Statement of Hammett & Edison, Inc., Consulting Engineers

The firm of Hammett & Edison, Inc., Consulting Engineers, has been retained by EchoStar Satellite L.L.C. to prepare an engineering statement in support of its Reply Comments to the FCC's Notice of Inquiry in ET Docket No. 05-182, "Technical Standards for Satellite-Delivered Network Signals."[1]

Background

In its Notice of Inquiry in ET Docket No. 05-182 ("NOI"), the Commission seeks, among other things, information and comment on current regulations that identify households that are unserved by local analog broadcast television stations in order to determine if the regulations may be accurately applied to local digital broadcast stations for the same purpose. Hammett & Edison, Inc. prepared an engineering statement and associated figures, dated June 17, 2005, in support of the initial comments of EchoStar Satellite L.L.C. to that NOI. This statement considers some of the comments filed by others.

Clutter is Not Included in the Longley-Rice Model

The Joint Network Affiliates have contended that the Longley-Rice propagation model upon which ILLR is based already incorporates relevant clutter data.[2] [3] However, their position is inconsistent with the citation that they offer as justification. At page 45, the Joint Networks quote from Hufford,[4] "It should then be noted that these data were obtained from measurements made with <u>fairly clear foregrounds</u> … [i]n general, <u>ground cover was sparse</u>…." (emphasis added) Fairly clear foregrounds and sparse ground cover are indicative of careful site selection, which is meant to minimize the effects of clutter.

As EchoStar has repeatedly pointed out, the Longley-Rice model does not incorporate land use and land cover (clutter) in any systematic or relevant way. A comparison between measured and predicted (using Longley-Rice) signal strengths was conducted and reported by Anita Longley, *et al*. of the Institute for Telecommunications Sciences.[5] As the report's principal author, Ms. Longley notes that there are many cases when the results of the predictive model do not agree with the field measurements. At page 5, she writes, "Some of the differences between predicted and measured median values may be caused by terrain clutter, such as buildings and trees, <u>which has not yet been</u>

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1 FCC 05-94, adopted April 29, 2005.

2 Joint Comments of the ABC, CBS, and NBC Television Affiliate Associations to ET Docket No. 05-182, pp. viii, 45, June 17, 2005.

3 Joint Comments of the ABC, CBS, Fox, and NBC Television Network Affiliate Associations to ET Docket No. 00-11, p. vii, February 22, 2000.

4 G.A. Hufford, "A Guide to the Use of the ITS Irregular Terrain Model in the Area prediction Mode," <u>NTIA Report 82-100</u>, p. 12, Apr. 1982.

5 A. G. Longley, "Measured and Predicted Long-Term Distributions of Tropospheric Transmission Loss," <u>OT/TRER Report No. 16</u>, July 1971.

included in the prediction models." (emphasis added) In 1978, she wrote, "The [Longley-Rice] propagation model calculates transmission loss, with allowances for radio frequency, terrain irregularity, path length, and antenna elevation. Most of the data previously considered [in developing the model] were from open areas, towns and small cities. To this model, we can now add an allowance for the additional attenuation due to urban clutter…."[6] (emphasis added) She then describes a method for incorporating the effects of clutter, but this method is not incorporated into version 1.2.2 of the ITS Irregular Terrain Model, which underpins ILLR.

While we agree that some of the data sets used in the development of the Longley-Rice model unavoidably contained clutter, most did not, and the type or degree of such clutter, when present, was not systematically collected or included in the model. Until better data are available, there is no justification for eliminating the ILLR clutter factors.

Downlead Line Losses Not Conservative

Based upon a review of one product from a single manufacturer (Channelmaster Pro Install), the Joint Networks infer that fifty feet of Type RG-6 coaxial cables have losses of less than 1 dB at low-band VHF channels, less than 2 dB at high-band VHF channels and less than 3 dB at UHF channels 14–51. The maximum loss at UHF is given as 2.76 dB. In fact, however, there is some variation in the loss of RG-6 cable. For example, Belden Cable[7] lists a loss of 3.3 dB at Channel 51 for its Model 1152A Type RG-6 cable. A 1979 study conducted by the NTIA[8] found a range of 2.7–4.3 dB for various models of dry Type RG-6 cable at Channel 51. In addition, not all consumers will use Type RG-6 cable. Type RG-59 cable is less expensive than Type RG-6 cable, and may be selected by price-conscious consumers; NTIA reports that this cable has losses of 3.5–6 dB. Aging of the downlead cable or water in it, regardless of type, would further increase its loss.

