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WASHINGTON, D.C.

Board of Directors 1996-1997

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November 22, 1996

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
Room 222
1919 M Street, N.W.
Washington, D.C. 20554

DOCKET FILE COPY ORIGINAL

Re: MM Docket 87-268

Dear Mr. Caton:

On behalf of the Association of Federal Communications Consulting Engineers transmitted herewith are an original and ten copies of the comment in the above Docket which is captioned, "In the Matter of Advanced Television Systems and Their Impact Upon the Existing Television Broadcast Service".

Sincerely,

S. K. Khanna

S. K. Khanna

SKK:mcw
Enclosure

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ASSOCIATION OF

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF SECRETARY

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554

In the Matter of Advanced Television Systems and Their Impact Upon the Existing Television Broadcast Service	)))))	MM Docket No. 87-268

SIXTH FURTHER NOTICE OF PROPOSED RULE MAKING

COMMENTS OF THE ASSOCIATION OF
FEDERAL COMMUNICATIONS CONSULTING ENGINEERS

These comments on the Sixth Notice of Proposed Rule Making (Sixth Notice) in the above captioned matter are submitted on behalf of the Association of Federal Communications Consulting Engineers (AFCCE). AFCCE is a professional organization whose members are professional engineers practicing as consultants to broadcasters and other segments of the communications industry, communications company engineering executives, representatives of equipment manufacturers and others working in the communications arena. AFCCE has a long history of participation in FCC rule making proceedings dating back to its founding nearly fifty years ago and welcomes this opportunity to submit its Comments to the Commission.

In order to properly address the issues raised in the Sixth NPRM, AFCCE formed an Ad Hoc Committee composed of 10 association members who are representative of a broad cross-section of the broadcast industry including consulting engineers, broadcasting group operators, manufacturers and communications tower owners. As AFCCE is primarily a technical/engineering organization, it has elected to limit its comments to those aspects of the NPRM which deal with technical issues.

AFCCE has participated in almost every docket involving television broadcasting since the late 1940s and its members were members of the historic Television Allocations Study Organization (TASO). TASO was formed with a mission to study the factors which would form the basis modifying VHF and UHF allocations methodology. A review of the work of TASO would remind the reader of the very fundamental work that was done in those early days of television broadcasting how that work has survived for forty years and has served the industry well.

As we now embark on the relatively untested waters of digital television broadcasting some of the same basic issues that confronted the Commission and the industry in the 1950's will require attention equal to that applied in the earlier TASO proceeding.

AFCCE commends the work accomplished by ACATS over the past 9 years since the inception of this proceeding in 1987. In 1994 AFCCE formed an engineering committee to monitor the work of ACATS and, when appropriate, to file comments in this proceeding on technical issues.

AFCCE has supported most of the findings, conclusions and recommendations of ACATS and has so stated in its earlier filings in this proceeding. However, AFCCE has also previously raised concerns regarding:

- assumed planning factors and related allotment issues,
- definition of service and coverage,
- measurement procedures for determining service.

In the months since the release of the Sixth Report & Order, AFCCE has reviewed the engineering/scientific foundations for the allotment proposals put forth by the Commission and the Broadcasters Caucus (under the technical leadership of MSTV). The foundation for any allotment plan must be a set of technical planning factors; these planning factors include the performance assumptions for receivers, propagation parameters, reliability/availability, statistical assumptions and unavoidable impairments, e.g., noise (from thermal, natural and man-made sources) and controllable phenomena such as interference. AFCCE notes that there are at least three different sets of planning factors under consideration:

- The ACATS report recommends a set of factors.
- The FCC in its Sixth Notice suggests the adoption of the ACATS recommendation except for the assumed receiver noise figures and assumed values of noise from all sources.
- The Broadcasters Caucus/MSTV has proposed yet another variant of these planning factors when it based its most recent allotment table offering.[1/]

To add further confusion or uncertainty, the Canadian DOC has proposed yet another set of factors.

[1/] This allotment table was released to broadcasters in early October may differ from the table included with the Broadcasters Caucus/MSTV comments to Sixth Notice.

The variations among these different sets of planning factors are not a few tenths of a dB but, rather, large variations of several dB. Since the bottom-line of the application of planning factors to the DTV service equation is the determination of the effective radiated power necessary to deliver the required signal level at the receiver input terminals, it is essential to note that a difference of several dB, for example, will translate directly into a requirement for doubling (halving) of transmitter power.

