LaHarpe Telephone Company

Field Test Results

November 17-18, 2015

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1. SUMMARY

LaHarpe's engineer made a fourth field trip on November 17 and 18, 2015 to investigate comments submitted by KwiKom on October 23, 2015. Based on the readings taken at the eleven previously tested locations, no reliable service is available at 10/1 speeds using the existing KwiKom wireless network.

In its October 23 filing, KwiKom never claims that it can provide service to any of the locations specifically identified by LaHarpe in its previous rounds of testing, but instead chose to provide irrelevant information to the Commission. KwiKom appears not to have conducted any testing whatsoever at the eleven locations identified by LaHarpe's engineers. Rather, KwiKom conducted testing only at LaHarpe City Hall less than 700 ft. from the transmitter location.

The field studies by LaHarpe's engineers still stand as a valid test and show no service (10/1 data rate) at the eleven locations tested in the LaHarpe Telephone exchange/study area.

KwiKom has not refuted nor presented any valid technical evidence that they can provide reliable 10/1 service to the eleven locations. It is clear that 100% competitive overlap does not exist.

The remainder of the report covers the methodology used and test results.

2. METHODOLOGY

On November 17 and 18, 2015, a field trip was made to the LaHarpe Telephone exchange to investigate the accuracy of the comments submitted by KwiKom on October 23, 2015. Using Ubiquiti NanoBridge M5 and PowerBeam M2 customer premise equipment (CPE), multiple scans were performed near known transmitter locations to identify Service Set Identifiers (SSIDs)[1] at 2.4 GHz and 5.8 GHz. Scans were performed on the following channel sizes configurable in the Ubiquiti NanoBridge M5 and PowerBeam M2: 5 MHz, 8 MHz, 10 MHz, 30 MHz, and Auto 20/40 MHz. Frequency, signal strength, channel size and SSIDs were recorded at previously tested locations. In addition, a spectrum analyzer was used to view and document the signal levels and bandwidths in the 2.4 GHz, 5.8 GHz and 3.65 GHz bands.

The tests were rerun at all eleven locations detailed in the filing by LaHarpe Telephone submitted on September 28, 2015. A 15' fiberglass pole was used to mount each Ubiquiti NanoBridge M5 and PowerBeam M2 CPE for testing. Testing was performed at the eleven potential customer locations from the bed of a pickup sitting in the driveway of the home using both pieces of Ubiquiti CPE. The testing from the pickup bed resulted in a final CPE height of 17' above ground level (AGL). In the cases where no SSIDs were initially identified from testing at 17' AGL, testing was performed to see if additional antenna height would help in receiving the signal. This was done using the fiberglass pole to hold the CPE 12' above the peak of the roof of the house which was approximately 27' AGL.

[1] The SSID is the name of the network that is broadcast from the transmitter to help the receiver identify the network.

3. TEST RESULTS

The table below details the results from the field trip on Nov. 17-18, 2015. To this date, no reliable 10/1 data rates are available at the eleven locations from the KwiKom wireless network that were tested. The tests did show KwiKom signals of varying strengths at the locations; however, none of such signals were sufficient to provide 10/1 service[2]. In the testing, if more than one KwiKom SSID was identified, the SSID with the strongest receive signal level was recorded. Two extra columns have been added to the signal measurement table to include the impacts of foliage loss and fade margin. The far right column indicates that no reliable service is available at any of the tested locations.

Foliage Loss:

During the November 2015 testing, almost all of the trees had lost their leaves resulting in a stronger receive signal than when the trees had all of their foliage from early April to mid-October as was the case in September when the previous testing was performed. A foliage loss of 10 dB has been added to the measured signal level due to the lack of leaves. This value is consistent with that derived in the independent testing of the effects of foliage on signal propagation[3].

Fade Margin:

Per the Ubiquiti datasheet for the NanoBridge M2, the receive threshold to meet the 10 Mbps on the link from the base station to the CPE is -89 dBm. Operating at or near the receive threshold will yield an availability of approximately 50% due to multi-path or Rayleigh fading. A fade margin of 8-10 dB would normally yield an availability around 90% which calculates to roughly 36 days a year of outage. An 8 dB fade margin has been added to the signal level to take this into account. The total projected signal strength expected during the majority of the year with a fade margin is illustrated in the second column from the right. This column shows

[2] Service is defined as meeting the receiver threshold with foliage loss and fade margin added. The receive threshold for the Ubiquiti NanoBridge M2 to meet 10 Mbps is -89 dBm which corresponds to MCS3. MCS3 was determined to meet the 10 Mbps from a selectable option in the CPE. The datasheet can be found at https://www.ubnt.com/downloads/datasheets/nanobridgem/nbm_ds_web.pdf.

