they state that indoor testing would be impossible to standardize.[205] The Network Affiliates add that local service would be eviscerated if the Commission was to recommend measuring signal strength indoors or establishing an indoor standard that the entire DTV service was never intended to meet.[206] The NAB and the Network Affiliates state that this is because the signal attenuation due to building materials coupled with the lower gain antenna would have the effect of decreasing the service area size. Moreover, the Network Affiliates state that EchoStar's claims with respect to indoor antennas and building penetration are irrelevant given that the Commission has always assumed that homeowners would use an outdoor directional gain antenna for over-the-air reception. The NAB adds that EchoStar does not provide any explanation for the unfairness of assuming that the same household that uses an outdoor dish to receive satellite TV would use an indoor antenna for over-the-air signals.[207]

118. A second area where EchoStar believes the current testing procedures should be modified is with regard to antenna pointing. The current procedure specifies that the measurement is to be taken with the antenna oriented in the direction of maximum signal strength. EchoStar claims that this requirement implicitly assumes that every household has a rotating antenna that can be re-pointed to optimize reception for each local station, which it contends is unrealistic.[208] To this point, it suggests that signal strength loss from mispointing should be taken into account in the measurement procedures. EchoStar suggests further study to determine the "average" signal loss due to mispointing and submits that this value should be subtracted from the measured signal before comparing to the Commission's signal strength standard.[209] It further suggests that because only 10-15% of households have rotors, those that do not may point the antenna in a direction other than the direction of maximum signal strength to achieve optimum reception for all stations. H&E argues that it would make sense to orient the measurement antenna in the same direction as other antennas in the area.[210]

119. The NAB and the Network affiliates disagree with EchoStar on this point. NAB avers that EchoStar fails to explain why it would be good policy to assume an incorrectly pointed antenna when the entire DTV transition has been premised on use of a properly oriented antenna.[211] The NAB and the Network Affiliates also state that EchoStar ignores obvious problems with their suggestion to point the measuring antenna in the direction of antennas at neighboring households. These include: 1) neighboring household's may have rotors and only temporarily point their antennas in a certain direction; 2) neighboring households may have antennas that have been abandoned; 3) there may be no neighboring households with outdoor antennas; and 4) there is no readily available methodology to determine the direction that neighboring households have oriented their antennas and translate that into a direction for orienting a test antenna.[212] NAB further points out that in many areas local installers can supply antennas that are non-rotating, but that point correctly at all of the local stations when installed.[213] They also state

[205] NAB comments at 27 and Att. 1 (Engineering Statement of MSW) at 22.

[206] Network Affiliates comments at 39-40.

[207] NAB reply comments at 3.

[208] EchoStar comments at 7.

[209] EchoStar comments at 8.

[210] *Id.*, Att. 1 (Engineering Statement of H&E) at 4.

[211] NAB reply comments at 4.

[212] Network Affiliates reply comments at 15; NAB reply comments at 6.

[213] NAB reply comments at 5.

that in 83% of the television markets where there is a full complement of major network affiliates (ABC, NBC, CBS, Fox), the digital television stations are co-located.[214]

120. Several other suggestions were made by EchoStar in response to our *Inquiry* questions concerning measurements. Specifically, it recommends that testing include collection of multipath and other interference data and that testing be done over time to account for time variability of the measurement. On the first point, EchoStar states that multipath interference is a more acute problem for digital television than for analog.[215] It argues that dynamic multipath, which occurs due to signals bouncing off of moving objects, is difficult to account for, but that static multipath interference can be measured and its severity can be expressed as a signal strength penalty. EchoStar states that this penalty should be subtracted from the measured digital signal strength before it is compared against the Commission's digital strength standard.[216] In addition, EchoStar submits that field measurements should include the collection of white noise enhancement values.[217] The Network Affiliates and the NAB both argue that such measurements and compensation are unnecessary. They point out that in the past it may have been true that digital television receivers had difficulty with multipath, but that current 5th generation receivers can easily handle multipath conditions that those earlier receivers could not resolve. The NAB also points out that 6th generation receivers that will encompass further improvements will soon be available.[218] The NAB further states that there is no need to account for white noise enhancement since it only adds about 0.2 dB of noise that is more than made up by factors that overestimate the available signal strength required and thereby make the planning factors conservative. It states that these include the fact that real antennas have gains that exceed the planning factors, available coaxial cables have losses less than those assumed, and low noise amplifiers are readily available.

121. With regard to digital television signal time variability, EchoStar comments that the H&E study shows significant variability over time and that because the Longley-Rice predictive propagation model is based on empirical data about time variability, it would be strange for actual testing to ignore it completely. It therefore asserts that the testing procedures be modified to account for variability in signal strength over time. EchoStar suggests that this could be done by taking the specified cluster measurements and assuming they provide a median signal level and then applying a correction factor to achieve 90% time reliability.[219] The result of such a correction would be to increase the minimum signal strength that defines digital television service. The NAB, in response, points out that the minimum signal level that defines digital television service is specified in the statute and as such any change cannot be done by regulation.[220] As with its response to EchoStar on multipath, the NAB again states that the

[214] *Id.*

[215] EchoStar comments at 5.

[216] *Id.*.

[217] White noise enhancement is the increased noise added to the system by the equalizer as it attempts to compensate for multipath. EchoStar comments, Att. A (Engineering Statement of H&E) at 8-9.

[218] NAB reply comments at 10-11; Network Affiliates reply comments at 10.

[219] EchoStar comments at 8. It states that a correction factor can be derived from the F(50. 50) and F(50. 90) curves by using the difference in values given the distance from the transmitter.

[220] NAB reply comments at 8.

Commission's planning factors are already conservative and there is no reason to account for time variability by increasing the minimum signal strength standard.[221]

122. *Evaluation.* Many of the suggestions made by commenters were noncontroversial and went unchallenged in the record of the *Inquiry*. In this regard, we note that the NAB and the Network Affiliates pointed out that the measurement rules are analog specific with respect to the signal strength standard and need to be modified. We agree and as supported by the record of the *Inquiry*, believe that the digital television measurement rules should specify the noise-limited field strength values as the minimum signal level that constitutes service to a household. We also agree with the NAB and the Network Affiliates that use of the average power in the DTV channel, rather than the level of the pilot signal, would provide a better measure of DTV signal strength for the reasons they indicate. Therefore, we plan to initiate a rule making proceeding in the near future to revise the measurement procedure to use average power integrated over the entire 6 megahertz bandwidth as the basis for measuring the digital television signal.[222] As for the question in the *Inquiry* regarding whether the i.f. of the measuring equipment needs to be specified, we believe that it is not necessary to specify an i.f. other than that it cannot be greater than 6 megahertz. Any of the methods suggested above will work and the i.f. is essentially irrelevant so long as it is not larger than 6 megahertz and the equipment is capable of integrating the power over the selected i.f. bandwidth.

