Further 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 a further engineering statement in support of its *ex parte* filing 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 engineering statements and associated figures, dated June 17 and July 5, 2005, in support of the initial and reply comments of EchoStar Satellite L.L.C. to that NOI. Partly in response to requests by some of the other commenting parties, this statement provides additional data.

Description of Measurement Equipment and Collection Method

The data documenting temporal variations of signal level reported in our June 17 statement[2] were collected using a spectrum analyzer-based system, which was originally developed by Hammett & Edison, Inc. about 10 years ago.[3] For this collection effort, a consumer television receiving antenna was used.[4] The antenna gain at the channels of interest was determined using the substitution (transfer) method,[5] [6] although gain information is unnecessary for purposes of showing temporal variation. This antenna was installed at approximately 30 feet AGL at the Hammett & Edison, Inc. offices in Sonoma, California. With the exception of Stations KRCB-DT, Channel D23, and KTLN-DT, Channel D47, all of measured stations are in or near the main beam of the receiving antenna.

The receive carrier level (RCL) of each DTV signal was determined by integrating the power in 30 kHz samples, equally spaced in frequency, over 5.38 MHz. Appropriate correction factors were applied to convert the Gaussian response of the 30 kHz resolution bandwidth filter to its equivalent

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

2 Comments of EchoStar Satellite LLC, Engineering Statement, pp. 6–7 and Figs 1–3.

3 Stanley Salek and Robert P. Smith Jr., "Transmitting Site Evaluation Using a Mobile Spectrum Measurement System," *50th Annual Broadcast Engineering Conference Proceedings*, National Association of Broadcasters, 1996, pp. 278-285. A soft copy is available at http://www.h-e.com/pdfs/ss_nab96.pdf

4 Radio Shack Model Type VU-90 combination VHF/UHF antenna.

5 C. Balanis, Antenna Theory. (New York: John Wiley & Sons Inc., 1982).

6 G. Evans, Antenna Measurement Techniques, (Boston: Artech House, 1990).

noise bandwidth,[7] to correct for the response of the envelope detector and logarithmic amplifier circuits, and to remove the added power of the DTV pilot.

When the DTV signal is within 10 dB of the analyzer noise floor, the displayed signal level will be higher than the actual value by a factor of up to 7.5 dB higher than the true value.[8] Although the measurements of the stations were in some cases near the noise floor of the analyzer, no correction factor was applied, except that values below -78.5 dBm (within 0.5 dB of the analyzer noise floor) were discarded. The discarded data amounted to about 0.7% of the data in the case of KNTV-DT, which was the only station that was sufficiently weak that more than a few data points had to be discarded. Therefore, some of the reported signal levels for KNTV-DT (and some of the other stations) may be *lower* than reported in the data, and the true statistical distribution would have additional weight at the weakest signal levels.

Measurements were taken approximately every 12 seconds over the period 20:35 (local time) May 17 until 15:33 May 31, 2005. During that time, the recording system was stopped three times.[9] Of the 15 stations monitored, four (D12, D41, D43, and D49) operated continuously, two left the air most nights from midnight until about 7 am (D23 and D47), one station (D27) left the air on May 27 and did not return during the monitoring period, and the remaining stations left the air sporadically for minutes to hours at various times for reasons unknown. The data during these off-air periods were not included in the analysis. As shown in the summary chart, a maximum of 99,148 signal level measurements were taken for each station.

Additional Data

Data for six representative stations were reported in the June 17 statement, of the total 15 stations monitored. The remaining nine datasets are reported here in the same format, along with some additional information. Eight of the stations are located at Sutro Tower in San Francisco, and operate using one of three shared DTV antennas, all having identical characteristics other than height and power. The remaining station, Channel D27, is located at San Bruno Mountain, just south of San Francisco.

The most striking feature across all of the receive signal level data is the significant fade that occurs from the afternoon of May 18 until the evening of May 19. Weather parameters, including barometric pressure, temperature, humidity, wind speed, and rainfall amount were recorded concurrently with the signal strength data, and are reported in Figure 2.[10] Comparison of the signal level data with the

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7 "Noise Measurements Using the Spectrum Analyzer," Tektronix Application Note 26AX-3260.

8 "Spectrum Analyzer Fundamentals," Tektronix Application Note 26W-7037-1.

9 May 18 13:08–18:05, May 20 17:32–19:28, and May 27 14:10–16:52.

10 Rainfall amount has been converted to rain-rate.

weather data shows a strong inverse correlation between rain rate and signal level. Although significant rainfall at the receive site occurred only during a portion of this fade, it can be expected that there was significant rainfall at some point along the path during the entire period.

Summary data for the fifteen stations are provided below:

Channel	Callsign	Prin. Community	ERP, kW	Median RCL	Valid Meas.	Path Length	Type of Path
D12	KNTV-DT	San Jose	8.9	-73.5 dBm	98,427	142 km	obstructed
D19	KBWB-DT	San Francisco	383	-67.8	95,214	59.7	obstructed
D23	KRCB-DT	Cotati	4.7	-64.3	72,170	11.6	line of sight
D24	KGO-DT	San Francisco	561	-63.5	95,430	59.7	obstructed
D27	KTSF-DT	San Francisco	220	-68.6	69,550	67.3	obstructed
D29	KPIX-DT	San Francisco	1000	-60.5	94,588	59.7	obstructed
D30	KQED-DT	San Francisco	777	-60.2	95,202	59.7	obstructed
D33	KMTP-DT	San Francisco	500	-63.8	89,633	59.7	obstructed
D34	KFSF-DT	Vallejo	150	-66.6	95,413	59.7	obstructed
D39	KCNS-DT	San Francisco	468	-69.2	95,036	59.7	obstructed
D41	KKPX-DT	San Jose	1000	-55.4	99,147	67.3	obstructed
D43	KCSM-DT	San Mateo	536	-63.7	99,148	59.7	obstructed
D45	KBHK-DT	San Francisco	400	-65.5	95,141	59.7	obstructed
D47	KTLN-DT	Novato	230	-61.5	73,201	19.6	line of sight
D49	KSTS-DT	San Jose	200	-71.1	98,957	102	marginal

Diurnal Variation

NAB's engineering consultant challenges the use of signal strength measured during the daytime as the median for calculating 90% time reliability on the ground that, "field strength measurements [under Section 73.686(d)], which are taken during the daytime, will typically be lower than at night …." This statement is based upon a specious reading of FCC Report No. R-6602.[11] As a threshold matter, that report supported the development of so-called area method propagation, which makes no use of the actual terrain between the transmit and receive antennas, and has been wholly supplanted by point-to-point propagation models, such as ILLR. Moreover, even if the cited report were applicable to this discussion, it states that, "the differential between the day and night field strengths was negligible in the VHF bands …."

The referenced report goes on to state, "In the UHF band, a diurnal correction was applied for adjusting the daytime mobile measurements …." The suggested correction is, at most, 3 dB, and varies according to a formula relating the transmit and receive antenna heights and a horizon calculation that assumes that the terrain is smooth along the transmit-receive path. The formula is based upon an assumption of propagation over smooth earth, which has been rendered wholly obsolete

[11] Jack Damelin, *et al*., "Development of VHF and UHF Propagtion Curves for TV and FM Broadcasting," FCC Report No. R-6602, September 7, 1966.

by the use of irregular terrain models, such as ILLR. Just as the FCC does not recognize diurnal variation for television stations, we are aware of no ITU or other reports recognizing such variation.

As a matter of interest, we calculated the median signal levels on an hourly basis for the 15 stations described above over the two-week data collection period, and the data from each hour of each 24-hour day were combined for analysis. The hourly median values were calculated and normalized by subtracting the global median for each station. The results are plotted in Figure 3. Clearly, there are some outlier points, and one station (KSTS-DT, Channel D49) was typically stronger by 4.5 dB late at night (1 AM) and typically weaker by 2.5 dB at mid-afternoon (2 PM). However, some stations (KRCB-DT, Channel D23, KTSF-DT, Channel D27, and KTLN-DT, Channel D47) were typically stronger during the day than at night – the reverse of what NAB's consultants postulate. As shown by the trend line, for the two-week period of data collection, the typical hourly variation for all stations over a 24-hour period is less than ±1 dB. More importantly, the variations are not systematic and so cannot be corrected.

It is incorrect to suggest that day-night variation introduces a systematic bias in field measurements. If that were the case, the FCC would issue separate daytime and nighttime authorizations for television stations, as it does for AM stations. Neither the available literature nor the data we collected support NAB's claim that field strength measurements taken during the daytime are likely to be below the median value. It follows that the use of daytime measurements as the median field strength is perfectly acceptable. Of course, measurements of median field strength, whether taken during the day or at night, must be adjusted for 90% or greater time reliability.

