Before the
Federal Communications Commission
Washington DC 20554

In the Matter of	|	
	|	
Establishment of an Interference	|	
Temperature Metric to Quantify and Manage	|	ET Docket No. 03-237
Interference and to Expand Available	|	
Unlicensed Operation in Certain Fixed,	|	
Mobile and Satellite Frequency Bands	|	

COMMENTS OF THE FIXED WIRELESS COMMUNICATIONS COALITION

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TABLE OF CONTENTS

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Pursuant to Section 1.415 of the Commission's Rules, the Fixed Wireless Communications Coalition (FWCC) hereby comments on the Notice of Inquiry and Notice of Proposed Rulemaking in the above-captions proceeding.[1]

A. Summary

The Commission proposes a novel "interference temperature" approach to regulating unlicensed transmitters in licensed spectrum: monitoring the ambient noise at the licensed receiver, and letting unlicensed devices exploit any headroom below the maximum noise level the receiver can tolerate without additional degradation.

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[1] *Establishment of an Interference Temperature Metric*, 18 FCC Rcd 25309 (2003) (Notice of Inquiry and Notice of Proposed Rulemaking) (Notice). The FWCC is a coalition of companies, associations, and individuals interested in the Fixed Service -- *i.e.*, in terrestrial fixed microwave communications. Our membership includes manufacturers of microwave equipment, licensees of terrestrial fixed microwave systems and their associations, and communications service providers and their associations. The membership also includes railroads, public utilities, petroleum and pipeline entities, public safety agencies, and/or their respective associations, landline and wireless, local, and interexchange carriers, and telecommunications attorneys and engineers. Our members build, install, and use both licensed and unlicensed point-to-point, point-to-multipoint, and other fixed wireless systems, in frequency bands from 900 MHz to 95 GHz.

The Notice repeatedly mentions the Fixed Service (FS) bands as a possible test bed. This raises grave concerns for the industries that provide and use FS equipment and services, because the FS bands have three characteristics that make them singularly *unsuited* to an interference temperature regime. First, the FS routinely carries critical public safety and infrastructure communications: forwarding police and fire dispatch communications, coordinating the movement of railroad trains, controlling natural gas and oil pipelines, regulating the electric grid and water utilities, and backhauling wireless telephone traffic, among many others -- services that require the highest levels of reliability. Second, because FS receivers use large, highly directional antennas, they are extremely sensitive to the azimuth (direction) of an emitter -- a likely cause of harmful interference the Commission's plan does not adequately take into account. Third, FS signals are subject to extreme and variable levels of atmospheric fading. A high fade margin at one moment can disappear the next, leaving the FS receiver suddenly vulnerable even to low levels of interfering signal.

The Commission cites two properties of FS systems as purportedly making them resistant to interference from unlicensed devices: highly directional antennas are said to afford protection from signals arriving toward the sides or back of the antenna; and remote siting is said to place FS receivers a long way from potentially interfering devices. We think the Commission has overestimated the protective effect of both characteristics.

Under realistic scenarios, we show that a single unlicensed emitter 100 meters from an FS receiver, and well outside the boresight, will cause interference if its power level exceeds 3 thousandths of a watt -- far below the 1 to 4 watts contemplated by the Commission for unlicensed transmitters in these bands. Multiple devices would have to operate at lower levels still. For unlicensed devices in the boresight, even great distances offer inadequate protection. Using a specific FS link in Phoenix, AZ, we show that a single one-watt emitter anywhere in a square-kilometer-plus area in central Phoenix will exceed the acceptable interference threshold hundreds of times over at an FS receiver on Thompson Peak, 24 km away. Safely accommodating just 1,000 unlicensed devices in that area requires limiting the power of each to the present Part 15 levels.

Two points need special emphasis. First, although FS links operate much of the time with high levels of signal margin, users need that margin to maintain reliability under fading conditions -- and they pay for it in equipment costs. The fade margin is not a public resource the Commission can allocate out for use by others. Second, the fundamental premise of the interference temperature concept -- monitoring noise to determine safe power levels for unlicensed operation -- fails where the licensed service uses large, highly directional antennas. Antennas in the 6 GHz band are usually six or eight feet in diameter. Their high gain enables FS receivers to make use of signals far too faint for detection by a smaller-sized monitoring device. An unlicensed device in the receiver boresight, unable to ascertain the band is in use and having no reason to refrain from transmitting, would almost certainly override the weak FS signal and cause harmful interference.

