Comparison Between Actual Sheath Feet and FCC Default Results

Q. How can embedded cable data be used to help calibrate the model to Kansas conditions?

A. The FCC model relies on existing wire center locations and boundaries. Therefore, at least in principle it should be feasible to reconcile the modeled quantities of cable for each wire center to the analogous data for the incumbent's embedded network. With this thought in mind, we spent several months analyzing the embedded sheath data in detail, and comparing it to the FCC default route feet results. Cable quantities are typically measured in terms of the number of sheath feet. The sheath is the protective outer layer which surrounds a bundle of copper wires or fiber strands. Route feet is a measure of the total distance along which cable is (or would be) installed. As I will explain, any such comparison must be made cautiously, since the embedded cable quantities need to be viewed in an historical context, taking into account various differences between embedded networks and the forward looking networks.

Q. How can the embedded sheath data for each wire center be used in evaluating the appropriate inputs to the FCC model?

A. Provided certain subtleties in the data are kept in mind, the embedded sheath data can provide some useful insights concerning the impact of PNR's road surrogate data, and it can be helpful in evaluating whether the feeder and distribution routing inputs to the FCC model should remain at their default setting of 1, or if a different input value should be used, in order to more accurately calibrate the model for Kansas geographic conditions.

These two issues are interrelated–the appropriate setting for the routing input may differ depending on the selected customer location input data. For example, if road surrogate data is selected, but the algorithm used in generating this data tends to spread customers out more widely than their actual locations, this will tend to bias the modeled cable quantities upward. This upward bias can be offset by reducing the routing input.

By carefully examining the embedded sheath data supplied by the incumbent LECs and the route feet generated by the FCC model, one can judge how well the FCC model reflects the geographic conditions in each wire center. While the existing network and the forward looking network would not be identical, they both need to connect the same customers to the same wire center location. Thus, the total cable quantities should be very similar; the differences that exist between the two sets of data should only reflect differences in an historic network and a forward looking network. If larger discrepancies are observed, this is an indication of flaws in the routing input and/or customer location data used in running the FCC model, and it suggests the need to use different routing inputs and/or more accurate customer location data. One of the advantages of the FCC model is that these inputs can be modified as necessary to enhance the accuracy of the cost results. By carefully analyzing the embedded sheath data, it is feasible to determine whether further refinement of the inputs is warranted, which in turn will cause the FCC's model to more accurately calculate costs and more easily allow the Commission to determine which areas have high costs.

Q. Have you compared actual sheath feet for Kansas wire centers to the FCC's model results using the road surrogate data and the default routing inputs?

A. Yes. We were able to match sheath data and FCC default route mile estimates for 164 wire centers within SWBT's Kansas service area. These results are shown on Schedule 1. For purposes of this comparison we included all of the embedded copper and fiber cable in each wire center. It should be recognized that some of this cable is used to connect different wire centers, and to perform the long-haul functions associated with the interLATA toll and access network. Since we are trying to evaluate the loop cable quantities generated by the FCC model the interoffice portion of the embedded cable inventory would ideally be excluded, just as we have excluded the corresponding "transport" cable quantities generated by the FCC model. Since we do not know the quantity of interoffice cable in each wire center it was not excluded, and thus the embedded sheath data is biased upward (when compared to the FCC model feeder and distribution quantities).

The embedded sheath feet ranged from a low of ***Proprietary Proprietary*** feet in the Towanda wire center to ***Proprietary Proprietary*** feet in the Murray wire center. In comparison, the route feet generated by the FCC model ranged from a low of 348,607 feet in Chetopa to 5,083,196 feet in Lawrence. In general, when using road surrogate data and the default routing variables, the FCC model tends to generate more route feet than the corresponding embedded sheath feet quantities. The FCC modeled route feet exceeded the historic sheath feet in 147 of the SWBT wire centers. In only 17 of the wire centers did actual sheath feet exceed modeled route feet, despite the fact that the embedded data should be consistently higher because of multiple sheaths and interoffice cable. Similarly, the average embedded sheath feet of ***Proprietary Proprietary*** per wire center is substantially lower than the corresponding average of 1,613,829 route feet per wire center generated by the FCC model using road surrogate data and the default routing inputs.