123. We make no make no specific recommendation on whether the measurement procedure should include provisions requiring the use of a directional antenna. However, we believe there may be merit to this suggestion by the NAB and the Network Affiliates. We believe that the proper place to address this is through a rule making proceeding conducted by the Commission. We point out, however, that should it be determined through rule making that a calibrated directional antenna is to be used, the requirements of the antenna (*e.g.*, gain, half-power beamwidth, etc.) must be standardized so that the measurement test is not arbitrarily subject to the particular antenna selected by the tester.

124. Further, we agree with NAB and the Network Affiliates that digital television measurements should be made at 6.1 meters (20 feet) for one-story structures and 9.1 meters (30 feet) for two-story or taller structures; the same as analog television. This height standard is central to the definition of the planning model for DTV service areas. We therefore recommend that the procedures for measuring digital signals not be changed from the analog standard with respect to measurement height.

125. The SHVERA specifically asks the Commission to consider whether to account for the fact that some households use indoor antennas. As discussed above in the section on signal strength standards, the channel allotment plan for digital television developed by the Commission which defines the DTV service areas is premised on the planning factors; one of which is that an outdoor antenna is used. Households may certainly employ indoor antennas, but for standardized testing and planning an objective procedure must be used. To do otherwise would introduce a level of subjectiveness such that the entire testing process could be rendered meaningless. To begin with, there is the question of where within a household would the testing take place? If the antenna is in an attic, it may not be easily accessible for conducting the test at its location. Then, what if modifications are made to the house, such as new siding or a new roof. Would that subject the household to additional testing? And what if there are several televisions in the household using different antennas? In that situation, it is possible to

[221] *Id.* at 9.

[222] 47 U.S.C. § 339(a)(2)(D)(vii) specifies the dates on which the measurement of stations' signals may begin for the purpose of determining if a household is unserved. The earliest measurement date is April 30, 2006 for stations in top 100 markets that have chosen a tentative digital channel that is the same as its current digital channel or have lost interference protection and not been granted a testing waiver.

conceive a scenario where one television could be eligible for receiving a distant signal and another could be ineligible. Further, there is the issue of what antenna to use for testing. EchoStar suggests using a typical antenna, but does not define a typical antenna. An essential part of the test system cannot be left to choice. A good test must be repeatable. There are too many elements of variation in an indoor measurement that would render such a test essentially meaningless.

126. In addition, the Commission is on record that it expects households to make similar efforts to receive digital television as they made for analog. There is good reason for this position. If it was expected that households could do less, then it could have the effect of drastically shrinking the service areas of television stations. Or, as discussed above, to keep the same service area, stations would need to significantly increase their power, which could lead to interference situations. Neither of these outcomes is desirable. Additionally, many stations already have fully operational digital television facilities that have been built based on the rules and policies in place. It is our opinion that forcing these stations to change now would have an unknown effect on the number of households considered unserved and could have the effect of stifling the transition to digital television. For the reasons articulated above, we recommend that the measurement procedures for determining whether a household is unserved not include provisions for indoor testing.

127. Concerning antenna pointing, we continue to believe that for testing purposes of determining if a household is unserved under SHVERA, the procedures should remain consistent with those in use today. As with the suggestion above regarding the use of indoor antennas, we believe that it would be arbitrary to allow for any practice other than pointing the antenna in the direction of maximum signal strength. To allow other antenna orientation would not satisfy good engineering practice as the outcome would be subject to the individual tester rather than being objective. Further, as discussed above, rotors are readily available at reasonable cost (approximately $55-$100).[223] Thus, there is no undue burden on households to use a rotor. To move away from current practice, especially in a manner that is subjective, for the purpose of determining if a household is unserved under SHVERA would have the effect of treating similarly situated households differently depending on the particular person conducting the measurement. Thus, we recommend that the measurement procedure not be modified with respect to the requirement to orient the test antenna in the direction of maximum signal strength.

128. We do not recommend that the digital television measurement procedures for determining if a household is unserved under SHVERA include adjustments for multipath or time variability as suggested by EchoStar. As the NAB states, our planning factors are already conservative and overestimate available signal strength. Thus, any variation in the signal values due to multipath, white noise enhancement, or time variability are already more than compensated for. In addition, if a time variability factor is added, a long term study possibly over several years would need to be conducted for it to be properly characterized. By the time such a study could be completed, it is likely that the transition to digital television would be near completion. Furthermore, many digital television stations have been operational for some time now and there is no evidence that the current minimum signal strength values have been inadequate over time.

129. Finally, we note that commenters did not address co-channel or adjacent channel interference or clutter with respect to measurement. However, on this point, we note that the Commission's channel allotment procedures were designed to minimize the possibilities of this type of interference. In addition, television manufacturers are aware of the planning factors and the Commission's rules regarding interference levels and account for interference in their receiver designs by adjusting the receiver selectivity and adjacent channel rejection characteristics of the receiver. We also

[223] Network Affiliates comments, exhibit 3 (rotors).

observe that, if interference is present whether from other television channels, clutter, etc., when conducting a measurement, then that interference is directly included in the measurement result. Thus, no special provisions are necessary in the measurement procedures.

130. *Summary of Field Strength Measurement Procedure Recommendations.* As stated above, the current measurement rules are specific to analog television and must be updated to properly provide for measurement of digital television signals. Based on the comments received as well as our own evaluation, we recommend that the procedures for measuring digital television signals generally be similar to the current analog procedures which have been in use for some time with good results. Certain modifications are needed, however, to address differences in the analog and digital television signals. These modifications include the measurement of average power in the 6 MHz channel rather than measurement of the analog video carrier and determination of whether a household is unserved based on comparison of measured field strengths to the DTV noise-limited field strength standards rather than the analog Grade B field strength standards. In addition, we recommend that the DTV measurement procedures allow the use of any i.f. bandwidth so long as it is not greater than 6 MHz bandwidth of the DTV channel.

131. Because the current test procedures are set forth in the Commission's rules, these changes can only be implemented via a rule making proceeding. Because measurements of station's digital signals may begin as early as April 2006, the Commission will explore, in the near future, the rule changes necessary to establish proper procedures for testing the strength of digital television signals in such a rule making proceeding. We provide a brief description of the measurement procedure that we believe should be used for the evaluation of digital television signals below:

- Test antenna - The test antenna shall be either a standard half-wave dipole tuned to the center frequency of the channel being tested or a gain antenna, provided its antenna factor for the channel(s) under test has been determined. Use the antenna factor supplied by the antenna manufacturer as determined on an antenna range.

- Testing locations - At the test site, choose a minimum of five locations as close as possible to the specific site where the site's receiving antenna is located. If there is no receiving antenna at the site, choose a minimum of five locations as close as possible to a reasonable and likely spot for the antenna. The locations shall be at least three meters apart, enough so that the testing is practical. If possible, the first testing point should be chosen as the center point of a square whose corners are the four other locations. Calculate the median of the five measurements (in units of dBu) and report it as the measurement result.

- Multiple signals - If more than one signal is being measured (*i.e.*, signals from different transmitters), use the same locations to measure each signal.

- Measurement procedure - Measurements shall be made in accordance with good engineering practice.