Transmitter power requirements are obviously important because of the following considerations:

- co-channel interference;
- adjacent-channel interference and adjacent-service interference;
- impact on allotments;
- acquisition, construction and operating costs.

For example, the Commission's proposed planning factors, coupled with its replication objectives, result in the specification of a transmitter power (effective radiated power) of 5 megawatts for some stations; even at this extremely high average power level, the replication objective is not achieved in all cases since the 5 MW power level simply represents the proposed maximum allowable power.

AFCCE has consulted with several major suppliers of television transmission products (transmitters, transmission lines and antennas) about the feasibility and practicality of building transmitters and antennas to achieve these extraordinary effective radiated power levels. An average transmitted ERP of 5 megawatts translates to a peak effective radiated power of over 20 megawatts and depending on actual peak-to-average ratio, perhaps as high as high as 24 megawatts. Since all TV transmitters are sized – rated – in terms of peak power, achieving this ERP on an omni-directional basis with practical antenna gains will require transmitters rated at

800-900 kW output. This is nearly four times larger than the largest UHF-TV transmitters being manufactured today and not practical given the limitations of output combining hardware. Likewise, antenna manufacturers do not believe that a practical antenna can be designed and fabricated to reliably handle this extraordinary input power; waveguide antennas might handle the power but bring along other problems such as frequency dependent vertical patterns which may result in amplitude and phase variations across the channel bandwidth with unknown results in the digital transmission domain.

All things considered, it is not at all clear that developing these high power levels will be either technically feasible or practical.

Another consideration with these high power levels must be the generation of non-ionizing radio frequency radiation (RFR) at transmitter sites. With colocation as an objective in the allotment scheme, it is possible that several such large transmitters could be sited together. Where relatively low antenna heights are involved, such as on a mountain-top, or situations where other supporting structures of comparable height are situated nearby, these heretofore manageable concerns may blossom into significant issues; the recent changes in the allowable RFR limits for uncontrolled areas certainly heightens these concerns.

Replication of Coverage

An objective of the allotment plan has been replication of each station's Grade B (NTSC) coverage contour by the DTV facility assigned to it. Replication of a low-band maximum facility VHF station with a UHF DTV facility is, to say the least, problematic.

It is interesting to note that service within the effective radio horizon can be readily replicated with reasonable UHF power levels. It is also notable that for the preponderance of UHF stations, the distance to the predicted Grade B contour and the effective radio horizon are very nearly the same. For example, a "typical" UHF station with a 1500 kW ERP and a 1000 ft. antenna height has a predicted distance to the Grade B contour of 45.6 miles; the distance to the radio horizon is 44.7 miles[2/]. For VHF facilities of comparable antenna height and maximum powers of 100 kW and 316 kW for low- and high-band respectively, the Grade B contour distances are 64.9 miles and 59.5 miles, respectively; the radio horizon distance is, of course independent of frequency. Thus, it is apparent that attempting to "replicate" a low-band facility's Grade B contour with a UHF facility means extending the Grade B contour nearly 20 miles beyond the radio horizon, a feat which requires 13-14 dB more transmitter power than that required to reach the radio horizon (based on the F50,50 curves).

AFCCE proposes, based on the planning factors described below, that a more reasonable approach to the allotment process is to define a "grade of service" within or to the effective radio horizon and a second grade of service beyond the radio horizon based on a different set of planning factors[3/]; the principal difference between the two grades of service in this concept is the assumption that receivers (antennas) located beyond the radio horizon would employ a low noise amplifier (LNA) in order to overcome the significant penalties associated with distance and over-the-horizon propagation and achieve the same degree of "replication" as now being proposed.

[2/] The contour distance is based on the F(50,50) and 2-10 mile terrain average; the radio horizon is based on smooth earth having a radius of 1.33 x true earth radius.

[3/] This not unlike the different planning factor assumptions for Grade A and Grade B services which underlie the NTSC coverage predictions.

Planning Factors

Attached hereto is a technical paper entitled "Planning Factors for HDTV Broadcasting – A Proposal" authored for the Committee by committee member Oded Bendov. It will be used as the technical reference for the comments contained in this section even though all of the technical details from the paper may not be specifically cited.

The AFCCE Committee has concerned itself with the "planning factors" issue almost since its inception nearly three years ago. The Committee strongly believes that any new system of broadcasting, and the assumptions on which channel allotments are made, must be based on sound engineering principles. To that end, the likely starting point in this process would seem to be the development of a set of planning factors. The objective of this exercise is to arrive at the desired field strength (and, thus, the required transmitter power) to deliver a signal of a level sufficient to produce the desired quality at the end user's receiver. The set of planning factors includes elements such as receiver noise figure, external noise sources from man-made and natural phenomena, receiving antenna system characteristics, propagation losses and adjustments for statistical reliability.

