

Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	
Unlicensed Use of the 6 GHz Band	)	ET Docket No. 18-295
	)	
Expanding Flexible Use in Mid-Band Spectrum Between 3.7 and 24 GHz	)	GN Docket No. 17-183
	)	

**COMMENTS OF THE
NATIONAL ACADEMY OF SCIENCES'
COMMITTEE ON RADIO FREQUENCIES**

The National Academy of Sciences, through its Committee on Radio Frequencies (hereinafter, CORF¹), hereby submits its comments in response to the Commission's *Further Notice of Proposed Rulemaking* ("FNPRM"), released April 24, 2020, in the above-captioned dockets. In these comments, CORF addresses the appropriate power level for proposed "very low power" operations of 6 GHz unlicensed devices without use of an automated frequency coordination ("AFC") system, while minimizing potential interference to protected passive scientific observations.

I. Introduction

CORF has a substantial interest in this proceeding, as it represents the interests of scientific passive users of the radio spectrum, including users of the Radio Astronomy Service ("RAS"). Radio astronomers perform important research that is extremely vulnerable to interference. The emissions that radio astronomers observe are extremely weak—a radio telescope receives less than 1 percent of one-billionth of one-billionth of

¹ See the Appendix for the membership of the Committee on Radio Frequencies.

a watt (10^{-20} W) from a typical cosmic object. Because radio astronomy receivers are designed to pick up such remarkably weak signals, radio observatories are particularly vulnerable to interference from in-band emissions, spurious and out-of-band emissions from licensed and unlicensed users of neighboring bands, and emissions that produce harmonic signals in the RAS bands, even if those human-made emissions are weak and distant. Even when, as in the present case, a band already has incumbent fixed operations, transmissions by unlicensed devices into protected RAS bands can be particularly harmful because, due to their mobility and lack of licensing records, it is very difficult to identify interference from such devices, to identify the operator of such devices, and to remedy the interference.

The RAS is an important and protected incumbent in the U-NII-7 sub-band. The 6650-6675.2 MHz band is important to the RAS for observation of methanol, which plays a significant role in research into star formation. In addition, observations of methanol can be used to determine temperature, density, and relative abundance of ortho and para molecular hydrogen, the most abundant element in the universe. The spectral line at 6668.518 MHz is among the spectral lines of greatest observational importance to RAS. See Recommendation ITU-R RA.314-10 at Table 1.² This band is protected by Footnote US342, which states that “all practicable steps shall be taken to protect the radio astronomy service from harmful interference” in this band.

In its April 24, 2020, Report and Order in this proceeding (“R&O”), the Commission recognized the public interest in protecting RAS observations in this band and implemented a number of rules designed to protect RAS observations from

² See also ITU Handbook on Radio Astronomy (ITU Radiocommunications Bureau, 2013) at Table 3.2.

interference from standard power operations using AFC. CORF greatly appreciates the Commission's actions in this regard. CORF urges the Commission to again be mindful of the public interest in protecting extremely vulnerable radio astronomy observations when considering the appropriate power level and appropriate protections for proposed "very low power" operations of 6 GHz unlicensed devices without use of an AFC system.

II. Appropriate Power Level for "Very Low Power" Devices, and Protection of RAS.

In the FNPRM, the Commission proposes the use of "very low power" devices to operate in the U-NII-5 and U-NII-7 bands with no requirement that the devices be kept indoors or be under the control of an AFC system. The FNPRM seeks comment on the appropriate power level for such device/uses, clearly with an intention of preventing interference to other users of the band.³ If the Commission chooses to implement this proposal, it should consider limited power level or other measures in order to fulfill its requirement to protect RAS observatories.