In addition to the attenuation (loss) of the cable itself, there are generally other losses in the downlead system between the antenna and the television set. Most television antennas are designed with an operating impedance of about 300 ohms, while Type RG-6 cables and television receivers are designed with an operating impedance of 75 ohms. The conversion between these two impedance values is typically accomplished at the antenna using a device called a "balun."[9] Baluns have loss associated

6 A. G. Longley, "Radio Propagation in Urban Areas," OT Report 78-144, p. 31, April 1978.

7 http://bwccat.belden.com/ecat/pdf/1152A.pdf

8 R.G. FitzGerrel, *et al*., "Television Receiving Antenna System Component Measurements," NTIA Report No. 79-22, pp. 32–37, June 1979.

9 An abbreviation for BALanced to UNbalanced transformer.

with them, averaging about 0.6 dB at low-band VHF channels, 1.5 dB at high-band VHF channels, and 2.5 dB at UHF channels.[10]

Many households have several television receivers,[11] which may share a common antenna. This sharing is accomplished by the use of a power divider (so-called "splitter"), which allows a single downlead cable to be split into two or more outlets. The minimum loss associated with such splitters is calculated as

$$L_{db} = 10\log\frac{1}{N}$$

where N is the number of outlets in the splitter. Thus, the two-outlet splitter typically found in many homes, therefore, has a loss of at least 3 dB. Finally, the impedance matches among the antenna, balun, downlead, splitter, and receiver are undoubtedly imperfect. Typical additional losses due to the impedance mismatch have been reported[12] [13] as approximately 2 dB at VHF low-band channels, and 2.5 dB at VHF high-band and UHF channels.

Thus, additional losses associated with a typical consumer downlead system, including balun, splitter, and impedance mismatch total about 5.6 dB at low-band VHF channels, 7 dB at high-band VHF channels, and 8 dB at UHF channels. The corresponding planning factor values of 1, 2, and 4 dB account only for cable losses. Thus, there is therefore considerable justification for increasing the losses assumed to be associated with the downlead system, and there is certainly no justification for reducing them.

Assumed Use of Separate VHF and UHF Antennas Not Appropriate

Both the Joint Networks[14] and NAB[15] suggest that the relevant figures for determining the gain of typical consumer receiving antennas should be taken from separate VHF and UHF antennas. We agree that the use of separate antennas for each band can result in improved receiving system performance, since each antenna can be optimized for its particular range of channels. However, the use of separate antennas is atypical in our experience, and the literature suggests strongly that combination antennas are commonly preferred by consumers.[16] Indeed, most of the product lines referred to by the Joint Networks and NAB show a preponderance of "all channel" antennas. For example, the Winegard

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[10] FitzGerrel, *op. cit.*, p. 25.

[11] GAO Report GAO-03-7, "Telecommunications: Additional Federal Efforts Could Help Advance Digital Television Transition," released December 2, 2002.

[12] Oded Bendov, *et al.*, "DTV Coverage and Service Prediction, Measurement and Performance Indices," Proc. IEEE Broadcast Technology Symposium, 2001.

[13] FitzGerrel, *op. cit.*, pp. 29–30.

[14] Joint Comments, *op. cit.*, pp. 18–23.

[15] Comments of the National Association of Broadcasters to ET Docket 05-182, pp. 21–22, June 17, 2005.

[16] *E.g.*, FitzGerrel, *op. cit.*

antenna cut-sheets submitted by NAB list 6 VHF-only antennas, 11 UHF-only antennas, and 16 combination "all channel" antennas, the latter representing nearly half of the total. One would expect that antenna manufacturers would devote the largest portion of their product lines to popular antennas designs, as opposed to specialty antennas. VHF-only and UHF-only antennas are used professionally, for example by cable television headends that seek maximum performance in the reception of a single station. It seems clear, on the other hand, that combination "all channel" antennas are the ones most commonly purchased and used by consumers.

There are also economic penalties and technical difficulties associated with the use of separate VHF and UHF antennas. Obviously, the cost of purchasing two antennas and two downlead cables will generally be greater than purchasing a single all-channel antenna and single downlead cable. Most, if not all, modern television receivers (including all of the DTV receivers we are familiar with) do not have the capability of switching between separate VHF and UHF antennas. So, some external means of switching between the two antennas or combining them together will have to be installed, if separate antennas are to be used. This additional equipment adds to the cost and complexity of the receiving installation, as well as additional downlead system losses, and may be beyond the technical capability of some consumers.