- Testing equipment set-up – Perform an on-site calibration of the test instrument in accordance with the manufacturer's specifications. Tune a calibrated instrument to the center of the channel being tested. Measure the integrated average power over the full 6 megahertz bandwidth of the television signal. The i.f. of the instrument must be less than 6 megahertz and the instrument must be capable of integrating over the selected i.f. Take all measurements with a horizontally polarized antenna. Use a shielded transmission line between the testing antenna and the field strength meter. Match the antenna impedance to the transmission line at all frequencies measured, and, if using an un-balanced line, employ a suitable balun. Take account of the transmission line loss for each frequency being measured.

- Weather - Do not take measurements in inclement weather or when major weather fronts are moving through the measurement area.

- Antenna elevation - When field strength is being measured for a one-story building, elevate the testing antenna to 6.1 meters (20 feet) above the ground. In situations where the field strength is being measured for a building taller than one-story, elevate the testing antenna 9.1 meters (30 feet) above the ground.

- Antenna orientation - Orient the testing antenna in the direction which maximizes the value of field strength for the signal being measured. If more than one station's signal is being measured, orient the testing antenna separately for each station.

- Test Records - Written record shall be made and shall include at least the following: 1) a list of calibrated equipment used; 2) detailed description of the calibration of the measuring equipment, including field strength meters, measuring antenna, and connecting cable; 3) all factors which may affect the recorded field, such as topography, height and types of vegetation, buildings, obstacles, weather, and other local features for each spot at the measuring site; 4) a description of where the cluster measurements were made; 5) the time and date of the measurements and signature of the person making the measurements; and 6) a list of the measured value of field strength (in units of dBu and after adjustment for line loss and antenna factor) of the five readings made during the cluster measurement process, with the median value highlighted for each channel being measured.

V. PREDICTIVE MODELING

132. Currently, households have two methods of determining if they are unserved by a local analog television signal: predictive modeling and testing. Predictive modeling is a simple, cost-effective method for determining if a signal at a given location meets certain criteria for availability, such as its strength over a percentage of time. The Commission has established a predictive model that evaluates the coverage and interference of a particular digital TV station. This model, described in OET Bulletin 69, uses the Longley-Rice radio propagation model to make predictions of radio field strength at specific geographic points based on the elevation profile of terrain between the transmitter and each specific reception point.[224] The Commission, in accordance with SHVIA, has also implemented the use of a modified Longley-Rice model known as the "Individual Location Longley-Rice" (ILLR) model, for identifying unserved households attempting to receive analog broadcast signals.[225] We implemented an improved version of the ILLR model in order to make the predictive model more accurate by taking terrain features (such as hills), buildings, and land cover (such as forests) into account.[226]

133. The ILLR model has proven over time to be an accurate and reliable predictor of signal strength and has been well accepted by both the broadcast and DBS industries. In the current satellite distant signal eligibility scheme for analog television signals, predictive modeling is used first to determine a household's status as served or unserved by a local television signal. Based on the model's results a household may request an actual field measurement if it believes the predictive modeling is not an accurate predictor of actual conditions. Under the SHVERA, Congress provided that eligibility

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[224] *See* OET Bulletin 69, "Longley-Rice Methodology for Evaluating TV Coverage and Interference". A computer is needed to make these predictions because of the large number of reception points that must be individually examined. Computer code for the Longley-Rice point-to-point radio propagation model is published in an appendix of NTIA Report 82-100, A Guide to the Use of the ITS Irregular Terrain Model in the Area Prediction Mode, authors G.A. Hufford, A.G. Longley and W.A. Kissick, U.S. Department of Commerce, April 1982. Some modifications to the code were described by G.A. Hufford in a memorandum to users of the model dated January 30, 1985. With these modifications, the code is referred to as Version 1.2.2 of the Longley-Rice model. This version is used by the FCC for its evaluations.

[225] *See* OET Bulletin 72, "The ILLR Computer Program". OET Bulletin 72 details the computer program that the Commission was instructed by Congress to established under SHVIA in Section 339(c)(3) of the Communication Act. It provides that "[i]n prescribing such model, the Commission shall rely on the Individual Location Longley-Rice (ILLR) model set forth by the Federal Communications Commission in Docket No. 98-201 and ensure that such model takes into account terrain, building structures, and other land cover variations." *See* also *See Satellite Delivery of Network Signals to Unserved Households for Purposes of the Satellite Home Viewer Act; Part 73 Definition and Measurement of Signals of Grade B Intensity*, Report and Order, CS Docket No., 98-201, 14 FCC Rcd 2654 (1999). A computer is needed to make these predictions because of the large number of reception points that must be individually examined. Computer code for the ILLR point-to-point radio propagation model is published in an appendix of NTIA Report 82-100, *A Guide to the Use of the ITS Irregular Terrain Model in the Area Prediction Mode*, authors G.A. Hufford, A.G. Longley and W.A. Kissick, U.S. Department of Commerce, April 1982. Some modifications to the code were described by G.A. Hufford in a memorandum to users of the model dated January 30, 1985. With these modifications, the code is referred to as Version 1.2.2 of the Longley-Rice model.

[226] *Id*. The *Inquiry* indicated several features of the improved ILLR model that make it unique. These include: the time variability factor is 50% and the confidence variability factor is 50%; the model is run in individual mode; terrain elevation is considered every 1/10 of a kilometer; the receiving antenna height is assumed to be 20 feet above ground for one-story buildings and 30 feet above ground for buildings taller than one-story; land use and land cover (e.g., vegetation and buildings) is accounted for; where error codes appear, they shall be ignored and the predicted value accepted or the result shall be tested with an on-site measurement; and locations both within and beyond a station's Grade B contour shall be examined.

determinations be made only on the basis of field testing and did not include any provisions for use of predictive modeling. Recognizing the benefits of predictive modeling, however, Congress, in Section 339(c)(1)(B)(iv) of the amended Communications Act, asked the Commission to consider whether to develop a predictive methodology for determining whether a household is unserved by an adequate digital signal under section 119(d)(10) of title 17, United States Code.[227] On a related issue, in Section 339(c)(1)(B)(vi) Congress also requested that the Commission consider whether to account for factors such as building loss, external interference sources, or undesired signals from both digital television and analog television stations using either the same or adjacent channels in nearby markets, foliage, and man-made clutter.[228]

134. To examine these issues, the Commission, in the *Inquiry*, requested comment on whether the improved ILLR model, with appropriate modifications, would accurately predict digital signal coverage at a specific location, or whether there is some other predictive model that would be more appropriate for this purpose. The Commission asked that commenters who propose either specific modifications to the improved ILLR model or alternative models provide detailed analysis as to how their proposed modifications will improve the ILLR model's prediction characteristics and/or an explanation of how the changes or alternatives would more accurately model the available signal level when accounting for terrain and possible signal interference.