As shown on Schedule 2, when we performed a similar comparison for Sprint's service area we observed a similar pattern. In 118 of the 146 matched wire centers, FCC modeled route feet exceeded Sprint's embedded sheath feet. The range for Sprint sheath feet was from *****Proprietary Proprietary***** in Quincy to *****Proprietary Proprietary***** in Gardner. The analogous range for route feet generated by the default version of the FCC model was from 216,623 in Quenemo to 3,434,732 in Junction City. Average embedded sheath feet is *****Proprietary Proprietary***** per wire center; the corresponding average modeled route feet is substantially higher--838,713 per wire center.

This comparison of the embedded sheath feet supplied by SWBT and Sprint with the FCC modeled route feet suggests that the FCC model overestimates the amount of cable actually needed to serve Kansas customers–at least when it is used with road surrogate data and the default routing inputs.

Q. Did you perform any statistical analyses to compare the embedded sheath feet with the modeled route feet?

A. Yes. We calculated statistical correlations between sheath feet and route feet. For both companies we found that total sheath feet and FCC modeled route feet are very highly correlated. Using the road surrogate data and the default routing inputs the correlations were .9231 for SWBT and .7048 for Sprint. Thus, while the quantity of route feet tended to be substantially more than the corresponding quantity of sheath feet, the two sets of data are closely correlated. Schedules 3 and 4 graphically confirm this pattern. For clarity, the wire centers have been organized in sequence based upon their number of access lines. As you move from left to right across the horizontal axis, wire centers have increasing numbers of access lines, as shown on the horizontal axis. The heavy solid line on the graph shows the embedded sheath feet for each wire center adjusted for increased backhaul, and the dashed line shows the corresponding route feet for the same wire center generated by the FCC default inputs.

As shown in Schedule 3, for SWBT, the FCC model tends to deploy lots of cable in those wire centers that actual have a lot of cable, and less cable in those wire centers that actually have less cable. The two lines tend to move in unison, but the route feet are typically higher than the sheath feet. The same basic pattern is revealed for Sprint in Schedule 4.

Q. You've been comparing sheath feet with route feet. Would you please describe the similarities and differences between these two sets of data?

A. Yes. Because multiple sheaths can be placed along the same route, sheath feet should always be equal to or greater than route feet, for a given data set. For instance, in the ARMIS report submitted by SWBT to the FCC, it lists the total number of underground sheath feet (11,992,500) and underground trench feet (4,101,500). Comparing these figures, one can confirm that many of SWBT's underground cable routes have more than one sheath. Dividing the cable quantity by the trench quantity, we see that the average underground route contains 2.9 sheaths.

Both SWBT and Sprint have supplied Staff with detailed historic data concerning the number of sheath feet installed in their respective service areas in Kansas. This data reflects the amount of cable that has historically been installed in each wire center–some dating back to before World War II. Since the customer locations and wire center locations in the embedded network are the same as those which the

FCC model is intended to reflect, the embedded cable data provides a useful point of comparison in evaluating inputs for the FCC model. For instance, if a particular set of inputs (e.g. road surrogate data) tends to overestimate cable requirements, this might be detected by a comparison of the historic network quantities with the modeled network quantities.

Of course, customer growth patterns within a wire center cannot be predicted by the LEC with complete accuracy. As customer growth occurs over time, additional cable may need to be added along existing routes, and thus multiple cable sheaths of different vintages may co-exist along the same route in the embedded network. In fact, it is a common practice for LECs to engineer their feeder cable to accommodate 5 to 10 years worth of growth. As growth occurs and the installed cable is used to capacity, additional cables are installed along the existing routes.

In contrast, the FCC model assumes that a single appropriately sized sheath of cable is installed to serve all customers in a given area–both recent arrivals and those who have lived in the area for decades. Given the "fresh build" assumption underlying the FCC model, multiple feeder and distribution sheaths are not included in the modeled network. Of course, separate feeder and distribution cables can be placed in a single trench, resulting in some placement cost savings. However, the FCC model doesn't explicitly recognize this potential for cost savings. Instead, the FCC models separate feeder and distribution cable quantities, and these are equal to the modeled route quantities, with no explicit recognition of the potential for placing feeder and distribution at the same time in the same trench.

While it is necessary to keep these various subtleties in mind, they do not preclude making useful comparisons between the cable quantities generated by the model and those reflected in the incumbent LECs' embedded sheath data.

