Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 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

REPLY COMMENTS OF WI-FI ALLIANCE

Wi-Fi Alliance®[1/] submits these reply comments in response to comments of other parties in the above-referenced proceedings in which the Commission proposes rules for mobile

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radio services in the millimeter wave bands.[2/] The record indicates that, *first*, the Commission should, as it proposes, designate the entire 64-71 GHz band for Part 15 unlicensed operations "to double the spectrum available for the next generation of unlicensed wireless broadband technologies."[3/] *Second*, in doing so, the Commission need not prohibit the use of the band on board aircraft to protect Earth Exploration Satellite Service ("EESS") or Radio Astronomy Service ("RAS") operations. Enabling flexible use of the 64-71 GHz band will support new, innovative applications requiring unlicensed spectrum without the risk of interference to existing operations.

I. INTRODUCTION

As Wi-Fi Alliance explained in its initial comments, unlicensed spectrum is a critical component of the wireless ecosystem and a significant driver of the U.S. economy.[4/] Wi-Fi has enabled anyone, at any time and any place to set up an affordable network that simply works. WiGig®'s support of very high data rates of up to 7 gigabits per second promises the same ease of use for a variety of additional applications, ranging from instant wireless synchronization and docking to mass video and data distribution to devices in classrooms or airplane cabins.[5/] Wi-Fi Alliance therefore appreciates the actions the Commission has taken to date to identify additional spectrum for unlicensed operations, and especially applauds the Commission's proposal to make

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2/ *See Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, et al.*, Notice of Proposed Rulemaking, 30 FCC Rcd. 11878 (2015) ("NPRM").

3/ *See id.* ¶ 58.

4/ *See* Comments of Wi-Fi Alliance, GN Docket No. 14-177, *et al.*, at 2-4 (filed Jan. 27, 2016) ("Wi-Fi Alliance Comments").

5/ *See id.* at 4. *See also* Wi-Fi Alliance, WiGig ® and the Future of Seamless Connectivity, at 2-4 (2013), *available at* http://www.wi-fi.org/file/wigig-and-the-future-of-seamless-connectivity-2013; Wi-Fi Alliance, Discover Wi-Fi, WiGig CERTIFIED, http://www.wi-fi.org/discover-wi-fi/wigig-certified (last visited Dec. 23, 2015); IEEE 802.11 TGay Use Cases (IEEE 802.11-2015/0625r3), at 7-12 (Sept. 2015), *available at* https://mentor.ieee.org/802.11/dcn/15/11-15-0625-03-00ay-ieee-802-11-tgay-usage-scenarios.pptx.

additional millimeter wave spectrum available for unlicensed use. Wi-Fi Alliance and other commenters agree that the Commission should proceed to designate the entire 64-71 GHz band for unlicensed operations. Further, to maximize the band's potential, the Commission should not unnecessarily prohibit use of the band on board aircraft.

II. THE ENTIRE 64-71 GHZ BAND SHOULD BE DESIGNATED FOR UNLICENSED OPERATIONS

In its initial comments, Wi-Fi Alliance expressed its support for the Commission's proposal to authorize operations in the 64-71 GHz band under Part 15 rules.[6/] Opening the 64-71 GHz band for unlicensed operations doubles the spectrum available for the next generation of unlicensed wireless broadband technologies, and permits new, longer-distance end-user applications.[7/] Numerous commenters agree.[8/] For example, the National Cable & Telecommunications Association highlights that "a contiguous band of unlicensed spectrum from 57-71 GHz would promote the expansion of existing unlicensed operations and the development of new and innovative unlicensed applications."[9/] Further, unlicensed spectrum's value in the U.S. economy could more than double by 2017 if the Commission designates sufficient unlicensed spectrum to meet rapidly increasing demand.[10/] Noting their strong support, Public Knowledge and New America's Open Technology Institute also explain that

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6/ Wi-Fi Alliance Comments at 5-6.

7/ *Id.* at 5-6 (citing NPRM ¶ 58).

8/ *See* Comments of Intel Corporation, GN Docket No. 14-177, *et al.*(filed Jan. 27, 2016); Comments of the National Cable & Telecommunications Association, GN Docket No. 14-177, *et al.*(filed Jan. 28, 2016) ("NCTA Comments"); Comments of Facebook, Inc., GN Docket No. 14-177, *et al.*(filed Jan. 27, 2016) ("Facebook Comments"); Comments of Microsoft Corporation, GN Docket No. 14-177, *et al.*(filed Jan. 27, 2016) ("Microsoft Comments"); Comments of Information Technology Council, GN Docket No. 14-177, *et al.*(filed Jan. 27, 2016); Comments of Dynamic Spectrum Alliance, GN Docket No. 14-177, *et al.*(filed Jan. 27, 2016) ("DSA Comments").

