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February 22, 2000

VIA HAND DELIVERY

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Magalie Roman Salas
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Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Re: In the Matter of Establishment of an Improved Model for Predicting the Broadcast Television Field Strength Received at Individual Locations, CS Docket No. 00-11

Dear Ms. Salas:

Please accept for filing the enclosed original and four copies of the Engineering Statement of Jules Cohen submitted in support of the joint Comments of the National Association of Broadcasters and the Association for Maximum Service Television, Inc. in the above referenced proceeding. Mr. Cohen's statement has also been electronically filed, however, because the attached appendices could not be electronically transmitted, we have enclosed paper copies of Mr. Cohen's statement with the attached appendices.

An extra copy is enclosed for date stamping. Thank you in advance for your assistance.

Sincerely yours,

Thomas Olson

Thomas P. Olson

Encl.

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Jules Cohen, P.E.
Consulting Engineer

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FEDERAL COMMUNICATIONS COMMISSION
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ENGINEERING STATEMENT
IN SUPPORT OF COMMENTS
ET DOCKET NO. 00-11

1. Pursuant to a request by the National Association of Broadcasters, an engineering analysis has been made of the proposal in ET Docket No. 00-11 *In the Matter of Establishment of an Improved Model for Predicting the Broadcast Television Field Strength Received at Individual Locations.* This engineering statement describes the results of the analysis.

Summary of Conclusions

2. Reliance on the Rubinstein[1] clutter losses is misplaced for reasons detailed below. Employment of the Longley-Rice model without additional clutter loss factors has been shown by approximately one thousand actual measurements within and in the area surrounding five communities to be a reliable predictor of whether or not an individual location can receive service at a Grade B level or greater. Television channels involved in the measurements included all three television bands: low VHF, high VHF, and UHF.

Inapplicability of the Rubinstein Data

3. Although the Rubinstein clutter loss data may be useful in a land mobile context, **they are** not applicable to television broadcast reception at the heights assumed for

[1] Thomas N. Rubinstein, "Clutter Losses and Environmental Noise Characteristics Associated with Various LULC Categories," *IEEE Transactions on Broadcasting,* Vol. 44, No. 2, September 1998, pp 286-293.

outdoor antennas. In his paper, Rubinstein does not provide information on the height or other characteristics of the land mobile transmitting systems providing the signals that his crews were measuring, nor does he provide the height above ground or a description of the receiving antennas; however, in a private telephone conversation, Mr. Rubinstein advised that, although he could not provide the actual heights of the transmitting land mobile antennas, the transmitting locations were all on "mountains" and the vehicle used to mount the receiving antennas was a station wagon. Rubinstein acknowledges, in his listing of error sources,[2] that "real estate" limitations on the vehicle roof made impossible the spacing of antennas at sufficient distances from each other as to avoid being in the near field of other antennas. In consideration of the type of vehicle used, the vertically-polarized antennas may be presumed to have radiation center heights above ground in the order of 6.5 feet (2 meters).

4. Rubinstein alleges that no "shadowed" locations were used in the survey.[3] Shadowed locations were defined as not complying with a requirement of 0.6 Fresnel zone clearance. But no antenna 2 meters above ground can have 0.6 Fresnel zone clearance at frequencies of 162 MHz or 460 MHz and, only occasionally can such clearance be achieved at 860 MHz. The problem is the presence of the ground in the near vicinity of the receiving antenna. Figure 1 illustrates the problem for the three frequencies used. Absent terrain or man-made obstructions on the path from transmitter to receiver, 0.6 Fresnel zone clearance

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[2] *Ibid*, p. 291.

[3] *Ibid*, p. 287.

can be achieved with antennas 6 and 9 meters above ground, the criteria for single story and multistory residences. The absence of 0.6 Fresnel zone clearance in Rubinstein's testing introduces a loss factor not present for the television receiving antenna. Considering again the land mobile case, Rubinstein's clutter losses may well be appropriate because the land mobile receiving antennas would suffer the same loss even where the path, in general, has Fresnel zone clearance.

