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

In the Matter of	)	
Use of Spectrum Bands Above 24 GHz For Mobile Radio Services	)	GN Docket No. 14-177
Establishing a More Flexible Framework to Facilitate Satellite Operations in the 27.5-28.35 GHz and 37.5-40 GHz Bands	)	IB Docket No. 15-256
Petition for Rulemaking of the Fixed Wireless Communications Coalition to Create Service Rules for the 42-43.5 GHz Band	)	RM-11664
Amendment of Parts 1, 22, 24, 27, 74, 80, 90, 95, and 101 To Establish Uniform License Renewal, Discontinuance of Operation, and Geographic Partitioning and Spectrum Disaggregation Rules and Policies for Certain Wireless Radio Services	)	WT Docket No. 10-112
Allocation and Designation of Spectrum for Fixed-Satellite Services in the 37.5-38.5 GHz, 40.5-41.5 GHz and 48.2-50.2 GHz Frequency Bands; Allocation of Spectrum to Upgrade Fixed and Mobile Allocations in the 40.5-42.5 GHz Frequency Band; Allocation of Spectrum in the 46.9-47.0 GHz Frequency Band for Wireless Services; and Allocation of Spectrum in the 37.0-38.0 GHz and 40.0-40.5 GHz for Government Operations	)	IB Docket No. 97-95

COMMENTS OF ZODIAC INFLIGHT INNOVATIONS

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February 24, 2016

SUMMARY

Zodiac Inflight Innovations ("Zii") submits these comments in response to the Notice of Proposed Rulemaking ("NPRM") in the above-referenced proceeding in which the Commission proposes rules for mobile radio services in four millimeter wave bands suitable for future fifth generation (5G) wireless services.[1] Zii agrees that the Commission's overall framework will enable flexibility in the uses and technologies that might be deployed in these bands, while protecting incumbent services. We applaud the Commission's willingness to consider service rules and licensing mechanisms including licensed, unlicensed and shared spectrum use.

We appreciate the Commission's proposal to expand the current 60 GHz band (57-64 GHz) to higher frequencies and make the spectrum available for Part 15 unlicensed operations under harmonized rules. We concur with Microsoft's comments[2] that the 60 GHz band should be extended to 72.5 GHz rather than 71.0 GHz to make the most efficient use of the spectrum, given the IEEE standard for channel size and ITU-R recommended channel plan.

Zii recommends that the Commission remove the existing prohibition against the use of the 57-64 GHz band on aircraft.

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[1] See In the Matter of Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, et al., GN Docket No. 14-177, et al., Notice of Proposed Rulemaking, FCC-15-138, 30 FCC Rcd 11878 (released October 23, 2015) ("NPRM").

[2] 14-177 01-27-2016 Microsoft Corporation (1 of 2) 60001415290

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I. EXTENDING THE EXISTING 60 GHZ BAND

a. The Commission Should Extend the Current 57-64 GHz Band for Unlicensed Devices to 72.5 GHz.

Zii agrees with the comments of Boeing, Microsoft, Nokia, ViaSat, Google, Qualcomm and IEEE to this NPRM recommending the upward expansion of the 57-64 GHz band to 71 GHz for unlicensed terrestrial use.

Further, we find Microsoft's argument for further expansion to 72.5 GHz compelling given the possibility of adding one additional channel and avoiding unused spectrum between bands in alignment with ITU-R M.2003-1 channelization recommendations.

b. The Commission Should Remove the Publicly-Accessible Coordination Channel

Zii is unaware of any technical communications solution that requires the use of the 50 MHz coordination channel at 57.00 - 57.05 GHz. The coordination channel concept appears to have been superseded by other commercial solutions since its inception in 1998.

Zii joins Microsoft, Intel and IEEE in recommending that this 50 MHz should be integrated into the 57-64 GHz band without specific allocation for coordination purposes.

c. The Commission Should Allow Unlicensed Devices to Operate on Transport Aircraft in the 57-64 GHz Band

Wireless In-Fight Entertainment (IFE) has the potential to eliminate hundreds of pounds of cabling per aircraft while expanding the communications and entertainment services offered to passengers. This translates to reduced fuel burn and reduced environmental impact as entertainment services are improved.

