NATIONAL RADIO ASTRONOMY OBSERVATORY
520 EDGEMONT ROAD CHARLOTTESVILLE, VA 22903-2475
TELEPHONE 434-296-0211 FAX 434-296-0278

21 November 2014

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

In the Matter of	)	
	)	
Amendment of Part 15 of the Commission's Rules for Unlicensed Operations in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37, and	)	ET Docket No. 14-165
	)	
Amendment of Part 74 of the Commission's Rules for Low Power Auxiliary Stations in the Repurposed 600 MHz Band and 600 MHz Duplex Gap	)	
	)	GN Docket No. 12-268
Expanding the Economic and Innovation Opportunities of Spectrum Through Incentive Auctions	)	

Comments of the National Radio Astronomy Observatory

Introduction

1. Here, the National Radio Astronomy Observatory ("NRAO" or "the Observatory") provides its comments responding to the Commission's Notice of Proposed Rule Making ("the NPRM") regarding Amendment of Part 15 of the Commission's Rules for Unlicensed Operations in the Television Bands, Repurposed 600 MHz Band, 600 MHz Guard Bands and Duplex Gap, and Channel 37, ET Docket No. 14-165.

2. NRAO (http://www.nrao.edu), operated by Associated Universities, Inc. (AUI), (http://www.aui.edu) under a cooperative agreement with the National Science Foundation, is the largest observatory dedicated to radio astronomy and one of the largest astronomical observatories in the world. NRAO operates all of the United States radio telescopes that are currently using the 608 – 614 MHz band (*aka* "channel 37") and 11 of the 12 radio astronomy stations whose protection from unlicensed operations of TV band white space devices (TVWS) is discussed in the NPRM: all save Arecibo.

3. In general, NRAO opposes the sacrifice of what has effectively been a passive service band to enable faster wireless streaming of so-called "information." However, the Observatory also recognizes that channel 37 sits squarely in the center of a 30 MHz-wide band (TV channels 35 through 39) occupying 5% of the total available spectrum, whose use by TVWS devices is sharply restricted by the need to protect RAS and WMTS operations in channel 37.

4. Indeed, NRAO finds the heart of the matter buried down inside the NPRM at ¶¶126 – 128 where the Commission expresses the desire to facilitate TVWS operations in channels 35 – 36 and 38 – 39 and the consequent need to relax the out of band emission limits into channel 37. Once this occurs there is little point in preserving channel 37 as a passive service band, hence the decision to also allow *in-band* emissions from TVWS devices in channel 37.

5. The Observatory notes many rich possibilities for irony in this proceeding. If sufficient spectrum is realized in the Incentive Auction, the former passive band could become the *only* channel that is available for TVWS operation in some places. Moreover, the Commission will in this case have relaxed the protection of channel 37 in order to advantage TVWS devices in adjacent channels that do not operate anyway, leaving channel 37 and its own adjacent 3 MHz "guard bands" to be used for TVWS while serving as the de facto guard band between wireless up and downlinks. In any case, the Observatory hopes that an (apparent) relaxation of emissions into channel 37 here does not leak into the related proceedings of the Incentive Auction, leading to a relaxation of protection of RAS use of channel 37 in other regards.

Sharing channel 37 between RAS and TVWS

6. *The VLBI case.* At ¶118 the NPRM notes the in-band separation distances that are needed to protect the VLBA sites from one TVWS device operating in direct line of sight:

Table 1

FCC-calculated co-channel separation distances from VLBA sites (km)					
16 dBm (40 mW)	**20 dBm (100 mW)**	**24 dBm (250 mW)**	**28 dBm (625 mW)**	**32 dBm (1600 mW)**	**36 dBm (4 watts)**
51	73	105	151	219	314

The terrain and situation of the VLBA sites vary widely (see http://tinyurl.com/yrvszk or http://www.vlba.nrao.edu/sites/). The antennas in Arizona, New Mexico and Hawaii are near the summits of high or very high mountains and have some very long unobstructed sightlines. Sightlines in New Hampshire are more restricted by local terrain. It is likely that coordination distances could be fashioned to fit individual circumstances (which in some cases might involve larger separations). However, this matter cannot be decided on the basis of the single-entry case that is the basis for Table 1 and the discussion in the NPRM; aggregation must be considered before these details are addressed.