5. As stated above, the absence of Fresnel zone clearance at the height of the Rubinstein test vehicle antennas and the presence of Fresnel zone clearance for the television receiving antennas makes the use of the Rubinstein clutter loss data inapplicable to the television case, but this is not the only effect of the height difference. Whether the clutter loss is to be applied in the urban case, where buildings are involved, or a forested situation where concern is with the blockage from trees, loss would be less for the greater heights. Intuitively, in an urban or suburban environment, we can expect that the higher the receiving antenna, the fewer the buildings obstructing the path. Similarly, in the forested case, the antenna at greater height would be expected to be looking through a lesser density of foliage. In addition to this intuitive reaction, a sound scientific principle dictates the lesser clutter loss for the antennas of greater height. When a transmission path is obstructed, the signal that reaches the receiving antenna is by diffraction. The simple sketch appearing as Figure 2 illustrates that the diffraction angle for the lower height is greater than for the lesser height. Diffraction loss increases as the angle of diffraction increases, so the loss measured at one

height is not applicable to heights that are three or more times greater.

6. If median data for the entire country are desired to weigh the impact of different environment classifications, the three areas where Rubinstein collected data are hardly representative of the country as a whole. Southern California at the extreme southwestern corner of the country, Whatcom County at the extreme northwestern corner of the country, and Atlanta, hardly represent a good statistical sample for the country as a whole. For example, the Northeast, with its high population densities and irregular terrain, the Gulf Coast area with its typically high humidity, and the Midwest with its extensive plains are not represented by the sample used.

7. As his base reference, Rubinstein used Okamura[4] rather than Longley-Rice. The Okamura prediction method was developed specifically for land mobile situations and is used widely for that purpose. Longley-Rice would not produce the same base predictions. That disparity alone would be sufficient reason to avoid use of the Rubinstein conclusions unless an analysis could be made showing the differences to be of little consequence. The task would be substantial considering the number of locations involved, but no matter how daunting the task, Rubinstein has not provided sufficient information to make the effort possible. The paper neither contains information on the transmitting systems nor the specific locations of the measuring sites.

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[4] *Ibid* p. 287.

8. Two other factors of significance in rejecting the Rubinstein data for application to the television broadcasting situation are the differences in antennas and frequencies. The land mobile antennas used were omnidirectional in the horizontal plane (except for the pattern distorting effect of nearby antennas) and vertically polarized. Television receiving antennas are directional and horizontally polarized. The use of an omnidirectional antenna, particularly in an urban or suburban setting, increases the effect of multipath. That effect increases the apparent signal loss. A directional antenna properly oriented in the direction of maximum signal strength discriminates against signals from other directions, thus decreasing the effect of multipath on the received signal. Polarization is important because trees and the taller buildings are predominantly vertical. Horizontally-polarized receiving antenna are less affected than vertically-polarized receiving antennas because of their being cross polarized with respect to the dominant obstructions.

9. To Rubinstein's credit, he honestly supplies information that casts doubt on the usefulness of his results even for the land mobile case.[5] His list includes the following: (a) In some LULC categories, little data are available so the potential for error is great. (b) Receiver calibration may have drifted. (c) Some grid categorization may be in error. (d) Errors may have occurred because the terrain data and LULC data were originally sampled on a Universal Transverse Mercator grid whose "... crossings do not precisely register with

[5] *Ibid* pp. 291 and 292.

the Latitude/Longitude crossings used by the prediction algorithm...". (e) "The automated test setup depends on a constant speed to make its measurements." Small increases or decreases in speed may have resulted in varying the sampling intervals between subsamples. (f) The proportional amounts of samples for each sub-category within each main category cannot, as a practical matter, be determined. The example cited is that the "Residential" category includes single family dwellings, apartment buildings, barracks, shacks, etc. (g) Narrow local streets are under-represented. (h) Insufficient room was available on the roof of the vehicle to permit spacing so that antennas were outside the near fields of other antennas. (i) The Okamura model could not be followed precisely. (j) Some vertical errors affecting the existence of shadowing may have been made, and (k) pattern distortions in the transmitting antennas were not taken into account.