AFCCE is recommending a somewhat different approach to define service than that proposed by the Commission. AFCCE proposes that the Commission establish two grades of DTV service: one within a "contour" defined by the radio horizon and the other for service beyond the radio horizon.

AFCCE further recommends the use of a low noise amplifier, electronically integrated with the DTV receiver but, perhaps, physically integrated with the receiving antenna.

AFCCE also recommends that planning factors should include channel specific consideration of dipole factors and other losses to properly account for the system differences between channels 14 and 69, for example. Also, the matter of electrical noise needs to be addressed to arrive at planning factor values which are representative of the "real world" environment.

The advantages of the AFCCE approach to the planning factors issue are:

- Creates a more level playing field for both UHF and VHF NTSC stations in the UHF-HDTV band by limiting the maximum ERP to 500 kW with replication equivalence of 5000 kW.
- Promotes the growth of HDTV service by restricting the cost of ownership and capital investment to a practical and economic level.
- Renders the DTV coverage contour essentially independent of receiver noise figure (assuming use of LNA).
- Provides signals for multiple receivers with virtually no availability penalty.
- Provides as much as 50,99 availability within radio horizon and 50,90 beyond horizon.
- Minimizes co-channel and adjacent-channel interference.
- Minimizes RFR hazards.
- Increases spectrum availability for both broadcast and LPTV/ translator assignments.

Specifically, AFCCE recommends the consideration of its planning factors proposals as outlined below and suggests further study of the related issues (see also following section on TASO-II).

- Replace the receive antenna in the planning factors with a "smart antenna" integrated with UHF-LNA capability biased on/off by the receiver.

- Use channel-specific planning factors which consider noise sources (sky temperature, ground temperature, downlead temperature), downlead loss and antenna dipole factor[4].

- Define the Effective Radio-Horizon as the first of two UHF contours with LNA not included in the planning factors.

- Define the second of two UHF contours with planning factors including an LNA to achieve replication.

- Assign measurable values to the DTV contours or, better yet, assign values that are measurable and can serve as service predictors (neither field strength nor total power are uniquely useful service predictors).

- Use one propagation mode for both power and interference determinations.

- Modify the single-carrier Longley-Rice propagation model to account for wide-band signals.

- Limit the UHF ERP to 500 kW for 10 years or until enough field data is available on signal availability, interference and fading statistics.

- Request comments from TV set manufacturers on the advisability and incremental cost of adding an LNA (as part of a "smart antenna") and appropriate biasing/control interfaces to the HDTV receiver.

4/ See mathematical model and table in attachment.

The actual power assigned to a TV station for digital television operation would be the higher of:

- The power required to provide the specified field strength at the distance defined as the radio horizon (one method is described in the attached technical paper) using Longley-Rice 50,99 without an LNA assumption.

- The power required to "replicate" the station's present NTSC F50,50 Grade B contour with the specified field strength based on LR 50,90, capped at a maximum of 500 kW (for UHF), assuming the use of an LNA.

Adjacent-Channel Considerations

The DTV signal appears to be virtually immune to interference from adjacent-channel undesired signals having levels of 47-48 dB greater for NTSC and 42-43 dB for DTV interferors. However, DTV interference into NTSC is another matter. The ATSC/ATTC tests determined that the thresholds for this form of interference are approximately -17 dB and -12 dB for lower and upper adjacent DTV channels, respectively, into NTSC.[4/]

It has been reported that the results of additional adjacent-channel testing has been recently reported to the by ATTC. At the time of preparation of these comments, the results of those tests were not available to AFCCE but it is our understanding that a practical DTV transmitter complying with the Commission's proposed emission mask and not exceeding the D/U ratio would, in fact, create

[4/] A desired signal quality of CCIR Grade 3 was used the ATTC tests for planning purposes.

interference (at the Threshold of Visibility – TOV) under the conditions of colocation where it is assumed that the DTV channel power was 12 dB below the adjacent NTSC station power.