[3] The *Materials' Insertion Loss at 2.4, 3.3, and 5.5 GHz Bands* (Ahmed, Calvo and Campos) report stated their test results on attenuation through a tree at 2.4 GHz and 5.5 GHz was 10.2 dB and 13.2 dB, respectively. These attenuation numbers are consistent with previous experiences of RF signal attenuation for foliage.

the signal levels are all below the required receive threshold to provide reliable service. For more details regarding fade margin and availability see Appendix A.

Reliable Service:

The receive level for reliable service is the combination of the receive threshold (in which the unit can distinguish a signal) plus additional signal level to the link budget to overcome foliage loss (10 dB) during all seasons and the added fade margin (8 dB) to raise the availability of service from 50% to 90% of the time. Based on this requirement, reliable 10/1 service is not available at any of the eleven tested locations.

Customer Location	Latitude	Longitude	Strongest SSID Found	SSID Rx Freq.	Rx Level Measured	Rx Level w/ Foliage	Rx Level w/ Foliage and 8 dB Fade Margin	Reliable Service Available
3361 Hawaii Rd	37.81985	-95.23726	kwi-stark	2.4 GHz	-86	-96	-104	N
2875 Hawaii Rd	37.8187	-95.28089	kwi-elsmore-nw	2.4 GHz	-85	-95	-103	N
2701 Hawaii Rd	37.81973	-95.29699	kwi-shaw-N	2.4 GHz	-89	-99	-107	N
2732 Hawaii Rd	37.82115	-95.29445	kwi-shaw-N	2.4 GHz	-87	-97	-105	N
697 2600th St	37.83455	-95.2987	kwi-vilas-2.4ap-se	2.4 GHz	-87	-97	-105	N
3203 Hawaii Rd	37.81989	-95.25097	kwi-elsmore-ap2-so	2.4 GHz	-76	-86	-94	N
2850 Iowa Rd	37.85191	-95.27557	kwi-vilas-2.4ap-n	2.4 GHz	-77	-87	-95	N
941 2400th St	37.87	-95.31653	kwi-humboldt-north-e	2.4 GHz	-82	-92	-100	N
2560 Utah Rd	38.00923	-95.30282	kwi-moran-pwwd-2.4ap-nw	2.4 GHz	-80	-90	-98	N
2695 Utah Rd	38.00768	-95.29392	kwi-moran-pwwd-2.4ap-nw	2.4 GHz	-88	-98	-106	N
1816 2800th St	37.99645	-95.28106	kwi-moran-ktwu-2.4w	2.4 GHz	-74	-84	-92	N

To illustrate the foliage difference for the area, LaHarpe has included pictures from the 2695 Utah Road test location providing an illustration of the change in landscape from August 2015 to November 2015. The foliage change for the one site is equivalent to the changes seen at the remainder of the test sites.

The picture above was taken in August 2015 looking toward the west.

The picture above was taken in November 2015 looking toward the west.

The picture above was taken in August 2015 looking toward the south.

The picture above was taken in November 2015 looking toward the south.

The picture above was taken in August 2015 looking toward the southeast.

The picture above was taken in November 2015 looking toward the southeast.

The picture above was taken in November 2015 looking toward the southeast.

4. REPLY COMMENTS

Below are responses to the five specific points submitted by KwiKom on October 23, 2015.

1. Channel Width Test Failures

KwiKom alleged LaHarpe's engineers only tested using a 20 MHz channel. Tests were originally performed with the channel size set to "Auto 20/40 MHz". Retesting was completed on other channel sizes during the field trip in November 2015 and found KwiKom to be operating on a 10 MHz channel size in the 2.4 GHz band. The test personnel initially assumed a network design to handle 10/1 data speeds for a number of potential subscribers would have used a wider channel to allow for more customers. A channel size of 20 MHz would have given the sector more total throughput for a given receiver threshold on the subscriber end. Given the fact that KwiKom is required to provide a 10/1 service to the customer, a higher receiver threshold would have been needed for a 10 MHz channel than a 20 MHz channel for the same 10/1 service. The 10 MHz channel would yield a lower sector throughput at a given receiver threshold and decrease the total number of households that could be served assuming the oversubscription rate did not change.

