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Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Spectrum Horizons	)	ET Docket No. 18-21
	)	

Comments of the National Radio Astronomy Observatory

Introduction

1. Here, the National Radio Astronomy Observatory (NRAO) provides comments on the Commission's Notice of Proposed Rulemaking and Order ("The NPRM and Order") concerning new service rules and the establishment of a new radio service for experimental radio licenses in the spectrum above 95 GHz.

2. The National Radio Astronomy Observatory and its sister observatories the Green Bank Observatory (http://greenbankobservatory.org/) and the Long Baseline Observatory (https://public.lbo.us) are operated by Associated Universities, Inc. (http://www.aui.edu) under cooperative agreement with the National Science Foundation. Their facilities include the Jansky Very Large Array (VLA) in New Mexico, the 100m Robert C. Byrd Green Bank Telescope (GBT) in West Virginia and the 10-element Very Long Baseline Array (VLBA) that is distributed from St. Croix to Hawaii. The GBT currently operates above 95 GHz and NRAO is developing a next-generation VLA (ngVLA) that will operate up to at least 100 GHz in multiple locations throughout the southwestern US.

3. Radio astronomy operations are also conducted above 95 GHz at the Arizona Radio Observatory (ARO) Kitt Peak 12m and Mt. Graham Sub-Millimeter Telescope (SMT), on Mauna Kea in Hawaii under the aegis of multiple operators foreign and domestic at the Sub Millimeter Array (SMA) and the James Clerk Maxwell Telescope (JCMT), and in Antarctica under various NSF-funded programs.

Atmospheric transmission in the vicinity of radio astronomy facilities

4. MM and sub-mm radio astronomy[1] is conducted at high-elevation sites where the atmospheric transmission differs substantially from that shown in the NPRM and Order's Fig. 1 "Specific attenuation due to atmospheric gases" computed at sea level for the standard atmosphere. Differences arise from the smaller amounts of air above the radio astronomy sites, and especially the low water vapor content of that air. Radio astronomers are not usually concerned with the local specific attenuation dB per km but an average value of 0.15 dB/km at 79 GHz was ascertained between the ARO Kitt Peak 12m at 6700 ft. and a distant location on the surrounding terrain[2]: this can be compared with 0.38 dB/km in Figure 1 of the NPRM and Order.

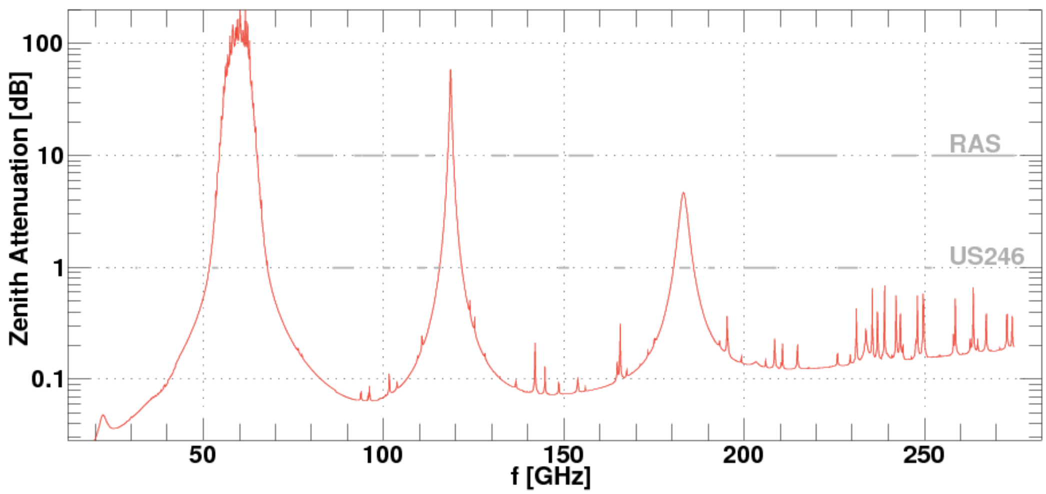

Figure 1. Atmospheric attenuation at the zenith under good conditions at the ALMA site (5100m) in Chile. Also indicated are the frequency bands subject to US246 and the shared bands allocated to the radio astronomy service (RAS) on a primary basis.

