. For instance, the
11 decision to rely upon geocoded customer locations was a sound one, the benefits of
12 which will increase as better geocoded data is gathered or becomes available. As the
13 FCC noted:

14

15 ...in addition to the current sources of geocode data, more
16 comprehensive geocode data are likely to be available in the
17 future. (¶ 34)

18

19 ...use of global positioning satellite (GPS) technology and E911
20 data may [also] be viable alternatives. (Footnote 75)

21

22

23 I believe the GPS option will be cost-effective in rural areas where street addresses
24 don't exist, and the number of customers needing to be located is not extremely large.
25 The E911 alternative also looks promising.

26

27 However, the FCC Model still falls short in some regards. For example, it
28 ignores rights of way, rivers, mountains and other physical constraints, much like
 BCPM and HAI. It clusters and connects customers using minimum air distance as the

1 sole criterion, which can lead to significant distortions, particularly since rights of way
2 and other physical constraints are ignored. But the FCC Model does offer at least
3 some improvements regarding the layout of the distribution network, as explained by
4 the FCC:

5
6 ...both BCPM and HAI, by relocating customers so as to
7 distribute them uniformly in square or rectangular distribution
8 areas, create an apparent systematic downward bias in the
9 required amount of distribution plant that is constructed in less
10 dense areas.

11
12 By designing plant to serve actual customer locations instead of
13 simplified representations of customer locations, HCPM is
14 substantially more likely to estimate the correct amount of plant
15 necessary for providing the supported services (§ 60).

16
17 The federal platform relies upon actual customer locations, without realigning them into
18 rectangles, squares, or other simplified geometric patterns.

19 The federal platform will offer a high degree of network optimization, but in
20 some cases the FCC may have gone too far, by “minimizing” costs below a realistic
21 level, since it ignores rights of way, rivers, lakes, mountain ranges, property boundaries
22 and other physical constraints.

23
24 **Q. Has the FCC chosen a source for its geocoded customer location data?**

25 A. Not at this time. It has deferred this decision, which will be resolved during the
26 currently pending “inputs” phase of its universal service proceeding. At least one
27 vendor, PNR, has made its data available in an FCC-compatible format for review by
28 interested parties, under the terms of a fairly restrictive licensing agreement. In

1 preparing for this phase of the proceeding, I have relied upon the PNR data to evaluate
2 the FCC model. However, it should be understood that the FCC has not endorsed this
3 particular data source, and other alternatives are available, including white page listings
4 and other data bases maintained by the local exchange companies. Needless to say,
5 the accuracy of the cost estimates developed by the FCC model will depend, in part,
6 on the quality of the data used as an input into the model. In the next phase of this
7 proceeding, the parties can investigate multiple data sources, with the potential for
8 further refining the cost estimates, particularly in rural areas.

9
10 **Q. The FCC model is a national model that is being developed to suit the needs of**
11 **the FCC. Can the FCC model be useful in determining the costs of universal**
12 **service in high-cost areas within a single state like Kansas?**

13 A. It has potential for being very useful, particularly if the Commission views the FCC's
14 cost model as a tool, rather than simply accepting or rejecting the cost data developed
15 by the FCC. Any national modeling effort is fraught with difficulty and tradeoffs. The
16 geographic and other attributes of each state are sufficiently unique that it is difficult, if
17 not impossible, to develop accurate cost estimates for every part of every state. This
18 certainly has been true for the proponents of HAI and BCPM, who have attempted to
19 maintain consistency of methodology and data sources and have been working within
20 time and budget constraints. And, it is likely to also be the case with the FCC's model,
21 which is being developed under tight time constraints.

22 The mere fact that the FCC's modeling efforts are adequate to meet the FCC's
23 needs for the federal USF doesn't necessarily indicate that those same results will be
24 adequate to meet the Commission's needs for the Kansas USF. The FCC is primarily
25 concerned about relative cost levels *between* states, and it has less reason to be

1 concerned about the accuracy of cost estimates at lower levels of granularity (within
2 states). In administering the KUSF, the Commission can potentially achieve a higher
3 level of accuracy, by narrowing the focus to individual wire centers within Kansas,
4 gathering additional data, and further refining the model inputs.