2. SSID Network Identification Premise is False

KwiKom alleges that SSIDs cannot be used to identify the network operator. The argument KwiKom makes about SSIDs is misleading, since the previous filings submitted by LaHarpe had already identified the SSID KwiKom provided in their filing on October 23, 2015. KwiKom's October 23 filing references two SSIDs identified in test locations due to the fact that test were performed in a more populated area where others were running their own wireless network inside their home. KwiKom appears to be using the "E246FD" and "Not Yours" SSIDs to hide the fact that LaHarpe has identified a KwiKom SSID. Before the retesting was performed at customer locations, testing was performed near known transmitter locations – most were within a ½ mile of the transmitter location. The purpose of this testing was to identify SSIDs from the transmitter location to eliminate other SSIDs

that might be found during testing at customer locations. Almost all of the SSIDs that were identified on each channel size for the 2.4 GHz and 5.8 GHz band near the known transmitter sites closest to the LaHarpe exchange all started with the letters “kwi”. It was reasonable to conclude that SSIDs beginning with the letters “kwi” identify KwiKom signals. For example, in the reply comments submitted on October 23, 2015, KwiKom confirmed the SSID of “kwi-laharpe-5.4ap-n” from the LaHarpe water tower as an SSID of their network.

3. **Proprietary Protocol Test Failures**

Considerable efforts were made to use the exact equipment for testing that KwiKom installs at the customer premise. KwiKom stated that they are using Cambium Networks equipment in their network. While an SSID may not appear in the scan results of the Ubiquiti CPE, the fact remains that 2.4 GHz and 5.8 GHz bands have effective radiated power (ERP) limits that cannot be exceeded. From a picture posted by KwiKom on their Facebook page, the Cambium ePMP Force 110 CPE they appear to be using, has the same gain as the Ubiquiti NanoBridge M5 used for testing in the 5.8 GHz band. Given that the Cambium CPE is in the 5.8 GHz band, foliage would attenuate the signal more than the 2.4 GHz band, making the service in the eleven rural test site locations even more unusable.

4. **3.65 GHz Test Failures**

KwiKom stated that they use 3.65 GHz equipment in their network. Search results on the FCC website prove that both KwiKom, LLC. and JMZ Corporation have a nationwide license (radio service NN) for 3650-3700 MHz, but neither licensee has registered any associated transmitter locations as required with the license.

5. **Known Tower Location Test Failures**

KwiKom stated LaHarpe has failed to detect signals from the LaHarpe water tower location. The LaHarpe water tower location cannot provide sufficient signal to serve any of the eleven locations. KwiKom stated that LaHarpe made the claim that KwiKom could not provide service to LaHarpe City

Hall, but LaHarpe made no such claim. KwiKom provided a screenshot of the water tower and CPE mounted on the LaHarpe City Hall building along with a screenshot from the status page of the CPE. KwiKom failed to test any of the eleven locations where LaHarpe has actually claimed no reliable service is available. Looking closely at the screenshot of the KwiKom status page, one will find the SSID "kwi-laharpe-5.4ap-n" is from the LaHarpe water tower. LaHarpe's engineers identified this SSID on page 19 of the "Field Test Results" document on September 8, 2015 submitted by LaHarpe Telephone on September 28, 2015. The same SSID was also identified in the "Field Test Results" document on September 22-23, 2015 on page 8. KwiKom's claim has no bearing on its inability to provide service at the eleven tested locations.

5. REFERENCES

Ahmed, Bazil Taha, Ignacio Alverez Calvo and Joes Luis Masa Campos. "Materials' Insertion Loss at 2.4, 3.3, and 5.5 GHz Bands." *Progress in Electromagnetics Research,* PIERM Vol. 30 (2013): 7-9.

6. APPENDIX A

Radio signals as measured over the air are not constant but vary over time due to multi-path and other types of fading. Multi-path fading is due to ground clutter in the radio environment. Unless there is an unobstructed or line-of-sight path between transmitter and receiver, the received signal is a composite of the main signal and reflections of that signal from natural and man-made "clutter" in the environment. These signals combine at the receiver in a way that can either add together or subtract from each other. Whatever the source of fading, the signal is not constant over time but varies, sometimes as much as 40 dB.

At the radio receiver, the signal will either be above or below the level that is adequate for proper reception. The point where the signal is adequate 50% of the time is defined as the threshold of the receiver. For this reason, radio networks are designed such that the signal level is above threshold by a given percentage. This extra signal is defined as the fade margin. The percent for above threshold reception is defined as the "availability" of the network. In microwave path design, this fade margin is by standard enough for what is called "five nines" or 99.999% availability. Most mobile or fixed point-to-multipoint systems that are not line-of-sight or unobstructed are typically designed with a fade margin adequate for 90% availability because the expense of achieving anything approaching five nines for this type of service would be prohibitive.

The amount of fade margin to achieve this availability is typically 8 dB; although, this can be highly variable as well due to differences in amount or type of ground clutter. However, the point is that radio networks are always designed with a fade margin to ensure an adequate signal level for good service. In this report we have applied 8 dB as an acceptable fade margin for 90% availability. This is actually rather generous as many networks are designed for 95% availability with a 12 dB or more fade margin.