135. *Inquiry Record*: The parties commenting in our Inquiry were supportive of the Commission developing a predictive model. For example, DirecTV states that the most important lesson from the last decade of distant network signal qualification with regard to analog television is that predictive modeling is better than on-site testing. EchoStar submits that it appears that the predictive methodology currently used in the SHVA context, *i.e.*, the ILLR model, has considerable applicability to the DTV world, although there remain improvements that might be made to accommodate reliable DTV reception. In supporting the ILLR model, the Network Affiliates explain that on-site testing is not the norm today[229] and that on-site testing frustrates and inconveniences subscribers, costs more money than it is worth, and should only be used as a last resort.[230] DirecTV describes the current process as one in

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[227] See 47 U.S.C. § 339(c)(1)(B)(iv). 17 U.S.C. § 119(d)(10) provides the following definition of unserved household:

> *(10) Unserved household.— The term "unserved household", with respect to a particular television network, means a household that—*
> *(A) cannot receive, through the use of a conventional, stationary, outdoor rooftop receiving antenna, an over-the-air signal of a primary network station affiliated with that network of Grade B intensity as defined by the Federal Communications Commission under section 73.683(a) of title 47 of the Code of Federal Regulations, as in effect on January 1, 1999;*
> *(B) is subject to a waiver granted under regulations established under section 339(c)(2) of the Communications Act of 1934;*
> *(C) is a subscriber to whom subsection (e) applies;*
> *(D) is a subscriber to whom subsection (a)(11) applies; or*
> *(E) is a subscriber to whom the exemption under subsection (a)(2)(B)(iii) applies.*

[228] *See* 47 U.S.C. § 339(c)(1)(B)(vi).

[229] DirecTv states that in last five years only 3,200 customers (0.3%) of those requesting distant network signals asked for an on-site test, and only about 1,400 of those actually received a test. DirecTv comments at 2.

[230] DirecTv comments at 2.

which subscribers must wait at least 30 days after receiving the results of predictive modeling while broadcasters decide whether to grant a waiver for them to receive distant network signals. It states that if such a waiver is denied, then the subscriber must wait until an independent, qualified tester can be identified in their area, wait for the tester to arrange an appointment and wait for the test to take place (and often tests are delayed due to weather or scheduling issues).[231] It further states that because the actual test is of a signal level rather than someone looking at their television picture, customers get frustrated with the testing process.[232] Finally, it provides that testing is a losing proposition as the average cost of a test is approximately $150 (with some as high as $450) and that it takes at least five years to recoup that cost from subscriber revenue.[233]

136. Those that commented on this issue all endorse use of the improved ILLR model that the Commission has already been using. CEA states that the ILLR model is a very good tool with years of engineering development and that it is not aware of any industry discussion regarding a better model for this purpose.[234] The Network Affiliates recommend use of the ILLR model. They state that analog TV coverage is predicated upon this model and the broadcast and satellite industries have five years of experience with its use.[235] However, the NAB and the Network Affiliates submit that a DTV ILLR model should only be used after the transition to digital television is complete. They believe that otherwise the process would be too complicated and confusing.[236] In this regard, the NAB explains that in the short term (prior to the end of the digital transition) problems could arise due to variations in dates that different stations will actually begin broadcasting digital signals.[237] It states that few translator stations have channel assignments, much less fully functioning facilities and many full power stations won't be subject to testing until July 2007 or later.[238] The NAB further states that Congress postponed the date on which many broadcast stations would begin to be subject to testing because Congress recognized that it would be unfair to penalize a station for not delivering a digital signal when it cannot be reasonably expected to do so.[239] It contends that Congress created a complex and somewhat unpredictable schedule for when

[231] *Id.* comments at 2-3.

[232] *Id.* comments at 3-4.

[233] *Id.* comments at 4-l

[234] CEA comments at 4.

[235] Network Affiliates comments at 44-45.

[236] *Id.* comments at 43-44.

[237] NAB comments at vi-vii and 31-33.

[238] *Id.* comments at 31. The testing referred to here is the measurement at an individual subscriber's location of a digital television signal level for the purpose of determining if the subscriber at that location is considered unserved and therefore eligible to receive a distant network signal.

[239] *Id.* comments at 34-35. 47 U.S.C. §˙339(a)(2)(D)(vii) provides trigger dates for testing. NAB characterizes the schedule set up by Congress as testing to begin on April 30, 2006, for stations in top 100 markets that have chosen a tentative digital channel that is the same as its current digital channel and have not been granted a testing waiver and for stations in top 100 markets that have been found to have lost interference protection. Testing begins on July 15, 2007 for stations in top 100 markets that have chosen a tentative digital channel different from its current digital channel and have not been granted a testing waiver and for stations below the top 100 markets that have not been granted a testing waiver. Finally, there are unknown future dates for translator stations – one year after the date on which commission completes all actions necessary for allocation and assignment of digital television licenses to translator stations; and for full power stations with testing waivers – continue to be exempt from testing as long as extensions of waivers are approved.

stations would be subject to testing in order to protect stations from a draconian loss of viewers due to circumstances beyond their control. On this point, the NAB argues that since Congress barred site testing of certain station's digital signals, it would be equally improper to subject those stations to predictions of the signal strength of those same signals.[240] The Network Affiliates offer similar comments.[241] The NAB further comments that it believes that what Congress intended here is that if a station is not yet eligible to have its digital signal evaluated, then the analog signal should be evaluated instead. This, the NAB and the Network Affiliates aver, would be the logical way to give stations "credit" for coverage when they have been excluded from testing.[242]

137. The NAB continues that the ILLR model should be used in the long term (after the digital transition) because it does exceptionally well at predicting whether or not particular locations will receive a signal above the DTV minimums. It states that the model provides correct predictions 95% of the time and that when errors do occur they are evenly divided between over and under predictions.[243] MSW draws a similar conclusion for use of the ILLR model with respect to DTV. It studied real world empirical data from thousands of measurements in 12 different U.S. cities and submits that the data shows that the Longley-Rice model correctly predicted 94.4% of the time when the signal would be above the DTV minimum.[244]

138. EchoStar submits that changes are needed in the ILLR predictive model to make it suitable for use in predicting the availability of DTV signals. It states that the model should be modified to include an improved time variability factor and to incorporate more realistic values for system noise, building penetration, and land cover and clutter.[245] EchoStar submits that the analog ILLR model is based on a time variability factor of 50%, which means that the model assumes that a household is unable to receive an analog signal at or above the minimum level about half of the time.[246] It infers that for digital television this similarly means that there will be an inability to receive a digital picture about half the time. EchoStar avers that even a time variability factor of 90% means a subscriber will not have reception for up to 5 weeks a year. As a remedy, it suggests that the model be modified to incorporate an increase in temporal reliability to 99% or more until there is greater experience with digital television.[247] H&E also argues that 90% time reliability seems not to be in the consumer's best interest.[248] The NAB and the Network Affiliates counter EchoStar by stating that changing to a 99% time variability factor amounts to changing the rules in the middle of the game.[249] MSW avers that EchoStar overestimates the

240 *Id.* at 36.

241 Network Affiliates comments at 43-44.

242 NAB comments at 37.

243 *Id.* NAB comments at vi.

244 NAB comments at MSW engineering study at 28.

245 EchoStar comments at 9.

246 As discussed below (and above in the section on signal strength), the signal strength standards in the rules are in fact based on an F(50,90) level of signal availability, which implies that a signal would be available at least 90% of the time, not 50% as EchoStar incorrectly states.