Accounting for Antenna Pointing Errors

As discussed above and in our June 17, 2005, statement,[12] few viewers of over-the-air television have or use outdoor antennas that can be rotated. Because in most markets, not all television stations transmit from a common site, reception of one or more stations will be impaired due to the reduced off-axis performance of the receiving antenna. NAB's engineering consultants argue instead that, "… in many cases, a viewer will have no need to reorient an antenna to point it towards a transmitter in a different direction."[13] If NAB's position were correct that antenna adjustment is not necessary in many cases, then it would be reasonable to take field strength measurements for several stations in only a single orientation.

[12] Comments of EchoStar Satellite LLC, Engineering Statement, p. 3.
[13] Reply Comments of NAB, Engineering Statement of Meintel, Sgrignoli, & Wallace, July 5, 2005, p. 3.

While the optimal orientation cannot be known *a priori* for a particular location, a more reasonable way to account for antenna mis-orientation would be as follows, when several stations are being measured to determine DTV field strength.

1. Orient the measurement antenna in the direction which maximizes the value of field strength for the first station to be measured, and record the field strength for that station, as described in Section 73.686(d)(2)(iv).

2. While maintaining this antenna orientation, record the field strength for the other stations to be measured.

3. Repeat steps 1 and 2 in turn for each of the other stations to be measured.

This procedure is compatible with the present rule, which specifies a cluster measurement of five points in the area of the subscriber's antenna. When measuring four network stations, for instance, the above procedure will result in 20 measurements for each station: one for each antenna orientation at each of the five cluster measurement points. From those data, one can calculate the median of the 20 measurements in units of dBu, and use that as the measurement result.

When it is unnecessary for the viewer to reorient his antenna for each station, as NAB states is often not done, this technique will result in the same result as the present technique as defined generally in Section 73.686(d). However, when the receive antenna mis-orientation results in sub-optimum reception for some stations, this technique will account for the typical signal strength penalty.

Television Equipment Survey

EchoStar retained a professional survey firm, The Survey Center of Mashpee, Massachusetts, to conduct a telephone survey of television viewers who rely upon off-air reception. The complete survey is appended to this filing. The survey sample was selected randomly and equally from four databases, which together comprise a nationwide sample. Each county in the U.S. is assigned by Nielsen Media Research into one of four databases, A, B, C, and D, based largely upon its population density.

The Survey Center characterizes the results of the nationwide sample as having a margin of error of 3.19% at a 95% confidence factor. The results of each of the individual "population density band" results are reported to have a margin of error of 6.39% at a 95% confidence factor. A 95% confidence factor means that if the study were repeated 100 times, for 95 of these times the results would be the same, plus or minus the margin of error.

Antenna and rotor usage. Of the households that rely on over-the-air ("OTA") reception, about one-half (49%) have a rooftop antenna,[14] with the other half using an indoor antenna. Of the households having an outdoor antenna, 41% of these reported that the antenna had a rotator installed.[15] In other words, just 20% of the households surveyed that relied on OTA reception had outdoor antennas that could be rotated. Even in the more rural counties ("C" and "D"), only 25–27% of the households that rely on OTA reception had outdoor antennas that could be rotated.

Height of receiving antenna. The Commission has recognized that most homeowners typically install outdoor antennas on roofs, rather than on free-standing towers. In my experience, rooftop installations are typically 8–10 feet above the roof height, so single-story homes have antennas that are 20 feet (or less) above ground, while two-story homes have antennas that are 30 feet (or less) above ground. The EchoStar survey shows that 49% of U.S. households that rely upon antennas for television reception live in single-story homes. The fraction increases to 57% in rural areas. Therefore, the assumed use of receiving antennas located at 20 feet above ground, or less, rather than 30 feet above ground, is not unreasonable in many or most cases. Finally, for households relying upon indoor antennas, 71% have their TV receiver located on the first floor. In essentially all of those cases, the receiving antenna will therefore be located less than six feet above ground. To the extent that indoor antenna reception might be assumed for DTV, an appropriate adjustment for this low antenna height will be required in most cases.

List of Figures

In carrying out these engineering studies, the following attached figures were prepared by me:

1. Measured DTV signal levels (1A–1C repeated from June 17, 2005, statement),
2. Weather conditions during measurement period, and
3. Diurnal variation of signal levels over measurement period.

REGISTERED PROFESSIONAL ENGINEER
ROBERT D. WELLER
No. E-12627
Exp. 09-30-05
ELECTRICAL
STATE OF CALIFORNIA

/s/ Robert D. Weller

Robert D. Weller, P.E.

August 23, 2005

[14] Antennas located in attics were considered to be rooftop antennas, since "outdoor" models are typically used.
[15] It was not asked whether the rotor was functional.

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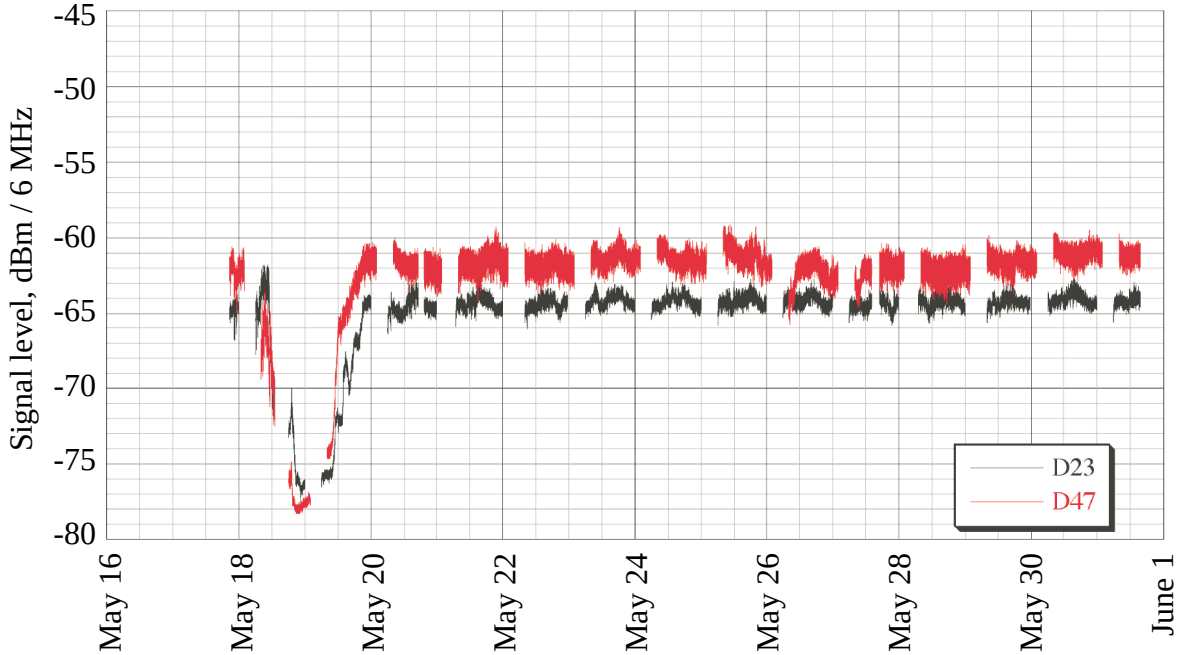
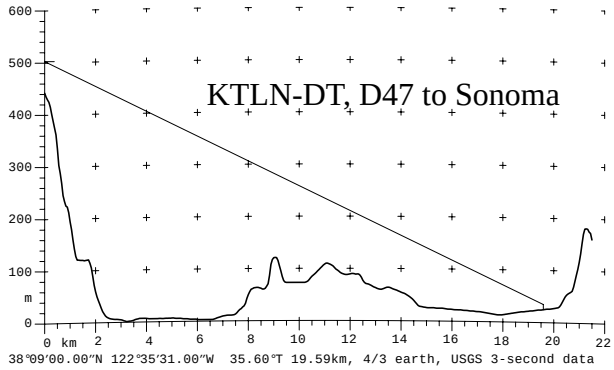
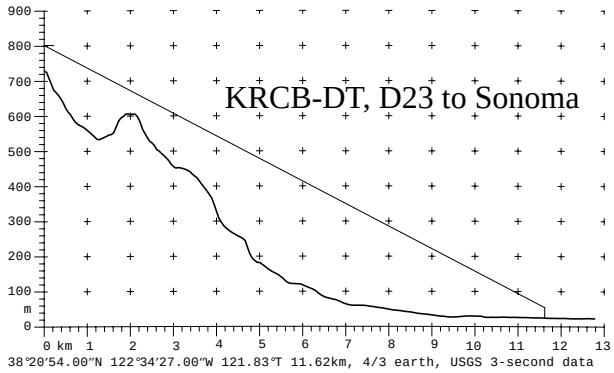
Measured DTV Signal Levels – Short Line-of-Sight Paths