It is noted that the tests on which the data is based did not include allowances for the vagaries of real world propagation. The variables include the differences in signal propagation due to frequency selective multipath effects, differences in horizontal and vertical antenna patterns and the fact that the paths are not physically identical unless the antennas have a common center of radiation (not likely unless a common antenna is employed which is an equally unlikely scenario for many reasons). These variables can, in a worst case scenario, produce differences of approximate magnitude as follows:

Horizontal Antenna Pattern (non-circularity)	3 dB
Vertical (Elevation) Pattern	10 dB
Frequency Dependent Reflection Effects[5/]	17 dB
Total Variation	30 dB

Some of these effects may be partially compensated for in system design, but there will be an avoidable residual effect of 10 dB or so that must be accounted-for in the allotment algorithm (in addition to the effects revealed in the most recent ATTC report). What is clear is that the adjacent-channel interference issue needs further review, particularly in cases where adjacent channels are specified for paired NTSC/DTV use in the same market. AFCCE believes that such adjacent channel use can be achieved with lower DTV power and/or significantly improved transmitter out-of-band attenuation relative to the Commission's proposed mask.

[5/] See Planning Factors for HDTV Broadcasting, appended hereto.

Adjacent Band Issues

The Commission's records are replete with the history of problems associated with band-edge interference and, in particular, with problems related to interference to land mobile facilities in the bands below 470 MHz (channel 14) and above 806 MHz (channel 69). While the Commission has instituted special requirements regarding channel 14/69 stations, not all of the related problems have been satisfactorily resolved.

In the NTSC service, it has been possible to install output filtering on the transmitters to attenuate out-of-band energy well below 100 dB near the band edge and greater than 150 dB beyond the 3 MHz from the band edge. These filters are physically large (assembled out of large waveguide components), very expensive and potentially unstable (with temperature variations). However, they do accomplish the desired protection of the receivers with respect to direct interference from out-of-band components. It is not clear that spurious components from the digital modulation can be reduced to the same degree because the out-of-band energy is greater than in the analog case and the use of filters with high attenuation/sharp frequency roll-off characteristics introduces group delay problems which the digital modulator may not be able to adequately correct with pre-distortion techniques.

The unresolved problems with facilities close to NTSC band-edges appear to be related to the very high power levels of the TV carriers and the inability of the affected receivers to attenuate these carriers; the result is a form of receiver desensitization through overload and/or receiver induced third order modulation effects rather than direct interference from undesired out-of-band products. This is particularly true of hand-held personal portable transceivers which have virtually no front-end pre-selection filters due to physical size constraints; fixed and mobile

receivers usually have some form of effective pre-selection and/or can be equipped with outboard filtering to render them immune to this problem.

AFCCE recommends that the Commission conduct further study on this issue for the benefit of both broadcast and land mobile interests. The use of channels close to land mobile band-edges only in rural areas and/or limiting the effective radiated power of these facilities is a possible result of such studies[6].

TASO II

In 1956, the Commission established the Television Allocations Study Organization (TASO) in order to resolve many technical issues which arose following the 1951 lifting of the "freeze" instituted in 1949[7]. In its final report[8] TASO stated that "the purpose of TASO was to conduct a study of the technical principals which should be applied in television channel allocation", a statement quoting from the Commission's Public Notice 35638 issued on August 31, 1956. Also, the TASO Report states "The sole task of TASO is to make a comprehensive study of the

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[6] A similar issue arises with TV channels now allocated in the 14-20 band for land mobile use. The adjacent channel interference protection criteria now in place for NTSC may afford adequate protection for these facilities if adopted for DTV.

[7] In a possible example of deja vu, the Sixth Report & Order of 1951 established the UHF service and the operating parameters (planning factors) upon which the VHF and UHF television allotments were based; we are now dealing – 45 years later – with a new Sixth Notice with similar objectives for the new DTV service.

[8] Final Report, Television Allocations Study Organization, March 1959.

engineering factors underlying the allocation of frequencies (or channels) to television broadcasting."[9]

AFCCE believes that these are still admirable and appropriate statements for the situation we face today. As noted above and as the Commission will no doubt hear from other parties, there are a number of substantial technical issues which are unresolved relative to the adoption of the allotment and operating standards upon which the new DTV service will be founded. Therefore, AFCCE strongly recommends that the Commission establish a new Television Allocation Study Organization (TASO-II) to deal with the technical issues on an ongoing basis as experience with actual DTV broadcasting is being gained. Specifically, AFCCE recommends an organizational structure for TASO-II not unlike the original TASO organization which included the following "panels" (each panel title is followed by the possible DTV assignment in [ ]):

