UNITED STATES DEPARTMENT OF COMMERCE
National Telecommunications and
Information Administration
Washington, D.C. 20230

JUL 12 2016

Mr. Julius Knapp
Chief
Office of Engineering and Technology
Federal Communications Commission
445 12th Street S.W.
Washington, DC 20554

Re: Use of Spectrum Bands Above 24 GHz For Mobile Radio Services (GN Docket No. 14-177, IB Docket Nos. 15-256 and 97-95, RM-11664, and WT Docket No. 10-112)

Dear Mr. Knapp:

The National Telecommunications and Information Administration (NTIA) submits the enclosed information for purposes of supplementing the record in the above-referenced proceeding. The rules and polices the Federal Communications Commission intends to adopt in this proceeding will unlock access to higher frequency bands (*i.e.*, the "spectrum frontier" bands) for fixed and mobile services by establishing a flexible regulatory framework for several bands in the millimeter wave range in order to facilitate the development and deployment of, for example, so-called "5G" services and applications.[1] The enclosed technical information: (1) summarizes current and projected federal agency operations in and adjacent to the specific bands identified in the *Spectrum Frontiers NPRM* and supports the proposed technical rules aimed at protecting them; (2) supplements technical analysis and data NTIA previously submitted to the Commission in other proceedings involving some of these bands; (3) supports a flexible and innovative sharing framework in the 37-38.6 GHz band; and (4) addresses issues related to the protection of the passive services in the 64-71 GHz band.

The *Spectrum Frontiers NPRM* sought comment on proposals to create flexible licensed services in the 27.5-28.35 GHz, 37-38.6 GHz, and 38.6-40 GHz bands. It also proposed allowing unlicensed operations under Part 15 of the Commission's rules in the 64-71 GHz band based on the current rules that govern unlicensed device access to bands below 64 GHz. Enclosure 1 provides a summary of current and projected federal uses in and adjacent to the subject bands. We briefly address below some of the proposed technical rules applicable to each band.

27.5-28.35 GHz Band. While currently there are no federal allocations in the 27.5-28.35 GHz band, the adjacent 27-27.5 GHz band includes federal primary allocations for fixed, mobile, and inter-satellite services. An out-of-band emission limit of -43 dBW/MHz expressed in terms

[1] *See* Use of Spectrum Bands Above 24 GHz For Mobile Radio Services, *Notice of Proposed Rulemaking*, 30 FCC Rcd 11878 (2015) (*Spectrum Frontiers NPRM*).

of an equivalent isotropically radiated power (EIRP) was proposed in the *Spectrum Frontiers NPRM*.[2] These adjacent bands impose a lower risk of interference from out-of-band emissions than lower microwave frequencies due to the much higher signal attenuation. NTIA urges the Commission to avoid adopting overly restrictive out-of-band emission limits that could negatively impact development of innovative equipment and services in the 28 GHz band. Several of the commenters expressed concern regarding specifying the out-of-band emission limits in terms of a radiated emission level rather than a conductive limit due to the significantly higher attenuation required for the more directive antenna systems that will be employed in the higher frequency bands.[3] Based on the record and the characteristics of the millimeter wave bands, NTIA recommends that the Commission adopt a conductive out-of-band emission limit for base and mobile stations of -43 dBW/MHz.[4]

37-38.6 GHz Band. As noted in the *Spectrum Frontiers NPRM*, the 37-38.6 GHz band is allocated on a primary basis to federal and non-federal fixed and mobile services and the federal Space Research Service (space-to-Earth) (SRS). The Commission sought comment on the protection of federal operations in the 37-38.6 GHz band and in the adjacent 36-37 GHz band, in which passive sensors in the Earth exploration satellite service (EESS) and SRS are authorized.[5] The products of passive sensor operations are used extensively in meteorology, climatology, and other disciplines for operational and scientific purposes. These sensors measure weak natural signals in a broad range of frequencies and are sensitive to emissions that fall within the EESS allocations. Thus, they may not be able to differentiate between the wanted signals and the interfering signals since they are not easily recognizable and can masquerade as valid scientific data.[6] The 36-37 GHz band is vital for the study of global water circulation, rain rates, snow, sea ice, and clouds. The National Aeronautics and Space Administration (NASA) has several ongoing and planned missions in the 36-37 GHz band as shown in Enclosure 1. In addition, footnote US342 to the U.S. Table of Frequency Allocations provides that all practicable steps must be taken to protect radio astronomy observations performed in the 36.43-36.5 GHz band.[7]

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[2] *See Spectrum Frontiers NPRM*, 30 FCC Rcd at 11959 ¶ 281 and 11988 § 30.203. The proposed out-of-band emission limit of 43 + 10 Log P in a 1 megahertz bandwidth represents an absolute level of -43 dBW/MHz (-13 dBm/MHz).

[3] *See* Ericsson Comments in GN Docket No. 14-177 et al. at 14 (filed Jan. 26, 2016) and Qualcomm Reply Comments in GN Docket No. 14-177 et al. at 8 (filed Feb. 26, 2016).

[4] An alternate out-of-band emission measurement approach based on total radiated power (TRP) was also proposed. *See* Qualcomm Reply Comments in GN Docket No. 14-177 et al. at 8 (filed Feb. 26, 2016). The TRP measurement procedure is currently not defined and would have to be developed through the FCC Laboratory's Knowledge Database process and will be reviewed by NTIA's Institute for Telecommunication Sciences.

[5] *See Spectrum Frontiers NPRM*, 30 FCC Rcd at11897-98 ¶¶ 51-53.

[6] *See, e.g.,* Recommendation ITU-R RS.1861, *Typical and Operational Characteristics of Earth Exploration-Satellite Service (Passive) Systems Using Allocations Between 1.4 and 275 GHz* at 1-2, (Jan. 2010); *see also*, The National Academies, *Handbook of Frequency Allocations and Spectrum Protection for Scientific Uses (2d Ed.)* at 89-90 (2015).