"Fifth-Generation" And Later Receivers Still Have Problems

We agree with NAB that the latest receivers, so-called "fifth generation" designs, do appear to have superior abilities to receive ATSC signals in the presence of certain types of multipath. However, the white noise enhancement penalty associated with the operation of the equalizer in the DTV receiver still remains and must be considered. As previously discussed,[17] the presence of multipath at a receiving site effectively reduces the available strength of the DTV signal at that site because the equalizer in the receiver generates noise in proportion to the degree of multipath. For example, if there is 3 dB of white noise enhancement, then a receiver that had a 15.2 dB noise threshold under ideal conditions (*i.e.*, no multipath) will have a 18.2 dB noise threshold under the multipath condition. This 3 dB increase is equivalent to a halving of the transmitter power of the DTV station. NAB presents data,[18] which shows that fifth generation receiver performance under some static multipath conditions requires 3–4 dB of additional signal to overcome the white noise penalty. Since white noise enhancement can be substantial at sites having severe multipath, it is important that this parameter be measured and subtracted from the nominal measured field strength in any field test.

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17 Comments of EchoStar, to ET Docket 05-182, Engineering Statement, p. 8.

18 NAB comments, *op. cit.*, Table 12 at p. 41.

Equally important difficulties associated with producing a usable DTV picture under dynamic (as opposed to static) multipath conditions remain largely unaddressed in the fifth generation designs, which may account for the continuing failure to receive about 10% of signals under empirical conditions.[19] Further, improvements in the performance of the fifth generation demodulators do nothing to improve the performance of other components in the DTV receiver. Specifically, the performance of the tuners in consumer DTV receivers has been criticized as limiting DTV reception in the presence of otherwise adequate signal levels.[20] While these DTV tuner problems are largely associated with the presence of strong interfering signals, there may be impacts at many locations on consumer reception of network signals.

Consumers also have no knowledge of what “generation” DTV receiver they are purchasing. The “generational” association is largely a consumer electronics industry distinction, which has not been communicated to the consumer. Indeed, despite our inspection of its internal components, we were unable to determine the “generation” of one of the receivers that we recently tested, and so tried to obtain that information from the manufacturer. The manufacturer flatly refused, stating that, “[it] does not supply any information about the design or components of its consumer retail products.” Unless the consumer is given information concerning the performance of his DTV receiver, as CEA is apparently attempting to do in the case of antennas with its “antenna labeling program,”[21] the advantages of the latest technological developments may be lost on the consumer, who can be expected to seek the product having the lowest cost.

FCC Planning Factors Were Intended Primarily For Channel Allotments

The planning factors for DTV used by the FCC were adopted years before any consumer DTV receivers were available. They were adopted, in part, in order that a Table of DTV Channel Allotments might be developed, which assigned a second channel to each analog TV station in the U.S. Some of the assumptions underlying these factors would be inappropriate in this context, as marketplace experience has been gained. For example, the FCC assumed different receiving antenna patterns for NTSC and DTV.[22] The counter-intuitive assumption resulting from that decision was that consumers would install better-performing antennas for DTV use. In fact, a more reasonable assumption for the purpose of assessing consumer reception is that they will not.

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19 Tim Laud, *et al.*, “Performance of 5th Generation 8-VSB Receivers,” IEEE Trans. Consumer Electronics, Vol. 50, No. 4, November 2004.

20 Charles W. Rhodes, “Interference Between Television Signals Due to Intermodulation in Receiver Front-ends,” Proc. IEEE Broadcast Technology Symposium, 2004.

21 Joint Comments, p. 21.

22 See H&E Petition for Reconsideration in MM Docket No. 87-268, filed June 13, 1997.

The specified 28 dBu minimum field strength required for DTV reception at VHF low-band has also been criticized as being sorely inadequate,[23] due in large part to an inadequate consideration of man-made noise at those channels. Additionally, the planning factors assumed that interference from DTV stations operating on other than co- and adjacent-channels would not exist. This assumption was based upon the performance of a dual-conversion prototype DTV receiver. However, most if not all consumer DTV receivers are single-conversion, meaning that they are far more susceptible to interference from some so-called "taboo channels." Now that several generations of consumer DTV receivers are available, it would be appropriate for the Commission to consider using more empirically tested planning factors in this proceeding, since they more accurately reflect the consumer's ability to actually receive a DTV picture.