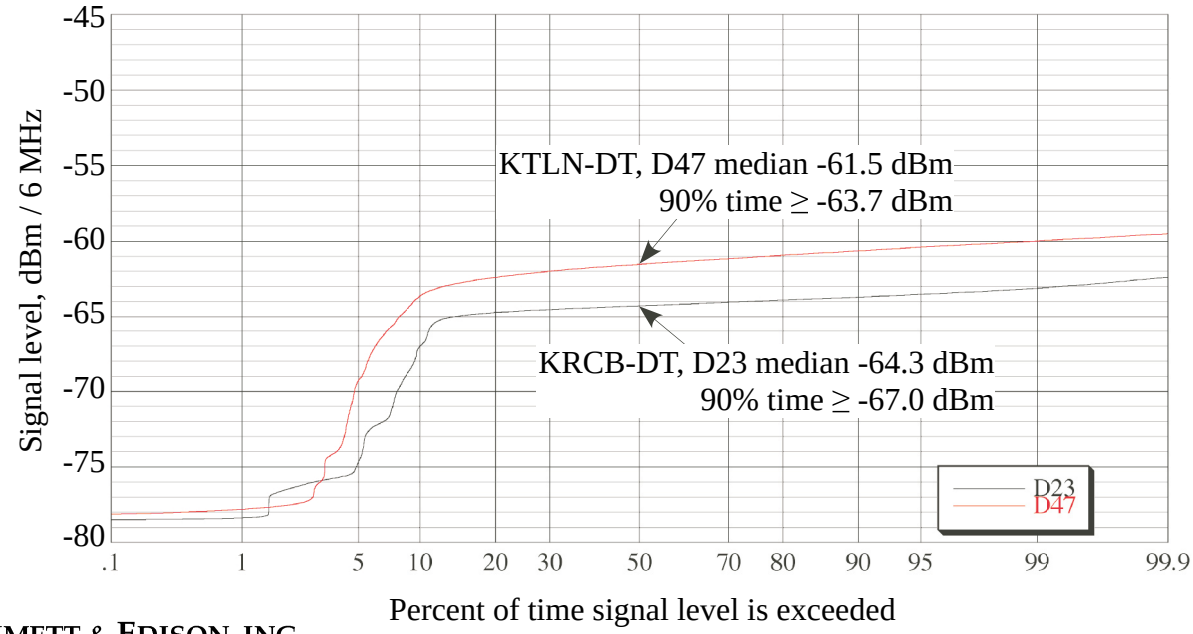


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Figure 1A

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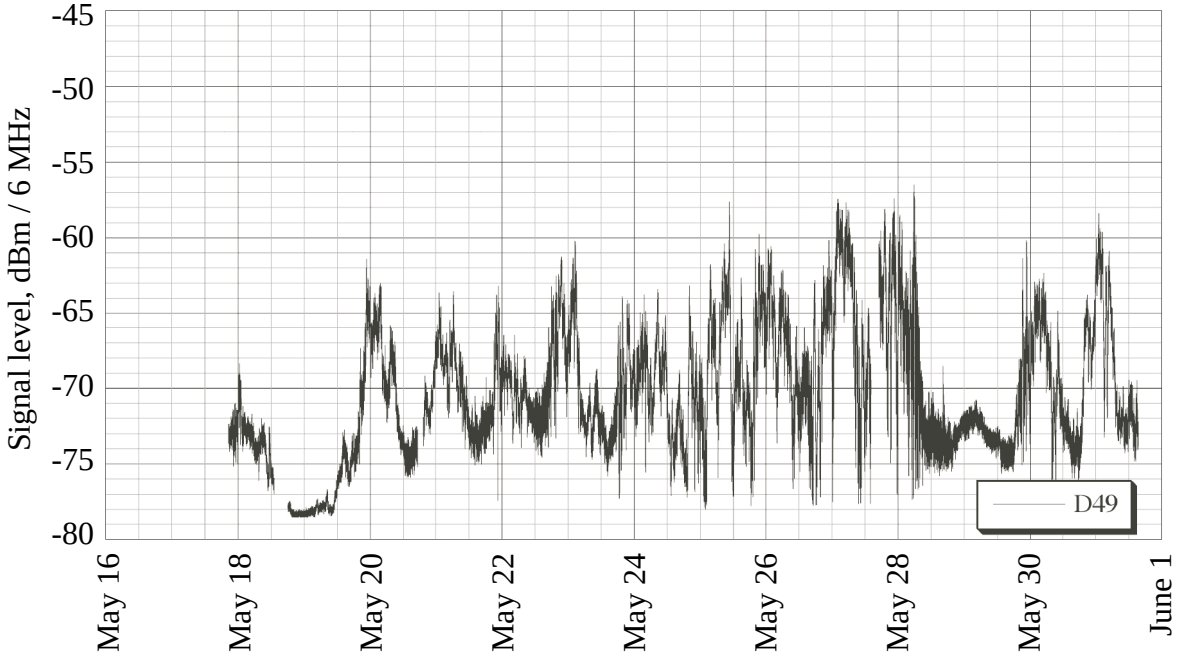
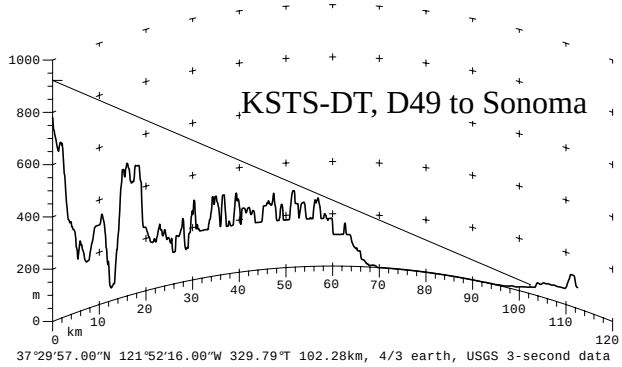
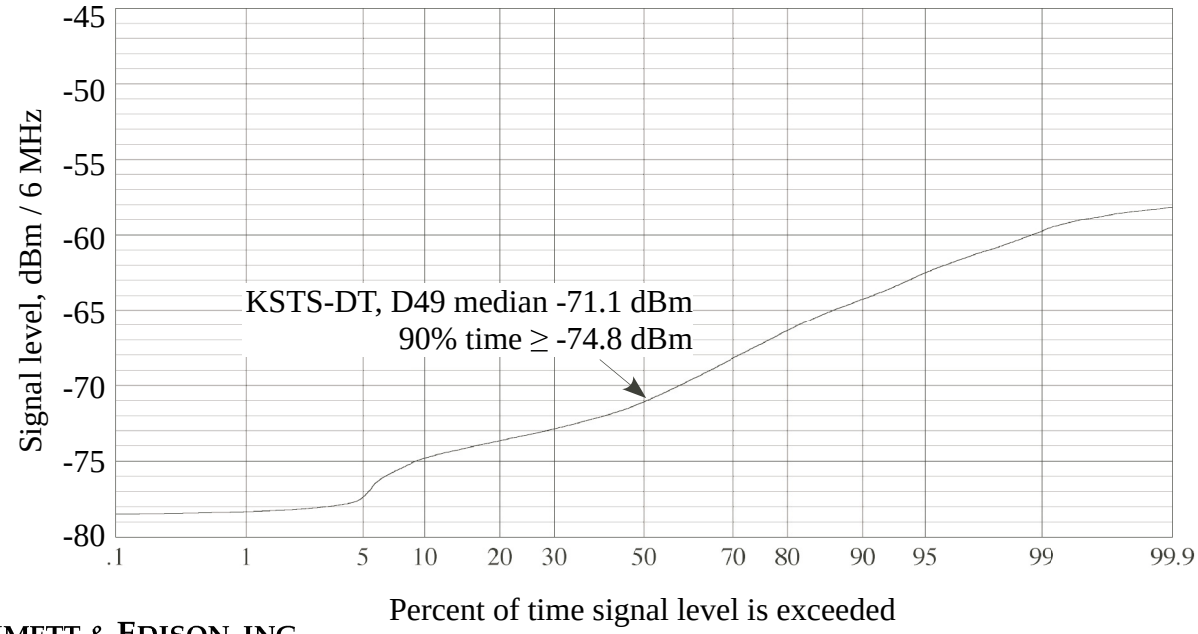
Measured DTV Signal Levels – Long Line-of-Sight Path