Panel 1	Transmitting Equipment [Maximum power, adjacent channel interference reduction techniques, antennas for combined/ colocated operations, adjacent band interference]
Panel 2	Receiving Equipment [Establish minimum receiver standards including noise figures, adjacent channel interference immunity, integration of "smart" LNA, LNA issues (non-linearity due to strong signals, input filtering)]
Panel 3	Field Tests [Collection of data on time variability particularly with propagation beyond radio horizon, noise data for impact on VHF DTV signals, adjacent channel propagation related issues, overall reliability/ availability data, indoor reception]

[9] Supra, Page 11, Section 2.1

Panel 4	Propagation Data [Collect propagation data from field tests and earlier work]
Panel 5	Analysis and Theory [Analyze all data collected and modify – if necessary – propagation models and curves, develop methodology for field measurement of DTV signals for purpose of defining coverage, prepare technical reports]
Panel 6	Levels of Picture Quality [Since the DTV signal "quality" is not variable with respect to propagation anomalies, as in the analog system (with acquisition being the primary issue due to cliff-edge effect) this panel might better deal with system improvements to improve reliability reducing the transmitting power required for DTV]

AFCCE presents this only as a possible guide for the on-going work of TASO-II. In this regard, AFCCE recommends that the Commission establish the TASO-II mechanism immediately so that the work can start coterminously with the establishment of a proposed allotment table (based on the new planning factors) so that the situation experienced with the original TASO work is not repeated. In that case, TASO's work was completed long after (almost 10 years) the establishment of the allotment tables/criteria; its findings and recommendations could not be fully adopted and implemented because the broadcasting services were already too well established.

OTHER MATTERS

AFCCE notes that the Commission has yet to adopt the Grand Alliance (GA) proposals for a digital television broadcast system. The issues relating to propagation and service planning factors discussed herein are really separate transmission/allotment issues unrelated to the basic system particulars.

AFCCE has previously supported the GA system in filing in this proceeding and urges the Commission to adopt the GA system as the standard for the US.

Given the issue related to interference, particularly adjacent-channel interference, it is probable that a realistic NTSC/DTV allotment scenario cannot be implemented using the "core spectrum" approach presently proposed. AFCCE strongly recommends that the Commission retain the entire UHF spectrum for television broadcast use until these interference issues are resolved. AFCCE makes no recommendation regarding the low band VHF channels as it believes that there is insufficient data available as to the effect of the much higher electrical noise in this band on the reception of DTV signals.

CONCLUSIONS

AFCCE proposes the adoption of a different approach to planning factors and the concept of service replication which involves the use of a common propagation prediction model and adjustments which include the use of an LNA. The proposal achieves the replication goal to the same extent as previous proposals while

reducing maximum power requirements. The power reductions will permit the construction of practical transmission facilities and will reduce co-channel and adjacent-channel interference; the interference reductions will increase the flexibility to provide similar allotments to all stations while reducing the interference to services in adjacent bands.

AFCCE recommends the re-establishment of the Television Allocations Study Organization – TASO II – to refine the planning factor issues which underlie the establishment of a technically sound service by building on the work already done in regard to DTV by ACATS, ATTC and MSTV.

REQUEST FOR EXTENSION

AFCCE believes that there are significant technical issues which remain to be more thoroughly addressed. The Sixth Notice fairly identifies many of the issues, and perhaps of singular importance to broadcasters, deals with the adoption of an allotment table; it appears to be the appropriate "vehicle" for the final resolution of these issues. It is clear, however, that significant work needs to be done and, therefore, the Commission is urged to keep this proceeding open by extending the reply comment date for at least several months. The upcoming holiday seasons, which extends for nearly six weeks, would be a major portion of this period. (This, of course, presumes that the Commission does not extend the original comments date at the "eleventh hour" on its own motion or in response to a request from another party.) AFCCE also suggests that the Commission accept late filed comments and that it treat these as comments or reply comments as appropriate. A Reply

Comment extension of two months would permit the industry to form reasoned responses to these and other proposals which may be submitted during the comment period.

Respectfully submitted,

Association of Federal Communications
Consulting Engineers

Sudhir Khanna, President

John F.X. Browne, Chairman
AFCCE Committee on Advanced Television

Attachment: "Planning Factors for HDTV Broadcasting – A Proposal"; Oded Bendov, November, 1996.