[7] Radio astronomy observatories are located at Green Bank, WV and Socorro, NM. *See* Letter from Fredrick R. Wentland, Associate Administrator, Office of Spectrum Management to Edmond Thomas, Chief, Office of Engineering and Technology, FCC (Mar. 24, 2004) (*NTIA 2004 Letter*); *see also* Letter from Fredrick R. Wentland, Associate Administrator, Office of Spectrum Management to Julius Knapp, Acting Chief, Office of Engineering and Technology, FCC (Sept. 13, 2006) (*NTIA 2006 Letter*).

To protect passive sensors in the 36-37 GHz band from interference, the 2007 World Radiocommunication Conference (WRC-07) adopted Resolution 752, which specifies mandatory sharing criteria for the EESS (passive) and fixed and mobile services in that band.[8] Thus, the Commission's rules (at footnotes 5.550A and US550A of the U.S. table) require that future fixed and mobile stations operating in the 36-37 GHz band do so in accordance with Resolution 752.[9] If the Commission adopts an out-of-band EIRP emission limit of -43 dBW/MHz for fixed and mobile stations operating in the band adjacent to the 36-37 GHz band, NTIA observes that this would be lower than the power levels specified in footnote US550A.[10] NTIA thus agrees that fixed and mobile stations complying with the proposed out-of-band emission limits would not cause interference to the passive sensors in the 36-37 GHz band. To protect radio astronomy observations in the 36.43-36.5 GHz band, NTIA agrees that the 500 megahertz frequency separation from the 37-38.6 GHz band, in conjunction with the proposed out-of-band emission limit, would be adequate.

Over the last several years, NTIA has identified a number of NASA and National Science Foundation (NSF) SRS earth station receive locations that would likely be subject to protection and coordination if the FCC authorized non-federal fixed and mobile operations in the 37-38.6 GHz band.[11] The 37-38.6 GHz band is important to support U.S. goals to provide a permanent manned presence in Earth's orbit (on or near the moon), initiate manned exploration of the planet Mars, and support data return links to the very long baseline interferometer (VLBI). The previously identified earth station receive locations included the following:

- NASA Goldstone Deep Space Communications Complex in Goldstone, CA;
- NASA Tracking Stations on Guam and in Merritt Island, FL; Wallops Island, VA, Blossom Point, MD, and White Sands, NM; and
- National Radio Astronomy Observatories in Socorro, NM, and Green Bank, WV.

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[8] *See* Resolution 752 *Use of the Frequency Band 36-37 GHz* (WRC-07).

[9] *See* Amendment of Parts 1, 2, 15, 74, 78, 87, 90, and 97 of the Commission's Rules Regarding Implementation of the Final Acts of the World Radiocommunication Conference (Geneva 2007) (WRC-07), Other Allocation Issues, and Related Rule Updates, *Report and Order, Order, and Notice of Proposed Rulemaking*, ET Docket Nos. 12-338 and 15-99, and IB Docket No. 06-123, 30 FCC Rcd 4183, 4232-33 ¶ 135 (2015).

[10] Footnote US550A states that in the band 36-37 GHz, the following provisions shall apply: (a) For stations in the mobile service, the transmitter power supplied to the antenna shall not exceed -10 dBW, except that the maximum transmitter power may be increased to -3 dBW for stations used for public safety and disaster management; (b) For stations in the fixed service, the elevation angle of the antenna main beam shall not exceed 20 degrees and the transmitter power supplied to the antenna shall not exceed: (1) -5 dBW for hub stations of point-to-multipoint systems; or (2) -10 dBW for all other stations, except that the maximum transmitter power of stations using automatic transmitter power control (ATPC) may be increased by a value corresponding to the ATPC range, up to a maximum of -7 dBW.

[11] *See NTIA 2004 Letter* at Enclosure 1 and *NTIA 2006 Letter* at 2. *See also* Letter from Karl B. Nebbia, Associate Administrator, Office of Spectrum Management, to Julius Knapp, Chief, Office of Engineering and Technology, FCC (Mar. 20, 2014) (regarding status of Tracking and Data Relay Satellite System (TDRSS) earth station at Blossom Point, MD).

After further consultations with NASA and NSF, NTIA has determined that only three of these sites would need specific protection and coordination in connection with the *Spectrum Frontiers* proceeding: Goldstone, White Sands, and Socorro.[12] To protect these three sites, NTIA recommends that the Commission require all fixed and mobile stations operating in the 37-38.6 GHz band within the geographic areas listed in Enclosure 2 be coordinated with NTIA. Operation within the coordination areas will be possible if the non-federal entity demonstrates to NTIA that its deployment will adequately protect the earth stations. NTIA, in coordination with NASA, NSF, and the Commission, may conduct additional analysis and testing to determine the extent to which the recommended coordination areas in Enclosure 2 can be reduced.

NTIA also previously identified 14 military installations where terrestrial fixed operations are likely to be deployed in the 37-38.6 GHz band.[13] After further consultation with the Department of Defense (DOD), NTIA has determined that these 14 sites, which are listed in Enclosure 3, still accurately represent locations where the military plans to operate systems consistent with the current allocation. In order to protect DOD operations, NTIA recommends that non-federal fixed and mobile stations operating in the 37-38.6 GHz band within these geographic areas be coordinated with NTIA. Operation within the coordination areas is possible if the non-federal entity can demonstrate to NTIA that its proposed deployment will adequately protect the existing and planned DOD operations.

In sum, NTIA believes that the *Spectrum Frontiers* proceeding provides an opportunity to develop a flexible and streamlined regulatory framework that will: (1) encourage innovative use of the spectrum; (2) accommodate potential future developments in technology and equipment; and (3) advance spectrum sharing between federal and non-federal systems. Historically, technology needs to mature to produce data on actual interference conditions. Establishing an overly restrictive coordination process, therefore, could have an adverse effect on the development of new services. A challenge is the inability to precisely define the extent and location of future federal operations at this time. NTIA recommends that the Commission adopt a modified version of its Alternative Proposal in the *Spectrum Frontiers NPRM*, creating a band plan with a 600 megahertz shared block in the 37-37.6 GHz band.[14] This 600 megahertz band segment would be fully available for use by federal and non-federal users on a coordinated, co-equal basis. Federal and non-federal users would access the band through a coordination mechanism, including exploration of potential dynamic sharing mechanisms in the lower 600 megahertz that can be developed through a federal and industry collaborative process. In the 37.6-38.6 GHz band segment, NTIA recommends federal co-primary use coordination zones around the 14 military installations in which the federal agencies will have the right to operate

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[12] The Green Bank site is within an existing Quiet Zone in which any fixed or mobile stations operating in the 37-38.6 GHz band are subject to the requirements set forth in Section 1.924(a) of the FCC's rules, 47 C.F.R. §1.924(a)(1).