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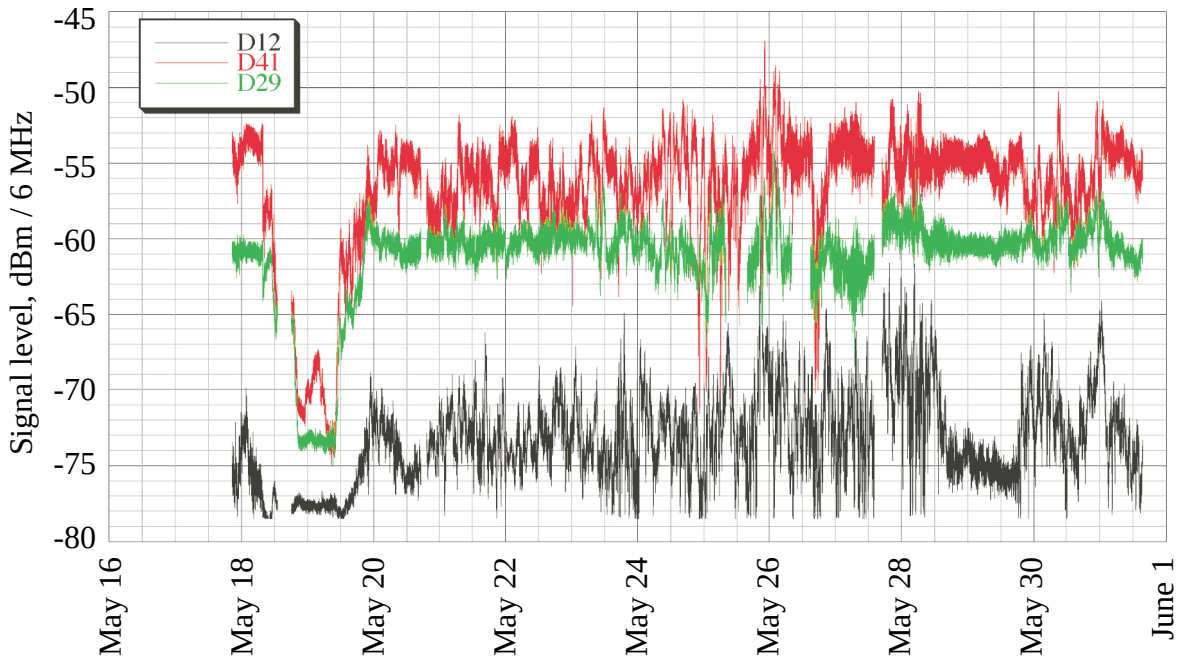
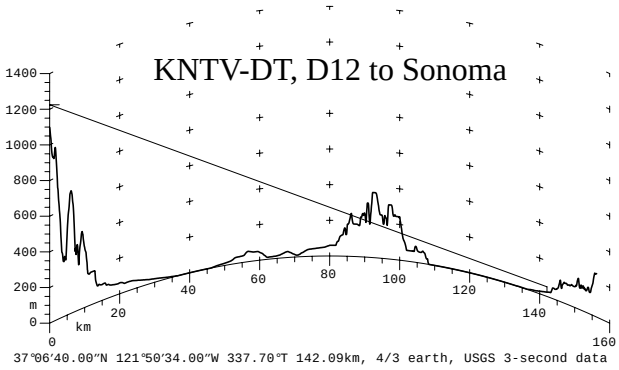
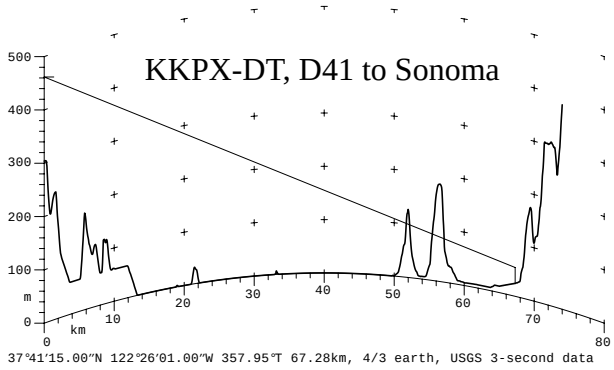
Measured DTV Signal Levels – Obstructed Paths