9/ NCTA Comments at 4-5.

10/ *Id.* at 5.

there are no licensed operations across the entire 57-64 GHz band, so the band is "particularly well suited for shared unlicensed use."[11/] Additionally, Vubiq Networks, Inc. agrees that the 64-71 GHz band supports even longer-range transmissions than 57-64 GHz because of less severe oxygen attenuation, meaning that the Commission would not simply be making more of the same type of spectrum available for unlicensed use.[12/]

A few commenters differ, suggesting that the Commission allocate a portion of the 64-71 GHz band for licensed use.[13/] However, while it is important to make spectrum available for both licensed and unlicensed uses, the Commission must recognize that the way consumers use wireless creates a disproportionate demand on unlicensed wireless capacity. *Most* of the Internet traffic today — which drives wireless demand — originates and/or ends on unlicensed spectrum.[14/] Therefore, it is critical that the Commission focus its efforts to increase capacity where it is needed most — on unlicensed spectrum.

[11/] Comments of Open Technology Institute and Public Knowledge, GN Docket No. 14-177, *et al.*, at 26-29 (filed Jan. 28, 2016) ("OTI/PK Comments").

[12/] *See* Comments of Vubiq Networks, Inc., GN Docket No. 14-177, *et al.*, at 4-5 (filed Jan. 27, 2016).

[13/] *See, e.g.*, Comments of CTIA®, GN Docket No. 14-177, *et al.*, at 17-19 (filed Jan. 28, 2016) ("CTIA Comments"); Comments of Mobile Future, GN Docket No. 14-177, *et al.*, at 16-17 (filed Jan. 27, 2016) ("Mobile Future Comments").

[14/] *See* Cisco, *The Zettabyte Era—Trends and Analysis* (May 2015), *available at* http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/VNI_Hyperconnectivity_WP.html ("By 2016, wired devices will account for 47 percent of IP traffic, and Wi-Fi and mobile devices will account for 53 percent of IP traffic."); Cisco, *Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2015–2020 White Paper* (Feb. 3, 2016) , *available at* http://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html ("Fifty-one percent of total mobile data traffic was offloaded onto the fixed network through Wi-Fi or femtocell in 2015."). In contrast, in 2015, only 6.2% of Internet traffic in developed economies was mobile wireless, and it is likely that consumers tend to minimize the data use on mobile networks. Rupert Wood, *Mobile Data Growth in Developed Economies Will Be Part of a Bigger Convergence Picture*, ANALYSYS MASON (Feb. 2016), http://www.analysysmason.com/Research/Content/Comments/mobile-data-convergence-Feb2016-RDTW0-RDTN0/article-PDF**.**

Indeed, as Facebook explains, authorizing Part 15 operations in the 64-71 GHz band would help strike "the right balance between licensed and unlicensed spectrum access to drive wireless innovation and expand connectivity."[15/] Expanding the unlicensed millimeter wave band from 57-64 GHz to 57-66 GHz, as some recommend, [16/]would not strike that balance; the added 2 gigahertz would only create one more additional channel (from three channels to four). Access to the entire 57-71 GHz band, in contrast, would create three additional channels for innovative uses. Moreover, the Commission should consider expanding the band even further, to 72.5 GHz, to create seven non-overlapping channels — which, as other commenters explain, would "make the most efficient use of spectrum in the band" and be "consistent with a globally harmonized channel plan."[17/]

Finally, the fact that some of the 64-71 GHz band has been designated for study for IMT-2020 by the World Radiocommunication Conference 2015 ("WRC-15") should not, as some suggest, stop the Commission from considering its use for unlicensed operations.[18/] As others have pointed out with respect to the 28 GHz band, which was not identified by WRC-15 for further study, the Commission can depart from international plans where appropriate.[19/] XO

15/ Facebook Comments at 5-6.

16/ *See* Comments of Ericsson, GN Docket No. 14-177, *et al.*, at 19-20 (filed Jan. 28, 2016) ("Ericsson Comments"); Comments of Nokia, GN Docket No. 14-177, *et al.*, at 17-18 (filed Jan. 27, 2016) ("Nokia Comments").

17/ *See* Microsoft Comments at 6-7; OTI/PK Comments at 29.

18/ *See* Ericsson Comments at 19-20; Nokia Comments at 4, 17.