247 *Id.*

248 EchoStar comments at H&E engineering study at 7.

249 NAB reply comments at 8; Network Affiliates reply comments at 8.

impact of the time variability factor. It explains that any loss of service does not occur over the entire service area, but only at outer edges of a television station's service area and even there any outage that occur are not consecutive, nor is the time duration of a particular outage known. MSW states that many instances of service loss will occur during times when no one is watching TV or may be so short as to only cause a momentary disruption. MSW offers that for those households at the edge of the service area, reception can be improved with a mast-mounted low noise amplifier (LNA).[250]

139. With respect to system noise, EchoStar states that the planning factors underlying the Commission's DTV field strength standards assume that the impedance is matched between the receiver and the antenna.[251] It claims that this is rarely the case in practice and that the predictive model should take this into account and use a noise figure increased by 3 dB to correct for this inaccuracy in the planning factors.[252] EchoStar obtains this 3 dB figure by observing that many DTV antennas have voltage standing wave ratio[253] (VSWR) values that exceed 3:1 over much of their design bandwidth and that exceed 2:1 over essentially all of their design bandwidth.[254] On this point, MSW argues that impedance mismatch loss between a TV antenna and receiver as well as a higher digital television receiver noise figure can be mitigated by a mast-mounted LNA. In cases where such losses might be a problem, MSW states that an LNA resolves the matter by isolating the antenna impedance from that of the downlead coaxial cable and the DTV tuner input impedance.[255]

140. EchoStar also argues that the DTV predictive model should account for building penetration. It contends that the H&E study shows building loss at VHF can be as high as 30 dB for high clutter areas. It adds that further study may yield a more complete set of figures on building penetration loss for incorporation into the model, especially for apartment dwellers with indoor antennas.[256] MSW argues that as far as the model is concerned building penetration is irrelevant given that TV service should be established on the basis of an outdoor model and that therefore indoor measurements should not be performed.[257]

141. Finally, on the topic of land use and land clutter, EchoStar notes that the Commission has recognized that incorporation of such factors into the predictive model would increase the model's accuracy. However, it observes that the Commission has set almost all the clutter-loss values for VHF channels to zero. It argues that this is a problem for analog television, but an even larger problem for

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[250] MSW reply comments at 10; Network Affiliates reply comments at 7.

[251] Impedance is the total passive opposition offered to the flow of electric current, *see* Federal Standard 1037C, "Telecommunications: Glossary of Telecommunications Terms, 1996."

[252] EchoStar comments at 10.

[253] Voltage standing wave ratio is the ratio of the maximum to the minimum voltage in a standing wave pattern in a transmission line. VSWR is a measure of impedance mismatch between a transmission line and its load; the higher the VSWR, the greater the mismatch, where a VSWR of 1 corresponds to a perfect impedance match. *See* Federal Standard 1037C, "Telecommunications: Glossary of Telecommunications Terms, 1996."

[254] EchoStar comments at H&E engineering statement at 11-12.

[255] MSW reply comments at 14.

[256] EchoStar comments at 10.

[257] MSW reply comments at 14.

digital because if the signal level falls below the minimum needed, then the entire picture is lost.[258] NAB notes that the ILLR model is partially based on actual field measurements and thus already takes clutter into account to a significant degree because clutter affects real world field measurements. It also states that the ILLR model is already in balance at low-VHF and so no additional factors to adjust for clutter loss are needed.[259]

142. *Evaluation.* When it enacted the SHVIA, Congress explicitly provided for the Commission to prescribe a predictive model to evaluate if a household is unserved by an analog television signal. That model – the modified individual location Longley-Rice propagation model - has served the industry well as it has proven to be highly accurate over time. Through the use of this model, both consumers and terrestrial and satellite television operators have saved considerable time, money, and frustration that would come with having to conduct an actual measurement test every time a satellite customer believes that he/she is unable to receive an adequate signal off-the-air from a local television network affiliated station. The same situation is likely to exist with regard to digital television signals. Therefore, we recommend that Congress provide for the Commission to explore a similar model for digital television through a rule making proceeding.

143. Those commenters that provided input on this issue were all in agreement that a predictive model should be available for determining if a household is unserved by a digital television signal and that the model be the ILLR. We agree with those comments. The Longley-Rice propagation model has been used for considerable time and it has proven to be highly accurate at predicting the field strengths of television stations at a location. This is illustrated by the data presented by the commenters showing an accuracy rate of almost 95%.[260] Additionally, because the standard Longley-Rice point-to-point coverage model was used to develop the digital television allotment plan, the industry already has considerable practice using this model for digital television in addition to the experience gained for analog television over the last few years. And since there do not seem to be any candidate models that would offer superior performance to the improved ILLR propagation model, a change at this point in time would entail substantial development and testing which would likely not be completed until after the transition to digital television is complete and a time when the satellite television providers offer local-into-local signals for most, if not all, TV designated market areas (DMAs). It is anticipated that at that point the requirements of SHVERA with respect to distant signal retransmission will be moot in most cases.

144. We note that while endorsing use of the ILLR, NAB and the Network Affiliates advocate its use only after the digital transition is complete, arguing that its use prior to this time would be confusing and serve to penalize stations that transition to broadcasting digital signals later rather than earlier but still in accordance with the prescribed timetable.[261] They argue that local stations that build out their digital facilities at a later time would lose their local viewers to a distant network signal even though they are fully compliant with the law and the Commission's rules. We agree with NAB and the Network Affiliates that the timing governing the use of a predictive model should be consistent with the SHVERA provisions that permit subscribers to receive distant digital signals under specified circumstances. These provisions take account of various factors that could legitimately prevent a station

[258] EchoStar comments at 10-11.

[259] Network Affiliates comments at 44-47.

[260] NAB comments at MSW engineering study at 28.

[261] [add a cite to the NAB and Network Affiliates Comments]

from serving its potential digital service area at this time.[262] The provision of the statute cited by NAB and the Network Affiliates applies to subscribers who are eligible for testing (*i.e.*, subscribers who live within the area predicted to be served by the analog predictive model of a local network station and are seeking a distant digital signal for a station affiliated with the same network as the local network station).[263] This provision further provides that stations that may be subject to a digital signal test may request a waiver from the Commission to prohibit such testing if the station proves that it satisfies the statutory criteria related to unremediable limitations on the station's digital signal coverage.[264] Thus, if Congress amends the statutory provisions to recognize a predictive model with respect to digital signals and provides discretion for the Commission to develop such a model, the appropriate timing for use of the model should also be considered by Congress in conjunction with such legislative changes. Congress could, for example, provide that use of the model would be subject to the same waiver provisions that apply to stations with respect to digital signal testing.[265] We also note that Congress is currently considering legislation to mandate the date on which the transition to digital television would end, which, in turn, is likely to influence the timing for use of a predictive model.