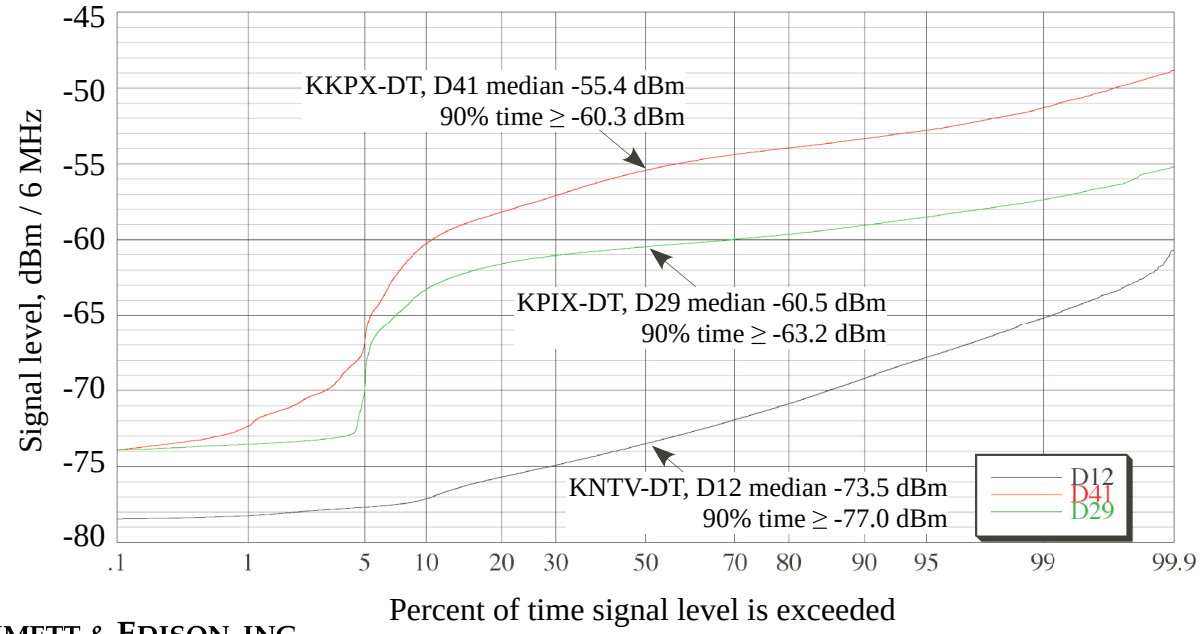


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Figure 1C

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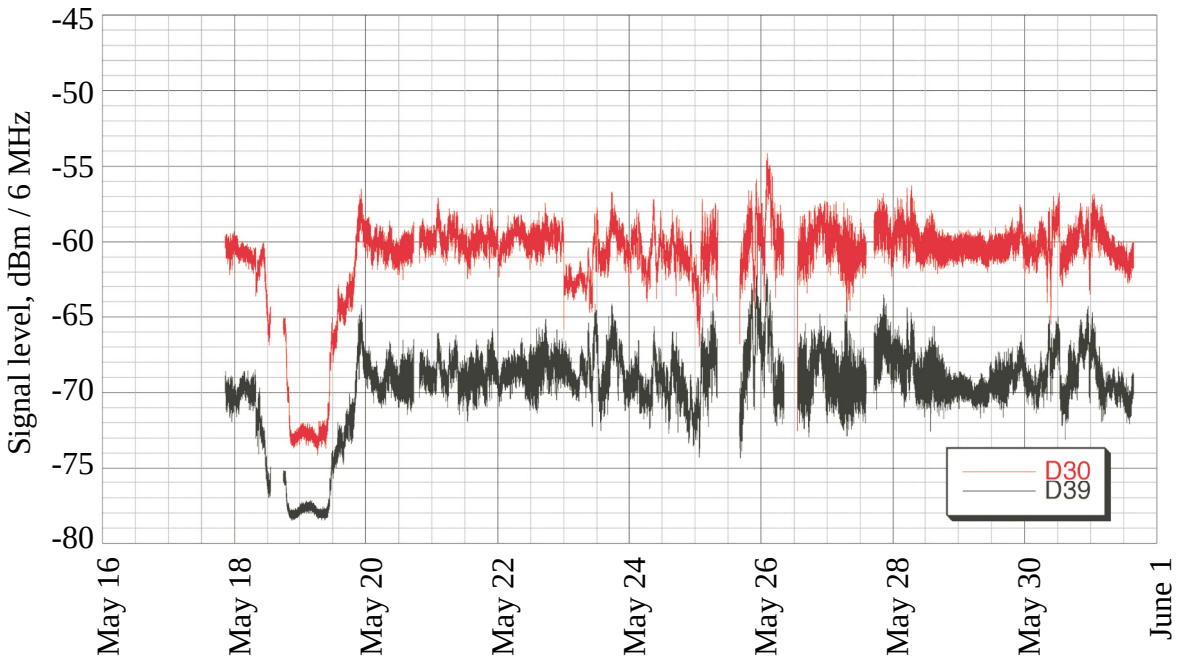
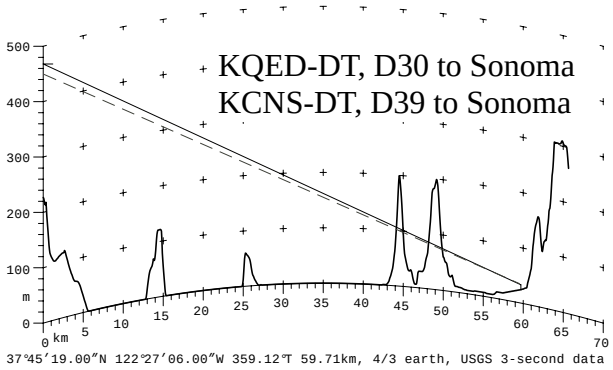
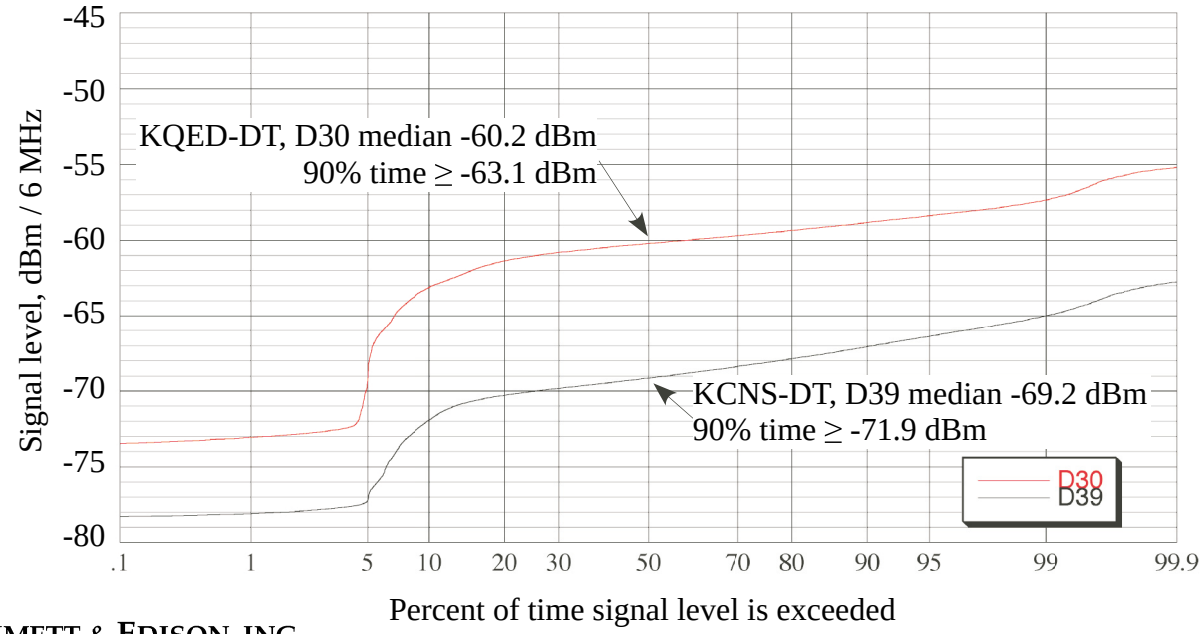
Measured DTV Signal Levels – Channels D30 and D39







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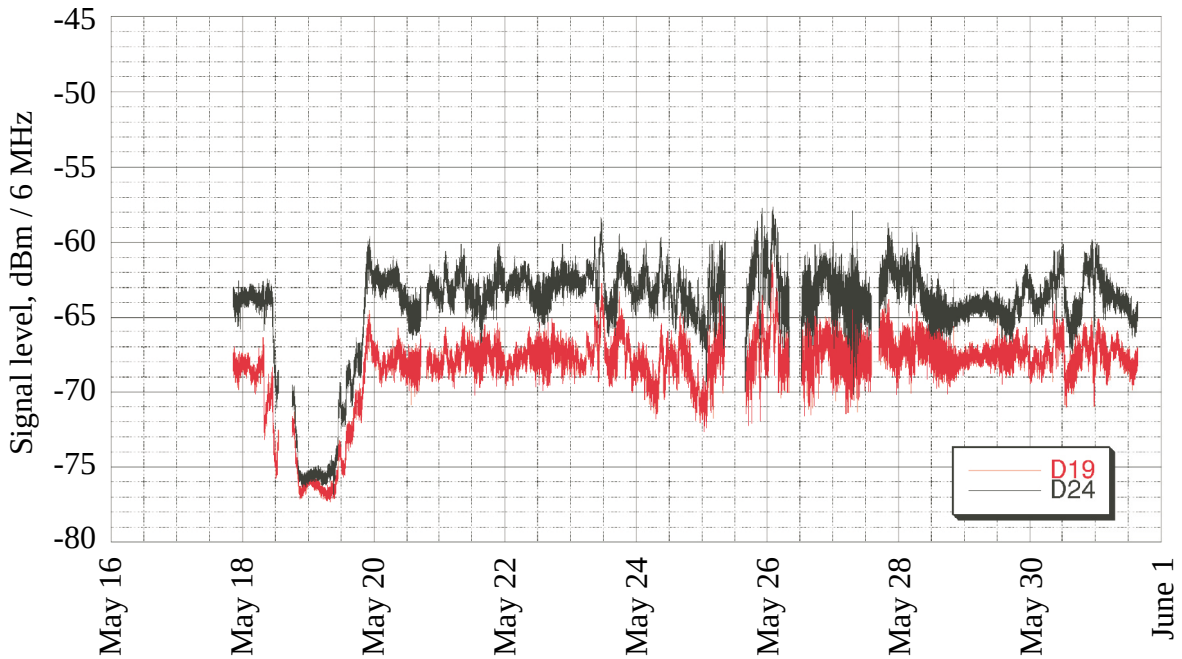
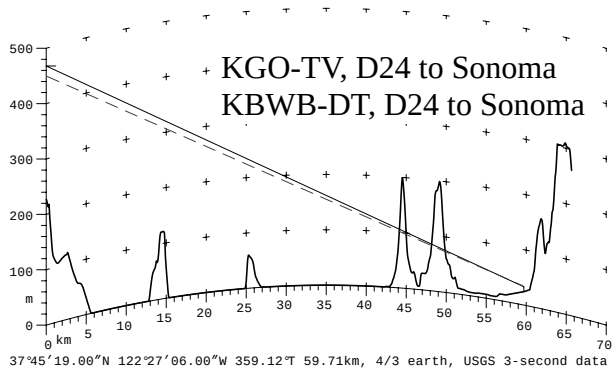
Measured DTV Signal Levels – Channels D19 and D24





