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# Before the

**FEDERAL COMMUNICATIONS COMMISSION**

**WASHINGTON, D.C. 20554**

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| In the Matter of  Petition to Modify Parts 2 and 101  of the Commission’s Rules to Enable Timely Deployment of Fixed Stratospheric-Based Communications Services in the 21.5-23.6, 25.25-  27.5, 71-76, and 81-86 GHz Bands | )  )  )  )  )  )  ) | RM-11809 |

**Opposition and comments**

**of**

**the National Radio Astronomy Observatory**

25 June 2018

The National Radio Astronomy Observatory (NRAO), on behalf of itself and its sister AUI-operated observatories the Green Bank Observatory (<https://greenbankobservatory.org/>) and the Long Baseline Observatory (https://www.lbo.us/), is taking the opportunity to remark on the Elefante Group’s recent petition for rulemaking. The AUI observatories host the Jansky Very Large Array in New Mexico, the Robert C. Byrd Green Bank 100m Telescope in West Virginia and the 10 stations of the Very Long Baseline Array, which stand to be profoundly affected by the operation of High Altitude Platform Systems (HAPS) such as those proposed by the Elefante Group.

1. **HAPS or STRAPS?**

Elefante Group’s version of HAPS is still HAPS. Elefante Group seeks to use the fixed service spectrum that is being considered for HAPS. A HAPS platform at 19.8 km is visible to an observer on the ground 502 km distant whereas one at 20 km is visible for 506 km. The focus on operating at 19.8 km, a mere 0.2 km below the range given in the ITU-R definition (20 – 50 km in Article No. 1.66A) is at odds with other elements of Elefante Group’s presentations. The title to Figure 6 in Elefante’s Appendix M describing the results of the dynamic compatibility calculation with radio astronomy notes a platform height of 21.3 km. The systems with which Elefante Group compares its system (Section E of its petition) and which it describes as operating at comparable altitudes, are self-described HAPS systems whose characteristics are among those that are being used for compatibility and sharing studies at ITU-R in the context of WRC-19 AI 1.14 (Annex 14 to the WP 5C Chairman’s Report 5C/531 on the ITU-R website; requires TIES access) with operating altitudes given as 20 km:

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Elefante Group’s own system will operate in the range 18-26 km (p. 80 of its petition). This is HAPS. The argument in favor of another identification is … HAP-less.

1. **Compatibility with radio astronomy service operations in the aggregate**

Lockheed Martin has done a credible job of studying the issue of compatibility with radio astronomy operations for the downlink transmissions of a single HAPS platform (Appendix M)

but platforms over El Paso, Las Cruces, Socorro, Albuquerque etc. would all be visible at the VLA site at the same time. With HAPS platform service radii of 50 – 70 km the possible number of simultaneously visible platforms is of order n ~ (500/70)2 to (500/50)2 ~ 50 to 100, and n = 81 is being used (see below) in studies at the ITU-R.

Lockheed Martin’s calculation, like many such, is not immediately obvious in all its ramifications. It is however easily checked in a way that elucidates the necessary elements of an aggregate analysis. Data loss to radio astronomy is equivalent to sky blockage owing to the need on the part of the radio astronomy telescope to avoid pointing too directly at a platform. A zone of avoidance about each platform will have to be programmed into each telescope’s operations as shown by the following argument:

i) Elefante Group’s suggested pfd limit -193 dB W/m2/MHz at a radio astronomy site from downlink operations is 20 dB below the protection levels given in Table 1 of ITU-R Recommendation RA 769. This allows a radio astronomy antenna to point at a platform with 20 dBi gain and still maintain protection at ITU-R Recommendation RA. 769 levels. According to ITU-R Recommendation SA. 509 giving the reference radio astronomy antenna pattern, 20 dBi gain occurs at a boresight angle of 3o, so a radio astronomy telescope could point within 3o of Elefante Group’s platform without receiving interference above the RA. 769 level.

ii) A cone of angular radius  subtends a fraction 1-cos() of the 2 steradians that are above the horizon at any time, and 1-cos(3o) = 0.14%. This is slightly increased to 1-cos()/(1-cos()) = 0.15% of the sky accessible above the 5o elevation pointing limit of a typical telescope. These are in good agreement with the protection level 0.1% noted in Appendix M.

Data loss and sky blockage are equivalent. If the incident pfd per platform is maintained at -193 dB W/m2/MHz with n > 1 platforms the data loss to radio astronomy increases directly as n because there would be n cones of avoidance of radius 3o. Alternatively, to maintain the data loss at the same level with 1 or with n > 1 platforms, the area of the cone of avoidance about each platform would have to shrink as 1/n, implying a smaller radio astronomy boresight angle and higher gain for the radio astronomy antenna, and a lower pfd at the radio astronomy site.