5. Figure 1 here shows the atmospheric attenuation under good conditions at ALMA in northern Chile, which is the only site for which radio astronomers have empirically characterized the atmospheric transmission in such detail over such a broad swath of frequencies: the horizontal resolution is 100 MHz. The best conditions at Mt. Graham and Mauna Kea are comparable to or better than what is shown in Figure. 1. Note that the attenuation around 183 GHz is much smaller than around 60 or 119 GHz owing to the dryness of the air, very different from the standard atmosphere at sea level to which the Commission refers in its description of the atmosphere, for instance at ¶55 of the NPRM and Order, where unlicensed use is proposed for bands around 183 GHz.

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[1]Radio astronomers consider only the spectrum above about 60 GHz as being in the mm-wave domain and spectrum above about 300 GHz to be in the sub-mm.

[2] http://www.gb.nrao.edu/electronics/edtn/edtn219.pdf, see also Shambayati, S., 2008: Atmosphere Attenuation and Noise Temperature at microwave frequencies, chapter 6 in "Low-Noise Systems in the Deep Space Network", by MacGregor S. Reid. Editor, John Wiley and Sons, Hoboken, New Jersey.

6. Compatibility with radio astronomy operations above 95 GHz requires that local conditions be taken into account, not merely assuming the standard atmosphere. Widely-recognized references for calculation of atmospheric attenuation to be used in compatibility studies include ITU-R Recommendations P. 620 and P. 676.

Experimental licenses and bands protected by US 246 and RR. No. 5.340

7. The Commission is proposing that licenses be granted to experimental devices that transmit in spectrum bands protected by US 246 and RR. No. 5.340 (the so-called passive bands, see ¶75), that such devices be allowed to be marketed (¶70-73), and that they be allowed to operate without divulging the details of their operations (¶67). NRAO opposes such use of bands protected by US246 and RR No 5.340, opposes the marketing of experimental devices except under conditions not considered in the NPRM and Order, and opposes operation under a too-strict cloak of secrecy.

8. Bands included in US246 are described here as US246 bands and transmitters using a US246 band, or part of such a band, are described as US246 band transmitters. US246 may require modification if the Commission's proposals for US246 band transmitters are implemented.

9. US246 band transmitters will continue to be illegal for general use, so any proposal to develope one should discuss its future; whether it is expected to exist only under the protection of the experimental license, or would lead to a device that could be marketed as a non-US246 band device, or is being developed in the expectation that it will eventually be allowed to operate in US246 bands without needing an experimental license.

10. Devices transmitting in the US246 bands are illegal in other administrations and the Commission must take steps to ensure that they do not proliferate and are not marketed beyond the borders of the US[3]. It has previously been pointed out to the Commission[4] that the ITU-R Radio Regulations Board has taken a position against assigning frequencies protected by RR. No 5.340 (ie most of the US246 bands) to transmitters on a non-interference basis. Such assignments may not be submitted to the ITU-R.

11. Devices that perversely seek to operate in US246 bands to take advantage of the radio-quiet environment for their own sake should not be considered for licensing: the bands have not been so zealously guarded just so that they could be marked in this way. Proposals for use of US246 bands that could conceivably be accomplished in other spectrum should be diverted into other spectrum.