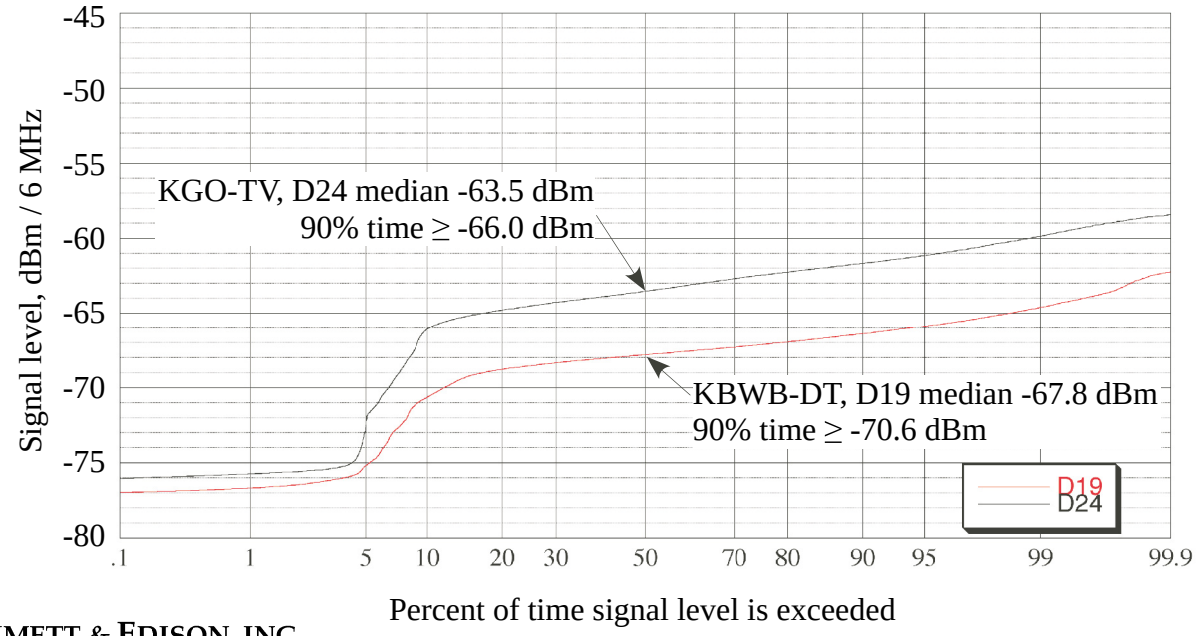


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Figure 1E

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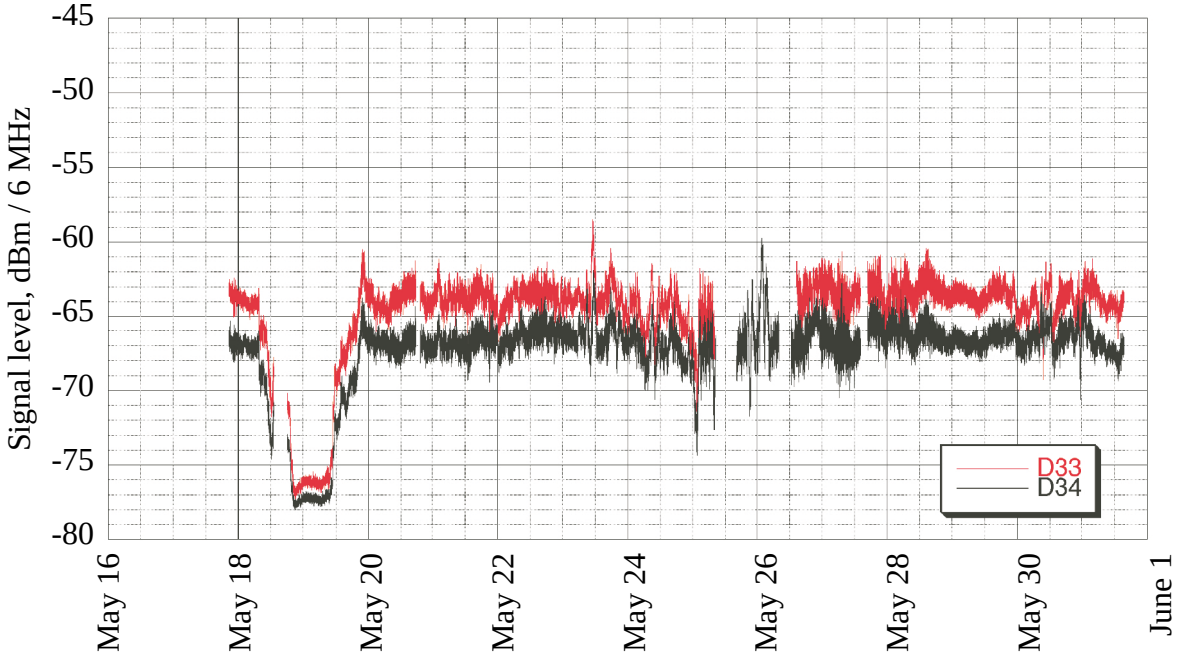
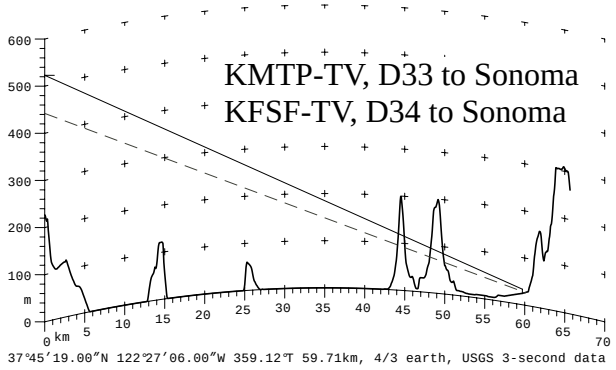
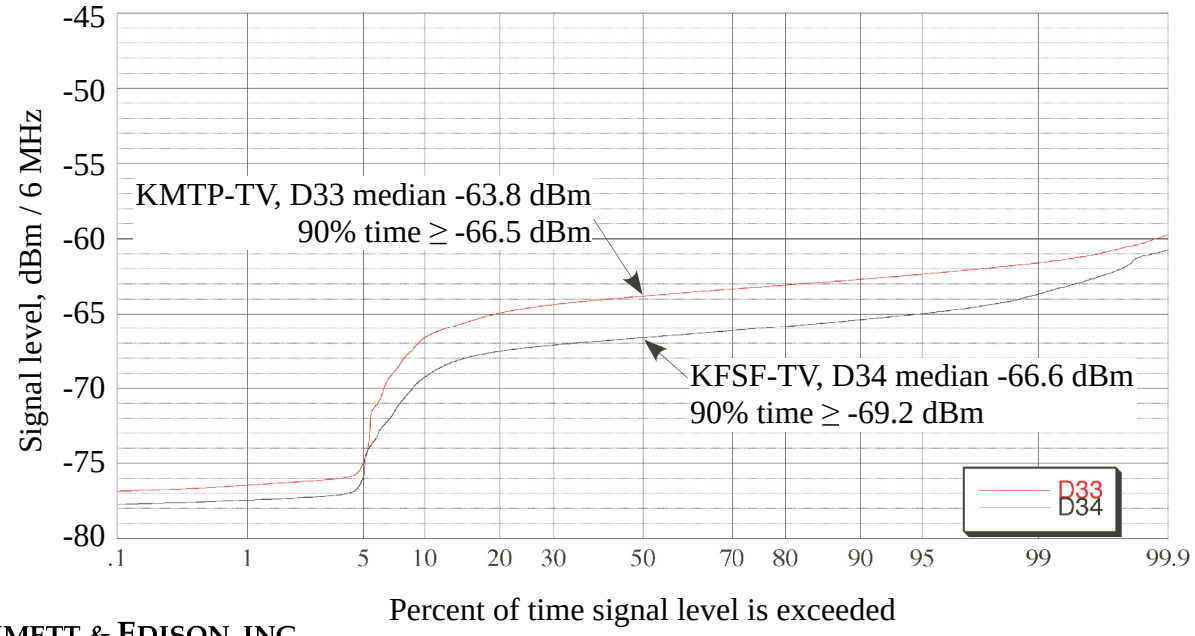
Measured DTV Signal Levels – Channels D33 and D34