Other Matters

10. LULC data are presented for a minimum size of 10-acre tracts in urban and suburban area, but 40-acre tracts in rural areas. Individual locations within even 10 acres may not conform to the category assigned to the entire area. Much of the LULC data are old -- as much as 20 years old. Categories are likely to have changed since the original analysis was made. This aspect of change is bound to continue in consideration of the constant flux of population movement and growth. At the very least, categorizations should be withheld until the data from the current project of mapping the Earth with great detail has been

completed and the data made available in a form that would permit easy access by a computerized process.

Measurements Show that Longley-Rice Predictions Without Clutter Loss Corrections are Highly Reliable

11. Actual measurements made in conformance with 47 C.F.R.§73.686 compared with Longley-Rice predictions are available. Over 600 separate measurements in more than 500 locations were measured and placed in evidence in the matter of CBS *et al* v. PrimeTime 24.[6] In addition, 199 measurements of NTSC transmission on channel 53 and an additional 199 measurements of NTSC transmission on channel 6 were made in connection with the comparison of NTSC and DTV performance as part of the field testing of the "Grand Alliance" DTV system now adopted by the Commission for digital television broadcasting. The total number of measurements thus available in the public record, all made pursuant to procedures prescribed in FCC rules, is approximately one thousand. Those measurements provide data on television channels 3, 4, 6, 7, 11, 13, and 53.

12. Individual Location Longley-Rice (ILLR) calculations were made for each of the approximately 1,000 measurements. For each path, and for each frequency, a calculation of the free space field intensity was made. From that determination, the excess path loss, calculated by use of the Longley-Rice, v1.2.2 Irregular Terrain Model, was subtracted to find

[6] *CBS Inc., et al v. PrimeTime 24 Joint Venture*, U.S. District Court, Southern District of Florida, Case No. 96-3650-CIV-Nesbitt.

the ILLR predicted field strength. Although the ILLR model includes predicted interference from other stations, there is no procedure for testing the presence of interference. SHVA Report & Order, ¶ 57. The ILLR analyses described here therefore do not take interference into account.

13. The set of measurements in the cited court case included: 106 in the Baltimore area with WJZ, Channel 13 as the primary station; 100 locations in the Miami area where both WSVN, Channel 7 and WFOR-TV, Channel 4 were measured; 104 locations in the Pittsburgh area with WPGH, Channel 53 as the primary station; 100 locations in the Raleigh/Durham area with WTVD, Channel 11 as the primary station; and 101 locations in the Charlotte area with WBTV, Channel 3 as the primary station.

14. In the Baltimore area, measurements showed that use of the standard ILLR model correctly predicted the availability of network service of at least Grade B field strength at 97 (91 percent) of the 106 locations, with 4 percent over-predictions and 5 percent under-predictions. In the Miami area, measurements on channels 4 and 7 showed that use of ILLR correctly predicted the availability of network service of at least Grade B field strength at all 100 locations. In the Pittsburgh area, where one of the upper UHF channels was measured in difficult terrain, measurements showed that ILLR correctly predicted the availability of network service of at least Grade B signal strength at 82 (79 percent) of the 104 locations, with 17 percent over-predictions and 4 percent under-predictions. In the Raleigh/Durham

area, measurements showed that ILLR correctly predicted the availability of network service of at least Grade B field strength at 96 (96 percent) of the 100 locations, with no over-predictions and 4 percent under-predictions. In the Charlotte area, measurements showed that ILLR correctly predicted the availability of network service of at least Grade B field strength at 89 (88 percent) of the 101 locations, with 1 percent over-predictions and 11 percent under-predictions.