12. The proposed experimental use would be subject to a compatibility study and a coordination process at the NTIA. Compatibility studies with radio astronomy should include a thorough analysis of both in-band and unwanted emissions, extending up to

[3] See https://tinyurl.com/y7zelhse for a US vendor selling a transmitter operating in the 1400 – 1427 MHz band for use abroad.
[4] Comments of Marcus Spectrum Solutions LLC, 30 September 2016, GN Docket 14-77, ¶28

the uppermost frequency limit of observation at whatever radio astronomy station might be affected. For the GBT and ARO Kitt Peak12m this is only 116 GHz, but it is 408 GHz for the SMA and 660 GHz for the JCMT on Mauna Kea, and 720 GHz for the ARO SMT on Mt. Graham. Proposals should discuss the means that will be undertaken to preclude the presence of US246 band transmitters inside the coordination radii that are established by compatibility studies. Proposals for US246 band transmitters should establish compatibility with the laboratories in which radio astronomical instrumentation for radio astronomy use of US 246 bands is developed.

13. The existence and expected number of each type of experimental device should be made known. The frequency range of operation, conducted power, mean and peak eirp (total and per Hz), level of unwanted emissions, power pattern and such other information as may be deemed necessary for an independent assessment of their compatibility, should be available to potential victims.

14. Regarding the term of the experimental licenses as discussed at ¶77 of the NPRM and Order, decade-long experimental licenses make little sense in an area of rapidly-developing technology but might well encourage a licensee who profits from marketing an otherwise-illegal transmitter to squat while conducting what is in essence a bootleg commercial operation. If the Commission wishes to foster the development of technology above 95 GHz the license term should be brief, and profit should only accrue outside the shadow regulatory world of the experimental license. Profit should not come from subversion of the concept of passive bands in which so much basic research and remote sensing has been done and, with careful regulatory protection, will be accomplished in the future.

Exculpating more unwanted emissions in US74

15. US74 omits the 182-185 GHz and 226-231.5 GHz bands and at ¶43 of the NPRM and Order, the Commission seeks comment on whether these two bands should be added to US74. It is somewhat inconsistent to include the higher band when the Commission's own rules do not necessarily require that the spectrum of unwanted emissions be examined to such high frequencies. NRAO previously suggested that the spectrum of 76 – 77 and 77 - 81 GHz field disturbance sensors (car radars) should be examined to 3x81 GHz = 243 GHz (NRAO comment at ¶18 in ET Docket No. 15-26) instead of 231 GHz.

16. When the FCC adopted operating rules for 76 – 81 GHz vehicular radar in ET Docket No. 15-26, US74 did not apply to their 3x harmonics. As noted in NRAO's comments in ET Docket No. 15-26, the levels of unwanted emissions allowed by the Commission or specified by car radar vendors both imply large separation distances for these harmonics. If the 226 – 231.5 GHz band is added to US74 after the fact, a strong potential for harmful interference to radio astronomy operations would be excused.

17. To protect its operations from potential harmful interference generated by vehicular radars and other devices, NRAO opposes addition of the 226 – 231.5 GHz band to

US74 until the allowed level of unwanted emissions falling into the US246 bands is revised to take account of the needs of the services that actually use the US 246 bands, as opposed to those of the services that generate unwanted emissions into them.

Fixed service operation above 95 GHz

18. Radio astronomy and the fixed service operate compatibly under the Commissions so-called 70/80/90 GHz rules as summarized in the NPRM and Order at ¶28. NRAO expects that an extension of these rules above 95 GHz will continue to foster coexistence of such operations as long as local conditions are considered, for instance, the lessened atmospheric absorption in the vicinity of radio astronomy observatories.

19. Compatibility with the radio astronomy service above 95 GHz is facilitated by the quite small number of radio astronomy facilities operating in the mm-wave domain. However, compatibility with the global mapping typically conducted by radio astronomy's sister passive service the Earth Exploration Satellite Service (passive) is less obvious. When ubiquitous fixed service operations use spectrum that is immediately adjacent to US246 bands, all of which are used by EESS (passive), care should be taken to ensure that out of band emissions from fixed service operations do not unduly bleed into the passive band, and this must be observed globally.