Based on the showings below, we foresee serious problems in applying the interference temperature concept in the FS bands. We ask the Commission not to introduce unlicensed devices at 6525-6700 MHz and 12.75-13.25 GHz above the present Part 15 limits.

B. Background

The demand for spectrum continues to accelerate beyond the supply. With only trivial exceptions, however, all of the non-Government frequencies that are technically and economically suitable for mobile use or medium- to long-range fixed communications have been fully allocated. A glance at the allocation tables shows that many bands below about 30 GHz (and some above) are already shared.[2] Fixed microwave operators, in particular, have shared bands with earth stations in the Fixed Satellite Service since the very beginning of geosynchronous satellite communications.[3] In addition, low-power unlicensed "underlay" operation is permitted on a non-interference, non-protection basis in most bands below 38.6 GHz.[4]

Especially in recent years, the increasing demand for mobile applications and wireless connectivity has given rise to new short-range digital radio technologies, including several types of Wi-Fi and U-NII, Digital Short Range Communications, 4.9 GHz public safety, ultra-wideband, and others. These in turn, and doubtless others still to come, highlight the need for a new kind of regulatory scheme that can accommodate rapid technical evolution, multiple signal waveforms, and high densities of low-power transmitters having relatively short ranges.[5]

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[2] *See* 47 C.F.R. Sec. 2.106.

[3] *Amendment of Part 2 of the Commission's Rules to Conform, to the Extent Practicable, with the Geneva (1959) Radio Regulations, As Revised by the Space EARC, Geneva, 1963*, 39 F.C.C. 975 (1965).

[4] *But see* 47 C.F.R. Sec. 15.205 ("restricted bands" where intentional unlicensed operation is barred).

[5] Notice at para. 6-7.

The Commission has traditionally regulated underlays on an unlicensed basis. That is, rather than license users, the Commission regulates the transmitters, typically as to power, frequency, and location.[6] That regulation is static -- *i.e.*, all unlicensed transmitters in a given band are permitted to operate at some maximum power, regardless of their density and duty cycles.[7] This means the unlicensed power must be set very low, so that even a worst-case accumulation of unlicensed devices will not cause harmful interference to licensed services.

This proceeding suggests an alternative approach. In principle, the goal is to regulate transmitters dynamically, so as to make maximum use of the spectrum without causing interference to licensed receivers.

The proceeding is in two parts: a Notice of Inquiry (NOI) and a Notice of Proposed Rulemaking (NPRM). As we show below, the two take fundamentally different approaches to regulation. We take them up separately.

C. Notice of Inquiry and Response

The Commission outlines a regulatory scheme based on the concept of interference temperature. The approach depends on developing a continuous estimate of the RF environment at the point where interference actually occurs, *i.e.*, at the location of the victim receiver.[8] The NOI suggests three possible locations for measuring interference temperature: at the unlicensed transmitter device; at the receiver (mentioning FS receivers as an example); or over a grid of

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[6] Notice at para. 5.

[7] Certain devices with extremely low duty cycles are permitted somewhat higher power. 47 C.F.R. Sec. 15.231.

[8] Notice at para. 7.

monitoring stations.[9] In the second two cases, data on interference temperature would be communicated to potentially interfering transmitters, which would use the information to dynamically control power, frequency, and/or antenna pattern to ensure that pre-set interference temperature limits are not exceeded.[10] The NOI seeks comment on a metric to gauge the success of introducing interference temperature devices into a frequency band,[11] factors to be considered in setting interferences temperature limits,[12] techniques for measuring and communicating interference temperature,[13] and how transmitters should respond if the limit is exceeded.[14] The NOI also seeks comment on measurement of the noise floor,[15] and on the quantification of harmful interference.[16]

The Notice repeatedly mentions point-to-point FS microwave as a suitable service in which to introduce interference temperature concepts.[17] The Commission states:

> [W]e believe that the use of relatively large, high-gain antennas in the 6525-6700 MHz and 12.75-13.25 GHz bands by existing licensees makes such operations highly immune to interference -- especially from the

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9 Notice at paras. 11-12.