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PLANNING FACTORS FOR HDTV BROADCASTING
A PROPOSAL

O. Bendov

This paper is divided into six parts. In the first part, the planning factors as proposed in the FCC's Sixth Further Notice of Proposed Rule Making are examined. Arithmetic and conceptual errors are highlighted and corrected. In the second part the analysis is extended to highlight the importance of channel-specific factors and the potential role of adding a "smart antenna" to the planning factors in the UHF band. Part three is a summary of the benefits of the proposed planning factors. In the fourth part, signal and interference percentage of time availability and HDTV contour definition are addressed. The fifth part is a short review of the adjacent channel protection ratio. The sixth part contains my recommendations.

In all respects, the planning factors of this proposal provide significant advantages, over the FCC and MSTV proposals, to all broadcasters without loss of "replication." It provides for higher ERP to VHF-HDTV channels and allows for multiple receiver connection to the same antenna without loss of coverage - - a feature not possible with the FCC/MSTV planning factors. It will minimize interference and provide for cost-effective facilities.

Most notably, the planning factors proposed herein will eliminate the possibility, unlikely as it may be, that a station may choose to exercise its extreme high power option to the detriment of other stations in the same market.

FCC Planning Factors for HDTV

The so-called "planning factors" refer to the components of the equation that relate the incident field strength (or power density) to the available CNR at the receiver. When expressed in dB, the factors can be entered in a table, and simple addition of the factors provides the required field strength for noise-limited coverage.

In the Sixth Further Notice of Proposed Rule Making the factors appear in Appendix A and the related field strengths in Appendix B. The final results are:

	Low VHF	High VHF	UHF
Geometric mean frequency (MHz)	69	194	615
Correct field strength (dBu)	22.8	30.8	43.8
Electrical noise allowance (dB)	4	1	0
Field strength as given by FCC (dBu)	26.8	31.8	43.8

The geometric mean frequencies are incorrect. By definition, the geometric mean of N frequencies is the positive Nth root of the product of N frequencies. Therefore, for the receiver model proposed by the FCC, the fields (less noise allowance) at the correct geometric mean frequencies are:

	Low VHF	High VHF	UHF
Geometric mean frequency (MHz)	70	195	630.5
Correct field strength (dBu)	23	30.9	44.1

There is an error in the FCC's receiver model. The model assumes that the sole source of thermal noise is the frequency-independent Johnson's Noise at a room temperature of 290^{0}K. In fact, the antenna's temperature, which depends on sky and ground temperatures, must be taken into account in addition to the ambient temperature of the downlead cable.

The average sky temperature[1] varies from 8400^{0}K at channel 2 to 10^{0}K at channel 69. Corrected for the sky temperature, the required field strengths (less the electrical noise margin of 4 dB and 1 dB) are:

	Low VHF	High VHF	UHF
Geometric mean frequency (MHz)	70	195	630.5
Correct field strength across band (dBu) for average sky temperature	28.6 ± .3	31.8 ± .8	44.5 ± 2.75
Correct field strength across band (dBu) for maximum sky temperature	32.5 ± .05	32.7 ± .5	44.6 ± 2.8

From the table above it is clear that the field strengths for the Low and High VHF bands as proposed by the FCC fall short of the values derived from the correct receiver model. Further, while the variation of the field within the VHF bands is small, it is substantial within the UHF band. In fact, the 5.5 dB variation from channel 14 to 69 means that the radiating power at channel 69 needs to be 3.5 times larger than the radiating power at channel 14 to attain the same coverage. Stated differently, with equal radiating power, the radius of channel 69's coverage noise-limited contour in average terrain will be shorter by 5-6 miles than channel 14's.

The FCC's Sixth Further Notice of Proposed Rule Making proposes to set minimum values for ERP in each of the three bands. However there is only one maximum value. The ratio of the allotted ERPs in the bands relative to the NTSC values are:

[1] Engineering Aspects of Television Allocations. Report of the TASO to the FCC. March 16, 1959.

		MAXIMUM ALLOTTED ERP		
		UHF	High VHF	Low VHF
NTSC	Peak (kW)	5000	316	100
HDTV	Average (kW)	5000	22	14.5
HDTV/NTSC	Ratio(dB)	0	-11.6	-8.4

The rationale for the different power ratios for NTSC and HDTV was not given.

New Planning Factors for HDTV

An examination of the FCC's Sixth Further Notice of Proposed Rule Making shows that more than 500 stations will need UHF-HDTV transmitters larger than 240 kW to "replicate" their NTSC service. In fact, more than 50 stations will need UHF-HDTV transmitters larger than 960 kW. Even with these powers, the "replication" is for one receiver , an outdoor antenna and with interference and/or signal loss up to 10% of time.