19/ *See* Comments of XO Communications, GN Docket No. 14-177, *et al.*, at 3 (filed Jan. 28, 2016) ("XO Communications Comments") ("[T]he Commission should not be deterred by recent activities at [WRC-15]. Application of flexible use policies to the LMDS band in the United States will spur innovation and generate enormous public interest benefits, setting an example for the rest of the world."). *See also* Comments of T-Mobile USA, Inc. GN Docket No. 14-177, *et al.*, at 5-6 (filed Jan. 27, 2016) (recommending that the Commission consider bands beyond those designated at WRC-15 for additional study); Comments of the Telecommunications Industry Association, GN Docket No. 14-177, *et al.*, at 15 (filed Jan. 27, 2016) (acknowledging that, although global harmonization is a worthy goal, "not every

Communications, for example, asserts that the United States can set an example in spurring innovation and producing public interest benefits by charting its own course.[20/] Just as the Commission proposes to depart from the WRC-15 recommendations with respect to the 28 GHz band, it should also proceed to designate the entire 64-71 GHz band for unlicensed operations despite WRC-15 designating a portion of the band for study as licensed spectrum.

III. THE COMMISSION NEED NOT PROHIBIT USE OF THE 60 GHZ BAND ON BOARD AIRCRAFT TO PROTECT EESS AND RAS OPERATIONS

Wi-Fi Alliance argued in its comments that unlicensed transmissions in the 57-71 GHz band on board aircraft should be permitted.[21/] Others agree.[22/] Intel Corporation notes, for instance, that it is difficult to enforce the current prohibition of 57-64 GHz unlicensed operations on board aircraft.[23/] The Boeing Company cites "substantial attenuation, free space losses, and low power levels" as providing "adequate protection for radioastronomy stations."[24/] Microsoft adds that, "[i]nside the controlled environment of a transport aircraft," the risk of harmful interference can be "managed and minimized."[25/]

The National Academy of Sciences, Committee on Radio Frequencies ("CORF") and the National Radio Astronomy Observatory ("NRAO") express concern about potential interference from unlicensed operations on board aircraft with EESS operations (in particular, satellite

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country will be able to designate exactly the same bands for similar uses because they will have a different needs and incumbent uses").

20/ *See* XO Communications Comments at 3.

21/ *See* Wi-Fi Alliance Comments at 7-8.

22/ *See* NCTA Comments at 7-8; Intel Comments at 19-20; Comments of The Boeing Company, GN Docket No. 14-177, *et al.*, at 13-14 (filed Jan. 28, 2016) ("Boeing Comments"); Microsoft Comments at 11-14; DSA Comments at 3.

23/ *See* Intel Comments at 19.

24/ *See* Boeing Comments at 13-14.

25/ *See* Microsoft Comments at 11.

weather monitoring operations) in the 64-71 GHz band.[26/] NRAO and CORF also assert that 64-71 GHz band operations, by their harmonics at 128-142 GHz and 192-213 GHz, could interfere with RAS, which does not have an allocation in the 64-71 GHz band.[27/]

As an initial matter, Wi-Fi Alliance observes that EESS operations are authorized on a co-primary basis only for one gigahertz (*i.e.*, 65-66 GHz) within the 64-71 GHz band.[28/] Even if those operations were fully protected, the data CORF cites to claim potential interference to EESS operations appears to apply to the 57-61 GHz band and not the 61-74 GHz band.[29/] In any case, WiGig technology is highly unlikely to cause any interference to either EESS or RAS operations. There are no line-of-sight transmissions — the most likely cause of interference — between WiGig devices and either EESS satellites or Radio Astronomy ground receivers. Importantly, WiGig's transmissions rely on beam forming, not omnidirectional radiation, between the access point and user device, which would both reside within the same aircraft. The most practical and effective placement of a WiGig access point will be in the ceiling of the plane, in order to efficiently transmit signals to client devices. Therefore, neither the transmitter nor the receiver would direct energy towards the aircraft's windows where transmissions could be directed to EESS or RAS facilities. Any energy not directed towards windows but "reflected" towards the windows would have negligible power levels, due to the properties of the spectrum, and further absorption of signals by human bodies and materials on the aircraft. Further,

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[26/] Comments of the National Academy of Sciences' Committee on Radio Frequencies, GN Docket No. 14-177, *et al.*, at 11-15 (filed Jan. 27, 2016) ("CORF Comments"); Comments of the National Radio Astronomy Observatory, GN Docket No. 14-177, *et al.*, at 5 (filed Jan. 22, 2016) ("NRAO Comments").

[27/] *See* NRAO Comments at 5 ("Radio astronomy's concerns, if such exist, are more likely with the harmonics above the fundamental that propagate more freely."); CORF Comments at 15-16.

[28/] *See* 47 C.F.R. § 2.106.