10 Notice at paras. 13-14.

11 Notice at para. 20.

12 Notice at para. 21.

13 Notice at para. 22.

14 Notice at para. 23.

15 Notice at paras. 24-26.

16 Notice at paras. 27-28.

17 *E.g.*, Notice at paras. 11, 31, 34, 36, 37, 40-45.

> relatively low power unlicensed devices contemplated by this proceeding.[18]

That statement is incorrect, in two important respects:

1. An FS receiver is exquisitely sensitive to interference within a few degrees of the antenna axis. There, even a single, low-power source tens of kilometers away can gravely impair receiver performance.

2. As to interference sources away from the antenna axis, the selectivity provided by antenna gain is insufficient to protect the receiver from even relatively quiet interference sources close by.

We document both of these statements in Part E, below,

The NOI seems to visualize interference temperature as a location-specific, scalar, isotropic property that changes gradually with location and is independent of azimuth -- something like a fog resting over the landscape. But this model is misleading when applied to a highly directional victim receiving antenna. Such an antenna does not average the radio signals reaching it from all directions, as the model suggests. Rather, the victim receiver is highly sensitive to the individual locations and direction of radiation of each separate interfering source.

Estimating the interference "headroom" in a highly directional receiver would entail the following considerations:

1. Interference temperature is dominated by the exposures along the boresight of the receiving antenna -- *i.e.*, it must be measured in terms of interference generated at the FS antenna terminal.

2. The interference temperature somehow must be measured independently of the desired (incoming FS) signal, also arriving along the boresight. The desired signal may be extremely weak -- which is why FS receivers use high-gain receiving antennas.

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[18] Notice at para. 40.

3. The FS receiver becomes much less tolerant of interference when the desired signal drops (as from atmospheric fading). Therefore, the interference temperature must be continuously measured from moment to moment relative to the received strength of the desired signal.

4. The varying available margin at each instant must be communicated to unlicensed transmitters in the field seeking to use it.

5. An unlicensed transmitter could be permitted to initiate operation only if it is sufficiently far off the main-beam axis of every FS receiver using that frequency so that each receiving antenna's discrimination provides adequate selectivity to reject the interfering signal.

The concept of controlling unlicensed devices by monitoring interference temperature does not appear viable in the FS bands. A grid of monitors cannot adequately protect an environment of highly directional FS receivers. Moreover, FS microwave links are used on a full-time basis, and do not offer quiet intervals for the operation of unlicensed devices.

In principle (although probably impracticable), a better solution for accommodating unlicensed devices would rely on spatial coordination, establishing exclusion zones for FS receiver patterns -- the same "keyhole" concept used for frequency coordination among terrestrial FS operations.[19] Unlicensed devices could operate in the open areas between the keyhole patterns, which are calculated to assure sufficient free space loss and antenna discrimination to nearby FS receivers on a given frequency. Within an exclusion zone, unlicensed devices could operate on frequencies sufficiently offset from the frequencies used by that link. If a mobile unlicensed device is frequency agile, it can adjust to avoid licensed frequencies as it passes through successive keyholes.

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[19] The keyhole shape consists of a roughly circular area around the receiver and a long, narrow cone radiating out along the antenna axis.

As we show in more detail below, however, unlicensed devices cannot avoid licensed FS frequencies by monitoring. The high-gain FS receive antennas rely on signals too faint for detection by a mobile antenna, or even by a fixed grid of monitoring antennas. An unlicensed transmitter can avoid licensed frequencies only if it is able to locate itself relative to all FS links using a given frequency. We might imagine equipping each unlicensed transmitter with a GPS finder and a database of all FS links. In practice that would be extremely difficult, inasmuch as FS operators are continually adding links and frequencies, which add more keyhole-shaped exclusion zones.