20. At ¶42 of the NPRM and Order, the Commission asks if the coordination distance between fixed service and radio astronomy operations above 95 GHz should be smaller than in US161 to account for the higher atmospheric attenuation above 95 GHz. The radio astronomy service has in effect already compensated for this by moving to higher and drier sites for its higher frequency operations. Table 1 here shows line of sight separation distances computed for a fixed service transmitter eirp density = -25 dB W/MHz, derived from the peak eirp density = 25 dB W/MHz and 50 dB attenuation in the proposed tables at § 101.113 and § 101.115 of the NPRM and Order: values are shown for several values of the specific atmospheric attenuations. Calculated distances are comparable to those in US161 even for the maximum off-axis beam attenuation. The coordination distance should not be adjusted for operation above 95 GHz.

Table 1. Separation distances for eirp = -25 dBW/MHz at various attenuation

Frequency GHz	RA. 769 Table 1 dB W/m^2/MHz	Separation distance at various specific attenuation			
		0.1 dB/km	0.15 dB/km	0.2 dB/km	0.3 dB/km
100	-167	236 km	175 km	140 km	103 km
220	-158	173 km	131 km	107 km	80 km

Mobile service operation above 95 GHz

21. The Commission proposes a peak spectral eirp of 25 dB W/MHz for mobile service operation in the proposed § 101.113, the same as for the fixed service. The results in

Table 1 therefore also can be used to assess the compatibility between radio astronomy service and mobile service operations, implying that mobile service operations will not be compatible with those of the radio astronomy service when in direct line of sight. This should therefore not be allowed. Actual coordination distances will depend on local details but are likely to be large.

22. Although the proposed power levels are the same for the fixed service and mobile service, the Commission is proposing rules requiring pre-coordination only between the operations of the fixed and radio astronomy services. This makes the compatibility scenario very different in the two cases. NRAO suggests that mobile service use should similarly be pre-coordinated by rule.

Unlicensed devices above 95 GHz

23. The Commission is not proposing that unlicensed devices share spectrum with radio astronomy but has proposed various adjacent band scenarios. To assess compatibility, we consider the limits on unwanted emissions appropriate to unlicensed devices at 57 – 71 GHz which the Commission proposes to extend to unlicensed use above 95 GHz: "§ 15.255 (d) Limits on spurious emissions: (3) Between 40 GHz and 200 GHz, the level of these emissions shall not exceed 90 pW/cm^2 at a distance of 3 meters." This is equivalent to a maximum eirp -10 dBm because $4\pi\ (300\ cm)^2*90x10^{-12}\ W/cm^2 = 10^{-4}$ W = 0.1 mW. If this is spread over 1 GHz = 1000 MHz = 30 dB MHz, the eirp density is -40 dBm/MHz which can be compared with the thresholds in the 2nd column of Table 1 to derive separation distances of 6-17 km depending on frequency and atmospheric attenuation. Spreading the unwanted emissions over 4 GHz leads to separation distances 3-9 km. Aggregation of unwanted emissions from multiple devices would increase these distances.

24. The indicated separation distances are larger than are directly controlled by the operators of radio observatories, requiring coordination for compatibility.

25. The especially high atmospheric attenuation around the 183 GHz water line of the standard atmosphere that is cited by the Commission at ¶55 as motivation to allow unlicensed use at 174.8-182 GHz and 185-190 GHz is not applicable to radio astronomy sites but given that coordination is required to achieve compatibility more generally, this high frequency spectrum is just a special case.

26. Assigning frequencies to unlicensed devices in the band 116 – 122 GHz used by EESS (passive) seems ill-advised. This band is to all intents and purposes a passive band. As noted in the NPRM and Order at ¶55 the radio astronomy service has a strong effort to observe a spectral line of carbon monoxide at 115.271 GHz that is a widely-used surrogate for the detection of molecular hydrogen. It is important that unwanted emissions from unlicensed devices operating in the 116 – 122 GHz band not be allowed to interfere harmfully with radio astronomy operations in the US246 band at 114.25 – 116 GHz.

Respectfully submitted,
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