[29/] *See* CORF Comments at 11-15 (providing an analysis of atmospheric attenuation from 57-60 GHz in its discussion of the 64-71 GHz band).

interior-exterior attenuation of these signals is at least 25 dB; an ITU report found the attenuation to be 25 dB for frequencies up to 18 GHz, and attenuation at 60 GHz would be the same at the least.[30/] Nor would there be any interference from side lobes or spurs, which would have significantly reduced (10 dB or more) power levels. Any device-to-device (as opposed to access point-to-device) WiGig transmissions would also use significantly less power than an access point (*i.e.*, because devices would generally rely on battery power), so the risk of interference from such transmissions is even lower.

Wi-Fi Alliance provides in the attached a brief analysis of WiGig devices' potential for interference.[31/] Using the same ITU-R RA.769 recommendation as CORF,[32/] the analysis shows no interference to either EESS or Radio Astronomy in even the worst case.

Because there will be no interference from WiGig devices on board aircraft to EESS and RAS operations, there need not be any requirement that WiGig devices have an "airplane mode" that would disable certain WiGig channels to mitigate interference.[33/] Moreover, such a requirement would produce consumer confusion. Airplane mode functionality typically implies that a device ceases transmitting certain kinds of signals (*e.g.*, cellular signals) altogether, so such a setting only applicable to certain WiGig channels would be counterintuitive. Likewise, creating exclusion zones, as one commenter suggests,[34/] produces unnecessary complications and will impede the reliability of WiGig services. The Commission should instead not restrict use of the 60 GHz band on board aircraft.

30/ *See* ITU-R, *Report ITU-R M.2283-0 (12/2013)* (2014), *available at* https://www.itu.int/dms_pub/itu-r/opb/rep/R-REP-M.2283-2013-PDF-E.pdf.

31/ *See* Wi-Fi Alliance, *60 GHz Use Aboard Aircraft Industry Interference Analysis* (Feb. 2016), attached hereto.

32/ *See* CORF Comments at 18.

33/ *See id.* at 14-15.

34/ *See id.* at 16.

IV. CONCLUSION

Wi-Fi Alliance again commends the Commission's proposal designate the entire 64-71 GHz band for unlicensed use to meet growing demand for unlicensed spectrum. The Commission should permit full use of the band by allowing unfettered use of spectrum on board aircraft.

Respectfully submitted,

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ATTACHMENT

60 GHZ USE ABOARD AIRCRAFT

INDUSTRY INTERFERENCE ANALYSIS

60 GHz Use Aboard Aircraft Industry Interference Analysis

Wi-Fi Alliance

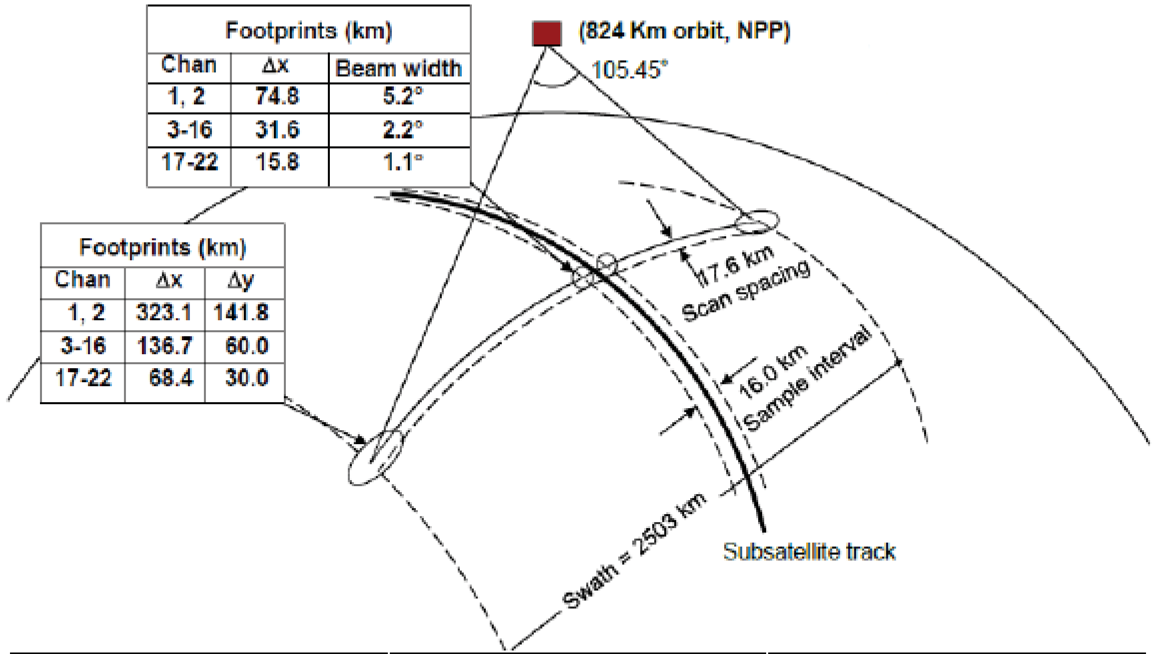
February 2016

Agenda

- Interference analysis for Earth Exploration Satellite Service (EESS) and Radio Astronomy
- Summary and conclusions