It should be noted that consideration of what constitutes "very low power" is in part relative to the sensitivity of the service for which protection is sought. As noted above, the receivers used in radio astronomy observatories are the most sensitive ones in existence. The level of protection for RAS is set by ITU-R RA.769. For spectral line

³ See, e.g., paragraph 234 noting that the proponents of this proposal assert that "these very low-power devices will not cause harmful interference to [incumbent] microwave receivers" Further evidence that the FNPRM seeks to protect incumbents from interference from wide-spread use of these devices without AFC is the Commission's inquiry, in paragraph 237 of the FNPRM, as to whether such devices should be required to "listen to the spectrum prior to transmitting to ... protect incumbent users." Unfortunately, because the incumbent RAS is a passive service that itself "listens" to spectrum rather than transmits, requiring unlicensed 6 GHz devices to listen before transmitting could not protect RAS observatories from interference.

observations at 6.65 GHz, a power level of -228 dB(W/m² Hz) is considered harmful, whereas the power level that is harmful to continuum observations at this frequency is even lower, at -241 dB(W/m² Hz), based on extrapolations of Tables 2 and 1 of ITU-R RA.769, respectively. Given that there is very little atmospheric attenuation at this frequency band, this confirms that aggregate power levels for outdoor devices located near a radio astronomy facility would have to be extremely low to avoid harmful interference. For example, an individual device operating with a power spectral density Effective Isotropically Radiated Power (EIRP) of -8 dBm/MHz (FNPRM paragraph 234) exceeds the ITU-R RA.769 threshold levels for spectral line observations, even at separation distances of several hundreds of kilometers.⁴ In other words, protection of RAS requires significant geographic or frequency separation for unlicensed devices operating at these power levels.

In paragraph 236, the FNPRM “seek[s] comment on the appropriate power level for very low power unlicensed devices in the 6 GHz band.” To provide an example of the appropriate power levels required to protect radio astronomy observatories, CORF starts with the assumption that radio observatories have some control over use of electronic devices on their premises. Thus, adopting a 1 km separation distance provides an indication of the threshold aggregate spectral power density required to protect spectral line radio astronomy observations (the threshold power level is even lower to protect continuum observations): -157 dBW/Hz. For 160 MHz channels, the

⁴ In the absence of significant atmospheric attenuation, the separation distance can be calculated directly from the inverse square law: flux = luminosity/(4 π d²). In the case of a threshold limit of -228 dB(W/m² Hz) and a transmit power of -98 dBW/Hz (-8 dBm/MHz), this corresponds to a separation distance for a single device of $d = \sqrt{10^{[-98 \text{ dBW/Hz} - (-228 \text{ dBW/Hz})]/10/4\pi}}$ (meters) = $\sqrt{10^{13}/4\pi}$ (meters) = 900 km. This calculated separation distance is larger than the horizon distance ($D = 4.12 * [\sqrt{H_{tx}} + \sqrt{H_{rx}}]$), where D is in kilometers and the heights of the transmitter and receiver are in meters) for most radio astronomy facilities in the United States. The appropriate exclusion zones are listed in Footnote US385.

maximum aggregate EIRP for very low power devices is therefore -45 dBm in the radio astronomy band.

Accordingly, pursuant to the requirements of Footnote US342 that “all practicable steps shall be taken to protect the radio astronomy service from harmful interference” at 6650-6675.2 MHz, if a proposed device is able to sense its geographic location, then geographic exclusion zones similar to those listed in Footnote US385 should be implemented.⁵ These exclusion zones must include geographic regions around protected RAS sites in the United States that operate in the 6-7 GHz band, including Arecibo Observatory, Green Bank Observatory, the Very Large Array, the 10 stations of the Very Long Baseline Array, the Owens Valley Radio Observatory, and the Allen Telescope Array. Alternatively, if the device is not able to sense its geographic location, then the RAS band protected by US342 (6650-6675.2 MHz) must be notched out of the device’s transmission band to protect sensitive radio astronomy observations.

Further, while CORF recognizes that in the R&O (at paragraph 173) the Commission did not implement protections for RAS from low-power indoor devices, the FNPRM considers raising the permitted power level of these devices. Specifically, CORF notes that even including a median attenuation of 20.5 dB for a building entry loss factor (footnote 297 of the R&O), the proposed power spectral density of 8 dBm/MHz (FNPRM at paragraph 244) for low-power indoor devices results in a separation distance far beyond the horizon distance to avoid harmful interference to spectral line observations by radio astronomy observatories.⁶ Thus, at these power

⁵ The spectral characteristics of transmissions at 6.6 GHz are extremely similar to those of transmissions at 4.9 GHz, which are subject to the exclusion zones in Footnote US385.

