

In the Matter of)	
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Unlicensed Operation in the TV Broadcast Bands)	ET Docket No. 04-186
)	
Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band)	ET Docket No. 02-380
)	

To: The Commission

COMMENTS ON THE FIRST REPORT AND ORDER AND FURTHER NOTICE OF PROPOSED RULE MAKING

BY TV TRANSMISSION ANTENNA GROUP

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CREDETIALS

Oded Bendov received his Ph.D in Electrical Engineering from Northwestern University in 1967. From 1967 until 1986 he was with RCA first as Principal Engineer and later as Engineering Manager at the Antenna Engineering Center of the Broadcast Division. After RCA was sold in 1986 his group moved to Dielectric Communications. At Dielectric, Dr. Bendov was first Vice President, Antenna Engineering and Advanced Technologies. In 1993 he was appointed Senior Vice President and Chief Scientist of Dielectric Communications, from which he retired in 2003. In 2003 Dr. Bendov launched TV Transmission Antenna Group, a company dedicated to the design and analysis of TV links from the transmitter through the receiver.

Dr. Bendov has contributed to fundamental published papers on TV antennas, receivers, interference and propagation. Copies of the most recent papers can be found in the company web site: www.tvantenna.tv. He is the author (with K. Praba) of the Transmitting Antennas chapter in the Television Engineering Handbook and in the Encyclopedia of Electrical and Electronics Engineering. He is the 2005 recipient of the NAB’s Television Engineering Achievement Award.

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I. SUMMARY

In NPRM 04-113 the Commission has proposed the introduction of high-power, broadband, unlicensed devices into the unused spectrum of Digital Television. It has been shown that the devices proposed in NPRM 04-113, even when operating under the rule of “Listen before Talk,” would cause significant harmful interference to broadcast television¹.

In the comments presented herein we show that, at their introduction to the market, the maximum allowable operating power of the unlicensed devices should be:

Unlicensed Device	Peak EIRP	Minimum Distance to the Nearest DTV Antenna
Fixed	100 mW	70 meters
Portable	1 mW	0.5 meter

¹ O. Bendov, “Interference to UHF-DTTV Channels by Unlicensed Devices,” IEEE Transaction on Broadcasting, Volume 52, December 2006.

These values were derived from the ITU proposed transmission mask, the Commission's mask for DTV transmitters and the Commission's interference protection ratio for first adjacent DTV channels. Were the Commission to grant higher power to unlicensed devices at their introduction to the market, without proven software that can reliably control the devices, new and significant interference power will be generated at the receiver. This secondary level of interference generated at the receiver by high-power devices will be well above that originating by the devices' transmitters.

Therefore, it would be prudent of the Commission to begin by authorizing only low-power devices and only in rural areas.

Once the network controlling software is proven in field trials, and the actual aggregate interference has been measured, and the actual transmitter masks of the new devices are known, then the Commission would be in a position to rationally amend the rules governing unlicensed (and in some markets perhaps licensed) devices.

II. INTRODUCTION OF UNLICENSED DEVICES SHOULD BE GRADUAL IN TERMS OF GEOGRAPHICAL LOCATIONS, MAXIMUM POWER AND AVAILABLE CHANNELS

There is no dispute that the public's interest demands that the available spectrum be used efficiently. In NPRM 04-113 and ET Docket 04-186 the Commission has indicated its intention to introduce unlicensed broadband devices into the unused television channels.

At the same time, the Commission is required by statute to avoid harmful interference by these devices to licensed television stations. In fact, even if the new devices work in accordance with the Commission's presently proposed rules, as promulgated in NPRM 04-113 and ET Docket 04-186, significant and harmful interference to the reception of over-the-air television is a certainty².

At this time it is not at all clear what new and revised technical rules must be adopted by the Commission to guarantee that television service will not be degraded or destroyed by the proposed unlicensed devices. That is so because the proponents of unlicensed devices have not demonstrated the actual transmitted spectrum of such devices. Neither have the proponents demonstrated the complex software that would reliably control thousands of such devices in major markets. Nor is there an acceptable model for the level of interference expected from the aggregate of unlicensed devices. This lack of fundamental knowledge of the expected operation of unlicensed devices in the real world is further aggravated by the Commission's lack of mandated tests, even small-scale tests, of actual operating systems.