Other factors should also be kept in mind. For instance, the forward looking network generated by the FCC model typically offers higher quality than the embedded network. Using the default inputs, the FCC model ensures that every customer is served by no more than 18,000 feet of copper cable. In practical terms, this requires placing numerous fiber terminals throughout each rural wire center, where fiber feeder is connected to copper distribution cable. This tends to generate more points of interface between feeder and distribution than actually exist, especially in the lower density wire centers.

To the extent the FCC models a forward looking network that requires more feeder cable, this is partly offset by a reduction in the quantity of forward looking distribution cable. Stated differently, the fiber-intensive design places the interface between feeder and distribution closer to the typical customer; in turn, this means that somewhat less copper distribution cable is needed to connect the typical customer to the Feeder/Distribution Interface (FDI). While the increase in feeder and reduction in distribution tend to be offsetting, they do not entirely cancel. On balance, an increased number of FDI's can create an increased amount of "back haul", which occurs when feeder cable is sent past a customer to an FDI, then distribution cable is sent back from the FDI to the customer, along the same route as the feeder cable.

It should be noted that in a "fresh build" scenario, the feeder and distribution cables can both be placed at the same time and in the same trench. Hence, the back haul phenomenon isn't as costly as it might appear, assuming one recognizes the cost savings from simultaneous placement. In any event, the total quantity of cable will tend to increase as the number of SAIs increases, and to that degree the modeled cable quantities may tend to increase relative to the embedded network.

Q. Did you perform any other analyses, to deal with the backhaul problem?

A. Yes. As I mentioned earlier, the FCC model tends to design a network with more FDIs, and thus somewhat more feeder and less distribution cable than the embedded network–particularly in rural areas. On balance, this can increase the amount of cable included in the modeled network. In an effort to evaluate the potential impact of this factor, we estimated the number of FDIs in the embedded network serving each wire center and compared this to the corresponding number of FDIs in the forward looking network generated by the FCC model. As shown on Schedule 5, in 141 of the 164 SWBT wire centers the modeled number of FDIs was greater than the embedded number. As depicted on Schedule 6, in 73 of the 146 Sprint wire centers the modeled number of FDIs was greater than the embedded number.

In the 214 wire centers where the number of FDIs increased, we calculated the amount of additional route feet that could result from increased backhaul. More specifically, we multiplied the increased number of FDIs times 15,000 feet, and used this as a reasonable upper bound on the amount of additional route feet generated by the FCC model due to increased backhaul. To be conservative, we ignored the potential for decreased backhaul in those wire centers where the modeled number of FDIs was less than the embedded number. For SWBT this conservative procedure resulted in an estimated increased backhaul amount of 24,761,250 feet. The corresponding figure for Sprint was 7,920,000 feet. We then added this estimated amount of additional backhaul to the embedded sheath feet, and compared the adjusted result to the FCC model results. This analysis is shown on Schedule 7 (for SWBT) and Schedule 8 (for Sprint).

The results of this analysis were quite interesting. Even after increasing the embedded sheath quantities to reflect the potential impact of extra backhaul, the comparison results remain largely the same. When using road surrogate data and the default routing variables, the FCC model still tends to generate more route feet than the corresponding embedded sheath quantities. After adding an allowance for increased backhaul, the average embedded sheath feet of ***Proprietary Proprietary*** per wire center is still lower than the corresponding average of 1,611,704 route feet per wire center generated by the FCC model using the default routing inputs. Moreover, the FCC modeled route feet still exceeds the historic sheath feet in 137 of the SWBT wire centers. In only 27 of the wire centers did the adjusted embedded sheath feet exceed modeled route feet. Logically, one would expect this pattern to be reversed given the conservative nature of this comparison. The embedded data includes multiple sheaths and interoffice cable, whereas the modeled data does not, and thus one would expect the embedded data to be higher than the modeled route feet in most, if not all, of the wire centers. The fact that the pattern is the opposite of what one would expect is a clear indication that the FCC model is deploying too much cable, at least when using the default routing inputs.

When we performed a similar comparison for Sprint's service area we observed a similar pattern. As shown beginning on page 1 of Schedule 8, in 97 of the 146 matched wire centers, FCC modeled route feet exceeded Sprint's adjusted embedded sheath feet. After making this adjustment, embedded sheath feet is ***Proprietary Proprietary*** per Sprint wire center; the corresponding modeled route feet is somewhat higher, averaging 838,713 feet per wire center.