In short, we think the NOI has not adequately considered the characteristics of FS receivers in the context of interference temperature regulation. Any further development of the concept in the FS bands must take into account the very high directivity of FS antennas and the very high sensitivity of FS receivers, not only to interference arriving along the antenna boresight, but also to interference sources off the antenna axis. We provide quantitative examples below. Those calculation show that any unlicensed power levels above the present Part 15 limits are unsafe for the FS.

D. Notice of Proposed Rulemaking

The NPRM portion of the document seeks to institute what it calls a form of interference temperature regulation, but "without full implementation of real-time monitoring of the interference temperature or feedback control of transmitters,"[20] and prior to completion of our studies of the noise floor.[21] This approach would:

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[20] Notice at para. 30.

[21] *Id.*

1. establish an interference temperature or equivalent metric based on the communications margins needed by existing licensed operations;

2. apply restrictions on unlicensed devices to minimize the likelihood they would cause an increase in interference temperature that exceeds the necessary operating margin of the licensed services; and

3. impose restrictions on unlicensed devices that could include limiting the transmitter output power and requirements for transmit power control (TPC), dynamic frequency selection (DFS), and duty cycle restrictions.[22]

The Commission proposes introducing this plan in the FS/FSS uplink band at 6525-6700 MHz, and the FS, FSS, and BAS/CARS band at 12.75-13.25 GHz,[23] based on the following justifications. **None of these points, alone or in combination, provides adequate assurance against disruption to FS communications.**

In general. The NPRM says:

- FS licensees are able to share the band at high powers.[24]
- Fixed operations can be adequately protected by DFS.[25]
- FS stations may operate at up to 85 dBm EIRP, while unlicensed devices in the FS bands are currently limited to –41.25 dBm, which is 126 dB lower. In view of that disparity, "sound engineering judgment intuitively suggests" the bands can

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22 *Id*.

23 Notice at para. 31. The proposal excludes 13.15-13.2125 GHz, which is set aside for mobile television pickup operations. *Operation of NGSO FSS Systems Co-Frequency with GSO and Terrestrial Systems in the Ku-Band Frequency Range,* 16 FCC Rcd 4096 at para. 126 (2000) (13.15-13.2125 GHz).

24 Notice at para. 40.

25 Notice at para. 34.

support expanded unlicensed operation regulated by interference temperature without detrimental impact.[26]

Interfering source away from the FS antenna axis. The NPRM says:

- "Divergent path geometries" will place most close-proximity, ground-based, unlicensed transmitters at least 20-30 degrees off-axis, where FS antennas are required to attenuate by 30 to 36 dB.[27]

- Large, high-gain antennas make FS operations "highly immune" to interference.[28]

Interfering source on or near the FS antenna axis. The NPRM says:

- "Isolated siting" of FS receive antennas will protect against interference by making the distance to an unlicensed device relatively large, perhaps 100 meters or more.[29]

- Free-space attenuation over 100 meters is 89 dB at 6600 MHz, and 95 dB at 13 GHz.[30]

Building scenario. The NPRM says:

- An unlicensed transmitter within the same building that supports an FS receiver will be shielded by the building and be far off axis.[31]

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[26] Notice at para. 37. More typically, FS links in the range 15-20 miles have EIRPs of 65-70 dBm.

[27] Notice at para. 40.

[28] *Id.*

[29] *Id.*

[30] *Id.*

[31] *Id.*

E. Response to NPRM

We show here why the elements listed above are inadequate to protect FS receivers from interference.

At the outset, however, we note a serious disconnect between the NOI and the NPRM portions of the Notice: unlike the NOI, the NPRM does not actually apply the concept of interference temperature. Instead, it merely proposes to authorize unlicensed devices under rules similar to those the Commission has already adopted for Part 15 U-NII devices.[32]

1. In general

We dispute a fundamental premise that runs through the NPRM. It is true, as the NPRM says, that FS stations operate at up to 126 dB above the unlicenced levels in Section 15.209.[33] This is because the FS operates over long distances and carries vitally important safety and infrastructure services, which need extremely high levels of reliability -- routinely 99.999% (*i.e.*, no more than five minutes outrage per year due to all causes) and up to 99.9999% (30 seconds maximum outage per year). FS communications are subject to high levels of atmospheric fading. To maintain the availability needed for critical services, FS manufacturers routinely select transmitter power and antenna gain so as to build in enough fade margin to overcome fading and ensure the link remains available for service under worst-case conditions.