Such high-power transmitters will be very expensive and uneconomical to operate. In some locations, where several such transmitters would be collocated (Denver, for example), the AC power load may be unacceptable. For the five VHF stations in Denver with a total of 22,000 kW average ERP, the estimated AC power load is 3.8 MW.

In locations where the towers are relatively short and must remain short, the RFR level resulting from the authorized powers may prove too high. The FCC's new guidelines are strict even for average power. The guidelines have not yet addressed the limits on peak power, but that is just a matter of time. If the five Denver stations, to cite an example, are to construct a common tower, their peak power would be 22.5 MW each.

In other locations (LA, for example) there could be intolerable areas of adjacent channel interference.

Additionally, the assignment of extremely high HDTV power to many stations may have limited the availability of channels for critical translators in some locations.

In fact, most if not all UHF stations may be able to provide service to their Effective Radio Horizon[2] with 1/10 the maximum power now proposed by the FCC and do so with percentages approaching 99% for signal availability and 1% for interference. The remainder of the area to be replicated, from the Effective Radio Horizon to the B-contour, can be "replicated" by a simple modification of the receiver model.

Specifically, the replacement of the receive antenna planning factor, during the transition years, by a "smart antenna" incorporating an "intelligent" UHF-LNA (Low Noise Amplifier). The antenna would provide a 10 dB improvement in CNR for a single receiver installation and 14 dB improvement in CNR for a three-receiver installation. The LNA

[2] The Effective Radio Horizon can be defined as the average of the longest 50% of N equally spaced radials to the radio horizon.

will be controlled by variable bias from the receiver or be cut-off as required. The additional cost to the HDTV receiver is expected to be minimal.

The proposed new field strengths (less the electrical noise margin of 4 dB and 1 dB) based on the correct receiver model and allowing for unavoidable in-band noise power penalty of .5 dB due to system VSWR and transmitter non-linearity, are shown below for average sky temperature, and graphically as Figure 1 (max. sky temperature) and Figure 2 (avg. sky temperature):

Channel	(dBu)	With LNA (dBu)	Channel	(dBu)	With LNA (dBu)
2	28.3		36	44.1	33.8
3	28.3		37	44.2	33.9
4	28.4		38	44.4	34.0
5	28.7		39	44.5	34.1
6	28.9		40	44.6	34.1
7	31.0		41	44.7	34.2
8	31.3		42	44.8	34.3
9	31.5		43	44.9	34.4
10	31.8		44	45.0	34.5
11	32.1		45	45.1	34.6
12	32.3		46	45.2	34.6
13	32.6		47	45.3	34.7
14	41.5	31.7	48	45.4	34.8
15	41.7	31.8	49	45.5	34.9
16	41.8	31.9	50	45.5	34.9
17	41.9	32.0	51	45.6	35.0
18	42.1	32.1	52	45.7	35.1
19	42.2	32.2	53	45.8	35.2
20	42.3	32.3	54	45.9	35.3
21	42.4	32.4	55	46.0	35.3
22	42.6	32.5	56	46.1	35.4
23	42.7	32.6	57	46.2	35.5
24	42.8	32.7	58	46.3	35.5
25	42.9	32.8	59	46.4	35.6
26	43.0	32.9	60	46.5	35.7
27	43.1	33.0	61	46.5	35.8
28	43.3	33.1	62	46.6	35.8
29	43.4	33.2	63	46.7	35.9
30	43.5	33.3	64	46.8	36.0
31	43.6	33.4	65	46.9	36.0
32	43.7	33.5	66	47.0	36.1
33	43.8	33.5	67	47.1	36.2
34	43.9	33.6	68	47.1	36.2
35	44.0	33.7	69	47.2	36.3

If the FCC includes the "smart antenna" in the planning factors recommended in this section and limits the maximum ERP for UHF-HDTV at 500 kW (≈120 kW Tx), all UHF channels are expected to provide reliable coverage to the Effective Radio Horizon, well above 90% of the time, without LNA. With LNA switched on and biased by the receiver, the effective coverage would increase to the same contour that would result from radiating 5000 kW ERP (≈1MW Tx) and a receiver without LNA.

Although usage of LNA is already widespread in TV reception from satellites, the inclusion of an optional LNA in the planning factors, during the transition years, should not be perceived as simply a consumer cost problem. It would free spectrum, substantially lower expected interference into NTSC channels, lower the RFR level and allow for practical investment and economic operation of HDTV stations. It would also allow for multiple home receivers without reduction in coverage. The effect of the LNA on the system's noise figure with multiple receivers is shown in Figure 4.