15. As part of the testing of the "Grand Alliance" Advanced (High Definition) Television System, field tests were conducted using a specially constructed transmitting system. New, nondirectional transmitting antennas were stacked on an existing tall tower near Charlotte, North Carolina. Since a major aspect of the field testing was a comparison of the reception performance of the existing NTSC system of television transmission and the proposed digital system of television transmission, the experimental station was equipped to transmit in both modes. The channels selected for test were VHF channel 6 and UHF channel 53. NTSC field strength measurements were made in accordance with 47 C.F.R. § 73.686. On each of the channels, sixteen measurements were made on each of eight radials at three-mile intervals from approximately 10 to 55 miles (16 to 88 kilometers), 25 measurements were made on each of two grids, one centered on Charlotte and the other centered on Rock Hill, South Carolina, eight measurements were made on each of two clusters within the Charlotte and Rock Hill grids but at closer spacings, and a third cluster of five measurements was made at a relatively close spacing to the transmitter to test the

effect of the vertical plane patterns of the antennas. The total number of field strength measurements was therefore 398, half of which were on each of the two channels used.[7] To assure a valid statistical sampling, measurements were made as close to the three-mile points as feasible on the radials and as close to the grid intersections as feasible in the grids and clusters. No attempt was made to make the measurements in "clear" locations.

16. For channel 6, the foregoing procedure produced the following results: (a) ILLR correctly predicted the presence or absence of Grade B or better field strength at 173 (87 percent) of the 199 locations. (b) 17 (8.5 percent) of the 199 calculations were under-predictions, *i.e.* at the 17 locations measurements showed the presence of at least a Grade B signal although ILLR had predicted a signal of less than Grade B. © At nine locations (4.5 percent) ILLR over-predicted, *i.e.* ILLR predicted signal strength of at least Grade B strength but measurements showed the contrary. (d) Only six locations (7.5 percent) had 0.6 Fresnel zone clearance. (e) None of the locations where ILLR failed to predict correctly the presence or absence of Grade B field strength were locations with at least 0.6 Fresnel zone clearance.

17. For channel 53, the following results were found: (a) ILLR correctly predicted

[7] Results of the measurements can be found in Document SS/WP2-1354 submitted to the SS/WP2 Field Testing Task Force of the Advisory Committee on Advanced Television Service of the of the FCC by the Association for Maximum Service Television, Inc., Cable Television Laboratories, Inc. and the Public Broadcasting Service; September 16, 1994.

the presence or absence of at least Grade B field strength at 161 (80.9 percent) of the 199 locations. (b) Seven (3.5 percent) of the 199 calculations were under-predictions. (c) At 31 locations (15.6 percent) ILLR over-predicted the presence of at least Grade B strength. (d) 53 locations (54.8 percent) had 0.6 Fresnel zone clearance. (e) Only four of the locations(10.5 percent of the failures) where ILLR failed to predict correctly the presence or absence of Grade B field strength were locations with 0.6 Fresnel zone clearance.

18. The ability of Longley-Rice to predict correctly, without the addition of clutter loss factors, the presence or absence of Grade B field strength at particular locations in the vast majority of situations is not surprising. The Longley-Rice Irregular Terrain Model is not just a theoretical construct. The model was tested against field strength measurements and its accuracy was improved by the introduction of empirical factors. Measurements introduced some clutter loss that is now incorporated in the program. The program also takes into account the presence or absence of Fresnel zone clearance.

19. My position is not that clutter loss does not exist. In the earlier days of television broadcasting, my office, and I personally, took many field strength measurements on television stations where owners and engineers were anxious to know whether their systems were functioning properly. Our general experience for a radial passing through a city was that the signal strength within the city appeared to be reduced approximately six decibels from the general trend of the measurements as plotted for the region before entering

the city and after leaving the city.

Conclusions

20. Reliance on the Rubinstein data is misplaced for the television broadcast case. Employment of Okamura to provide a base reference is inappropriate for use in an ILLR context. Further, and of major importance, is the use of a vertically-polarized test receiving antenna height at approximately two meters above ground when data are required for six and nine meters above ground. At two meters, clutter loss is bound to be greater than at the greater heights employed by television receiving antennas, and 0.6 Fresnel zone clearance is not likely to exist for such a low receiving antenna center of radiation.

21. Comparison of Longley-Rice predictions without the addition of clutter loss factors, and over 1,000 actual field strength measurements on television channels in all three bands shows a very high degree of correlation. Furthermore, terrain characteristics varied from the smoothness of the Miami, Florida, area to the extreme irregularity of the Pittsburgh, Pennsylvania, area. For many locations, ILLR under-predicted the availability of at least a Grade B network signal. The addition of an additional clutter loss factor would further tip the scale in favor of the satellite program provider at the expense of the local network broadcast provider.