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[32] *Unlicensed National Information Infrastructure (U-NII) Devices in the 5 GHz Band*, 18 FCC Rcd 24484 (2003).

[33] Notice at para. 37.

FS users need a high level of reliability and pay for it in their equipment costs. The resulting fade margin is not a public resource the FCC can allocate for use by others.

The derivation of the fade margin required to achieve the customer's specified level of availability takes into account identified sources of interference at the time of construction. There is no allowance for unknown and unanticipated future interference exposures.

Sharing among FS licensees is carefully planned so it does not cut into the fade margin. Through the process of prior frequency coordination, each proposed new link is checked against a database of existing links.[34] Potentially affected licensees are notified of the proposed link, and have the opportunity to object if their service will be impaired. The proposals here to deploy unlicensed devices in the FS bands offer nothing comparable in the way of protection.

2. Interfering source away from the FS antenna axis

Several passages in the NPRM argue the high directivity of FS antennas will protect FS communications from interfering sources at a sufficient angle from the antenna boresight.[35] We disagree.

The Commission correctly recognizes the need to maintain a certain signal-to-noise ratio on the microwave link in order to demodulate the microwave signal. The NPRM mentions 30-50

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[34] Frequency coordination among FS users is required under 47 C.F.R. Sec. 101.103.

[35] *E.g.*, Notice at paras. 37, 40.

dB.[36] The low end of this range is about right for a 64-QAM signal, not counting fade margin.[37] Although 50 dB would allow for approximately a 15-20 dB fade margin, that is rarely enough to keep non-diversity availabilities even in the 99.99+% range, and is 10 or 20 dB lower than the value typically needed. The Commission assumes that the closest point of approach of the unlicensed device is 100 meters.[38] Let us assume a device at that distance, located far enough off the receiver antenna axis so the antenna attenuates by 40 dB, relative to a signal arriving along the boresight.[39] This approximately equals the minimum required antenna gain.[40] A typical microwave receive level is –35 dBm. If we subtract 50 dB for signal-to-noise, the maximum unlicensed signal acceptable at the receiver input would be –85 dBm.[41] Free-space loss at 100 meters is approximately 89 dB.[42] This limits the unlicensed device to a maximum EIRP toward the FS receiver of 4 dBm, or *3 thousandths of a watt* -- far below the 1 to 4 watts EIRP

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36 Notice at para. 42.

37 TIA specifies a threshold-to-interference ratio of 34 dB for the upper 6 GHz band. *Interference Criteria for Microwave Systems*, TIA/EIA Telecommunications Bulletin TSB 10-F at Sec. 2.5.5 (June 1994).

38 Notice at paras. 40, 43.

39 This roughly corresponds to 30-100 degrees off the axis for Category A antennas, and 100-140 degrees for Category B. 47 C.F.R. Sec. 101.115(c).

40 *Id*.

41 As noted above, this level neither takes into account the fade margin on the FS link nor protects the FS receiver threshold. The required interference level objective would be –110 dBm for an FS receiver with a threshold of –76 dBm, *i.e.*, –76 dBm threshold – 34 dB (required threshold to interference ratio) = –110 dBm.

42 Notice at para. 40.

contemplated by the Commission.[43] And this reflects the presence of only a single unlicensed device.[44] Multiple devices would have to reduce power further, in proportion to their numbers.

3. Interfering source on or near the FS antenna axis

The NPRM likewise fails to offer adequate assurance against interference from an unlicensed device that lies along the boresight of the receiving antenna. The Commission correctly points out that free-space attenuation over 100 meters is 89 dB at 6600 MHz, and 95 dB at 13 GHz.[45] But free-space attenuation increases by only 6 dB for each doubling of the distance. At 24 km, for example, free-space attenuation is 137 dB. The high-gain antennas and sensitive receivers used by the FS easily overcome this loss.