Similarly, the ERPs for VHF-HDTV could be limited to 1/10 of the NTSC values with the added man-made electrical noise margin. For example, assuming the proposed margins of 4 dB for the Low-VHF and 1 dB for the High-VHF, the corresponding limits on the ERP for HDTV would be 25 kW for the Low-VHF band and 40 kW for the High-VHF band.

The equations governing the development of the planning factors are attached as a mathematical appendix.

Summary of the Benefits of the New Planning Factors

✓ Create a level-playing field for both UHF and VHF NTSC stations in the UHF-HDTV band by limiting the maximum ERP to 500 kW with replication equivalence of 5000 kW.
✓ Promote growth of HDTV service by restricting the cost of ownership and capital investment to a practical and economic level.
✓ Minimize cochannel and adjacent channel interference.
✓ Increase spectrum availability for translator assignments.
✓ Allow for multiple receiver connection to a single antenna without loss of coverage for all practical downlead cable lengths.
✓ Render coverage contour practically independent of the receiver's noise-figure.
✓ Minimize RFR hazards.

HDTV Contours and Percentage of Time Availability.

What the correct value is for the percent time of signal and interference availability has not yet been determined. The correct value will not be known until after several years of operation. It is unlikely that the same percentages would apply to HDTV and NTSC system design because a viewer's reaction to a fading NTSC signal will be different than that to lost HDTV signal for the same percentage of time. The MSTV has publicly stated that, because the correct percentage is unknown, and because the statistics cannot be applied outside the 10%-90% range, the 90% value used for NTSC system design is the correct value to be used for HDTV system design. In fact, no restriction on the range of

percentages applies either to the FCC propagation model or to the Longley-Rice model. Rice himself has written[3] extensively regarding equations that govern the statistics of fading from 1% to 99%. Referring to the FCC curves, Rice says: "The data show that E(1)-E(50) is very nearly equal to 2[E(10)-E(50)] for any distance, antenna height, or frequency; so separate E(1)-E(50) have not been drawn." Note that Rice's statement refers to measured 99% and 1% data .

HDTV service contours may be planned in terms of field strength, but they cannot be measured by conventional (tunable to a single carrier) field strength meters. In HDTV, the total (or RMS) signal power or CNR contours are measurable with a spectrum analyzer. It would be advantageous to define the contours in terms of measurable values. As proposed herein, the two VHF ranges will be assigned one contour each at the geometric mean frequency. The UHF range will be assigned two contours, one ("Radio Horizon" or "A") without LNA and one ("B") with LNA based on channel-specific planning factors. The ERP for both UHF contours will be determined by the Longley-Rice propagation model with different percentages. The ERP for the "A" contour will be based on LR(50,99) without LNA and the ERP for the "B" contour will be based on LR(50,90) with LNA. The corresponding cochannel interference will be based, respectively, on LR(50,1) and LR(50,10). The larger of the two ERPs, limited by 500 kW, will be designated as the "HDTV Power."

The ERP of both VHF contours will be based on LR(50,99) and 28.6 dBu [+electrical noise] for Low-VHF and 31.8 dBu [+electrical noise] at the Effective Radio Horizon limited by 25 kW for the Low-VHF band and 40 kW for the High-VHF band.

Adjacent Channel Protection

As an example of the expected interference that would be eliminated by adopting the planning factors outlined above, consider HDTV channel 33 and NTSC channel 34 in LA. The proposed ERP of the HDTV channel is 1453.5 kW which is only 1.28 dB below 1950 kW, the ERP of the NTSC channel. With ground reflections, not accounted for in the FCC protection ratio, the D/U ratio is likely to exceed the protection ratio of -17.43 dB in several areas as shown in Figure 3. By adopting the new planning factors (500 kW maximum, "smart antenna," channel-specific), an additional margin of approximately 10 dB against cochannel and adjacent channel interference would be available in the UHF band. What's more, the out-of-band noise, spilled-over from channel 33 into channel 34 would be lowered to a level consistent with the desired ratio of -12 dB between NTSC and HDTV.

Recommendations

- Request comments from TV set manufacturers on the advisability and incremental cost of adding a "smart antenna" to the HDTV receiver.

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[3] Rice, P. A. "Tropospheric Fields and Their Long-Term Variability as Reported by TASO," Proceeding of the IRE, June 1960.