[13] *See NTIA 2004 Letter*. The 14 military installations include: China Lake, CA; San Diego, CA; Nanakuli, HI; Fishers Island, NY; Saint Croix, VI; Fort Irwin, CA; Fort Carson, CO; Fort Hood, TX; Fort Bliss, TX; Yuma Proving Grounds, AZ; Fort Huachuca, AZ; White Sands Missile Range, NM; Moody Air Force Base, GA; and Hurlburt Air Force Base, FL.

[14] *See Spectrum Frontiers NPRM*, 30 FCC Rcd at 11911 ¶ 105.

fixed and mobile operations. The three SRS sites will be protected from interference. NTIA and the Commission would develop and establish a coordination process that can allow non-federal users to access these locations.

38.6-40 GHz Band. The 39.5-40 GHz portion of this band is allocated to military mobile-satellite service (MSS) and fixed-satellite service (FSS) earth stations. Federal MSS earth stations cannot claim protection from non-federal fixed and mobile stations, as specified in footnote US382 of the U.S. Table of Frequency Allocations. However, federal earth stations in the MSS are not required to protect non-federal fixed and mobile services. Federal FSS is allocated on a co-primary basis to non-federal fixed and mobile services in the 39.5-40 GHz band. Given the existing regulatory constraints in the 39.5-40 GHz band segment, the *Spectrum Frontiers NPRM's* proposed non-federal fixed and mobile operations will not impact federal satellite operations.

57-64 GHz Band. The Commission proposed in the *Spectrum Frontiers NPRM* to unify the current Part 15 rules for the 64-71 GHz band with those proposed for the 57-64 GHz band. This proposal raises a potential concern for remote sensing in the 57-59.3 GHz sub-band if unlicensed devices are permitted to operate on board aircraft. Specifically, section 15.255(a)(1) of the Commission's rules (47 C.F.R. § 15.255(a)(1)) prohibits operation of unlicensed devices on aircraft in the 57-64 GHz band. This band segment is vitally important to weather forecasting as virtually all weather forecast models utilize atmospheric temperature data derived from this band to initialize the models. As discussed in the comments submitted in this proceeding by the National Academy of Sciences Committee on Radio Frequencies (CORF) and other parties, technical issues exist related to the use of unlicensed devices aboard aircraft and the impact on these remote sensing operations.[15] Accordingly, NTIA recommends that the Commission develop a more comprehensive record that includes data and analysis (ideally gathered and conducted through collaboration among the affected parties) that more adequately address the important technical concerns related to interference to remote sensing operations before allowing unlicensed devices in the 57-71 GHz band to operate aboard aircraft.[16]

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[15] *See* CORF Comments in GN Docket No. 14-177 et al. at 14 (filed Jan. 21, 2016) and CORF Reply Comments at 11-12 (filed Mar. 13, 2016); *see also* Comments of the National Radio Astronomy Observatory (NRAO) at 5 (filed Jan. 21, 2016) and Reply Comments the IEEE Geoscience and Remote Sensing Society Technical Committee on Frequency Allocations in Remote Sensing at 5-7 (filed Mar. 13, 2016).

[16] NTIA also urges the FCC to extend the spurious emission limits specified in Section 15.255(c) and apply them to operations in the 64-71 GHz band. *C.f.* Comments of NRAO at 5-6 and Comments of CORF at 12-15. As discussed in Enclosure 4, the existing emission limits are adequate to protect the identified RAS sites, but further study would be necessary to assess the protection of sites in more populated areas.

NTIA looks forward to the Commission's forthcoming actions in this important rulemaking proceeding. If you have any questions about the issues addressed herein, please contact me or Edward Drocella, Chief, Spectrum Engineering and Analysis Division, Office of Spectrum Management at edrocella@ntia.doc.gov or (202) 482-2608.

Sincerely,

Paige R. Atkins
Associate Administrator
Office of Spectrum Management

Enclosures (4)

ENCLOSURE 1

This enclosure provides a summary of the federal usage in and adjacent to the frequency bands under consideration in the Spectrum Frontiers rulemaking proceeding, as shown in Table 1.

Table 1. Summary of Federal Usage

Frequency Band	Federal Agency Operations
27-27.5 GHz	▪ National Aeronautics and Space Administration (NASA) operates Tracking and Data Relay Satellite System (TDRSS) constellation data relay satellites in the 25.25-27.5 GHz band to provide return links to Earth orbiting spacecraft. ▪ NASA uses the 25.25-27.5 GHz band for proximity link communications between orbiting spacecraft. ▪ Federal agencies plan on using this band for high data rate fixed systems.
36-37 GHz	▪ NASA conducts surface (land and water) mapping throughout the United States in this band. ▪ NASA uses this band for passive remote sensing studies of terrestrial water vapor, rain, snow, ocean ice, oil spills, clouds, water and precipitation. ▪ Ongoing and planned NASA missions include: - Advanced Microwave Scanning Radiometer-Earth Observing System (AMSR-3) AQUA filed in ITU-R as EOS-PM - Advanced Microwave Scanning Radiometer-2 (AMSR-2) Global Change Observation Mission-Water 1 (GCOM-W1) - Global Precipitation Measurement (GPM) Microwave Imager (GPI) ▪ Remote sensing missions with international partners currently operate in this band. ▪ Radio astronomy service (RAS) observations are performed in the 36.43-36.5 GHz segment of the band. ▪ The Department of Defense (DOD) plans to operate high data rate fixed microwave systems on military test ranges.
37-38.6 GHz	▪ NASA plans to use this band for future manned exploration of the solar system and for wideband data return links to the very long baseline interferometer (VLBI). ▪ On national and military test ranges, systems in this band will support Research Development Test and Evaluation (RDT&E) activities as well as serve as range data links. ▪ This band is planned to be used by the military services in the RDT&E of high data rate fixed and mobile theater deployable communications systems.
38.6-40 GHz	▪ The 39.5-40 GHz portion of the band can be used for military mobile-satellite service (MSS) and fixed-satellite service (FSS) earth stations ▪ NASA identified this band as a possible space research band to accommodate future Earth-to-space wideband data requirements.
64-71 GHz	▪ Fixed and mobile high data rate systems are planned to operate in this band.