The Commission states that "isolated siting" of FS receivers will make the distance to an unlicensed device "relatively large," perhaps 100 meters or more.[46] We can adjust the preceding calculation for an on-axis interfering source at 100 meters simply by putting back in the 40 dB of antenna gain that the calculation omitted. That reduces the permissible maximum EIRP to 3/1000 watt divided by 10,000, or *1/4 of one millionth a watt* -- yet this is still three times higher than the present Part 15 levels in the FS bands.

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[43] Notice at para. 38.

[44] Even a single device at 4 watts (+36 dBm) located 100 meters *directly behind* an FS antenna would greatly exceed the –110 dBm interference objective into an FS receiver that has a –76 dBm threshold. Details: (+36 dBm EIRP) – (89 dB free-space loss) + (–17 dBi antenna gain for a Category A antenna [*i.e.*, + 38 dBi main beam gain – 55 dB suppression at back of antenna]) – (2 dB line loss) = –72 dBm.

[45] *Id*.

[46] Notice at para. 40.

In practice, unlicensed devices may tend to be farther away than 100 meters. But there could be a lot more of them in view of the antenna. We take up a specific example.

Most antennas used by the FS in the 6525-6700 MHz band are 6 or 8 foot diameter parabolas.[47] With normal manufacturing tolerances and typical feed horn illumination, a 6 foot diameter parabolic antenna has an isotropic gain of 39 dBi and a 3 dB beam width of 1.7 degrees. For an 8 foot antenna, the typical gain is 42 dBi with a beam width of 1.3 degrees. While this may seem narrow, the following calculations show otherwise.

We examined several FS links in the area surrounding Phoenix, AZ to estimate the interfering effect of unlicensed devices operating in the Phoenix metropolitan area. A 6 foot antenna on Thompson Peak,[48] at a distance of approximately 24 km from the Phoenix population "center of gravity," would see an area of approximately 1.6 square kilometers. (Similarly, an 8 foot antenna at the same location would see an area of approximately 1.2 square kilometers.) As we show below, almost any unlicensed emitters anywhere within these areas, operating on the same frequencies as the FS links, will cause interference. Here, the high gain of the antennas provides no protection, but rather exacerbates the interference, as the interfering signals will be on (or very near) the FS antenna boresite.

FS system users in the 6 GHz band include public safety, power utilities, and wireless service providers. In order to provide the high levels of availability they need, FS links are typically designed with fade margins against dispersive fading that are based on interference

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[47] This statement relies on an analysis of the FCC ULS database as of March 9, 2004.

[48] This location is in the FCC ULS database as of March 9, 2004, at site coordinates 33.64419N, 111.8120833W.

power levels below the total noise levels in the receiver, that is, below kTB.[49] A typical value for interference level is 6 dB below thermal noise (kTB).[50] The accompanying chart (next page) shows the number of unlicensed devices at each of several power levels, and the resulting interference level imposed on a 10 MHz bandwidth FS receiver using a 6 foot antenna at a range of 24 km. Power levels shown range from –41.25 dBm (the current Part 15 limit in the band) to the +30 dBm (1 watt) level proposed in the NPRM.[51] As the chart shows, *a single one-watt device anywhere in the square-kilometer-plus area seen by the antenna will reduce the fade margin by more than 30 dB.* This is unacceptable. It leaves the FS link virtually unprotected from anything other than trivial fading activity.

Multiple devices in the area would make the problem much worse. Some limit on the number of unlicensed devices operating simultaneously is obviously necessary, in view of the cumulative effect that multiple interference sources would have on the threshold degradation of the FS receiver. The aggregate of ten similar devices results in a composite interference power level 10 dB above that of a single device. This cumulative effect would quickly degrade the operating margin on the FS link. As the chart shows, accommodating just 1,000 devices would require limiting their power levels to the present Part 15 rules.[52] On the other hand, we do not see any readily practical way to control the number of unlicensed devices in a given area.

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49 *See Interference Criteria for Microwave Systems*, TIA/EIA Telecommunications Bulletin TSB 10-F (June 1994).