Zii agrees with the comments of Microsoft, Boeing, Intel and IEEE recommending the removal of the prohibition of 57-64 GHz on aircraft.

Current entertainment technologies require bandwidth beyond the capacity of the 2.4 and 5 GHz unlicensed bands. The 60 GHz band is the obvious choice for aircraft wireless entertainment solutions over the next decade or more but only if we can clearly demonstrate that airborne use of the 60 GHz band will not interfere with radio astronomy.

Radio astronomy sites are intentionally situated in remote locations to ensure minimal radio frequency interference. The fact that radio astronomy sites are remote locations means that any Air Transport aircraft passing near or over a site will be operating in cruise flight. The altitude for cruise flight for Air Transport aircraft varies from 9.1 km (30,000 ft) to 13.7 km (45,000 ft).

The curvature of the earth defines the maximum line-of-sight distance from which a passing aircraft could potentially impact a radio astronomy receive signal, as depicted in Figure 1. Please note that Figure 1 is intentionally distorted in order to depict the various distances associated with line-of-sight around the Earth's radius.

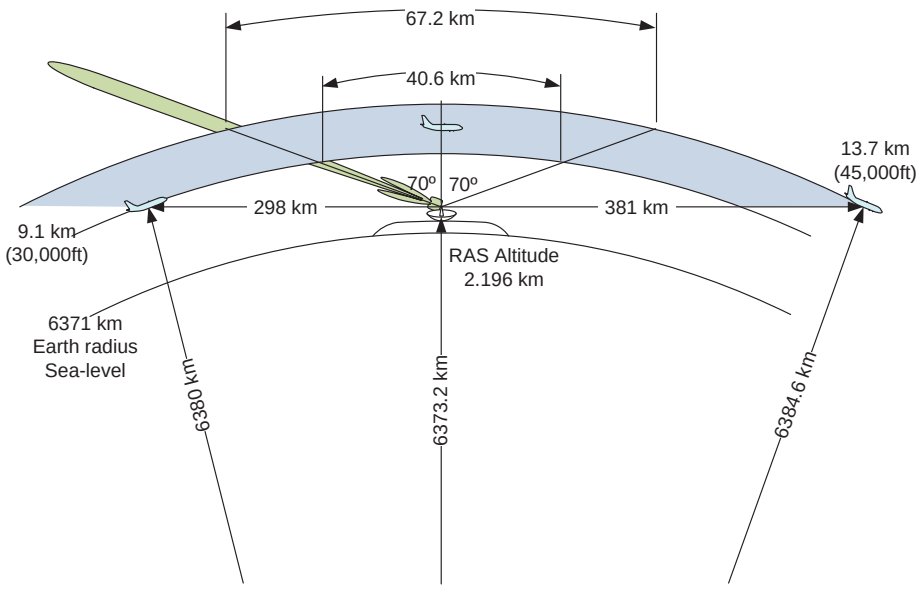

Figure 1 Line-of-Sight Distances

Table 1 Selected Major U.S. Radio Observatories Around the World: Operating, Under Construction, Being Planned[3]

Observatory	Location	Frequency (GHz)	Collecting Area (m2)
Selected Operating Facilities			
Allen Telescope Array (42 dishes)	Hat Creek, California	0.5-11.2	1,230
Arecibo Observatory	Arecibo, Puerto Rico	0.3-10	73,000
Arizona Radio Observatory	Tucson, Arizona	68-500	78 and 113
Atacama Cosmology Telescope	Chile	150-270	28
Caltech Submillimeter Observatory	Mauna Kea, Hawaii	200-950	85
Combined Array for Research in Millimeter-Wave Astronomy	Owens Valley, California	70-260	770
Green Bank Telescope	Green Bank, West Virginia	0.3-100	7,850
Large Millimeter Telescope	Mexico	85-275	1,960
South Pole Telescope	South Pole	95-275	78
Submillimeter Array	Mauna Kea, Hawaii	180-900	226
Very Large Array	Socorro, New Mexico	0.07-50	13,250
Very Long Baseline Array *(Observatory list expanded from original)*	Mauna Kea, HI Owens Valley, CA Brewster, WA North Liberty, IA Hancock, NH Kitt Peak, AZ Pie Town, NM Fort Davis, TX Los Alamos, NM St. Croix, Virgin Islands	0.3-90	4,900
Selected Facilities Under Construction			
Allen Telescope Array (350 dishes)	Hat Creek, California	0.5-11.2	10,220
Atacama Large Millimeter Array	Chile	30-960	6,000
Long Wavelength Array 1+	New Mexico	0.015-0.09	20,000 @ 15 MHz
Murchison Widefield Array	Murchison, Australia	0.08-0.3	8,000
Selected Facilities in Planning			
Cornell Caltech Atacama Telescope	Chile	200-900	490
Square Kilometer Array	To be determined	To be determined	1,000,000