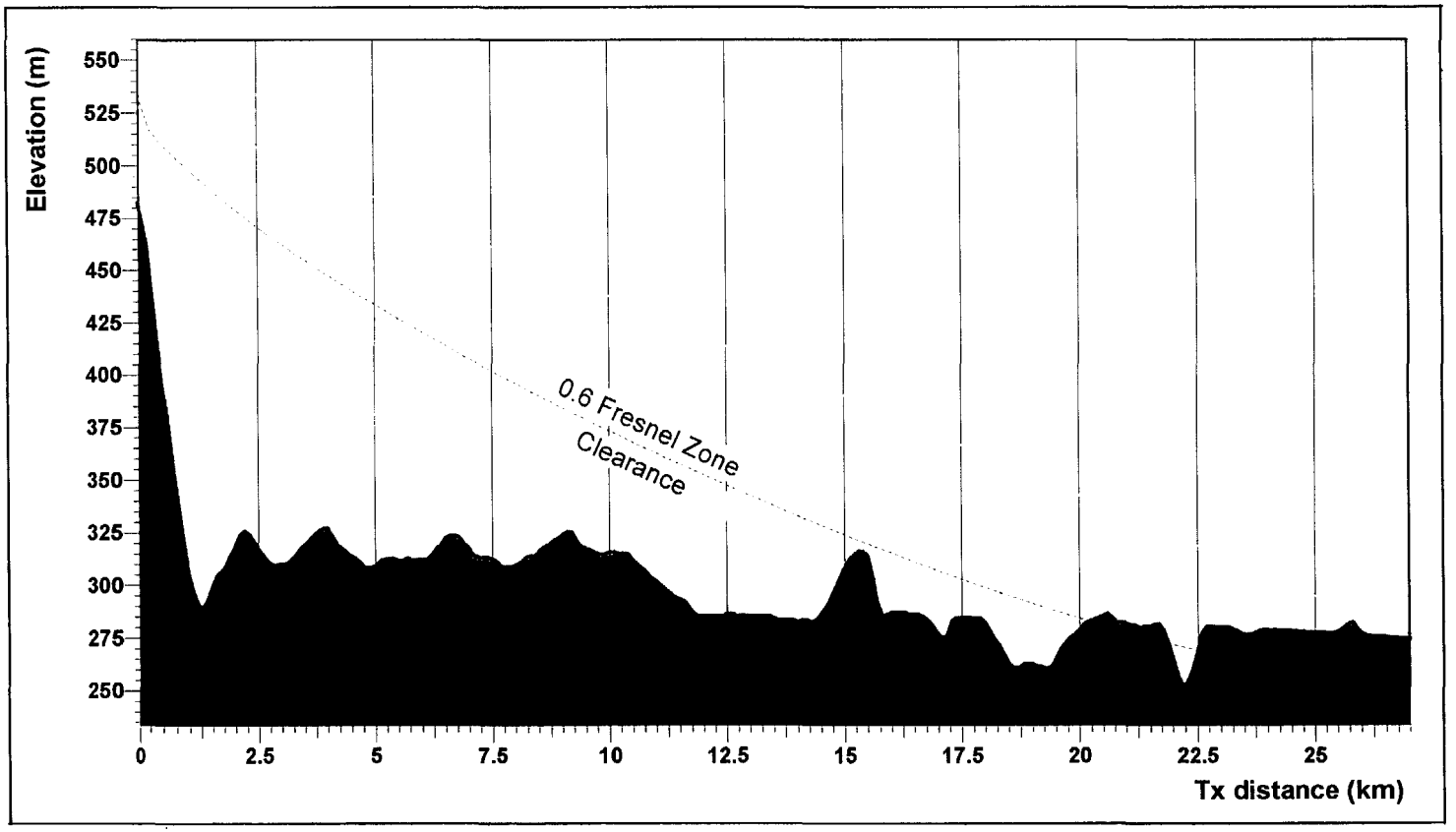
22. Until further data, tested by actual measurements, permitting an even better

prediction of the presence or absence of Grade B field strength at particular locations becomes available, reliance should be placed on ILLR predictions without further adjustment.