ENCLOSURE 2

Summary

This enclosure provides the coordination areas for the National Aeronautics and Space Administration (NASA) Deep Space Communications Complex, Goldstone, CA; NASA Tracking Station, White Sands, NM; and the National Science Foundation's National Radio Astronomy Observatory, Very Large Array, Socorro, NM space research service (SRS) receive earth station sites that operate or plan to operate in the 37-38.6 GHz band. Coordination areas will be established for two transmitter equivalent isotropically radiated power (EIRP) levels: -35 dBW/Hz (75 dBm/100 MHz) and -50 dBW/Hz (60 dBm/100 MHz).

Fixed Service Parameters

The parameters for the fixed service transmitter used to develop the coordination areas are provided in Table 1.

Table 1. Fixed Service Transmitter Parameters

Parameter	Value
Frequency (GHz)	37
EIRP (dBW/Hz)	-35 and -50
Antenna Height (m)	100

Federal Receive Station Parameters

The parameters for the federal SRS receive stations used to develop the coordination areas are provided in Table 2.

Table 2. SRS Receiver Parameters

Parameter	Value
Frequency (GHz)	37
Interference Protection Criteria (dBW/Hz)[1]	-217
Latitude/Longitude (decimal degrees)	35.44333/-116.89166 (Goldstone, CA) 35.33989/-116.87479 (Goldstone, CA) 35.33761/-116.87536 (Goldstone, CA) 35.33567/-116.87301 (Goldstone, CA) 32.34972/-106.6 (White Sands, NM) 34.07916/-107.61666 (Socorro, NM)
Antenna Gain (dBi)[A]	20
Antenna Height (m)	40
Note A: Antenna gain is based on 32 - 25 Log (Elevation Angle) mask. A 3 degree elevation angle was used to compute the antenna gain.	

[1] Recommendation ITU-R SA.1396, *Protection Criteria for the Space Research Service in the 37-38 GHz and 40-40.5 GHz Bands* at 2 (1999).

Required Propagation Loss Calculation

The minimum required propagation loss to preclude exceeding the SRS receive station interference protection criterion is computed using Equation 1.[2]

$$L_{Required} = EIRP_T + G_R - I_T \quad (1)$$

Where:

$L_{Required}$: Minimum required propagation loss necessary to preclude exceeding the interference protection criteria (dB);
I_T: Interference protection criteria (dBW/Hz);
$EIRP_T$: EIRP density of the transmitter (dBW/Hz); and
G_R: Antenna gain of the receive station in the direction of the transmitter (dBi).

$L_{Required}$ = -35 dBW/Hz + 20 dBi - (-217 dBW/Hz) = 202 dB

$L_{Required}$ = -50 dBW/Hz + 20 dBi - (-217 dBW/Hz) = 187 dB

Coordination Areas

The minimum required propagation loss given by Equation 1 is used to determine the minimum separation distance between the fixed station transmitter and the receive station. The minimum separation distance establishes the coordination area around the receive station. The Irregular Terrain Model (ITM) in the Point-to-Point mode is used to generate the terrain dependent coordination area. The ITM parameters are summarized in Table 3.

Table 3. ITM Parameters

Parameter	Value
Frequency (GHz)	37
Transmit Antenna Height (m)	100
Receive Antenna Height (m)	40
Polarization	Vertical
Surface Refractivity (N-units)	301
Dielectric Constant of Ground	15
Conductivity of Ground (S/M)	0.005
Radio Climate	Desert
Topographic Database	United States Geological Survey - 3 second data
Distance Increment Along Terrain Radial (m)	90

[2] Interference protection criteria is a relative or absolute interfering signal level defined at the receiver input, under specified conditions, such that the allowable performance degradation is not exceeded. *See* NTIA Report 05-432, *Interference Protection Criteria Phase 1 - Compilation from Existing Sources* (Oct. 2005).

Angular Resolution for Radial (degrees)	0.5

The atmospheric losses in Recommendation ITU-R P.676-10 are added to the predicted ITM propagation loss.[3] Figures 1 through 3 show the envelopes of the terrain based coordination areas for the Goldstone, CA; White Sands, NM; and Socorro, NM SRS receive sites. The blue envelope is the coordination area for transmitters with an EIRP of 75 dBm/100 MHz and the yellow envelope is the coordination area for transmitters with an EIRP of 60 dBm/100 MHz. Transmitters operating between the two coordination areas with an EIRP greater than 60 dBm/100 MHz or antenna height greater than 100 meters must coordinate their operations.

