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Secretary
Federal Communications Commission
Washington DC 20554

Re: WT Docket No. 00-32

Gentlemen:

This information is submitted on behalf of Microwave Radio Communications. The attached paper shows that airborne microwave transmissions in the 4950-4990 MHz band will not cause interference to radio astronomy observatories, because, with one exception, the radio astronomy observatories are shielded by nearby mountain ranges.

Sincerely,

Jeffrey Krauss

Interference from Airborne Microwave into Radio Astronomy

This paper examines the potential of harmful interference into a radio astronomy (RA) receiver from an airborne microwave transmitter employing a directional antenna in the 4950-4990 MHz band. The conclusion is that, with one exception, all RA receivers within 200 km of any major city are shielded from interference coming from that nearest city by an intervening mountain ridge.

ITU-R Recommendation RA.769-1 establishes threshold interference levels for RA continuum observations at 4995 MHz as follows:

Maximum power flux density PFD	-171 dB(W/m^2))
Maximum spectral power flux density PFSD	-241 dB (W/(m^2Hz))
Maximum harmful interference	-207 dbW

Transmitter specifications:
Output power = 1 W = 0 dBW @ 4945 Mhz
antenna gain = +13 dbi (on the main beam)
sideband attenuation @ 4950 Mhz = -48 db (per plots)

Power spectral density @ 4950 Mhz - +30 dbm +13 dbi - 48 db = -5 dbm (-35 dbW)

Separation distance = 50 mi = 80 km

Propagation loss = 32.4 + 20 log f + 20 log d = 32.4 + 20 log 5000 + 20 log 80 = 144 dB
Note: this is the same as -20 log ($4\pi d/\lambda$)

Thus, PFSD = -5dbm - 144 dbm = -149 dbm (-179 db W) -207 dbW – spec limit

This exceeds the allowable interference threshold by 28 dB.

However, this result does not consider signal blockage due to ground clutter or shielding between the transmitter and the RA receiver. This assumes a perfect line of sight into the RA receiver.

Protection of RA Sites by Mountain Ridges

The following table shows that, with one exception (Los Alamos), the radio astronomy sites that are located within 200 km of any large city are protected from interference in the direction of the city by shielding from a mountain ridge. These conclusions are based on path profiles derived from the NTIA program "PROFILE" downloaded from http://ntiacsd.ntia.doc.gov/msam/ and the terrain data base from NOAA http://www.ngdc.noaa.gov/seg/topo/gltiles.shtml.

The first six columns identify the transmit and receive locations. The seventh column (receive altitude) is the altitude of the radio astronomy receiver based on the NOAA terrain data. The eighth column is the altitude of the nearby mountain ridge. The ninth column is the difference between the seventh and eighth column values. The tenth column is the distance along the path from the nearby mountain ridge to the receiver location. The eleventh column is the total path length from the transmit location at ground level to the receiver location at ground level. For an airborne transmitter, the actual path length would be the hypotenuse rather than the base of the triangle. Finally, using simple trigonometry, the twelfth column is the altitude that a transmitter could reach above the transmit site and still have the receiver shielded by the nearby mountain ridge. Other than the Los Alamos site, others are shielded from transmitters as high as 1500 meters.

Summary of Protection Afforded to Radio Astronomy Sites by Nearby Mountain Ridges											
transmit location	lat	long	radio astronomy receive location	lat	long	receive altitude (meters)	ridge altitude (meters)	shielded height (meters)	distance to ridge (kilometers)	total path length (kilometers)	protected transmiter altitude (m)
Tucson	32-13-37	110-58-36	Kitt Peak	31-57-00	111-37-00	1781	1989	208	2.2	67.7	6401
LA County	34-48-00	117-42-00	Goldstone	35-18-00	116-54-00	996	1038	42	0.6	91.6	6412
Davenport IA	41-32-24	90-34-12	North Liberty IA	41-46-00	91-34-00	224	252	28	1.6	86.5	1514
Boston MA	42-21-24	71-3-11	Hancock NH	42-56-00	71-59-00	298	555	257	12	99.5	2131
Washtn DC	38-54-00	77-3-00	Green Bank, WV	38-24-00	79-30-00	1088	1266	178	23.7	219.9	1652
Albuquerque NM	35-5-24	106-39	Los Alamos NM	35-47-00	106-15-00	1934	1935	1	0.7	85.2	122
Honolulu HI	21-20-12	157-52	Mauna Kea HI	19-48-00	155-27-00	3769	4032	263	2.3	304.1	34773

Shielding by Soil

The RF attenuation through a material can be predicted if the conductivity and permeability values of the material are known. The relationship of these values are given in the following formula which calculates the penetration depth of the material where the RF signal voltage is reduced to 37% of its surface value.

$$D = \sqrt{(1/\pi fqx)}$$

where

D = penetration depth into material of 37%, meters (20 log 0.37 = 8.64 dB)
f = RF frequency, Hz
q = permeability of material, Henrys/meter (1.257×10^{-6} for non-magnetic material)
x = conductivity of material, mho/meter (2 mhos/meter for soil)

For a 5 GHz signal, D is calculated to be 0.00503 meters = 0.198 inches.
Thus, 1 inch of soil will attenuate a 5 GHz signal by about 43 dB.

Conclusion

While attenuation due to distance alone might not be sufficient to protect against interference into the designated radio astronomy receivers, they are protected against interference because their sites are shielded by intervening mountain ridges. The shielding provided by the mountains is sufficient to protect against interferenec from airborne transmitters flying as high as 1500 meters. The one exception is the Los Alamos site, which is not protected against transmissions from Albuquerque.