Jules Cohen, P.E.

February 21, 2000

FEBRUARY 2000



FRESNEL ZONE CLEARANCE PLOT
RECEIVING ANTENNA AT TWO METERS AGL
162 MHZ

Jules Cohen, P.E. Consulting Engineer

Figure 1
Sheet 1 of 3

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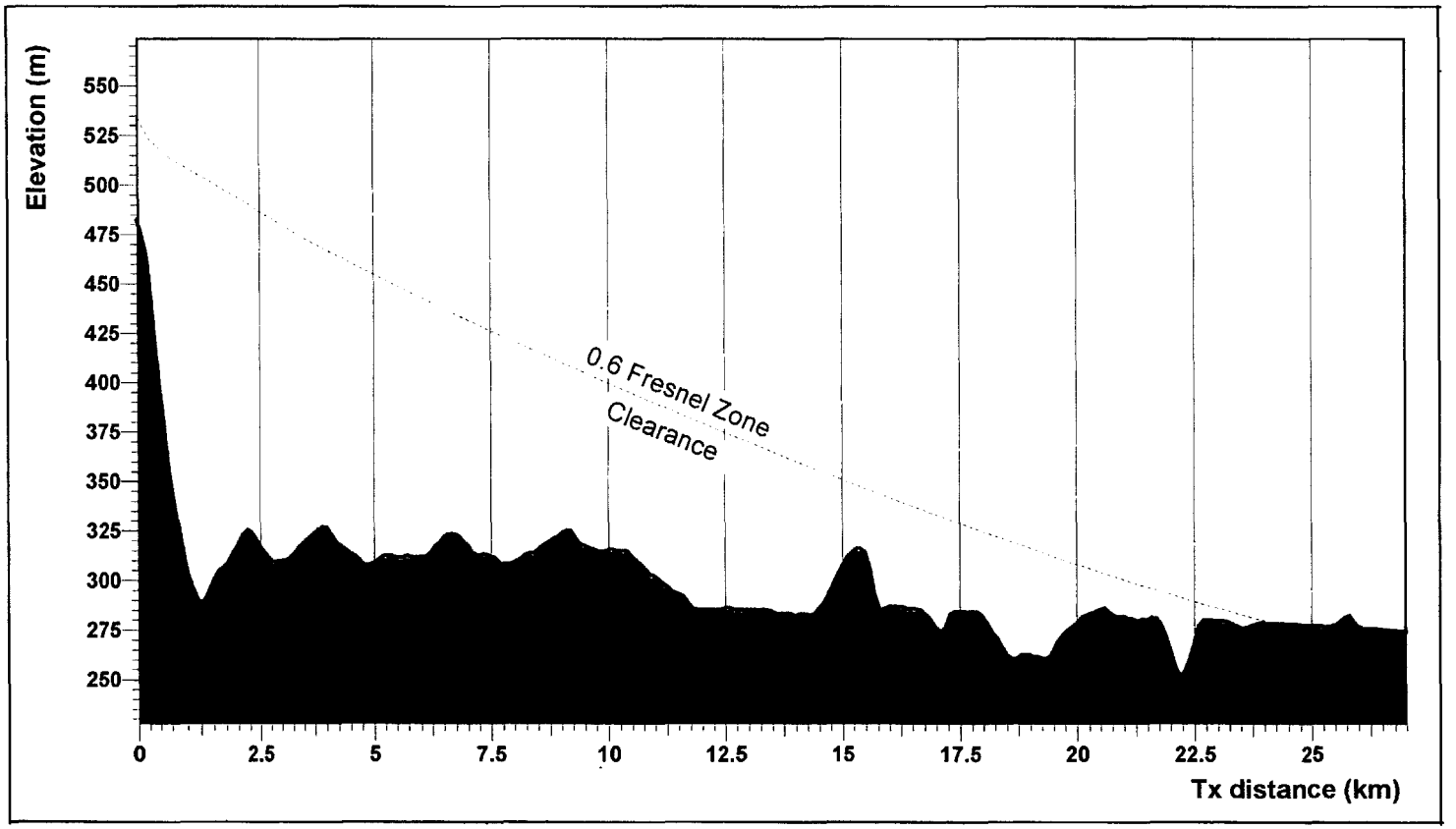