This comparison of the embedded sheath feet supplied by SWBT and Sprint with the FCC modeled route feet further confirms that the FCC model tends to over estimate the amount of cable actually needed to serve customers in Kansas–at least when it is used with road surrogate data and the default routing inputs. We also calculated statistical correlations between the adjusted sheath feet and default route feet. The correlations were .9189 for SWBT and .7109 for Sprint. Thus, the route feet remain closely correlated with the embedded sheath feet after making our backhaul adjustment.

Q. What conclusions have you drawn from the above analysis?

A. First, I concluded that the FCC model does a very good job modeling the specific geographic conditions in Kansas. Even using road surrogate data (which is not perfect, as I discuss below) and using the default routing inputs (which can be refined, as I discuss below), the model does a remarkably good job designing loop networks that conform to conditions in Kansas. This conclusion is supported by the high correlations between embedded sheath feet and route feet generated by the model.

Second, I concluded that when PNR's road surrogate data is used in conjunction with the default routing inputs, the FCC model tends to over estimate the amount of cable needed to connect Kansas customers to their wire center. Even after adjusting for the greater amount of backhaul reflected in the forward looking network design, in most wire centers the model tends to produce more route feet than the actual sheath feet–despite the fact that the latter data reflects multiple sheaths along individual routes.

Q. Why does the FCC default model tend to overestimate cable, and what should be done about it?

A. The second part of your question is more easily answered than the first. As I mentioned earlier, the FCC model provides adjustable input parameters that allow the modeler to increase or decrease the amount of cable deployed in each wire center. Accordingly, if there is a problem with excessive feeder cable, the feeder routing input can be reduced below its default value of 1. Similarly, if the model deploys too much distribution cable, the corresponding distribution routing input can be reduced below 1. If both types of cable are being overdeployed, both inputs can be reduced. In turn, the model will develop smaller cable quantities. For example, if both routing inputs were reduced to .8, the total quantity of cable would be reduced by approximately 20% below the level generated using the default values of 1.

As explained by the FCC, these inputs are used to specify the relationship between the route distance generated by the model, which is based upon rectilinear assumptions, and the actual distances which would be needed in order to follow rights of way:

> We tentatively conclude that the synthesis model should use rectilinear distance, rather than airline distance, in calculating outside plant distances,[1] because this more accurately reflects the routing of telephone plant along roads and other rights of way. In fact, research suggests that, on average, rectilinear distance closely approximates road distances.[2] As a result, we tentatively conclude that the road factor in the model, which reflects the ratio between route distance and road distance, should be set equal to 1. [Id., ¶ 62]

For example, in a mountainous area roads may curve back and forth up the mountain, requiring much more cable than the rectilinear routing assumed by the model. Similarly, where cable must be routed around lakes, military bases, airports, and other obstacles,

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[1] In short, this means that telephone plant will be built on north-south and east-west routes, rather than "as the crow flies."

[2] *See* Robert F. Love, James G. Morris, and George O. Wesolowsky, *Facilities Location: Models and Methods*, Chapter 10 (Elsevier Science Publishing Co. 1988) (*Facilities Location Models*).

more cable might be required to follow actual rights of way than the amount generated by the simplified rectilinear assumptions used in the model. Conversely, in some areas the actual rights of way might follow more direct routes than the simplified rectilinear assumptions used in the model. Either way, the routing inputs can be adjusted above or below 1 to more closely match the model results to the rights of way and other circumstances specific to a particular geographic area. The inputs in question were primarily intended to deal with differences between actual rights of way and the rectilinear assumptions used in the model.

As I will explain in detail below, our analyses demonstrate that cable can be routed along Kansas rights of way more efficiently than the FCC model estimates. To correct for this discrepancy, the routing inputs can be adjusted to a more appropriate number than the default value of 1. With regard to the question of why the FCC model overestimates cable, I do not have a complete answer. However, I am convinced that one cause of the problem is the use of road surrogate data. Another part of the problem may be that the model is designed to work with "average" geographic conditions, reflecting a mixture of geographic conditions. In Kansas, roads tend to be straight, and there are few obstacles to preclude direct routing. Perhaps the FCC model provides extra cable to compensate for curving roads, mountains, lakes and other obstacles that simply don't appear in Kansas as frequently as expected in the average state.