7. *Single-dish:* The protection criteria for single-dish use of channel 37 at Green Bank or Arecibo are 41 dB more stringent than those for VLBI observing, according to ITU-R Recommendation RA. 769 (comparing the entries in Tables 1 and 3 there). These 41 dB can be converted into an equivalent multiplier for the separation distances in Table 1 using the $1/r^{2.53}$ power-law discussed at ¶117 in the NPRM: the multiplier is 41.74 = $10^{41/10/2.53}$. Thus the shortest distance extrapolated for in-band sharing with the least powerful TVWS device in Table 1, operating at 40mW eirp, is 41.74 x 51 km = 2100 km.

8. Given this result, *for a single device*, it makes sense for the Commission to have proceeded as it did by setting the default in-band exclusion zones for Green Bank and Arecibo as their respective quiet zones (¶¶122-124 of the NPRM). The National Radio Quiet Zone around Green Bank has an area of 13,100 sq. miles, comprising some 0.4% of the total US land area. Forgoing the use of channel 37 over this fraction of the US does not seem like an enormous sacrifice.

Compatibility between RAS operating in channel 37 and TVWS operating in adjacent and nearby bands

9. This subject is treated in somewhat more diffuse manner in the NPRM. Separation distances and unwanted emissions limits are closely related and can be traded off against each other, but the extent of this interaction is not always clear in the NPRM. For instance the NPRM asks whether adjacent channel separation distances should be established with VLBA stations at ¶121, while the issue of the proper level of unwanted emissions into channel 37 is addressed separately only later, at/after ¶126.

10. An implied out of band (OOB) emission mask can be inferred from the difference between proposed adjacent band operations at 2.4 km separation (the present default for TVWS) and the distances for in-band operation given in Table 1 above. The dB levels at which OOB emissions from TVWS devices are presumed to have been suppressed in order to permit adjacent band TVWS operation within 2.4 km of the VLBA antennas and the Robert C. Byrd Green Bank Telescope, calculated for a $1/r^{2.53}$ spreading loss (¶117) are as follows (the tables differ by a constant 41 dB):

Table 2a

Implied OOB suppression of TVWS emissions - VLBA					
16 dBm (40 mW)	**20 dBm (100 mW)**	**24 dBm (250 mW)**	**28 dBm (625 mW)**	**32 dBm (1600 mW)**	**36 dBm (4 watts)**
34 dB	38 dB	42 dB	46 dB	50 dB	54 dB

Table 2b

Implied OOB suppression of TVWS emissions – Singledish					
16 dBm (40 mW)	**20 dBm (100 mW)**	**24 dBm (250 mW)**	**28 dBm (625 mW)**	**32 dBm (1600 mW)**	**36 dBm (4 watts)**
75 dB	79 dB	83 dB	87 dB	91 dB	95 dB

11. The actual OOB emission mask is discussed in the NPRM at ¶59 where it is noted that the conducted emissions in 100 kHz of adjacent bandwidth are set at a level 72.8 dB below those in the 6 MHz band of operation in a single TV channel. Suppression at the level 72.8 dB into 100 kHz is equivalent to suppression at the level 72.8-10*log(6 MHz/100 kHz) = **54 dB** into 6 MHz. Remarkably, this is just equal to the maximum implied suppression required for TVWS operation at a distance of 2.4 km in Table 2a. *Therefore, the OOB emission limits proposed in the NPRM appear to permit TVWS operation in adjacent bands within the present regulatory minimum distance, 2.4 km, for a single TVWS device.*

12. *By the same token, the separation distance of 2.4 km for TVWS operation in nearby and adjacent bands is far too short for compatibility with single dish radio astronomy operations, even for a single TVWS device*. If the VLBA entries in Table 2a should be compared with 54 dB, those in Table 2b should be judged against 54 + 41 = 95 dB and they all fall far short. The deficit for adjacent channel TVWS operations at levels compatible with single dish radioa stronomy observations ranges from 21 dB for the lowest-power TVWS devices to 41 dB for the most powerful. *For $1/r^{2.53}$ propagation this implies separation distances of 16 – 100 km*.

13. At ¶62 and ¶¶126 – 128 the NPRM discusses relaxation of OOB emission limits for TVWS devices. We agree with the proposal at ¶128 to use separation distances to control emissions into channel 37. No matter how large the exclusion zones around radio observatories might be, they will always comprise a very small fraction of the land area, hence should not by themselves constrain the hardware implementation.