Time Variability of DTV Signal

None of the other commenters in this proceeding appears to mention that a correction is needed to account for the variation over time of the DTV signal. The FCC's criterion for DTV coverage is a specified threshold field strength with 50% confidence, 90% of the time, that is, a situational variability factor of 50% and a time variability factor of 90%, commonly written as F(50,90). As previously mentioned, a single set of cluster measurements cannot adequately characterize the time variability to provide reasonable assurance that the DTV signal will be available 90% of the time. So, a 90% time (or greater) reliability factor should be applied to the assumed median value obtained during the cluster measurements to adjust the assumed "typical" measured field strength to a 90% time value.

Additional Data on Variability Among Consumer DTV Receivers.

Tests on an additional DTV receiver, Dish Model DP942, have been completed since our June 17, 2005, statement was prepared. For completeness, data on all six DTV receivers (five consumer and one professional model) are presented here for comparison with the FCC's planning factors, as follows:

1. LG LST-4200A
2. Samsung SIR-T451
3. Motorola HDT101
4. Dish DP942
5. RCA DTC100
6. Zenith DTVDEMOD-S

[23] Victor Tawil and Charles Einolf, Jr., "Impact of Impulse Noise on DTV Reception at Low VHF," Proc. IEEE Broadcast Technology Symposium, 2004.

Receivers 1, 2, 3, and 4 were obtained from retail vendors in May 2005. Receiver 5 is an older model, purchased in 2000. All of the consumer receivers are set-top boxes in the under $300 price range.[24] Receiver 6 is a professional ATSC demodulator, which provides detailed information concerning equalizer performance, error rate, and other parameters.

The receivers were set up at a location (Alameda, California) having favorable path characteristics for DTV reception; that is, relatively constant signal levels, and multipath components having minimal amplitude and short delay. The receivers were connected to a common antenna and attenuation was added in 1 dB steps until visible failure of DTV reception occurred. The measurements show the differences in sensitivity of the receivers under favorable field conditions. The estimated margin of error for these measurements was ±1.5 dB.

	Measured Sensitivity by Channel, dBm						
Receiver	D12	D23	D29	D41	D43	D47	D49
1	-81.9	-82.6	-84.1	-82.8	-80.4	-81.1	-81.8
2	-80.9	-80.6	-83.1	-80.8	-81.4	-81.1	-82.8
3	-78.9	-83.6	-83.1	-83.8	-83.4	-82.1	-82.8
4	-81.7	-82.9	-84.1	-82.9	-82.8	-81.5	-81.9
5	-75.9	-78.6	-82.1	-77.8	-77.4	-78.1	-78.8
6	-75.9	-78.6	-79.1	-77.8	-79.4	-79.1	-79.8
Variation in Sensitivity, RX1–5	5.8 dB	5.0 dB	5.0 dB	6.0 dB	6.0 dB	4.0 dB	4.0 dB
Average Sensitivity, dBm, RX 1–5	-79.9	-81.7	-83.3	-81.6	-81.1	-80.8	-81.6
FCC PF, dBm	-81.2	-84.2	-84.2	-84.2	-84.2	-84.2	-84.2

The above results show that consumer receivers can differ in sensitivity by 2–6 dB under favorable field conditions.

After compensating for the white noise enhancement of the equalizer (typically 0.2 dB), which was taken from Receiver 5 and assumed to apply to all of the other receivers, the sensitivities can also be compared with the FCC planning factor (“PF”) values of -81.2 dBm at VHF and -84.2 dBm at UHF. Depending upon the channel involved, some receivers were up to 6.8 dB less sensitive than the planning factors specify. Considering all channels, the typical receiver was 2.4 dB less sensitive than the FCC planning factors.

Bear in mind that this sensitivity field test was intended to minimize, but not eliminate, the generational differences between the 8-VSB demodulators within the various receivers. During testing, it was clear that the oldest receiver (#5) had difficulties with adjacent-channel interference. Specifically, the DTV Channel D43 had a collocated NTSC facility on Channel N44, and DTV Channel

[24] The Dish unit includes a satellite receiver and digital video recorder, and is provided to subscribers free of charge when ordered with certain service tiers.

D49 had a collocated NTSC facility on Channel N48, which also affected reception on Channel D47. All of the receivers tested showed improvement over this "first-generation" model.

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