Without the relevant test data of actual hardware and software of unlicensed devices operating in a real world environment it would be impossible to simulate the design and performance of large-scale systems of unlicensed devices. The missing data are mandatory if the Commission is to establish technical rules that would in fact protect over-the-air broadcast television from victimization by a sudden and large-scale introduction of unlicensed devices into the unused TV spectrum.

From the public interest viewpoint the introduction of wideband unlicensed devices in the vacant TV spectrum may be useful, but it would not be a compelling technology. Most of the public,

² See Footnote 1.

except perhaps in some rural areas, already has several means of access to broadband services³. On the other hand, the proponents, mainly computer manufacturers, stand to reap huge financial rewards if allowed to deploy unlicensed devices in the TV spectrum.

It has taken more than a decade, many laboratory and field tests, extensive analyses and simulations, not to mention billions of dollars to make sure digital television would be a technically viable replacement to analog television, and that process continues. Still, major technical issues related to the transition from analog to digital television remain unsolved: DTV reception via indoor antennas, self-interference and adjacent channel interference by non-located distributed DTV transmitters, and digital to analog settop box converters are examples of yet unsolved problems.

In the next section it will be demonstrated that at the outset of their introduction, the power of unlicensed devices should be limited to 100mW for fixed and 1mW for portable devices. Further, the Commission should limit the distance between fixed devices and the nearest rooftop TV antenna to a minimum of 70 meters.

Therefore, the Commission should permit only gradual introduction of the new and unproven unlicensed hardware and of controlling software into the TV spectrum. The introduction in selected markets should be gradual in terms of geographical location of fixed devices, the maximum transmitted power, and available channels for all unlicensed devices.

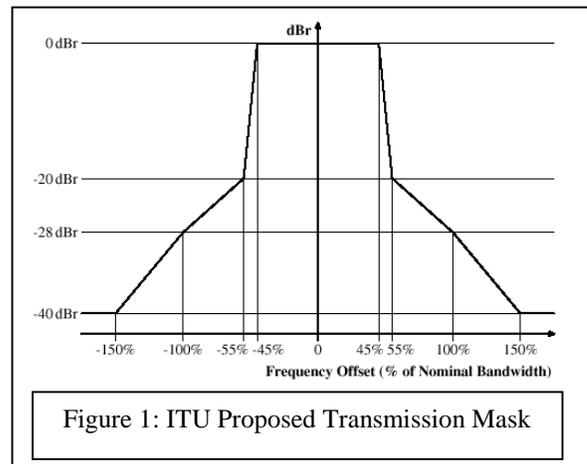
³ Even in rural areas access to wideband services is rapidly growing. For example, WildBlue Communications now offers wideband access using a 26-inch dish at a price comparable to cable access.

Gradual introduction should start in rural areas where the aggregate interference from the new devices would be relatively small and controllable. The software and hardware performance of small-scale systems would be evaluated together and the interference mechanisms and the interference area determined. The data would then be applied to computer simulations of larger systems. The results of these simulations would form basis for the Commission's technical rules consistent with the market size. It may well be that in larger markets powerful fixed devices with EIRP above 100mW will have to be licensed.

III. RATIONAL SYSTEM PLANNING IS NOT POSSIBLE WITHOUT KNOWING THE TRANSMITTER SPECTRUM OF ACTUAL UNLICENSED DEVICES

Because the devices must be frequency-agile so that their transmitters can hop on command among the unused allowable TV channels, it would be impractical to equip the devices with an agile channel filter of essentially 6MHz bandpass. Therefore, by necessity, the expected transmission spectrum of the devices will be spread into several channels beyond the channel allocated to the device. It is this spread of undesired transmission into non-assigned channels that will potentially be one of the major causes of harmful interference into TV. Because it would be impossible to equip the devices with an agile sharp-cutoff 6MHz filter, it would be necessary to limit the power of the unlicensed devices and/or to assign them an operating channel sufficiently separated from the nearest TV channel.

Figure 1 depicts the transmitted spectrum mask proposed by the International Telecommunication Union for unlicensed devices intended for operation



in 5, 10 & 20 MHz channels⁴. It shows that the average undesired transmitted power in the first adjacent channel could be as high as -28dB relative to the assigned power of the unlicensed device. Similarly the average undesired transmitted power in the second adjacent channel could be as high as -40dB relative to the assigned power of the unlicensed device. This mask is based on actual devices. Unfortunately at this time there is no comparable mask for the actual devices that the proponents intend to deploy in the U.S.