Earth Exploration Satellite Service (EESS)

Advanced Technology Microwave Sounder (ATMS)



Channel	Beamwidth° (AMSU/MHS)	Sampling° (AMSU/MHS)
23,31 GHz	5.2 (3.3)	1.11 (3.33)
50-57 GHz	2.2 (3.3)	1.11 (3.33)
88 GHz	2.2 (1.1)	1.11 (1.11)
165-183 GHz	1.1 (1.1)	1.11 (1.11)

Source: https://cimss.ssec.wisc.edu/itwg/itsc/itsc17/session9/9.10_leslie.pdf

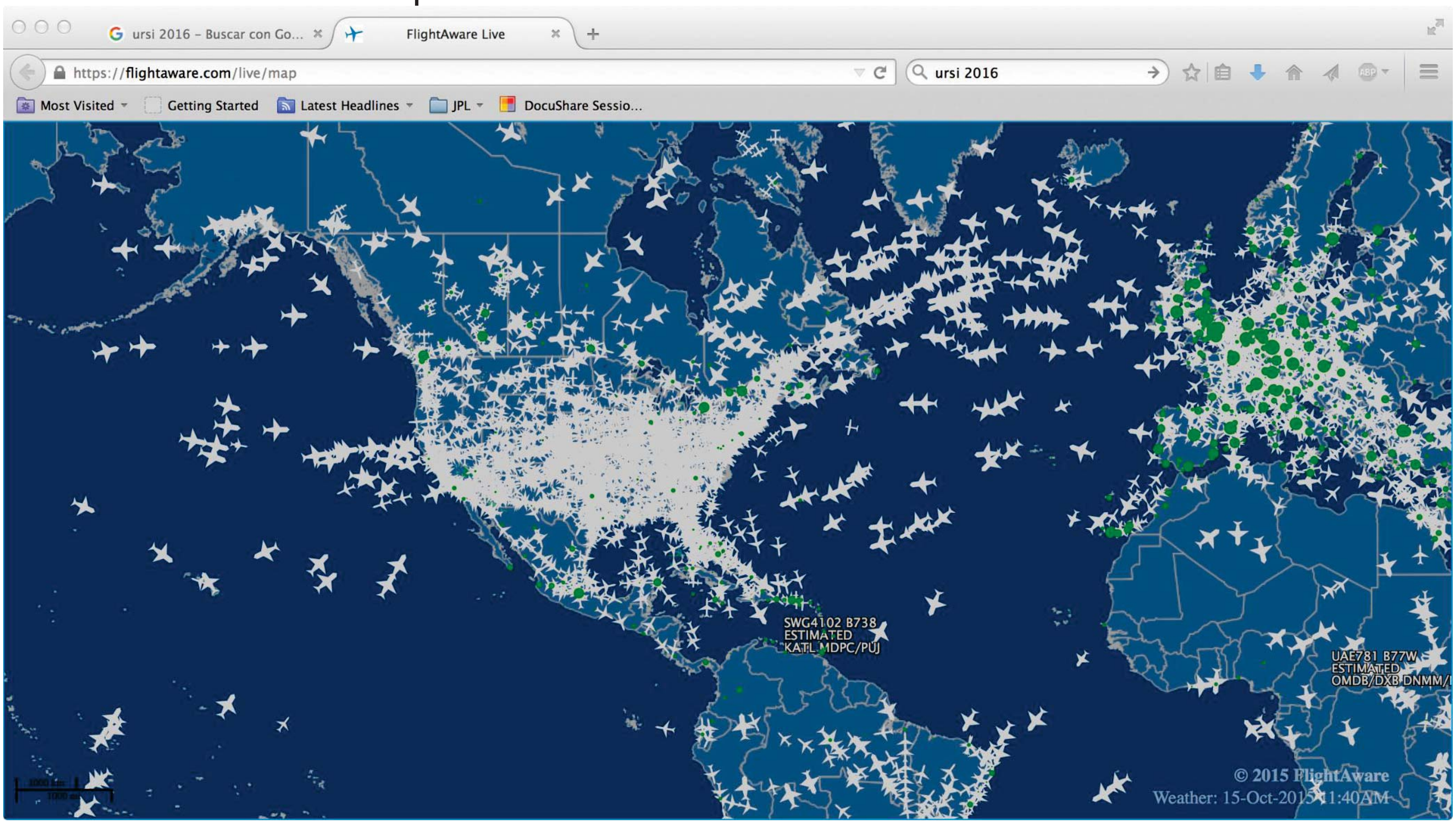
Link Budget

8 cm dish, gain =38.35 dB, beam width=2.2 degree, at 57GHz

Parameters		Unit	Comments
TX Peak EIRP	30.0	dBm	
Antenna Sidelobe	-10.0	dB	Main beam not directed at window
Aggregation	6.0	dB	320 people on board, 4 channels, 20 APs, 80% activity factor
Energy Loss from inside to outside	-25.0	dB	
Free Space Loss @ 1m	-68.0	dB	
Space Loss Exponent	2.0		
Free Space Loss from 30000ft to 824 km	-186.2	dB	824km-30000ft
Atmospheric Loss from 35000 ft	-22	dB	
Receiver antenna gain	38.35	dB	ATMS 8 cm dish, gain =38.3 dB, beamwidth=2.2 degree
Power at the ATMS receiving antenna	-168.9	dBm	
Signal Bandwidth @ 1.9 GHz	92.8	Hz-dB	
Received power densitiy at ATMS receiving antenna	-261.7	dBm/Hz	
Receiver Sensitivity .43 Kelvin	-202.3	dBm/Hz	10*log(k*T) where k is Boltzman constant
Margin for one plane (Receiver sensitivity -Received Power Density)	59.4	dB	
Margin after aggregate 1000 planes	29.4	dB	Estimate number of planes = 1000

What if the assumptions are incorrect?

Number of commercial planes in the air



Radio Astronomy – 120 GHz

Analysis at 120 GHz - ITU-R RA.769-2 Table 1

Parameters		Unit	Comments	
TX Peak EIRP	-10.0	dBm		
Antenna Sidelobe	-10.0	dB	Main beam not directed at window	