5 When closely focusing on the results for individual wire centers or companies in
6 Kansas, it will likely become apparent that a “one size fits all” approach, uniformly
7 applied across the entire country, involves limitations and compromises which reduce
8 the usefulness and accuracy of the resulting cost estimates. Accordingly, if the
9 Commission were to rely upon the FCC model, it should anticipate the need to refine
10 and improve the model inputs, in order to more closely fit conditions in Kansas.
11 Conceivably, it may also be appropriate to modify the FCC model itself, or to make
12 adjustments to the model or its outputs, in order to correct for weaknesses or errors
13 that are detected during the refinement and review process.

14 I should also note that the versions of the FCC model which I have reviewed
15 contain errors, which will need to be corrected. At the time this testimony was prefiled,
16 the FCC model was still undergoing debugging and refinement by the FCC staff, and it
17 was not considered “final.” The staff has been periodically issuing updated versions of
18 the model, as frequently as every two weeks, which contain various corrections and
19 improvements. Accordingly, it wouldn’t be particularly useful at this point to identify the
20 specific “bugs” or problems which we noted during our review. However, if the
21 Commission decides to use the FCC model, any remaining errors or problems should
22 be identified and corrected during the next phase.

23

1 While I would not go so far as to urge the Commission to limit itself to a single
2 set of cost estimates for all purposes, I recognize there are benefits to extracting
3 multiple types of cost outputs from a single model or set of models. In addition to
4 reducing the arbitrage opportunities mentioned by the FCC, the time and effort
5 expended on developing and refining cost data for one purpose can potentially pay
6 dividends if the same inputs and/or models are used for other purposes.

7 With regard to switching costs, there is another advantage to using the SWBT
8 models. SWBT uses the Switching Cost Information System (SCIS) model, developed
9 by Bellcore, which is more detailed, and has the ability to produce more precise cost
10 data than the FCC model. Another potential advantage of the SWBT models, to the
11 extent they are applied to SWBT, is that they rely heavily upon internal LEC data bases
12 that reflect actual geographic and other conditions in Kansas. Hence, there is less risk
13 that the model will fail to capture Kansas-specific factors that influence costs.

14
15 **Q. Are there any drawbacks to using SWBT's models in this proceeding?**

16 A. Yes, there are some significant disadvantages to using these models for KUSF
17 purposes, particular for estimating loop costs. Many of SWBT's models are not
18 designed to develop cost results for narrow geographic areas like individual wire
19 centers, or zones within wire centers. In the recent UNE proceeding, the cost results
20 were developed for large groups of wire centers, referred to as zones 1, 2 and 3.
21 While it might be feasible to modify the SWBT models to provide more granular cost
22 data, this could prove to be difficult to accomplish, and it might require a major
23 overhaul of the SWBT models. Simplifying assumptions and weaknesses in the SWBT
24 models which were not of serious concern when producing cost data for three broad
25 geographic zones could have a far more serious adverse impact on the accuracy of the

1 output, when trying to develop costs for individual wire centers, or zones within wire
2 centers. Needless to say, if it becomes necessary to heavily revise the SWBT models
3 in order to develop accurate enough data for universal service purposes, the continuity
4 advantages mentioned earlier would largely be lost.

5 Moreover, SWBT's models are unique to SWBT, and cannot readily be
6 applied to other incumbent LECs in Kansas. SWBT's models are heavily dependent
7 upon the use of internal SWBT data bases. Other LECs won't necessarily maintain the
8 same data bases, and thus it might be difficult, or impossible to apply the SWBT
9 models to other LECs. Furthermore, SWBT claims that the data bases in question are
10 proprietary. Other LECs may rightly object to the idea of basing KUSF payments on
11 data which is controlled by and proprietary to SWBT—data which is not readily
12 available for examination by other LECs operating in Kansas and especially SWBT's
13 competitors.

14
15 **Q. Would it be possible to develop forward looking costs for SWBT using its own**
16 **models for KUSF purposes?**

17 A. Yes. This is certainly an option. I have attached to my testimony a copy of a Report
18 which was prepared under my supervision and direction and submitted on behalf of the
19 Kansas Corporation Commission Staff pursuant to the Commission's Order On
20 Reconsideration of November 6, 1998 in Docket No. 98-SWBT-677-GIT. In this
21 Report, we illustrate an approach which could be used in developing costs for KUSF
22 purposes, based upon the costs that were developed by the Commission for UNE
23 pricing purposes.