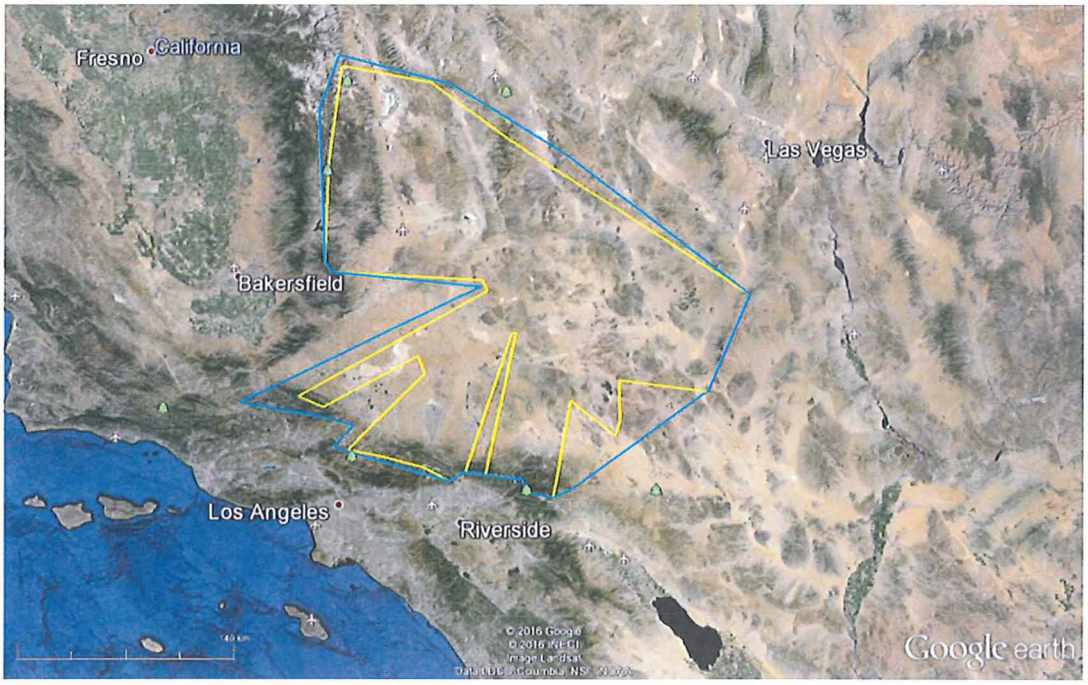

Figure 1. Goldstone, CA Coordination Area

[3] Recommendation ITU-R P.676-10, *Attenuation by Atmospheric Gases* at Annex 2 (Sept. 2013).

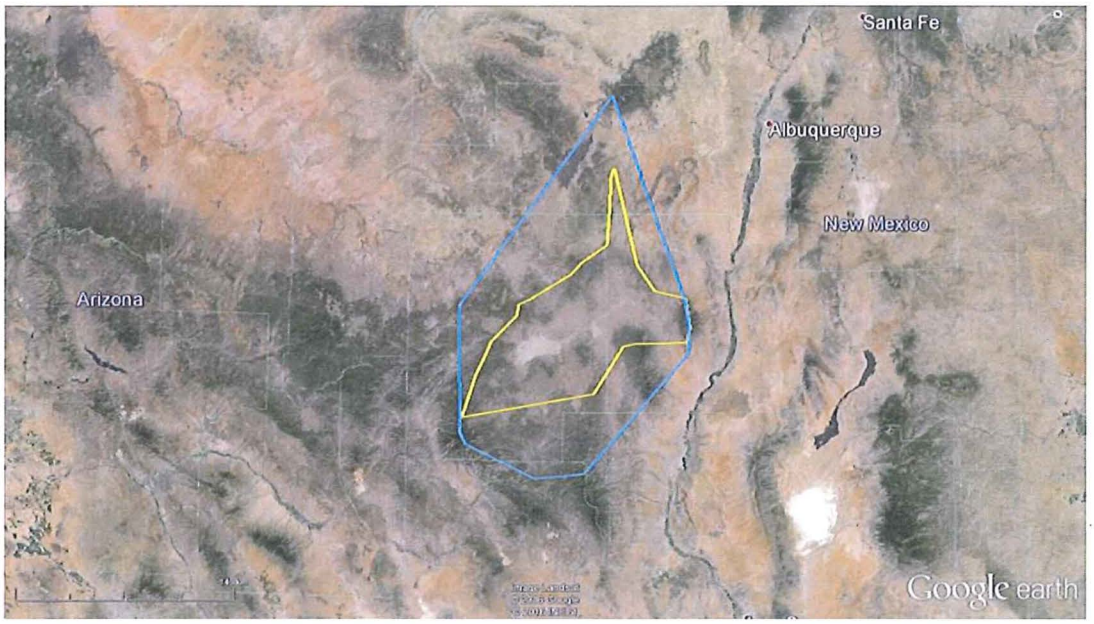

Figure 2. Socorro, NM Coordination Area

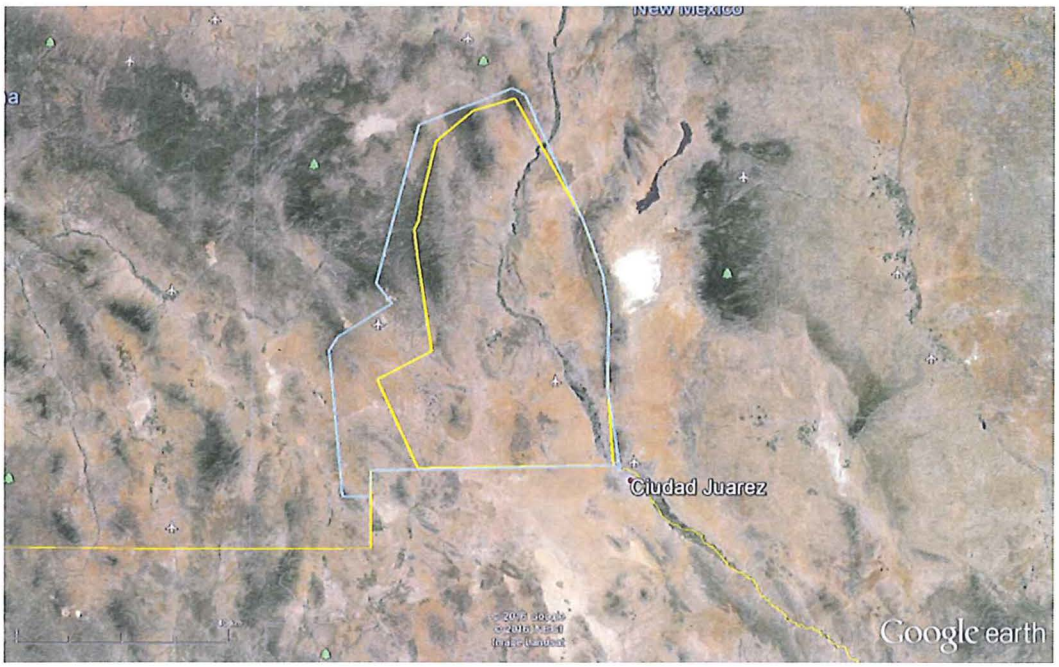

Figure 3. White Sands, NM Coordination Area

The specific coordinates for the envelope of each coordination area are provided in Tables 4 through 6.