Aggregation	6.0	dB	320 people on board, 4 channels, 20 APs, 80% activity factor	
Energy Loss from inside to outside	-25.0	dB		
Free Space Loss @ 1m	-74.0	dB	120GHz	
Space Loss Exponent	2.0			
Free Space Loss from 7205 to 30000 ft	-151.6	dB	30000.0	ft
Oxygen Absorption Loss from 7205 to 30000	0.0	dB		
Received Antenna Gain	71.3	dB	3.5 Meter Dish @120GHz	
Received Power at the receiver	-119.3	dBm		
Radio Astronomy P_H (Fc=88~150GHz)	-159.0	dBm	-159 dBm from ITU Table 1	
epfd/pfd_{peak} integrated over antenna pattern mask (2000 s)	-42.8	dB	epfd is obtained from integration, pfdpeak corresponds to peak antenna gain	
Received Signal Power at the receiver	-162.0	dBm		
Margin (Receiver Noise Floor - Received Signal Spectral Density)	3	dB		

Analysis at 120 GHz - ITU-R RA.769-2 Table 2

Parameters		Unit	Comments	
TX Peak EIRP	-10.0	dBm		
Antenna Sidelobe	-10.0	dB	Main beam not directed at window	
Aggregation	6.0	dB	320 people on board, 4 channels, 20 APs, 80% activity factor	
Energy Loss from inside to outside	-25.0	dB		
Free Space Loss from 7205 to 30000 ft	-151.6	dB	30000.0	ft
Oxygen Absorption Loss from 7205 to 30000	0.0	dB		
Received Antenna Gain	71.3	dB	3.5 Meter Dish @120GHz	
Received Power at the receiver	-119.3	dBm		
Signal Bandwidth @ 1.9x2 GHz	95.8	Hz-dB		
Radio Astronomy P_H @1MHz BW (Fc=88~150GHz)	-179.0	dBm	-179 dBm from ITU Table 2	
epfd/pfd_{peak} integrated over antenna pattern mask (2000 s)	-42.8	dB	epfd is obtained from integration, pfdpeak corresponds to peak antenna gain	
Received Signal Power at the receiver @1MHz	-197.8	dBm/MHz		
Margin (Receiver Noise Floor - Received Signal Spectral Density)	19	dB		