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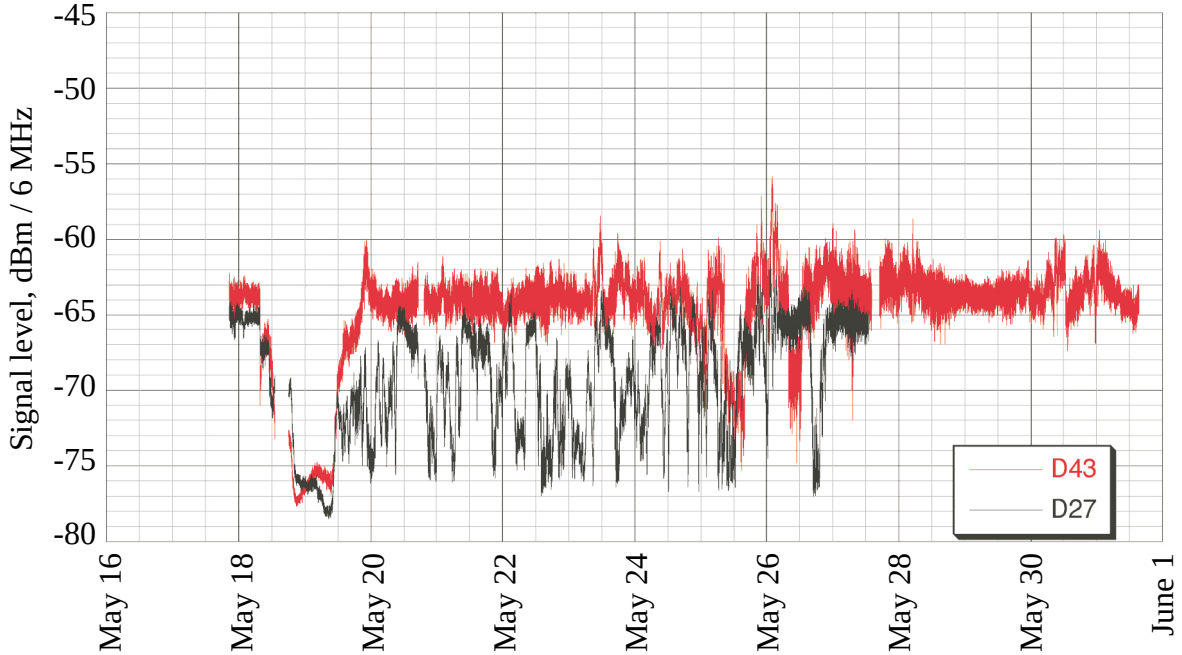
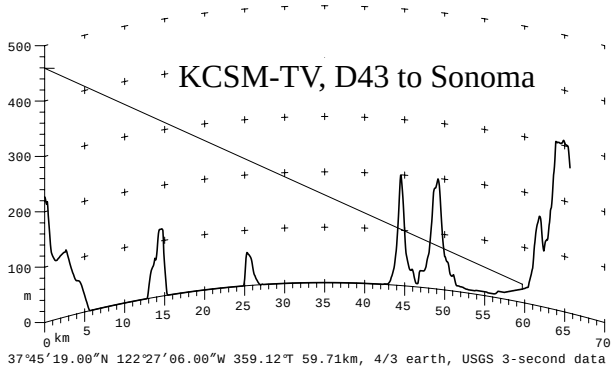
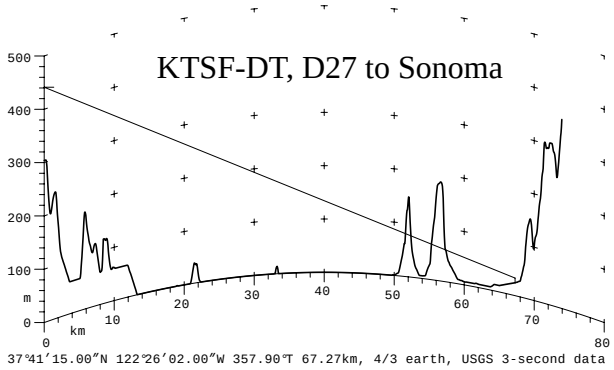
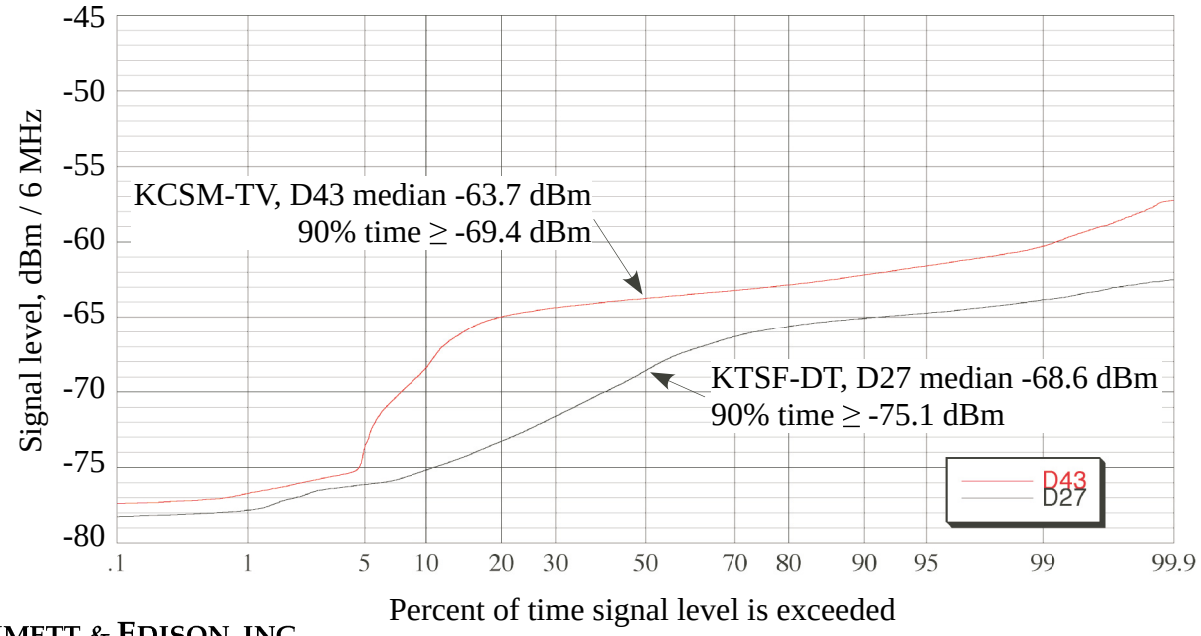
Measured DTV Signal Levels – Channels D27 and D43









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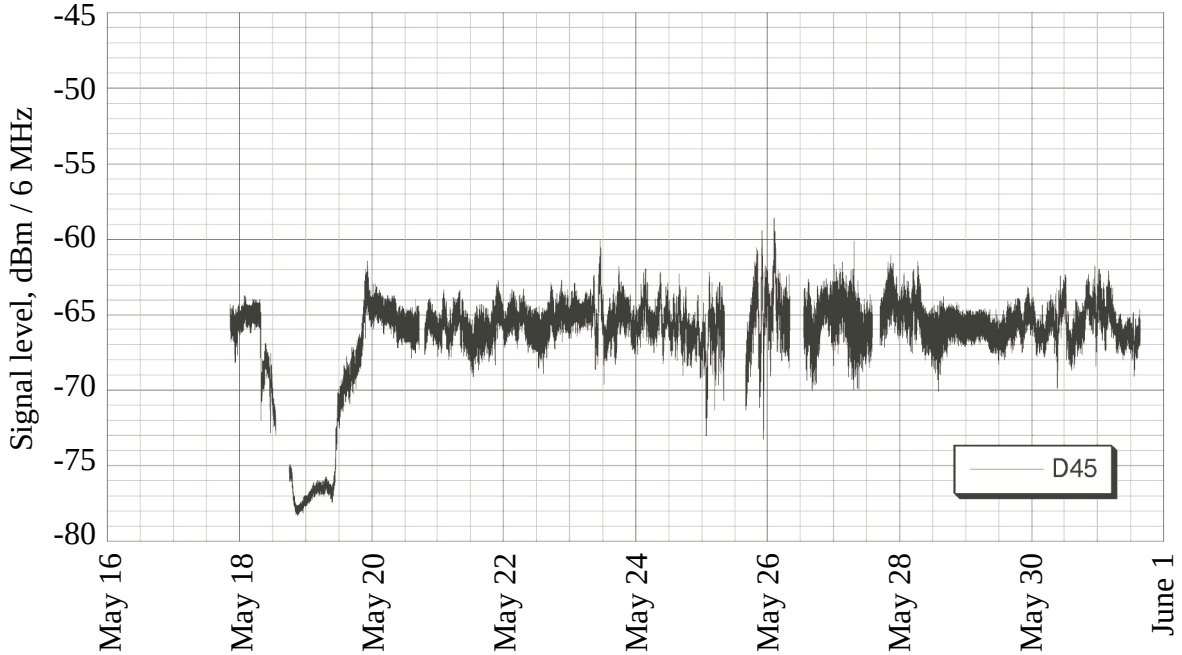
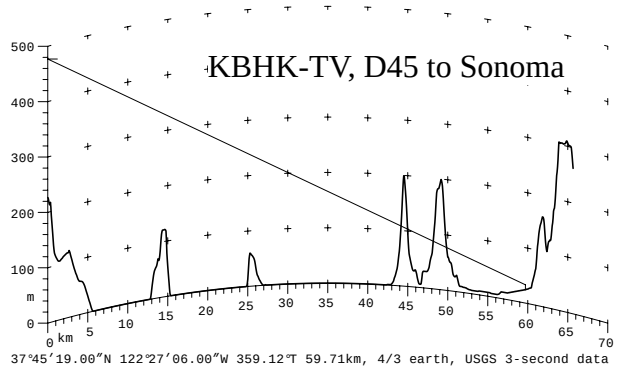
Measured DTV Signal Levels – Channel D45