Observatories potentially receiving signals in the 57-64 GHz band are highlighted in blue (12 in total).

Observatories potentially receiving signals in the second and/or third harmonic of the 57-64 GHz band are highlighted in green (6 in total).

[3] *Spectrum Management for Science in the 21st Century, Table 3.1, page 112, National Academy Press, Copyright 2010*

The Atacama Large Millimeter Array in Chile is the only observatory listed that is capable of receiving signals in the 57-64 GHz band and the second and third harmonics of that band.

The observatory sites in Table 1 capable of receiving the 57-64 GHz band or its second and third harmonics are shown on the map in Figure 2.

The large light-red circular area around each observatory represents the line-of-sight from each observatory to potential aircraft cruising at 9.144 km (30,000 ft), assuming each observatory is located at an altitude of 2196 meters (7, 204 ft) above sea-level with a clear view to the horizon in all directions. For observatories at lower altitudes or aircraft at higher cruise altitudes the line-of-sight area will increase somewhat in size from that shown.

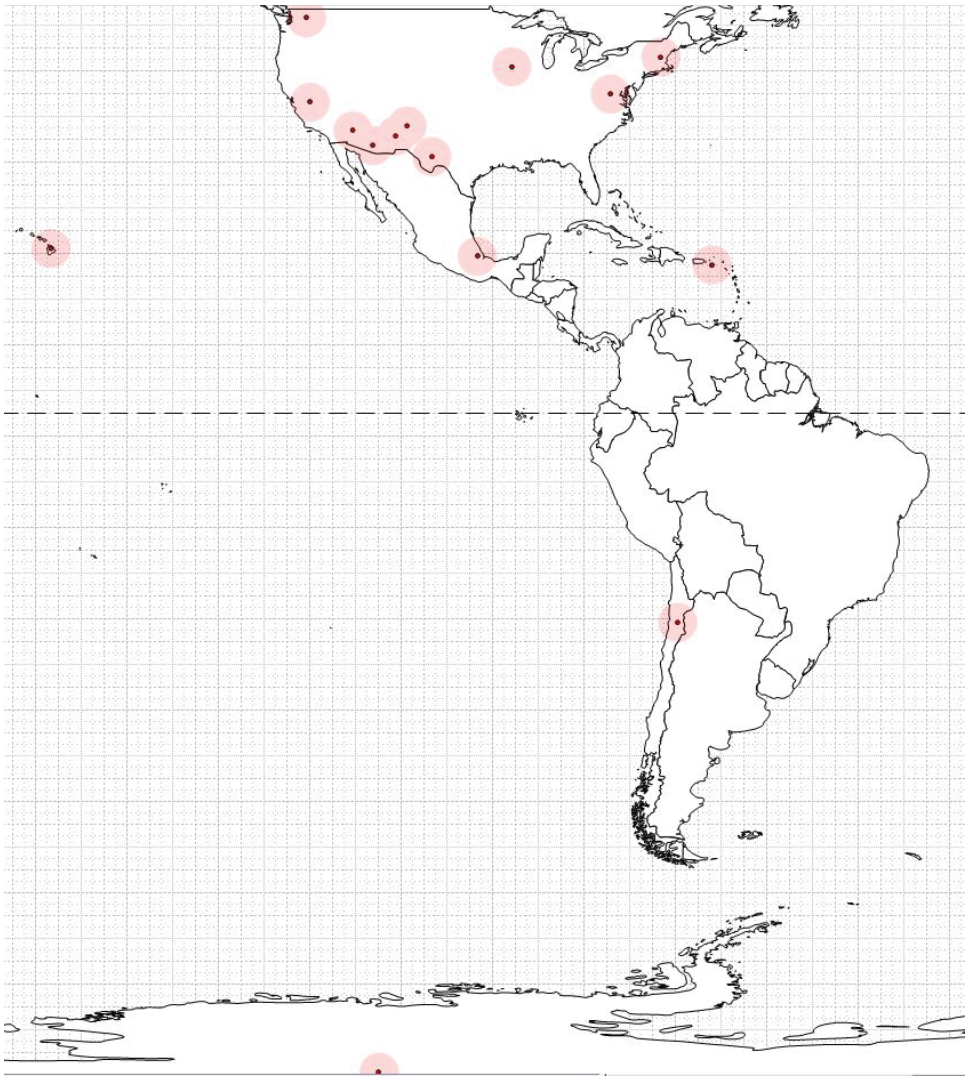

Figure 2 US Observatories Affected by 57-64 GHz on Aircraft

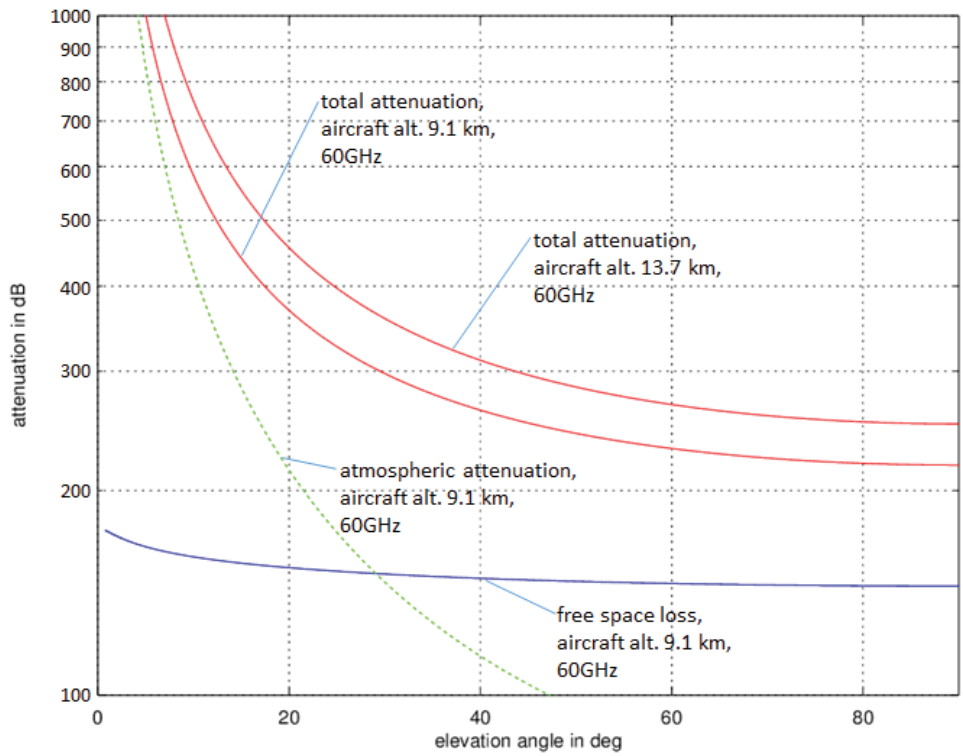

Figure 3 Slant Path Attenuation Over Elevation Angle (RAS altitude 2.2 km)

A majority of the attenuation in the 57-64 GHz band is due to atmospheric absorption. Specific attenuation due to atmospheric gases increases at lower altitudes. Cruise aircraft that are visible at lower elevations are significantly further away than aircraft overhead. The combination of increased atmospheric density and distance at lower elevations focuses any potential interference threat into a reduced area around the zenith of the observatory as shown in Figure 3.

The following atmospheric parameters were used to generate Figure 3:

$p = 1013hPa$, dry air pressure

$t = 0°C$, temperature

$\rho_1 = 7.5\frac{g}{m^3}$, water vapour density

The atmospheric attenuation due to atmospheric gases used in Figure 3 is specific to 60 GHz. The atmospheric attenuation is lower for 57 and 64 GHz.