So how much maximum allowable power should be assigned to unlicensed devices? Maximum power should be limited so as to cause no higher interference than presently allowable by full-power DTV stations into low-power DTV stations. In fact, the maximum interference level should be lowered because the new devices will introduce *new and added* degradation to the reception of licensed TV. The maximum power allowed for a DTV station in the U.S. is 1,000kW through a transmitter mask that permits no more than -110dB below the licensed power into the second and all higher adjacent channels. Therefore, the maximum undesired spill into a 1kW LPTV on a second adjacent channel would be -20dBm. That would be 80dB below the LPTV licensed power of 1kW (60dBm).

If the ITU mask of Figure 1 were to be used in the U.S. for system planning of unlicensed devices with interference level not exceeding DTV into DTV interference, the maximum allowable power for *a single fixed unlicensed device* would be 20dBm or 0.1W. That level would produce the same maximal -20dBm that DTV stations are permitted to spill into the second adjacent channel. However, the -20 dBm should represent the aggregate power of all unlicensed fixed and portable devices in the neighborhood they serve. Consequently, the power of individual unlicensed devices will have to be below 20dBm, depending on the yet-to-be developed aggregate model. In contrast,

⁴ ITU-R M.1450-2

NPRM 04-113 proposes a fixed device power as high as 4W (36dBm) with a spillover of .72mW (-1.4dBm) into the first, second, and higher adjacent channels⁵. In other words, the Commission's proposed power and spillover for a *single* device is higher by at least 16dB than the level that should be allowed for the *aggregate* of fixed and portable unlicensed devices.

In accordance of Figure 1, for a fixed device transmitting 100mW, the power in the first adjacent channel would be 28dB lower, or -8dBm. The Commission's Planning Factors⁶ specify a DTV receiver sensitivity of -84dBm at the tuner and a Desired/Undesired protection ratio against first adjacent channel interference of -27dB for "weak" DTV signals. Therefore, within the DTV station's service area the adjacent channel's interfering signal at the DTV tuner may not be higher than $-84+27 = -57$ dBm. How far away should the fixed device be so that transmitted -8dBm is attenuated to at least -57dBm at the tuner? Transmitting on an UHF channel, a fixed device would have to be a minimum of 70m from the nearest rooftop antenna with a gain of 10dBd and a downlead loss of 4dB.

A fixed 100mW device could be installed at least 70m from the nearest rooftop antenna, but a portable device, especially in apartments, could be as close as 0.5m to the nearest indoor TV antenna. The International Telecommunications Union has specified a distance of 0.5m for portable unlicensed devices⁷. So, how much power should be allowed to a portable device transmitting on the first adjacent channel? For a portable device 0.5m away from a settop antenna whose gain is 0dBd, the transmitted power of the device into the first adjacent channel should not exceed -37dBm. That transmitted power will be attenuated to -57dBm, the threshold of visible interference at the DTV tuner by undesired first adjacent channels.

⁵ Based on 46dBu @3meters in the UHF band as per Part 15.209.

⁶ OET-69

If the maximum power transmitted by a portable device into its first adjacent channel must not exceed -37dBm and the device mask is per Figure 1, then the maximum allowable operating power of the device cannot exceed $-37+28 = -9\text{dBm}$, or 1.26mW .

In summary, if unlicensed devices were allowed on a first adjacent channel to a DTV channel in the UHF band, the power of a fixed device would have to be limited to a 100mW provided that its antenna is at least 70m away from the nearest rooftop antenna. For a portable device 0.5m away from a settop antenna the same power would have to be limited to a maximum of 1mW . Increase in operating power could be permitted if one or more empty channels separate the device from the victimized DTV channel.

It should be clear that **rational system planning of unlicensed devices must begin with knowledge of the device's transmission spectrum and its related mask**. That is a necessary condition for the start of planning but not a sufficient one to complete the design of systems that must not victimize viewers of free over-the-air television.