Radio Astronomy – 180 GHz

Analysis at 180 GHz - ITU-R RA.769-2 Table 1

Parameters		Unit	Comments	
TX Peak EIRP	-10.0	dBm		
Antenna Sidelobe	-10.0	dB	Main beam not directed at window	
Aggregation	6.0	dB	320 people on board, 4 channels, 20 APs, 80% activity factor	
Energy Loss from inside to outside	-25.0	dB		
Free Space Loss @ 1m	-78.0	dB	180GHz	
Space Loss Exponent	2.0			
Free Space Loss from 7205 to 30000 ft	-155.6	dB	30000.0	ft
Oxygen Absorption Loss from 7205 to 30000	0.0	dB		
Received Antenna Gain	74.8	dB	3.5 Meter Dish @180GHz	
Received Power at the receiver	-119.7	dBm		
Radio Astronomy P_H (Fc=88~150GHz)	-159.0	dBm	-159 dBm from ITU Table 1	
epfd/pfd_{peak} integrated over antenna pattern mask (2000 s)	-44.4	dB	epfd is obtained from integration, pfdpeak corresponds to peak antenna gain	
Received Signal Power at the receiver	-164.2	dBm		
Margin (Receiver Noise Floor - Received Signal Spectral Density)	5	dB		

Analysis at 180 GHz - ITU-R RA.769-2 Table 2

Parameters		Unit	Comments	
TX Peak EIRP	-10.0	dBm		
Antenna Sidelobe	-10.0	dB	Main beam not directed at window	
Aggregation	6.0	dB	320 people on board, 4 channels, 20 APs, 80% activity factor	
Energy Loss from inside to outside	-25.0	dB		
Free Space Loss @ 1m	-78.0	dB	180GHz	
Space Loss Exponent	2.0			
Free Space Loss from 7205 to 30000 ft	-155.6	dB	30000.0	ft
Oxygen Absorption Loss from 7205 to 30000	0.0	dB		
Received Antenna Gain	74.8	dB	3.5 Meter Dish @180GHz	
Received Power at the receiver	-119.7	dBm		
Signal Bandwidth @ 1.9x3 GHz	97.6	Hz-dB		
Radio Astronomy P_H @1MHz BW (Fc=88~150GHz)	-179.0	dBm	-179 dBm from ITU Table 2	
epfd/pfd_{peak} integrated over antenna pattern mask (2000 s)	-44.4	dB	epfd is obtained from integration, pfdpeak corresponds to peak antenna gain	
Received Signal Power at the receiver @1MHz	-201.7	dBm/MHz		
Margin (Receiver Noise Floor - Received Signal Spectral Density)	23	dB		

Radio Astronomy – 240 GHz

Analysis at 240 GHz - ITU-R RA.769-2 Table 1

Parameters		Unit	Comments	
TX Peak EIRP	-10.0	dBm		
Antenna Sidelobe	-10.0	dB	Main beam not directed at window	
Aggregation	6.0	dB	320 people on board, 4 channels, 20 APs, 80% activity factor	
Energy Loss from inside to outside	-25.0	dB		
Free Space Loss @ 1m	-80.0	dB	240GHz	
Space Loss Exponent	2.0			
Free Space Loss from 7205 to 30000 ft	-157.6	dB	30000.0	ft
Oxygen Absorption Loss from 7205 to 30000	0.0	dB		
Received Antenna Gain	77.3	dB	3.5 Meter Dish @240GHz	
Received Power at the receiver	-119.2	dBm		
Radio Astronomy P_H (Fc=88~150GHz)	-158.0	dBm	-159 dBm from ITU Table 1	
epfd/pfd_{peak} integrated over antenna pattern mask (2000 s)	-45.6	dB	epfd is obtained from integration, pfdpeak corresponds to peak antenna gain	
Received Signal Power at the receiver	-164.9	dBm		
Margin (Receiver Noise Floor - Received Signal Spectral Density)	6	dB		

Analysis at 240 GHz - ITU-R RA.769-2 Table 2

Parameters		Unit	Comments	
TX Peak EIRP	-10.0	dBm		
Antenna Sidelobe	-10.0	dB	Main beam not directed at window	
Aggregation	6.0	dB	320 people on board, 4 channels, 20 APs, 80% activity factor	
Energy Loss from inside to outside	-25.0	dB		
Free Space Loss @ 1m	-80.0	dB	240GHz	
Space Loss Exponent	2.0			
Free Space Loss from 7205 to 30000 ft	-157.6	dB	30000.0	ft
Oxygen Absorption Loss from 7205 to 30000	0.0	dB		
Received Antenna Gain	77.3	dB	3.5 Meter Dish @240GHz	
Received Power at the receiver	-119.2	dBm		
Signal Bandwidth @ 1.9x4 GHz	98.8	Hz-dB		
Radio Astronomy P_H @1MHz BW (Fc=88~150GHz)	-177.0	dBm	-179 dBm from ITU Table 2	
epfd/pfd_{peak} integrated over antenna pattern mask (2000 s)	-45.6	dB	epfd is obtained from integration, pfdpeak corresponds to peak antenna gain	
Received Signal Power at the receiver @1MHz	-203.7	dBm/MHz		
Margin (Receiver Noise Floor - Received Signal Spectral Density)	27	dB		