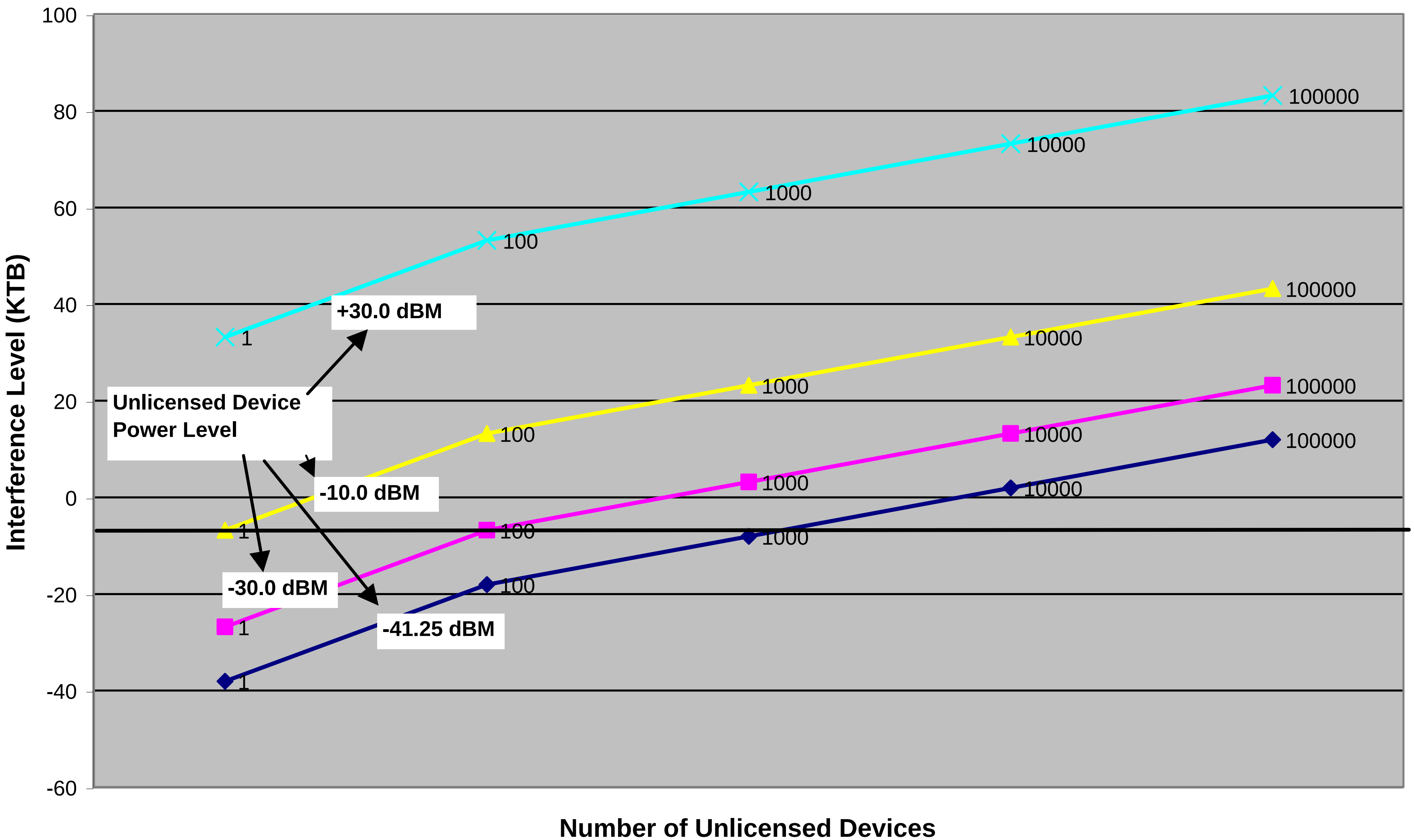
50 *Id.*

51 Notice at para. 38.

52 To the best of our knowledge, no one presently manufactures Part 15 devices for either of the bands at issue in this proceeding.