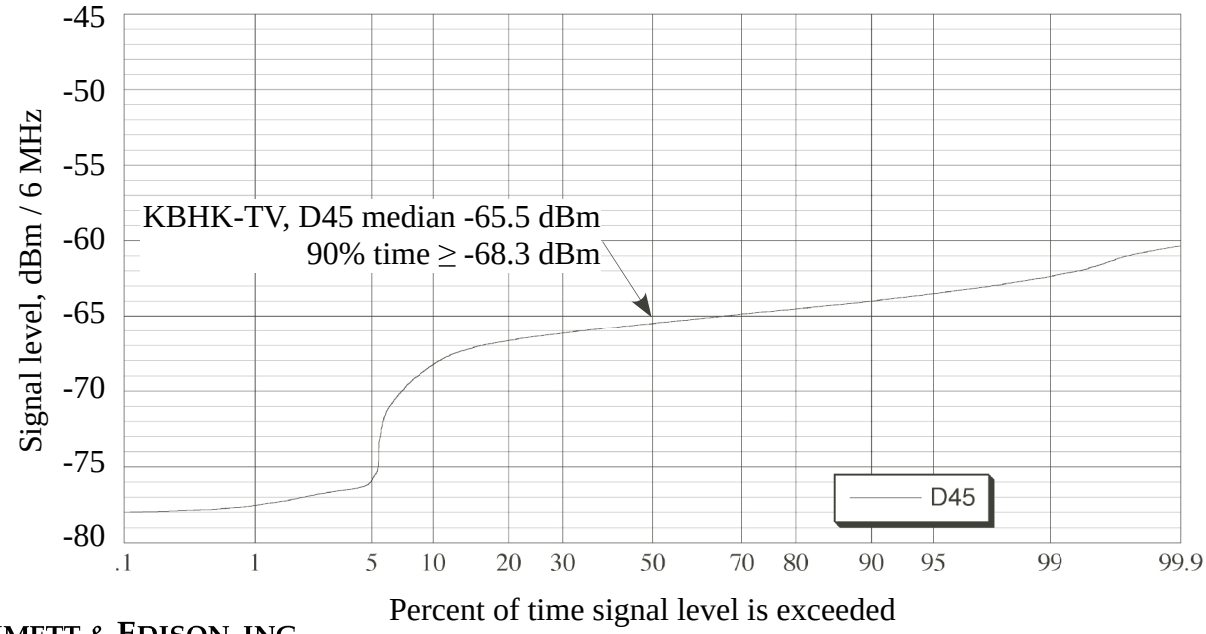


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Figure 1H

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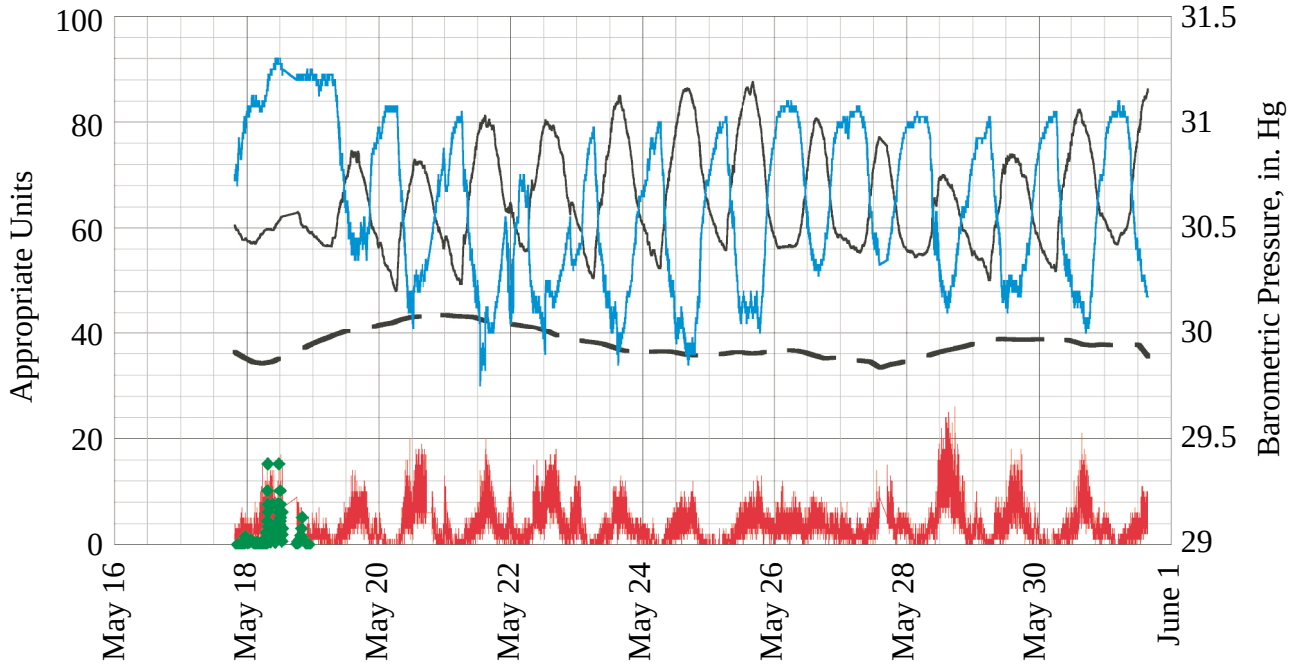
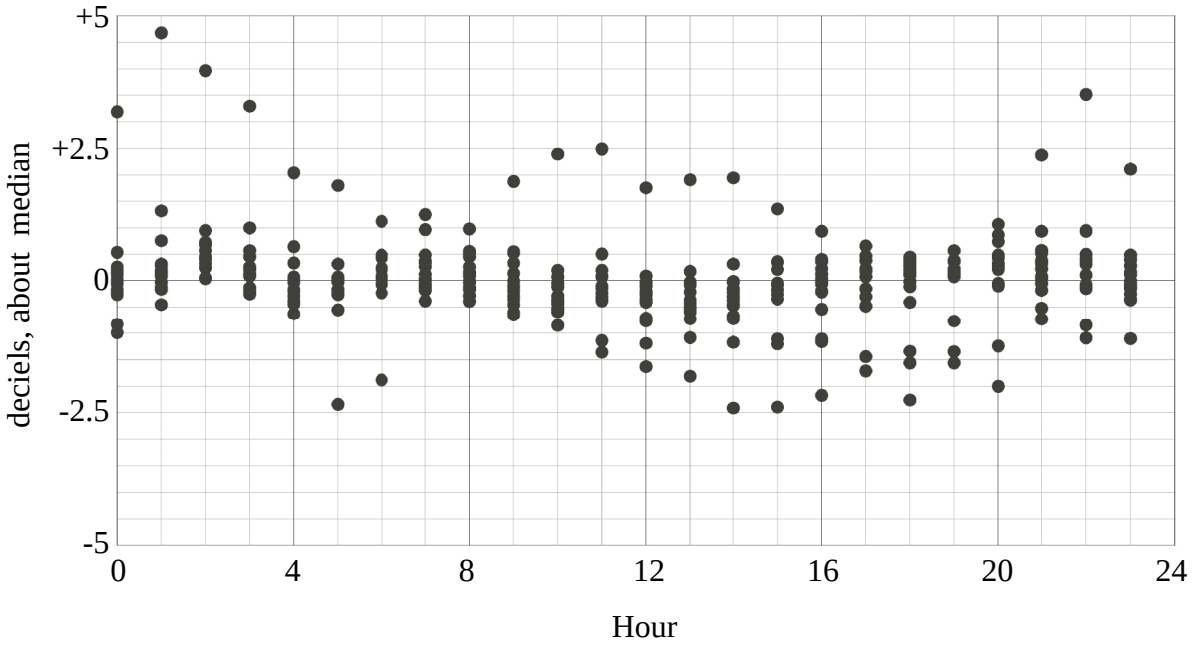
Weather Conditions During Measurement Period



Legend		
— —	Barometric Pressure	in. Hg
———	Temperature	°F
———	Humidity	%
———	Wind Speed	mph
◆ ◆	Rain Rate	mm/hr

EchoStar Satellite L.L.C. • Englewood, Colorado

Diurnal Variation of Signal Level Over Measurement Period



Zero decibels represents the median signal level, calculated for each station over the entire measurement period. Data points represent the calculated hourly median for each station.