Aggregation and the local interference temperature

14. The discussion in the NPRM is cast in terms of the single entry case while TVWS devices work in systems and, if successful, in large quantities. Issues of aggregation and the infamous hidden-node problem could be addressed by sufficiently capable TVWS devices and databases after deployment begins. For now, the separation distances discussed here and in the NPRM must be regarded as being quite permissive and it is premature to discuss relaxing them.

15. The ability to account for aggregation during actual operations is contingent on the capabilities of the TVWS database and the nature of the devices that are operating. For the somewhat limited example where all the personal/portable devices in a system

access a fixed device (ie are of Type 1), and if the aggregate eirp of those personal/portable devices is small compared to that of the fixed device, registration by the fixed device alone would enable an approximate accounting of the aggregate emission. A more informed use of the database might have the fixed TVWS device reporting the total system eirp.

16. Type II devices and Type I devices not tied to fixed systems do not register with the TVWS database and assessing the local aggregate emission including their contribution does not seem possible. This inability to assess the aggregation of possible interference to RAS also impacts the permissible operation of fixed TVWS systems because these might be permitted to operate (with reference to the TVWS database) in cases where the aggregate interference to RAS, if known, would indicate otherwise.

17. The Observatory suggests that personal/portable TVWS devices whose emissions are not accounted for in the TVWS database, at least in the approximate sense discussed at ¶15 here, should not be allowed to operate in *or near* channel 37. This addresses, although more broadly, the issue raised at ¶102 in the NPRM regarding which types of TVWS devices should be allowed to operate in channel 37.

"Rural" Areas

18. At ¶¶49 – 53 the NPRM seeks comment on whether to allow higher-power operation in "rural" areas. This is a matter of some indifference to the Observatory as long as the level of emissions into the radio astronomy band is maintained below the interference threshold, presumably by lengthening the separation distance. The need for more spectrum and utilization of channel 37 for TVWS in "rural" areas seems somewhat at odds with the supposed sparseness of population, hence demand, which defines them.

US 246

19. The Observatory wonders whether TVWS would be allowed to operate on channel 37 without modification of footnote US 246 to the table of frequency allocations and notes that no such modification was discussed in the NPRM. The structure of US 246 and other possible future footnote protection of the 608 – 614 MHz band are of concern to the Observatory, and we respectfully suggest that they should be explicitly addressed in this Proceeding.

Summary

20. *In-band channel 37 TVWS operation:* RAS and TVWS can probably share channel 37 with suitable separation distances, but the present discussion, based on the single-entry TVWS case, is only a very rough means of deriving them. Because they ignore aggregation of emission, the separation distances proposed in the NPRM, large as they are in some cases, are actually quite permissive. They should not be adjusted downward by the Commission based on considerations of the single-entry case.

21. *Operation on nearby and adjacent channels.* RAS and TVWS can probably operate compatibly given suitable separation distances, which is the proper means for allowance of out of band emissions by TVWS. However, a discussion based on the single-entry case is not strong grounds for ensuring protection of RAS operations. *For the single entry case*, the present 2.4 km separation between TVWS and RAS operation suffices with respect to VLB observing (the VLBA stations) but is far too small to support compatible operation in Green Bank or Arecibo where separation distances of 16 – 100 km are required. Aggregation of TVWS emissions will increase these separation distances.

22. *Aggregation.* Because it is important to be able to assess the local aggregate emission into channel 37, devices whose presence is not known to the TVWS database should not be allowed to operate in or near channel 37. This includes unlicensed wireless microphones.

23. *Other considerations:* i) The present rules for operation of personal/portable devices preclude an assessment of aggregate emissions and invite the infamous hidden node problem, which could allow operation of TVWS devices in situations where it should not occur. ii) The structure of US 246 and future footnote protection for RAS operations in channel 37 should be addressed as part of this Proceeding.

Respectfully submitted,
National Radio Astronomy Observatory

_____
Harvey S. Liszt
Astronomer and Spectrum Manager

Direct correspondence to:
Dr. Harvey S. Liszt (hliszt@nrao.edu)
Spectrum Manager
National Radio Astronomy Observatory
520 Edgemont Road
Charlottesville, VA 22903-2475