The maximum cruise altitude for Air Transport aircraft is 13.7 km (45,000 ft). The smaller, dark-red circular area around each observatory in Figure 2 represents the line-of-sight distance to aircraft cruising at 13.7 km within 70 degrees of perpendicular to the observatory antenna. This circle is 67.2 km (42 miles) across as measured in Figure 1 for the exposure to aircraft flying overhead at 13.7 km.

The transit time for an aircraft flying at 13,700 m (45,000 ft) at 800 kph (500 mph) across the 70 degree cone above an observatory is 5.04 minutes. This is worst case. For aircraft flying at lower altitudes or not flying directly over the observatory zenith the transit time will be less.

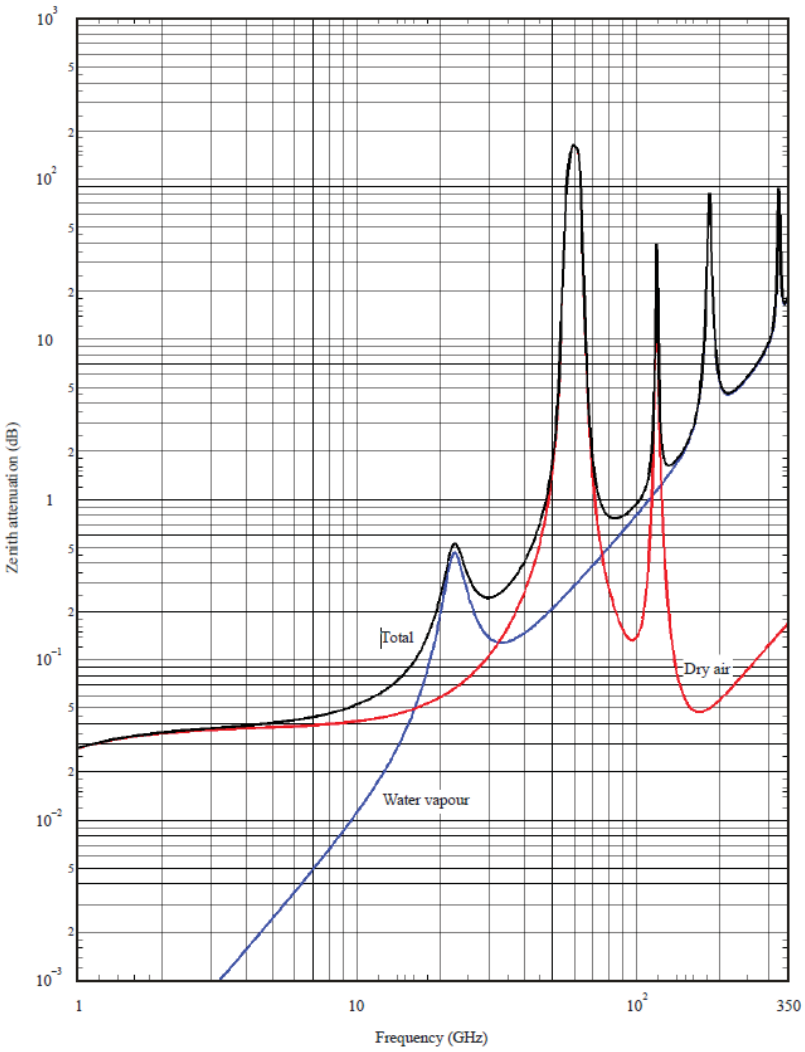

Figure 4 Specific Attenuation Due to Atmospheric Gases[4]