Table 4. Coordinates for Goldstone, CA Coordination Area

60 dBm/100 MHz EIRP		75 dBm/100 MHz EIRP	
Latitude/Longitude (decimal degrees)	Latitude/Longitude (decimal degrees)	Latitude/Longitude (decimal degrees)	Latitude/Longitude (decimal degrees)
34.69217/-115.6491	34.19524/-117.47963	34.69217/-115.6491	34.19524/-117.47963
35.25746/-115.32041	34.24586/-117.36210	35.25746/-115.32041	34.24586/-117.36210
36.21257/-117.06567	35.04648/-117.03781	36.11221/-116.63632	34.21748/-117.12812
36.55967/-117.63691	35.04788/-117.00949	36.54731/-117.48242	34.20370/-116.97024
36.66297/-118.31017	34.22940/-117.22327	36.73049/-118.33683	34.12196/-116.93109
36.06074/-118.38528	34.20370/-116.97024	36.39126/-118.47307	34.09498/-116.75473
35.47015/-118.39008	34.12196/-116.93109	36.36891/-118.47134	34.13603/-116.64002
35.40865/-118.34353	34.09498/-116.75473	35.47015/-118.39008	34.69217/-115.6591
35.35986/-117.24709	34.19642/-116.72901	35.40865/-118.34353	34.69217/-115.6491
35.29539/-117.21102	34.64906/-116.62741	35.32048/-117.26386	
34.67607/-118.55412	34.44404/-116.31486	34.63725/-118.96736	
34.61532/-118.36919	34.52736/-116.27845	34.55789/-118.36204	
34.91551/-117.70371	34.76685/-116.27930	34.51108/-118.15329	
34.81257/-117.65400	34.69217/-115.6591	34.39220/-118.28852	
34.37411/-118.18385	34.69217/-115.6491	34.38546/-118.27460	
34.33405/-117.94189		34.37524/-118.24191	
34.27249/-117.65445		34.37039/-118.22557	

Table 5. Coordinates for Socorro, NM Coordination Area

60 dBm/100 MHz EIRP		75 dBm/100 MHz EIRP
Latitude/Longitude (decimal degrees)	Latitude/Longitude (decimal degrees)	Latitude/Longitude (decimal degrees)
34.83816/-107.66828	33.44401/-108.67876	33.10651/-108.19320
34.80070/-107.68759	33.57963/-107.79895	33.11780/-107.99980
34.56506/-107.70233	33.84552/-107.60207	33.13558/-107.85611
34.40826/-107.71489	33.85964/-107.51915	33.80383/-107.16520
34.31013/-107.88349	33.86479/-107.17223	33.94554/-107.15516
34.24067/-107.96059	33.94779/-107.15038	33.95665/-107.15480
34.10278/-108.23166	34.11122/-107.18132	34.08156/-107.18137
34.07442/-108.30646	34.15203/-107.39035	34.10646/-107.18938
34.01447/-108.31694	34.29643/-107.51071	35.24269/-107.67969
33.86740/-108.48706	34.83816/-107.66828	34.06647/-108.70438
33.81660/-108.51052		33.35946/-108.68902
33.67909/-108.58750		33.29430/-108.65004
33.50223/-108.65470		33.10651/-108.19320

Table 6. Coordinates for White Sands, NM Coordination Area

60 dBm/100 MHz EIRP		75 dBm/100 MHz EIRP	
Latitude/Longitude (decimal degrees)	**Latitude/Longitude (decimal degrees)**	**Latitude/Longitude (decimal degrees)**	**Latitude/Longitude (decimal degrees)**
33.98689/-107.15967	31.78455/-106.54058	31.7494/-106.49132	32.88382/-108.16588
33.91573/-107.46301	32.24710/-106.56114	32.24524/-106.56507	32.76255/-108.05679
33.73122/-107.73585	32.67731/-106.53681	32.67731/-106.53681	32.56863/-108.43999
33.37098/-107.84333	32.89856/-106.56882	32.89856/-106.56882	32.48991/-108.50032
33.25424/-107.86409	33.24323/-106.70094	33.04880/-106.62309	32.39142/-108.48959
33.19808/-107.89673	33.98689/-107.15967	33.21824/-106.68992	31.63664/-108.40480
33.02128/-107.87226		33.24347/-106.70165	31.63466/-108.20921
32.47747/-107.77963		34.00708/-107.08652	31.78374/-108.20798
32.31543/-108.16101		34.04967/-107.17524	31.78322/-106.52825
31.79429/-107.88616		33.83491/-107.85971	31.7494/-106.49132

ENCLOSURE 3

This enclosure provides the coordination areas for the current and future fixed terrestrial systems in the 37-38.6 GHz band, as shown in Table 1.

Table 1. Coordination Areas for Federal Terrestrial Systems

Location	Agency	Coordination Area (Decimal Degrees)
China Lake, CA	Navy	30 kilometer radius centered on latitude 35.59527 and longitude -117.22583 30 kilometer radius centered on latitude 35.52222 and longitude -117.30333 30 kilometer radius centered on latitude 35.76222 and longitude -117.60055 30 kilometer radius centered on latitude 35.69111 and longitude -117.66916
San Diego, CA	Navy	30 kilometer radius centered on latitude 32.68333 and longitude -117.23333
Nanakuli, HI	Navy	30 kilometer radius centered on latitude 21.38333 and longitude -158.13333
Fishers Island, NY	Navy	30 kilometer radius centered on latitude 41.25 and longitude -72.01666
Saint Croix, VI	Navy	30 kilometer radius centered on latitude 17.74722 and longitude -64.88
Fort Irwin, CA	Army	30 kilometer radius centered on latitude 35.26666 and longitude -116.68333
Fort Carson, CO	Army	30 kilometer radius centered on latitude 38.71666 and longitude -104.65
Fort Hood, TX	Army	30 kilometer radius centered on latitude 31.11666 and longitude -97.76666
Fort Bliss, TX	Army	30 kilometer radius centered on latitude 31.8075 and longitude -106.42166
Yuma Proving Ground, AZ	Army	30 kilometer radius centered on latitude 32.48333 and longitude -114.33333
Fort Huachuca, AZ	Army	30 kilometer radius centered on latitude 31.55 and longitude -110.35
White Sands Missile Range, NM	Army	30 kilometer radius centered on latitude 33.35 and longitude -106.3
Moody Air Force Base, GA	Air Force	30 kilometer radius centered on latitude 30.96694 and longitude -83.185
Hurlburt Air Force Base, FL	Air Force	30 kilometer radius centered on latitude 30.42388 and longitude -86.70694