145. There were several suggestions made by commenters for further changing the ILLR model. These include changing the time variability factor, and incorporating different values for system noise figure, building penetration, and land cover and clutter. First, EchoStar argues that the time variability factor for DTV should be increased from 50% to 99%. We first note that the noise-limited contour that defines the digital television service area is based on planning factors which specify use of the F(50, 90) curves, not the F(50, 50) curves as implied by EchoStar; that is the digital signal level is at or above the minimum level at 50% of the locations for 90% of the time, not 50% of the time as suggested by EchoStar.[268] We also note that the 90% availability level defines the edge of a station's service area and that at locations inside this contour the availability percentage would be greater than 90%. Further, as stated by MSW, the time when a signal is below the specified minimum value is likely to occur in small increments, some of which are when viewers are not even watching television. Thus, only a small minority of the total number of viewers may experience outages as high as 10% of the time. We also observe that the 90% availability level has been used to define analog TV service and has historically served viewers well. For these reasons, we do not recommend any changes to the digital television time variability factor for the purposes of SHVERA.

146. EchoStar also argues that the input for the system noise figure to the predictive model should be increased by 3 dB to account for impedance mismatch between the antenna and the receiver. We agree with EchoStar that there may be some loss in the transmission line and associated balun due to impedance mismatch. However, we do not believe that this loss is significant or that the predictive model

[262] *See, e.g.*, 47 U.S.C. § 339(a)(2)(D)(viii). These provisions further recognize that household digital signal testing with respect to translators is on a different schedule from full power stations. 47 U.S.C. § 339(a)(2)(D)(vii)(II).

[263] 47 U.S.C. § 339(a)(2)(D)(vii)(I).

[264] 47 U.S.C. § 339(a)(2)(D)(viii). *See also* 47 U.S.C. § 339(a)(2)(D)(ix) (providing special waiver provision for translator stations).

[265] 47 U.S.C. § 339(a)(2)(D)(viii), (ix).

[268] *See* 47 C.F.R. § 73.622(e).

input needs to be modified to account for such loss. First, as NAB states and we discuss above, our planning factors are conservative in that the available coaxial cable generally have losses less than those assumed in the planning factors.[269] Second, there are readily available devices that consumers can use, including LNAs, to reduce mismatch in the transmission line and thus reduce such loss. We also believe that the other planning factors such as antenna gain and receiver noise performance are generally conservative such that together there is sufficient margin to compensate for any signal losses that may result from impedance mismatching. We therefore see no reason that the system noise figure should be increased for the purpose of using a predictive model to determine if a household is unserved.

147. Another area where EchoStar seeks changes in the improved ILLR predictive model is signal loss from building penetration. We disagree that this model should be augmented to account for signal loss from building penetration. As discussed above in the section on signal measurement, the channel allotment plan for digital television is based on the assumption that an outdoor antenna is used and the expectation that households will make similar efforts to receive digital television as they made for analog. Thus, any predictive modeling must reflect these assumptions consistent with the digital television planning factors. Otherwise, inaccurate results will ensue which could have the effect of decreasing confidence in the model. In addition, there is no accepted value for modeling the loss for building penetration as this phenomenon varies depending on the building materials, configuration of the structure, and other related factors. For these reasons, and given our recommendation in the section on measurement procedure that all measurements continue to be conducted outside, there is no reason for a predictive model to assume any building penetration loss. Therefore, we do not recommend that the model input reflect any such losses.

148. The last area where commenters seek changes in the predictive model is with respect to land use and land clutter. Currently, the predictive model used for analog television accounts for additional signal loss due to land use and land clutter. In developing the land use and land clutter adjustment values, the Commission determined, after careful consideration of the available data, that the correct loss value for VHF channels is 0 dB in all cases and for UHF channels the loss values vary depending on the type of land cover over which the television signal propagates.[270] EchoStar argues that in addition to the loss added for UHF channels, there should be some loss associated with VHF channels. NAB and the Network Affiliates argue otherwise and take the position that the improved ILLR model already takes clutter into account to a significant degree because the model is partially based on actual field measurements and clutter affects real world field measurements. Any predictive model that is prescribed should provide output that is as accurate as possible; anything less would diminish its value as a tool for determining whether a household is able to receive off-the-air digital television signals. For the analog model, we believe that we struck the correct balance for clutter loss. This has been borne out by the data on the record of its performance, which shows that using the values adopted by the Commission the ILLR model produces approximately an equal number of over predictions as under predictions.[271] Thus, a range of values, including zero, that correspond to different land cover types are valid. For any digital model that may be developed, we believe that the values currently in use for the analog model will similarly yield accurate results. We believe that the proper arena for discussing correct clutter loss values is in a rule making proceeding. Therefore, we believe that a range of clutter loss values ranging from zero upwards may all be valid inputs for a version of the ILLR model that is used for predicting the availability of digital television signals and recommend that clutter loss values be determined and then incorporated

[269] NAB reply comments at 11.

[270] *See ILLR First Report and Order* at ¶¶ 14-15.

[271] *Id.*

into the digital model through a process similar to that used to determine the clutter loss values used in the analog TV ILLR model.

149. *Summary of Predictive Model Recommendations.* In summary then, we recommend that Congress amend the copyright and Communications Act to recognize digital signal strength predictions for the purpose of determining whether a subscriber is "unserved." We also recommend that Congress provide the Commission with authority to develop a predictive model for the purpose of determining households that are unserved by local digital signals for purposes of determining eligibility to receive retransmitted distant network signals under the SHVERA. For such purpose, we recommend that the existing Individual Location Longley-Rice (ILLR) predictive model be used. This model has been used to develop the channel allotment plan and we do not believe that any additional changes to the model inputs are necessary for purposes of SHVERA.

APPENDIX A

Section 339(c)(1) of the Communications Act of 1934, As Amended

Section 339(c)(1) of the Communications Act of 1934, as amended by the SHVERA, provides as follows:

(1) STUDY OF DIGITAL STRENGTH TESTING PRODEDURES-

(A) STUDY REQUIRED- Not later than one year after the date of the enactment of the Satellite Home Viewer Extension and Reauthorization Act of 2004, the Federal Commissions Commission shall complete an inquiry regarding whether, for purposes of identifying if a household is unserved by an adequate digital signal under section 119(d)(10) of title 17, United States Code, the digital signal strength standard in section 73.622(e)(1) of title 47, Code of Federal Regulations, such statutes or regulations should be revised to take into account the types of antennas that are available to consumers.

(B) STUDY CONSIDERATIONS- In conducting the study under this paragraph, the Commission shall consider whether--

(i) to account for the fact that an antenna can be mounted on a roof or placed in a home and can be fixed or capable of rotating;
(ii) section 73.686(d) of title 47, Code of Federal Regulations, should be amended to create different procedures for determining if the requisite digital signal strength is present than for determining if the requisite analog signal strength is present ;
(iii) a standard should be used other than the presence of a signal of a certain strength to ensure that a household can receive a high-quality picture using antennas of reasonable cost and ease of installation;
(iv) to develop a predictive methodology for determining whether a household is unserved by an adequate digital signal under section 119(d)(10) of Title 17, United States Code;
(v) there is a wide variation in the ability of reasonably priced consumer digital television sets to receive over-the-air signals, such that at a given signal strength some may be able to display high-quality pictures while others cannot, whether such variation is related to the price of the television set, and whether such variation should be factored into setting a standard for determining whether a household is unserved by an adequate digital signal; and
(vi) to account for factors such as building loss, external interference sources, or undesired signals from both digital television and analog television stations using either the same or adjacent channels in nearby markets, foliage, and man-made clutter.