Summary and Conclusions

- Analysis shows no interference to EESS with margins of 59 dBm and 29 dBm respectively.
- Analysis shows no interference to Radio Astronomy with margins ranging from 3 dBm to 27 dBm depending on the frequency and integration.
- Analysis did not comprehend additional losses due to atmospheric attenuation which could further improve margins by 10 and 100 dB depending on the frequency (ITU-R P.676-10).
- Fuselage attenuation at 60 GHz could be more than 25 dBm. 25 dBm (ITU-R M.2283-0) was measured at frequencies up to 18 GHz.
- Based on the properties of the spectrum, technology. implementation, and conservative assumptions, our conclusion is that there should be no harmful interference to incumbent operations.

References

ITU-R RA.769-2 2000s integration time

TABLE 1

Threshold levels of interference detrimental to radio astronomy continuum observations

Centre frequency (1) f_c (MHz)	Assumed bandwidth Δf (MHz)	Minimum antenna noise temperature T_A (K)	Receiver noise temperature T_R (K)	System sensitivity(2) (noise fluctuations)		Threshold interference levels(2) (3)		
				Temperature ΔT (mK)	Power spectral density ΔP (dB(W/Hz))	Input power ΔP_H (dBW)	pfd $S_H \Delta f$ (dB(W/m^2))	Spectral pfd S_H (dB(W/(m^2 · Hz)))
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
13.385	0.05	50 000	60	5 000	–222	–185	–201	–248
25.610	0.12	15 000	60	972	–229	–188	–199	–249
73.8	1.6	750	60	14.3	–247	–195	–196	–258
151.525	2.95	150	60	2.73	–254	–199	–194	–259
325.3	6.6	40	60	0.87	–259	–201	–189	–258
408.05	3.9	25	60	0.96	–259	–203	–189	–255
611	6.0	20	60	0.73	–260	–202	–185	–253
1 413.5	27	12	10	0.095	–269	–205	–180	–255
1 665	10	12	10	0.16	–267	–207	–181	–251
2 695	10	12	10	0.16	–267	–207	–177	–247
4 995	10	12	10	0.16	–267	–207	–171	–241
10 650	100	12	10	0.049	–272	–202	–160	–240
15 375	50	15	15	0.095	–269	–202	–156	–233
22 355	290	35	30	0.085	–269	–195	–146	–231
23 800	400	15	30	0.050	–271	–195	–147	–233
31 550	500	18	65	0.083	–269	–192	–141	–228
43 000	1 000	25	65	0.064	–271	–191	–137	–227
89 000	8 000	12	30	0.011	–278	–189	–129	–228
150 000	8 000	14	30	0.011	–278	–189	–124	–223
224 000	8 000	20	43	0.016	–277	–188	–119	–218
270 000	8 000	25	50	0.019	–276	–187	–117	–216

ITU-R RA.769-2 Spectral Line – BW=1MHz, IT=10h

TABLE 2*

Threshold levels of interference detrimental to radio astronomy spectral-line observations

Frequency f (MHz)	Assumed spectral line channel bandwidth Δf (kHz)	Minimum antenna noise temperature T_A (K)	Receiver noise temperature T_R (K)	System sensitivity[2] (noise fluctuations)		Threshold interference levels[1] [2]		
				Temperature ΔT (mK)	Power spectral density ΔP_S (dB(W/Hz))	Input power ΔP_H (dBW)	pfd $S_H \Delta f$ (dB(W/m²))	Spectral pfd S_H (dB(W/(m² · Hz)))
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
327	10	40	60	22.3	–245	–215	–204	–244
1 420	20	12	10	3.48	–253	–220	–196	–239
1 612	20	12	10	3.48	–253	–220	–194	–238
1 665	20	12	10	3.48	–253	–220	–194	–237
4 830	50	12	10	2.20	–255	–218	–183	–230
14 488	150	15	15	1.73	–256	–214	–169	–221
22 200	250	35	30	2.91	–254	–210	–162	–216
23 700	250	35	30	2.91	–254	–210	–161	–215
43 000	500	25	65	2.84	–254	–207	–153	–210
48 000	500	30	65	3.00	–254	–207	–152	–209
88 600	1 000	12	30	0.94	–259	–209	–148	–208
150 000	1 000	14	30	0.98	–259	–209	–144	–204
220 000	1 000	20	43	1.41	–257	–207	–139	–199
265 000	1 000	25	50	1.68	–256	–206	–137	–197

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