Boresite Interference at 24 KM

6.7 GHz with Standard 6' Dish



Monitoring by unlicensed devices is emphatically not the answer, because an unlicensed device will be incapable of detecting the presence of an FS signal when the FS receiver is most vulnerable. The signal power received by the unlicensed device will always be about 40 dB lower than that at the FS receiver, because of the difference in their antenna gains. When the FS receiver is subject to multipath fading, the incoming FS signal at the unlicensed device is likely to fall below the thermal noise floor of the unlicensed receiver. For example, suppose multipath fading reduces the desired signal power into a 64-QAM FS receiver to 30 dB above the total noise of the system. At any lower signal-to-noise ratio, the FS receiver will begin making errors. But the equivalent fade to a nearby unlicensed device results in a signal that, at best, is 10 dB below the noise floor of the unlicensed system -- and lower still if the unlicensed device lacks a line-of-sight path to the FS transmitter, or has a lower bandwidth than the FS link. Unable to detect the FS signal, the unlicensed device meets all criteria to transmit. But the interference it causes will take the FS receiver's signal-to-noise ratio below 30 dB, and thus take the receiver out of service.[53]

We see no way to avoid harmful interference into FS receivers from unlicensed devices in the antenna boresight, if they are tens of kilometers away. And we see no way to keep unlicensed devices out of the boresight.

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[53] Some might question why FS receiver need a full 30 dB of signal-to-noise ratio. The Commission requires 6 GHz FS equipment using bandwidths of 10 MHz or more to achieve spectrum efficiencies of at least 4.5 bits/second/Hertz. 47 C.F.R. Sec. 101.141(a)(3). These capacities can be achieved only with higher level digital modulations such as 64-QAM, 128-QAM, etc. It follows from basic principles of communications theory that modulations employing a higher number of states require a correspondingly larger signal-to-noise ratio.

4. Building scenario

The Commission notes that an unlicensed transmitter within the same building that supports an FS receiver will be shielded by the building and be far off axis.[54] We disagree. As we showed in Section E.2 above, the off-axis attenuation will not protect the FS receiver even from a single unlicensed device operating at just a few thousandths of a watt at a distance of 100 meters. Even allowing for building attenuation of, say, 10 dB would increase the permitted power for a single device to just a few tens of milliwatts, still far below the 1-4 watts contemplated in the NPRM.[55]

But there is a much worse, yet equally plausible, scenario: an unlicensed transmitter in a building across the street from a rooftop-mounted victim FS antenna. Suppose the FS antenna is receiving a faded signal level at –112 dBm from a transmit site 32 km away.[56] An unlicensed device operating *at the current Part 15* limit of –41.25 dBm, located 100 meters away would put an interfering signal level of –130.25 dBm into the victim antenna -- far above the 34 dB below the received signal needed to protect a digital FS receiver threshold in the upper 6 GHz band.[57] An increase in unlicensed power above the Part 15 limit, or the introduction of multiple unlicensed devices, obviously makes things still worse.

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54 *Id*.

55 Notice at para. 38.

56 Details: (+66 dBm EIRP) – (139 dB free space loss) – (39 dB fade margin allowance for 99.999% availability at 32 km) = –112 dBm into the FS receive antenna.

57 *Interference Criteria for Microwave Systems*, TIA/EIA Telecommunications Bulletin TSB 10-F at Sec. 2.5.5 (June 1994).

CONCLUSION

The FWCC agrees the Commission must find new ways to accommodate more users in the spectrum. The concept of interference temperature may indeed become part of the solution. As presented so far, however, the interference temperature approach is singularly unsuited to bands populated by highly directional and extremely sensitive receivers, carrying continuous data over tens of kilometers, and needed at 99.999+% availability for critical public safety and infrastructure applications. The combination of high FS antenna gain and receiver sensitivity means that monitoring receivers will completely miss FS signals that are tens of dB above the FS receiver threshold. As we showed above, neither directivity nor distance can adequately protect FS receivers from interference caused by unlicensed devices on their frequencies.

In short, the safeguards set out in the NOI and NPRM are not sufficient. The calculations above show that harmful interference is likely to result from unlicensed devices operating at levels higher those presently permitted under Part 15. For that reason, we ask the Commission to abandon the idea of introducing higher-powered unlicensed devices in the 6525-6700 MHz and 12.75-13.25 GHz bands.

Respectfully submitted,

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