FRESNEL ZONE CLEARANCE PLOT
RECEIVING ANTENNA AT TWO METERS AGL
460 MHZ

Jules Cohen, P.E. Consulting Engineer

Figure 1
Sheet 2 of 3

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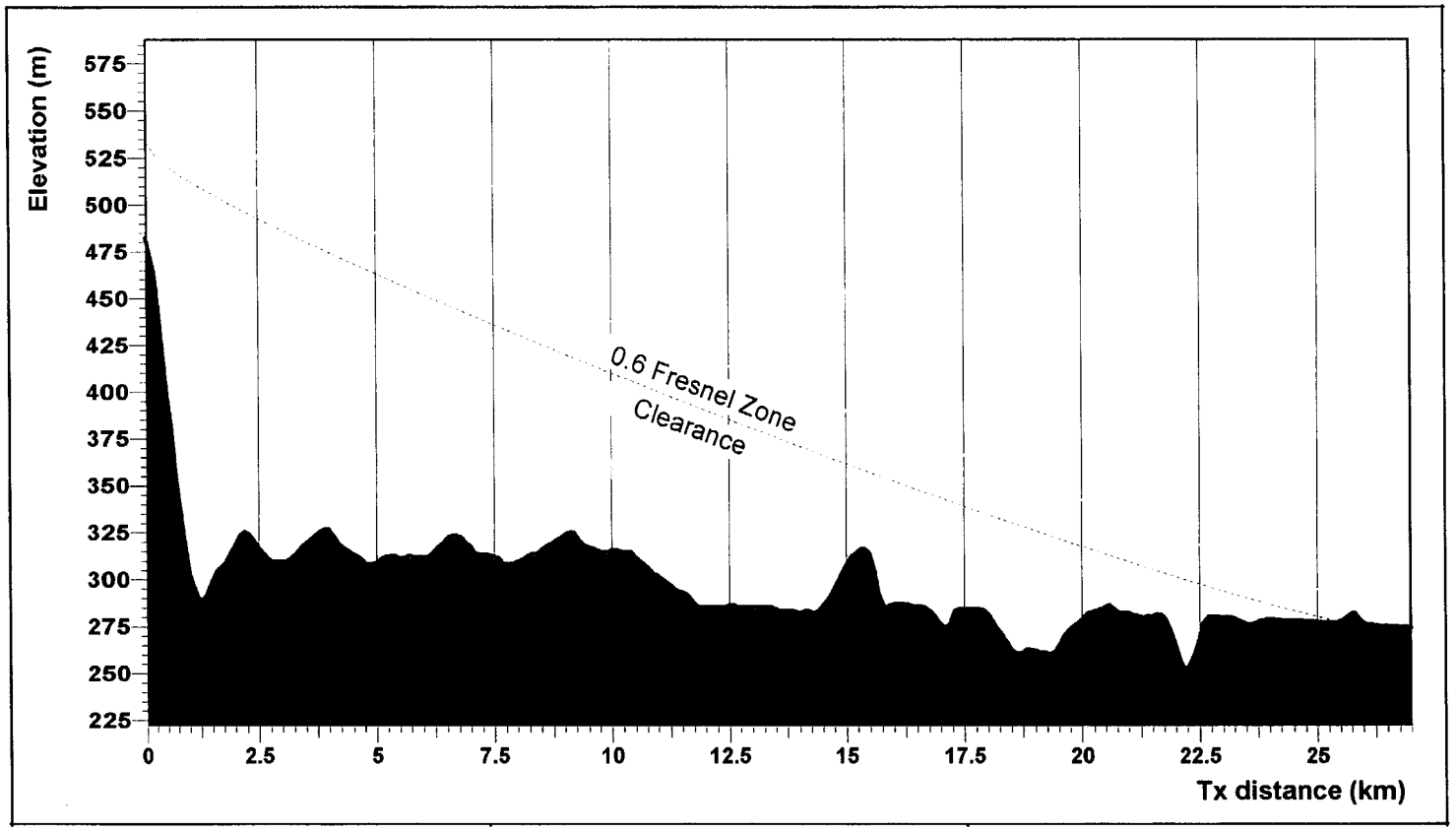