ENCLOSURE 4

Summary

This enclosure provides an assessment of the potential for second and third harmonic interference from unlicensed devices operating in the 64-71 GHz band to radio astronomy service (RAS) sites performing observations in the 128-142 GHz and 192-213 GHz bands.

Unlicensed Device Parameters

The parameters for the unlicensed device transmitter used in the assessment are provided in Table 1.

Table 1.

Parameter	Value
Center Frequency (GHz)	135 and 203
EIRP (dBW/MHz)	-40 (Section 15.255 Limit)

RAS Receive Site Parameters

The parameters for the RAS receive site used in the assessment are provided in Table 2.

Table 2.

Parameter	Value
Center Frequency (GHz)	135 and 203
Protection Criteria (dBW/MHz)	-209
RAS Sites	Kitt Peak, AZ Mount Graham, AZ Mauna Kea, HI
Antenna Gain (dBi)	0

Received Power Calculations

The received power at the RAS receiver input will be calculated to establish the separation distance ($D_{Separation}$) at which the interference protection criteria is exceeded. The received power is calculated using Equation 1.

$$P_{Received} = EIRP_T + G_R - L_P - L_A \quad (1)$$

Where:

$P_{Received}$: Received power level at the input to the RAS receiver (dBW);
$EIRP_T$: EIRP density of the unlicensed device transmitter (dBW/MHz);
G_R: Antenna gain of the RAS receive antenna in the direction of the unlicensed device transmitter (dBi);
L_P: The freespace propagation loss (dB); and

L_A: The additional atmospheric gases loss computed using Annex 2 of ITU-R P.676-10 (dB).[1]

The calculated received power levels for 135 GHz are shown in Table 3 and for 203 GHz in Table 4.

Table 3. 135 GHz Received Power Level Calculations

$EIRP_T$ (dBW/MHz)	G_R (dBi)	$D_{Separation}$ (km)	L_P (dB)	L_A (dB)	$P_{Received}$ (dBW)	Amount Interference Protection Criteria is Exceeded (dB)[a]
-40	0	1	135	1	-176	33
-40	0	2	141	1.9	-182.9	26.1
-40	0	3	144	2.8	-186.8	22.2
-40	0	4	147	3.8	-190.8	18.2
-40	0	5	148.9	4.7	-193.6	15.4
-40	0	6	150.6	5.7	-196.3	12.7
-40	0	7	151.9	6.6	-198.5	10.5
-40	0	8	153.1	7.5	-200.6	8.4
-40	0	9	154	8.5	-202.5	6.5
-40	0	10	155	9.4	-204.4	4.6
-40	0	11	155.8	10.4	-206.2	2.8
-40	0	12	156.6	11.3	-207.9	1.1
-40	0	13	157.3	12.3	-209.6	-0.6
Note a: Negative value indicates received power does not exceed interference protection criteria.						

Table 4. 203 GHz Received Power Level Calculations

$EIRP_T$ (dBW/MHz)	G_R (dBi)	$D_{Separation}$ (km)	L_P (dB)	L_A (dB)	$P_{Received}$ (dBW)	Amount Interference Protection Criteria is Exceeded (dB)[a]
-40	0	1	138.6	3	-181.6	27.4
-40	0	2	144.6	5.9	-190.5	18.5
-40	0	3	148.1	8.9	-197	12
-40	0	4	150.6	11.9	-202.5	6.5
-40	0	5	152.6	14.8	-207.4	1.6
-40	0	6	154.2	17.8	-212	-3
Note a: Negative value indicates received power does not exceed interference protection criteria.						

Terrain Dependent Required Loss Contours

The calculations shown in Table 3 and 4 do not take into account the effects of terrain shielding. The minimum required propagation loss to preclude exceeding the RAS receive station interference protection criteria is computed using Equation 1.[2]

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[1] Recommendation ITU-R P.676-10, *Attenuation by Atmospheric Gases* (Sept. 2013).

$$L_{Required} = EIRP_T + G_R - I_T \quad (1)$$

Where:

$L_{Required}$: Minimum required propagation loss necessary to preclude exceeding the interference protection criteria (dB);
I_T: Interference protection criteria (dBW/Hz);
$EIRP_T$: EIRP density of the transmitter (dBW/Hz); and
G_R: Antenna gain of the RAS receive station in the direction of the transmitter (dBi).

$L_{Required}$ = -40 dBW/Hz + 0 dBi - (-209 dBW/MHz) = 169 dB

Using the Irregular Terrain Model in the Point-to-Point mode with the parameters shown in Table 5 terrain dependent required loss contours were generated around the three RAS sites shown in Figures 1 through 3.

Table 5.

Parameter	Value
Center Frequency (GHz)	135 and 203
Required Loss Contour Center Point Latitude/Longitude (decimal degrees)	31.9564/-111.6125 (Kitt Peak, AZ) 32.7017/-109.9547 (Mount Graham, AZ)) 19.8258/-155.4797 (Mauna Kea, HI)
Transmit Antenna Height (m)	3
Receive Antenna Height (m)	30
Reliability and Confidence (percent)	50
Surface Refractivity (N-units)	301
Dielectric	15
Conductivity	0.005
Topographic Database	United States Geological Survey 3 second data
Distance Increment Along Terrain Radial (m)	90
Angular Resolution for Radial (degrees)	0.5

[2] Interference protection criteria is a relative or absolute interfering signal level defined at the receiver input, under specified conditions, such that the allowable performance degradation is not exceeded. National Telecommunications and Information Administration, NTIA Report 05-432, *Interference Protection Criteria Phase 1 - Compilation from Existing Sources* (Oct. 2005).