⁶ The separation distance calculation for indoor 6 GHz unlicensed devices is similar to that for outdoor devices but includes an additional attenuation factor due to building entry loss. Footnote 297 of the R&O

levels, geographic exclusion zones, such as those listed in Footnote US385, must be implemented for unlicensed low-power indoor devices as well. Alternatively, the RAS band protected by US342 (6650-6675.2 MHz) should be notched out of the device's transmission band to protect sensitive radio astronomy observations.

Lastly, as the Commission knows, aeronautical transmissions are particularly troublesome sources of interference to radio astronomy.⁷ The R&O properly recognized the public interest importance of this issue and implemented substantial limits on airborne use of 6 GHz devices with AFC: prohibiting use on unmanned aircraft systems, limiting airborne use only to large aircraft when flying above 10,000 feet, and limiting airborne use to the U-NII-5 band where such passive scientific operations do not occur. See R&O at para. 215. The public interest in protecting vulnerable passive observations is the same *vis a vis* 6 GHz devices without AFC, and thus at very least, these same prohibitions should apply if the Commission authorizes such devices as well. Such limits are critical to the protection of RAS observations.

III. Conclusion.

The Commission has recognized the public interest in protecting RAS observations in the 6 GHz band, and in the R&O it implemented a number of rules

adopts a 70/30 mix of traditional versus thermally efficient building types to arrive at a median building entry loss of 20.5 dB. The proposed power spectral density of 8 dBm/MHz corresponds to -82 dBW/Hz. The separation distance is thus $d = \sqrt{10^{(-82 - 20.5 - (-228))/10}/4\pi}$ (meters) = $\sqrt{10^{12.55}/4\pi}$ (meters) = 530 km, which is larger than the horizon distance for most radio astronomy observatories in the United States. Thus, the appropriate geographic exclusion zones are those listed in Footnote US385.

⁷ Footnote 5.458A states that "[i]n making assignments in the band 6700-7075 MHz to space stations of the fixed-satellite service, administrations are urged to take all practicable steps to protect spectral line observations of the radio astronomy service in the band 6650-6675.2 MHz from harmful interference from unwanted emissions." While this footnote is intended to protect RAS observatories from satellite space stations, the concern is the same for other aeronautical uses.

designed to protect RAS observations from interference from standard power operations using AFC. CORF greatly appreciates the Commission's actions in this regard. The public interest in protecting extremely vulnerable radio astronomy observations is the same when considering the proposed "very low power" operations of 6 GHz unlicensed devices without use of an AFC system. The geographical area required to protect the RAS within the United States is relatively small, but these facilities are at great risk with the proliferation of unlicensed devices anticipated by the Commission in this proceeding. As noted above, the most straightforward approaches to satisfying the requirements of Footnote US342 are either geographic exclusion zones or frequency separation (notching). Thus, if 6 GHz unlicensed devices are to operate at the power levels proposed, and geographic exclusion zones cannot be implemented, then the frequency band 6650-6675.2 MHz should be notched out of the transmission band.

Respectfully submitted,

NATIONAL ACADEMY OF SCIENCES'
COMMITTEE ON RADIO FREQUENCIES

By:

A handwritten signature in dark ink, appearing to read "Marcia McNutt", with a long horizontal flourish extending to the right.

Marcia McNutt
President, National Academy of Sciences

Direct correspondence to:

CORF
Keck Center of the National Academies
of Sciences, Engineering, and Medicine

500 Fifth Street, NW, Keck 954
Washington, D.C. 20001
(202) 334-3520

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Appendix

Committee on Radio Frequencies

Members

Liese van Zee, Indiana University, *Chair*

Nathaniel Livesey, Jet Propulsion Laboratory, California Institute of Technology, *Vice Chair*

William Emery, University of Colorado

Dara Entekhabi, Massachusetts Institute of Technology

Philip Erickson, Haystack Observatory, Massachusetts Institute of Technology

Kelsey Johnson, University of Virginia

Mahta Moghaddam, University of Southern California

Scott Paine, Center for Astrophysics | Harvard & Smithsonian

Frank Schinzel, National Radio Astronomy Observatory

Gail Skofronick-Jackson, NASA Headquarters

Consultants

Darrel Emerson, retired

Tomas E. Gergely, retired