(C) REPORT- Not later than one year after the date of the enactment of the Satellite Home Viewer Extension and Reauthorization Act of 2004, the Federal Communications Commission shall submit to the Committee on Energy and Commerce of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate a report containing—
(*i*) the results of the study under this paragraph; and
(*ii*) recommendations, if any, as to what changes should be made to Federal statutes or regulations.

APPENDIX B

Parties Submitting Comments and Reply Comments

Parties Submitting Comments

1. ABC, CBS, NBC, Network Affiliates
2. The Association for Maximum Service Television, Inc.
3. ATI Technologies, Inc.
4. Consumer Electronics Association (CEA)
5. DIRECTV Inc.
6. EchoStar Satellite L.L.C.
7. National Association of Broadcasters (NAB)
8. Paul Robinson
9. Viamorph

Parties Submitting Reply Comments

1. ATI Technologies, Inc.,
2. ABC, CBS, and NBC Television Affiliate Associations
3. Cohen, Dippell and Everist, P.C.,
4. EchoStar Satellite L.L.C.,
5. National Association of Broadcasters

APPENDIX C

Tests of ATSC 8-VSB Reception Performance of Consumer Digital Television Receivers Available in 2005

November 2, 2005

Technical Research Branch
Laboratory Division
Office of Engineering and Technology
Federal Communications Commission

OET Report
FCC/OET TR 05-1017

Prepared by:
Stephen R. Martin

FOREWORD

The author gratefully acknowledges the advice and technical support offered by the following individuals and organizations. Gary Sgrignoli and Dennis Wallace of MSW provided technical guidance at the inception of the project, and Gary Sgrignoli also provided guidance later and reviewed an early draft of this report. Mark Hryszko, Mike Gittings, Raul Casas of ATI Research, Inc. identified degraded performance of the FCC's RF capture player (which was subsequently repaired and calibrated before conducting the tests reported herein) and provided technical advice; Mark Hryszko and Kevin Murr assisted in comparative testing at ATI's laboratory using ATI's equipment as a double-check of the FCC equipment and measurement procedures for the FCC Laboratory tests reported herein. Wayne Bretl of Zenith Electronics Corp. and Rich Citta of Micronas Semiconductors, Inc. provided technical advice regarding testing with RF captures. Victor Tawil of the Association for Maximum Service Television (MSTV) and Sean Wallace of Wavetech Services, LLC provided RF captures and technical advice.

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EXECUTIVE SUMMARY

This report presents the results of laboratory tests of over-the-air digital (ATSC/8-VSB*) reception performance of 28 consumer digital television (DTV) receivers. The tests were performed to provide an empirical basis for answering questions about DTV reception capability that derive from study requirements imposed by Congress as part of the *"Satellite Home Viewer Extension and Reauthorization Act of 2004"* (SHVERA). The Act requires that the FCC conduct a six-element study. The element relevant to this report is as follows:

> *"consider whether ... there is a wide variation in the ability of reasonably-priced consumer digital television sets to receive over-the-air signals, such that at a given signal strength some may be able to display high-quality pictures while others cannot, whether such variation is related to the price of the television set, and whether such variation should be factored into setting a standard for determining whether a household is unserved by an adequate digital signal."*

SAMPLES

Two categories of DTV receivers were acquired for this project: digital set-top boxes (STBs) and DTVs with integrated over-the-air ATSC tuners. All receivers are standard, off-the-shelf consumer products currently on the market. STBs were included in the study because connection of an STB to an existing television represents the lowest-cost alternative for DTV reception. The measurement results in this document are reported by category (STB or integrated DTVs) and, within the DTV category, by price range ($370 - $1000, $1001 - $2000, and $2001 - $4200). Brands and model numbers are not reported.

TEST RESULTS

The tests performed for this report were laboratory-based measurements emulating two types of over-the-air reception conditions for DTV receivers:

(1) Unimpaired signal (i.e., no multipath) [Chapters 3 – 5], and

(2) Signal impaired by multipath (ghosts) [Chapter 6].

The unimpaired signal measurements can be used to quantitatively predict receiver performance under benign reception conditions—i.e., with little multipath or interference. The multipath tests, which focus primarily on particularly difficult multipath conditions, provide a basis for comparing the ability of different DTV receivers to handle difficult multipath conditions. A link between these laboratory-based measurements and earlier FCC field-test data provides a basis for anchoring the multipath results to representative, real-world reception conditions [Chapter 7].

Benign Multipath Conditions

Overall performance under benign reception conditions is indicated by minimum signal level at the threshold of visibility of errors (TOV) for each receiver. The median measured values of this parameter across all of the tested consumer DTV receivers were -82.2 dBm, -83.2 dBm, and -83.9 dBm, respectively, in the low-VHF, high-VHF, and UHF bands. These values comply, within measurement accuracy, with the -83 dBm minimum performance standard recommended by the ATSC. The corresponding medians for just the low-cost category of DTVs (-83.3 dBm, -83.4 dBm, and -84.1 dBm, respectively) were very slightly better than the medians across all of the receiver categories.

* 8-level Vestigial Side Band (8-VSB) is the over-the-air digital television (DTV) transmission format recommended by the Advanced Television Systems Committee (ATSC) and adopted by the FCC as the U.S. standard for terrestrial DTV transmission.

OET Bulletin No. 69, *"Longley-Rice Methodology for Evaluating TV Coverage and Interference"*, presents a methodology for predicting whether a household is served by a given broadcast signal. The DTV receiver model in that bulletin predicts minimum signal levels at TOV of -81.0 dBm and -84.0 dBm for VHF and UHF, respectively. While the test results presented in this report—together with data based on earlier FCC field tests—could be used to fine tune those parameters, the net effect of such changes would be small; consequently, no compelling reason is seen for such fine tuning.

Variation in minimum signal at TOV among the receivers was found to be moderately high in the low-VHF band, but small in the high-VHF and UHF bands.

In the low VHF band (as represented by TV channel 3 in these tests), the moderately high variability in performance among the samples is indicated by the 3.7-dB standard deviation among the receivers and the fact that two same-brand receivers exhibited performance significantly worse than the median—by 11 and 12 dB. (It is noted that, absent those two receivers, the standard deviation would have been a more modest 2.3 dB.)

Though the performance variation among the receivers in the low VHF band was moderately high, no statistically significant price-dependence of that variation was found. In fact, the median performance of the low-cost TVs was slightly better than that of either the mid-priced or high-priced TVs. The median performance of the tested set-top boxes was poorer than that of the integrated DTVs by 2.3 dB, though it must be noted that these were older designs (2004 and earlier models that were still on the market at the time of this report) than the integrated DTVs.