This accounts for the difference between the pfd level suggested by Elefante, -193 dB W/m2/MHz, and those for the various bands in the draft CPM text that is being prepared for consideration at WRC-19, which are 10 dB more restrictive corresponding to 30 dBi RAS gain (see Annex 14 to the WP 5C Chairman’s Report 5C/531 on the ITU-R website; requires TIES access):

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The draft ITU-R pfd limit arises from considering 2% data loss (ITU-R Recommendation RA. 1513) and a full deployment of HAPS (n=81) as discussed in 5C/535 at the ITU-R (also requires TIES access):

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In practice the zone of avoidance used by the radio astronomy operator might be the convolution of a platform’s orbit as seen from the radio telescope and the cone of avoidance calculated for a stationary platform, increasing the amount of sky blockage and data loss.

1. **Concerns of compatibility and survivability**

As the discussion in Section II suggests, compatibility in the radio astronomy band requires mutual avoidance by HAPS platforms and radio telescopes. If a platform points too directly at the radio telescope it could violate the pfd limit. For the radio telescope, if an antenna with 80 dBi peak gain points within 3o of a platform it could receive radiation in a protected band that is (-20+80) = 60 dB above the RA. 769 protection threshold. Indiscriminately averaging 1s of such data could contaminate data taken over ~ 106 s.

As things now stand, radio astronomy receivers accept radiation in the HAPS downlink bands at the same time that they observe in the radio astronomy band, and this has not been an issue.

However, consider what could happen if there were to be strong beam coupling at the frequencies of the HAPS downlink signal: This signal is much stronger than the unwanted emissions in the radio astronomy band, and perhaps 140 dB above the radio astronomy protection threshold in the radio astronomy band. The same -3 dB W/MHz eirp spectral density that produces a pfd equal to -111.5 dB W/m2/MHz at the edge of a 70 km-radius platform service area in clear weather puts 1/6 mW across the geometric surface area of a 100m telescope over the 2250 MHz bandwidth of a platform’s downlink band at 25.25 – 27.5 GHz.

Although 1/6 mW is not enough to burn out a radio astronomy receiver, which requires ~ 25 mW according to ITU-R Report RA. 2188, it is enough to overload and damage the radio astronomy receiver. And although this is an approximate envelope calculation, the platform’s eirp could be 10 or more dB higher when conditions underneath it are inclement and ATPC is used. The possibility of damage is a concern for all radio telescopes with HAPS platforms in line of sight, including the VLBA stations whose observing is normally so much less affected by ordinary RFI (Table 3 of ITU-R Recommendation RA. 769).

To eliminate the possibility of damage, the cone of avoidance of angular radius 3o about the HAPS platform could be placed below the 5o observing limit of the typical radio telescope. For a telescope at sea level the HAPS platform would not appear above 2o elevation at a nadir separation roughly calculated as (57.3o/2o)\*20 km = 573 km, even beyond the limit of visibility. If HAPS platforms are to operate within line of sight of radio telescopes, viability of the radio astronomy operations will require protection from the platform’s in-band signal.

1. **Prospective fixed-service use of passive service spectrum at 23.6 – 24.0 GHz**

In its ex-parte presentation and in footnote 64 of its petition, the Elefante Group contemplates enlisting the assistance of the FCC to appropriate the passive service band at 23.6 – 24 GHz for use by the fixed service. This is a colossally bad idea whose unfortunate nature is compounded by the intention to co-opt a passive band for an application whose signals would not be contained within the US borders, while being subject to RR. 5.340. The Elefante Group should disavow this idea.

1. **Use of FS spectrum above 70 GHz for HAPS feeder links, and RAS sites at higher elevation**

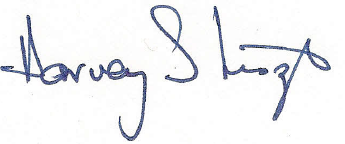
Radio telescopes using mm-wave spectrum are often sited at high elevations: Examples are the LBO VLBA telescopes at 13,000 ft on Mauna Kea and at 6,700 ft on Kitt Peak, the Arizona Radio Observatory (ARO) Kitt Peak 12m telescope at 6,700 ft and the ARO 10m Sub Millimeter Telescope near 10,000 ft. on Mt. Graham (<http://aro.as.arizona.edu/>). These telescopes have very distant horizons.

Elefante Group’s petition seems not to recognize this. For instance in Section VIII B it reads “In the case of RAS the same argument holds to ensure compatibility. High elevation angle transmitters will present dramatically lower EIRP toward RAS sites than low elevation transmitters, and coordination with RAS sites will require less separation distance.” The NRAO is not sure what kind of drama the Elefante Group is imagining but their assertion is quite wrong regarding the high elevation sites in this very early draft of the script.

1. **NRAO’s requests for consideration by the Commission**

The FCC should not act in haste or redefine domestic HAPS systems to be other than HAPS. The FCC should not authorize domestic HAPS operations in all but name under a regulatory regime that differs from that for HAPS, or at lower pfd levels for the protection of passive services than will be placed in the Radio Regulations at WRC-19 under Agenda Item 1.14. The FCC should recognize the profound implications for radio astronomy operations of allowing HAPS operations within line of sight of radio telescopes. The safest course would be to disallow HAPS operation within line of sight of radio telescopes but otherwise to require HAPS operators to pre-coordinate with radio astronomy operators before beginning operations to ensure compatibility and the survivability of the affected radio astronomy operations.

Respectfully submitted,



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