[4] *ITU-R REC-P.676 (09/2013) Attenuation by atmospheric gases*

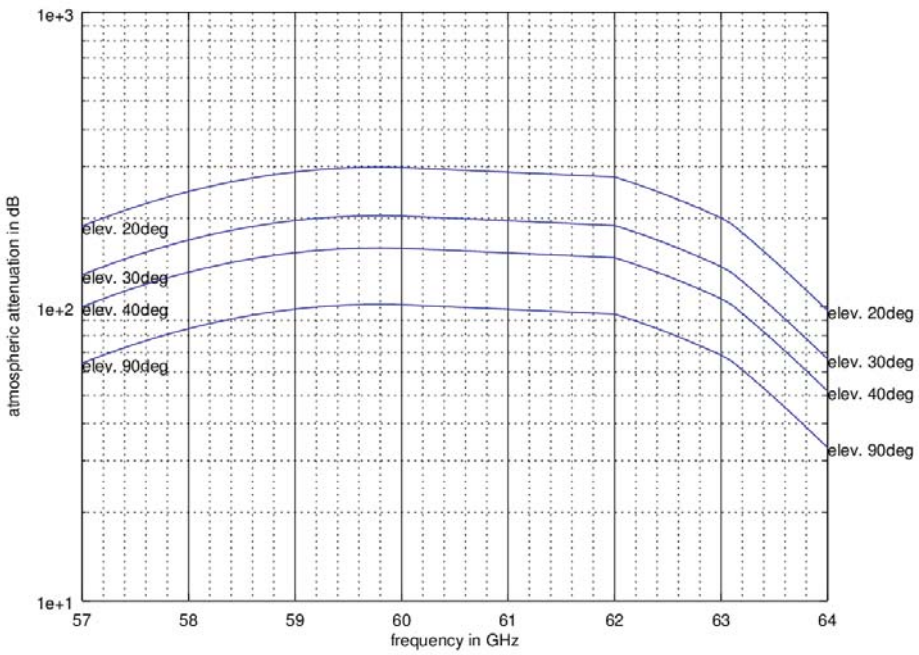

Figure 5 Atmospheric Slant Path Attentuation (RAS altitude 2.2 km, aircraft altitude 13.7 km)

Zii has reviewed the 60 GHz Use Aboard Aircraft presentation[5] given to the FCC and NSF on June 30, 2015 and we generally concur with the conclusions presented recommending removal of the prohibition on aircraft in CFR 14 Part 15.255.

Zii has independently analyzed the potential interference to radio astronomy of a Zii developed aircraft cabin Radio Local Area Network (RLAN). That analysis was based on the recommendations in ITU-R RA.769-2 as applied to a 70 degree cone above a theoretical observatory. Our calculations utilized the aircraft fuselage attenuation values provided in ITU-R M.2238. Our analyses show 18 - 35 dB of interference margin in some channels of the 57-64 GHz band. However, our analyses also show that interference margin begins to drop off very rapidly above approx. 63 GHz toward the top

[5] *60 GHz Use Aboard Aircraft Industry Interference Analysis - Boeing, Broadcom, Intel, Marvell, MediaTek, Qualcomm, Panasonic, Peraso*

of the 57-64 GHz band as atmospheric attenuation falls above the oxygen absorption peak as shown in Figure 4 and Figure 5.

Zii analyses utilize values specific to a Zii-developed aircraft RLAN solution which was optimized to meet the recommendations of ITU-R RA.769-2. During our analysis design we became aware that some combinations of transmit power levels, antenna radiation patterns and beam steering algorithms used on commercial radio components can result in systems that do not meet those recommendations in all conditions, specifically in frequencies above approx. 63 GHz.

Per NRAO comments[6], radio astronomy observations are not conducted in the 52-68 GHz range today. Further, Zii analyses confirm that RLAN can be designed and operated on aircraft without interference to radio astronomy observations if they were performed in the 57-64 GHz band. It is therefore Zii's recommendation that the prohibition against aircraft use of the 57-64 GHz band in CFR 14 Part 15.255 be removed.

However, if the prohibition is removed, due to the variations we found during system development, Zii strongly recommends that airborne systems be required to meet the recommendations of ITU-R RA.769-2 to ensure a minimum impact to radio astronomy.

Zii believes that aircraft fuselage attenuation will increase from the values in ITU-R M.2238 when applied to RF above 50 GHz. Zii has an aircraft measurement program planned for later this quarter to confirm that belief. Once our measurement program is complete we will have sufficient data to complete detailed analyses of the potential interference generated by aircraft RLAN operating in the 65-71 GHz range.

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[6] *14-177 01-22-2016 National Radio Astronomy Observatory 60001409866*

As much as we like the idea, until the Zii aircraft measurement campaign is complete we are not prepared to recommend that aircraft RLAN be allowed to operate in the 65-71 GHz range.