In the high-VHF and the UHF bands (represented in the tests by channels 10 and 30, respectively), the variation in reception performance among the tested receivers was small—as indicated by the 1.6-dB standard deviation in the high-VHF band and 0.9 dB in the UHF band. The variation of performance with price was judged to be both small and not statistically significant. The median performance of the high-cost TVs differed from that of the low-cost TVs by less that 0.2 dB. Set top boxes exhibited median performance 0.6 dB and 0.7 dB worse than the median of all TVs in the low-VHF and UHF bands, respectively.

Most of the variation in reception performance among the tested receivers was due to differences in *effective* noise figure rather than in the carrier-to-noise ratio (CNR) required for successful demodulation. The noise figure variations were larger than the required-CNR variations by factors ranging from 4, in the UHF band, to 16, in the low-VHF band.

Difficult Multipath Conditions

The tested receivers fall into two distinct tiers of multipath-handling capability—the upper tier representing a significant performance improvement associated with at least two companies' newest generation of demodulator chips. While the difference in ability to handle difficult multipath conditions between the two tiers is large, linkage of the current results with earlier field test results (Chapter 7) suggests that the observed performance differences are of no consequence in the vast majority of reception locations, if an outdoor, mast-mounted antenna is used. When an indoor antenna is used, the linkage suggests that the observed performance differences would be significant in many, but probably not most, locations.

Given that both tiers of performance appeared in all three price ranges of DTVs, there appears to be no price dependence of multipath performance; however, there was a complete absence of upper-tier performers among the tested set-top boxes. This absence is attributed to the older designs of the set-top box products—all of which were introduced in the year 2004 or earlier. Among the tested DTV receivers, none that were introduced before March 2005 were found to exhibit upper-tier performance, whereas 48 percent of those introduced in or after that month performed at the upper tier level.

CHAPTER 1
INTRODUCTION

BACKGROUND

This report presents the results of laboratory tests of terrestrial over-the-air digital (ATSC/8-VSB*) reception performance of 28 consumer digital television (DTV) receivers. Though the tests involve terrestrial reception performance, the tests were performed to provide an empirical basis for answering questions about DTV reception capability that derive from study requirements imposed by Congress as part of the *"Satellite Home Viewer Extension and Reauthorization Act of 2004"* (SHVERA).

SHVERA, passed by Congress in December 2004, extends and amends the *"Satellite Home Viewer Act of 1994"*. The Act allows satellite communications providers to provide broadcast programming to satellite subscribers that are unserved by local—over-the-air—broadcast stations.

Section 204 of SHVERA requires that the Commission conduct an inquiry regarding "whether, for purposes of identifying if a household is unserved by an adequate digital signal under section 119(d)(10) of title 17, United States Code, the digital signal strength standard in section 73.622(e)(1) of title 47, Code of Federal Regulations, or the testing procedures in section 73.686(d) of title 47, Code of Federal Regulations, such statutes or regulations should be revised to take into account the types of antennas that are available to consumers."

The act specifies six areas of inquiry. The relevant area for this report is the one that relates to characteristics of consumer digital television receivers. It states that the inquiry should

> *"consider whether ... there is a wide variation in the ability of reasonably-priced consumer digital television sets to receive over-the-air signals, such that at a given signal strength some may be able to display high-quality pictures while others cannot, whether such variation is related to the price of the television set, and whether such variation should be factored into setting a standard for determining whether a household is unserved by an adequate digital signal."*

The Act requires that the results and recommendations from this inquiry be reported to the Committee on Energy and Commerce of the House of Representatives and the Committee on Commerce, Science, and Transportation of the Senate.

OBJECTIVES

This report presents the results of a measurement program that was undertaken by the Technical Research Branch of the FCC Laboratory in order to address those portions of the SHVERA-required inquiry that involve characteristics of consumer digital television receivers. Accordingly, the objectives are to provide an empirical basis for answering three questions.

* 8-level Vestigial Side Band (8-VSB) is the over-the-air digital television (DTV) transmission method recommended by the Advanced Television Systems Committee (ATSC) and adopted by the FCC as the U.S. standard for terrestrial DTV transmission.

(1) Is there a wide variation in the ability of reasonably-priced consumer digital television sets to receive over-the-air signals, such that at a given signal strength some may be able to display high-quality pictures while others cannot?
(2) Is such variation is related to the price of the television set?
(3) Should such variation be factored into setting a standard for determining whether a household is unserved by an adequate digital signal.

ABILITY TO RECEIVE SIGNALS

The ability of a television receiver to receive over-the-air signals and display a high quality picture is influenced by the level and quality of the television signal reaching its antenna input terminal from the antenna downlead, the amount of noise or interference reaching the input terminal, and the properties of the television receiver—including the amount of noise created by the input circuitry of the television receiver.

Threshold

When a television receives a signal from an analog TV station using the NTSC transmission system that has been employed in the U.S. for decades, the TV exhibits a noisy picture at low signal levels. The noise is frequently termed "snow". If the signal level increases, the amount of snow in the picture decreases very gradually. If signal level is increased until it exceeds the internally generated noise of the television's input circuits by 34 dB (carrier-to-noise ratio = 34 dB), the picture level improves to the point that typical viewers consider the noise to be "slightly annoying".[*] The noise remains perceptible but is not considered annoying at a 40-43 dB carrier-to-noise ratio,[†] and ceases to be visible at all when the carrier-to-noise ratio (CNR) is 51 dB.[‡]

When a digital television receives a signal from a digital television station using the ATSC transmission system adopted by the FCC for terrestrial DTV broadcasts in the U.S., the transition from no picture to a virtually perfect picture occurs over a much narrower range of signal levels. Once a threshold signal level is reached, the TV picture is virtually perfect—limited only by the quality of the source material and the characteristics of the television display (for example, the picture tube and associated image forming circuits and software). This threshold corresponds to a carrier-to-noise ratio of only about 15 dB. If the signal is reduced below this threshold value, visible errors begin to occur in the picture—becoming more frequent with further reductions in signal level, until the picture becomes essentially unusable at a level only about 1 dB below the threshold.

Part of the task of determining the ability of a DTV receiver to receive over-the-air signals is to determine this threshold when only a DTV signal is applied to the antenna terminal (i.e., without any noise or interfering signals), as well as when both a DTV signal and source of electronic noise are applied simultaneously to the antenna terminal. The resulting measured parameters are the minimum signal at the threshold of visibility of errors (TOV) and the white noise threshold—also known as the required carrier-to-noise ratio (CNR).

[*] Citta, Richard, and Sgrignoli, Gary, "ATSC Transmission System: VSB Tutorial", Montreux Symposium, June 12, 1997, p.8.

[†] Sgrignoli, Gary, "Interference Analysis of Co-Sited DTV and NTSC Translators", IEEE Transactions on Broadcasting, Vol. 51, No. 1, March 2005, p.3.

[‡] Eilers, Carl, and Sgrignoli, Gary, "Digital Television Transmission Parameters-- ATSC Compliance Factors", IEEE Transactions on Broadcasting, Vol. 45, No. 4, December 1999, p.12.