FRESNEL ZONE CLEARANCE PLOT
RECEIVING ANTENNA AT TWO METERS AGL
860 MHZ

Jules Cohen, P.E. Consulting Engineer

Figure 1
Sheet 3 of 3

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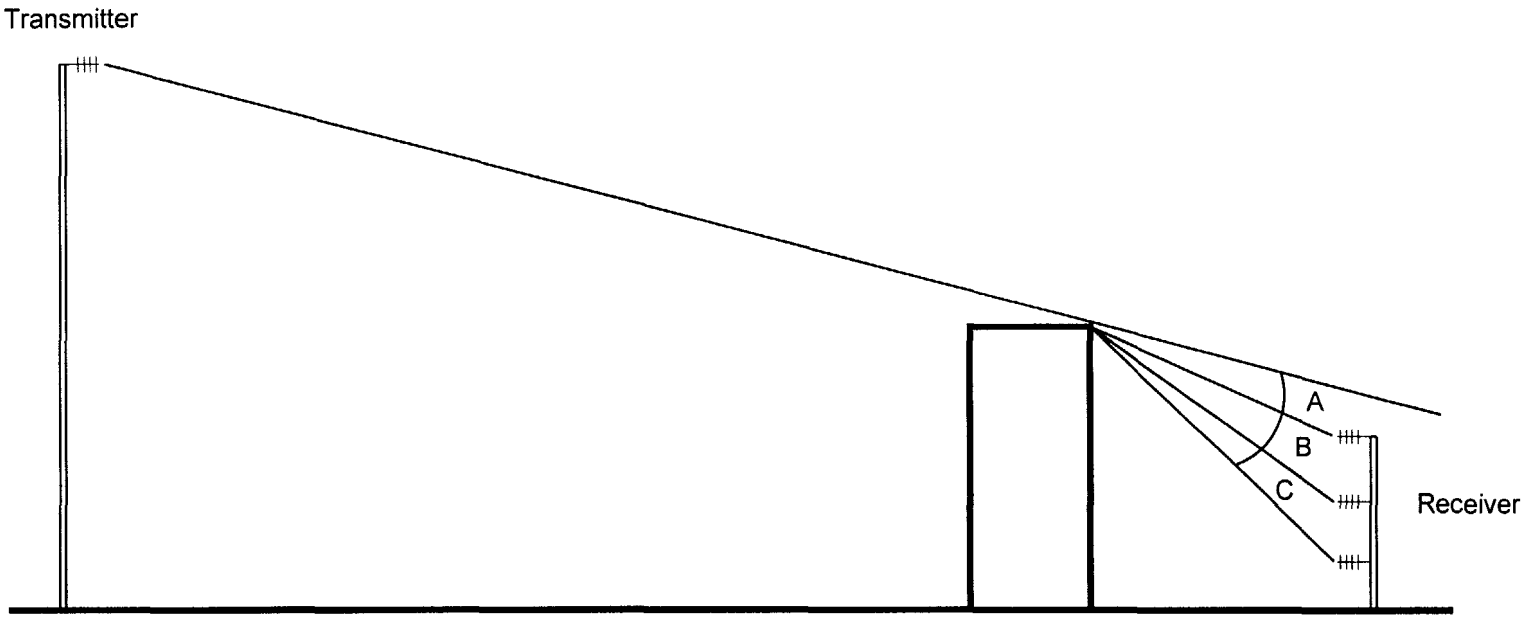
Not to scale



EFFECT ON ANGLE OF DIFFRACTION
FOR DIFFERENT RECEIVING ANTENNA HEIGHTS

ET DOCKET NO. 00.11

Jules Cohen, P.E. Consulting Engineer

Figure 2