IV. ADDITIONAL INTERFERENCE GENERATED AT THE DTV RECEIVER BY HIGH-POWER UNLICENSED DEVICES

In NPRM 04-113 the Commission proposes that fixed devices, not on a cochannel, could operate at a peak EIRP of 4W at a distance no greater than 10m from a rooftop DTV antenna. If the device's channel were within the passband of the front-end filter of the DTV receiver⁸, the power delivered to the DTV tuner would be -4dBm . This level of power would exceed the maximum

⁷ ITU Document 1/88-E, 21 October 2005 and Attachment 5 to document 1/90-E, 24 October 2005.

power received from a DTV station operating at its licensed maximum of 1,000kW! For the proposed portable devices, the received level even at 3m away from an indoor antenna, would be -10dBm ⁹. Such strong undesired signals will cause strong new interference to be generated at the receiver causing receiver blocking or at least severe desensitization. This interference would be in addition to the undesired and unavoidable transmission spectrum of the devices. Moreover, a new mode of cochannel interference will be generated by certain pairs of high-power devices transmitting in tandem neither on adjacent nor cochannel relative to the victimized DTV channel. **Heretofore, the Commission, the proponents and those objecting to the introduction of unlicensed devices into the unused TV channels have overlooked this mode of cochannel interference.**

It is well known¹⁰ that a pair of unlicensed devices transmitting in tandem on channels:

$$[(N-2k);(N-k)] \text{ or channels } [(N+k);(N+2k)]$$

where N is the victimized DTV channel and k is an integer, would generate cochannel-like interference into the desired DTV channel N if the unlicensed pair enter the tuner with a strong signal. For example, if N=DTV38, then two devices transmitting in tandem on channels [34; 36] or on channels [40; 44] will cause cochannel-like interference to DTV38. Note that none of the channels in the brackets is adjacent or cochannel to DTV38. The signal level of the high-power devices proposed by the Commission in NPRM 04-113, 4W for fixed and 0.4W for portable devices would generate such cochannel interference at the DTV receiver.

⁸ There is neither ATSC recommendation nor an FCC rule relative to the maximum allowable bandpass of DTV tuners.

⁹ See footnote 1.

¹⁰ C.W. Rhodes and G.J. Sgrignoli, "Interference Mitigation for Improved DTV Reception," IEEE Transactions on Consumer Electronics, Volume 51, Number 2, May 2005

In the example shown, where $k=2$, the tuner's bandpass would have to be 10-channels wide. For $k=1$, the tuner's bandpass would have to be only 5-channels wide. It should be noted that neither the Commission nor the standard setting Advanced Television System Committee have issued minimum recommended tuner bandpass specifications, and the tuner's bandpass may be assumed wide enough to accommodate unlicensed pairs with low k values.

V. HIGH-POWER FIXED DEVICES SHOULD BE LICENSED AND EXCLUDED FROM CERTAIN TABOO CHANNELS

In Section IV it was explained that high-power devices would generate intolerable interference at the DTV receiver apart from the interference originated with the devices' transmitters. The interference generated at the DTV receiver cannot in general be mitigated by the receiver's Automatic Gain Control circuits or by inserting attenuation at the front-end of the receiver. This is so because at the locations where the DTV signal is already weak, not necessarily at the fringe of the service area, any attenuation of the strong signal of unlicensed devices would also attenuate the DTV signal, probably to below the threshold of visibility.

Further, cochannel-like interference by certain pairs of high-power unlicensed devices would require the Commission to generate a table of market-specific Taboo channels. Mapping a dynamic table of Taboo channels onto the controlling software in order to prevent tandem transmission on Taboo channels by pairs of devices in a pool of thousands would be a major development task.

For these reasons, fixed high-power devices should be licensed, at least in the major markets. The only way to positively limit the interference with DTV service is by controlling the fixed devices' channels, their location relative to nearby DTV receivers, their antenna heights

above ground and their antenna radiation patterns. Alternatively, the Commission could limit the transmitted power levels in accordance with the recommendations submitted in the Summary section of this document and thus avoid the issues of Taboo channels mapping and the licensing of fixed devices.

VI. THE MISSING MODELS OF INTERFERENCE BY AGGREGATE DEVICES IN URBAN, URBAN AND RURAL AREAS SHOULD BE DEVELOPED FIRST

In the Commission's rules regarding interference to DTV stations by other TV stations and also in the rules regarding RF hazards by multiple TV stations at a common site, the Commission clearly specified the methodology of calculation the cumulative effect of multiple sources.

In ET Docket 04-186 the Commission did not propose how the aggregate interference from multiple unlicensed (and possibly some licensed) devices could or should be accounted for. To be consistent with past practices and more importantly to avoid harmful interference to licensed DTV stations, the Commission should establish aggregate interference models for urban, suburban and rural areas. The underlying principle of these models would be that the aggregate new interference of all devices not exceeds the present rules regarding DTV into DTV interference.

Respectfully submitted,

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