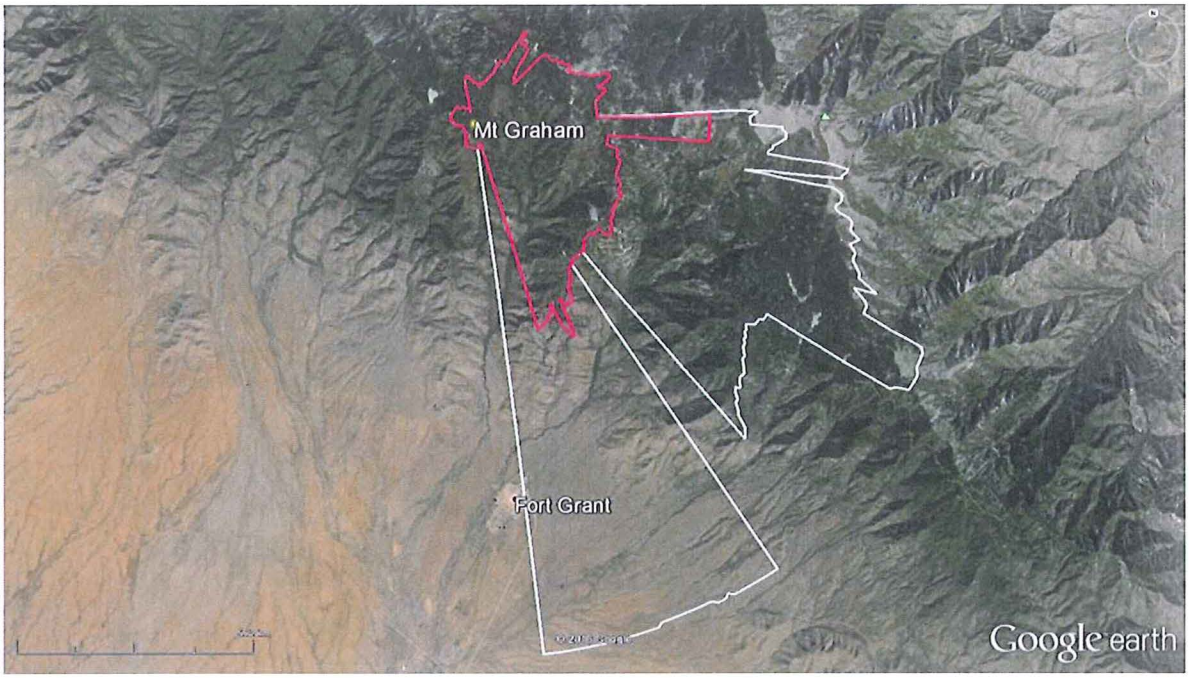

Figure 1. Mount Graham, AZ (White Contour - 135 GHz, Red Contour - 203 GHz)

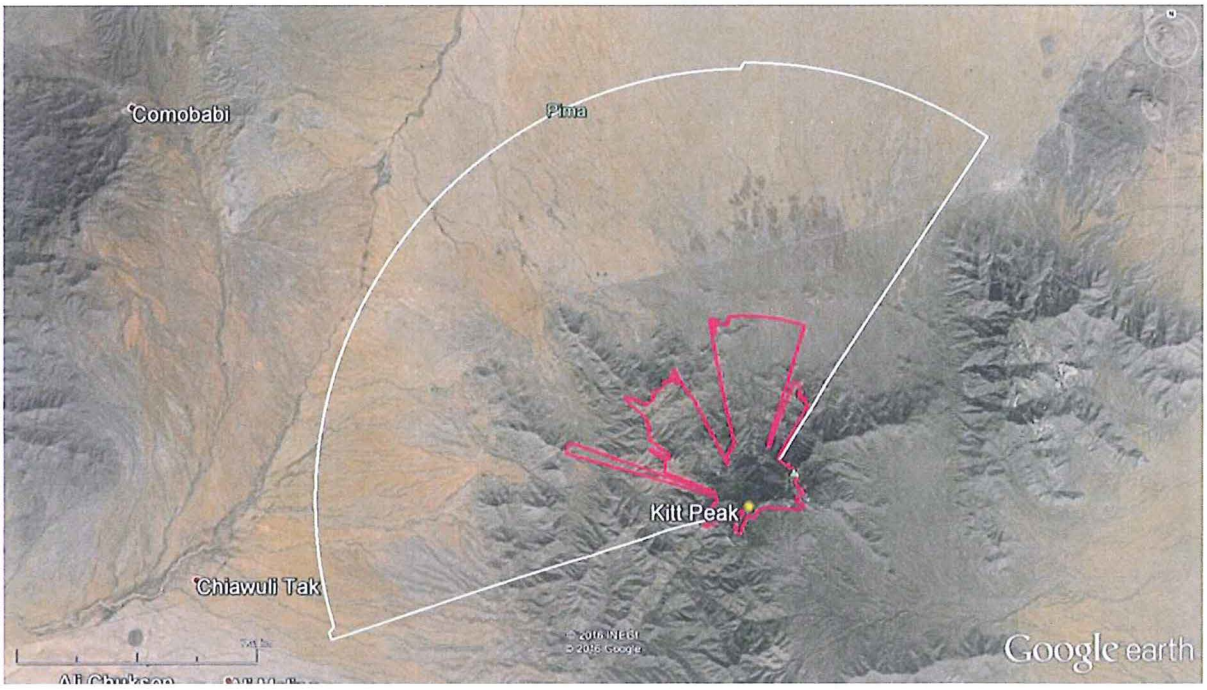

Figure 2. Kitt Peak, AZ (White Contour - 135 GHz, Red Contour - 203 GHz)

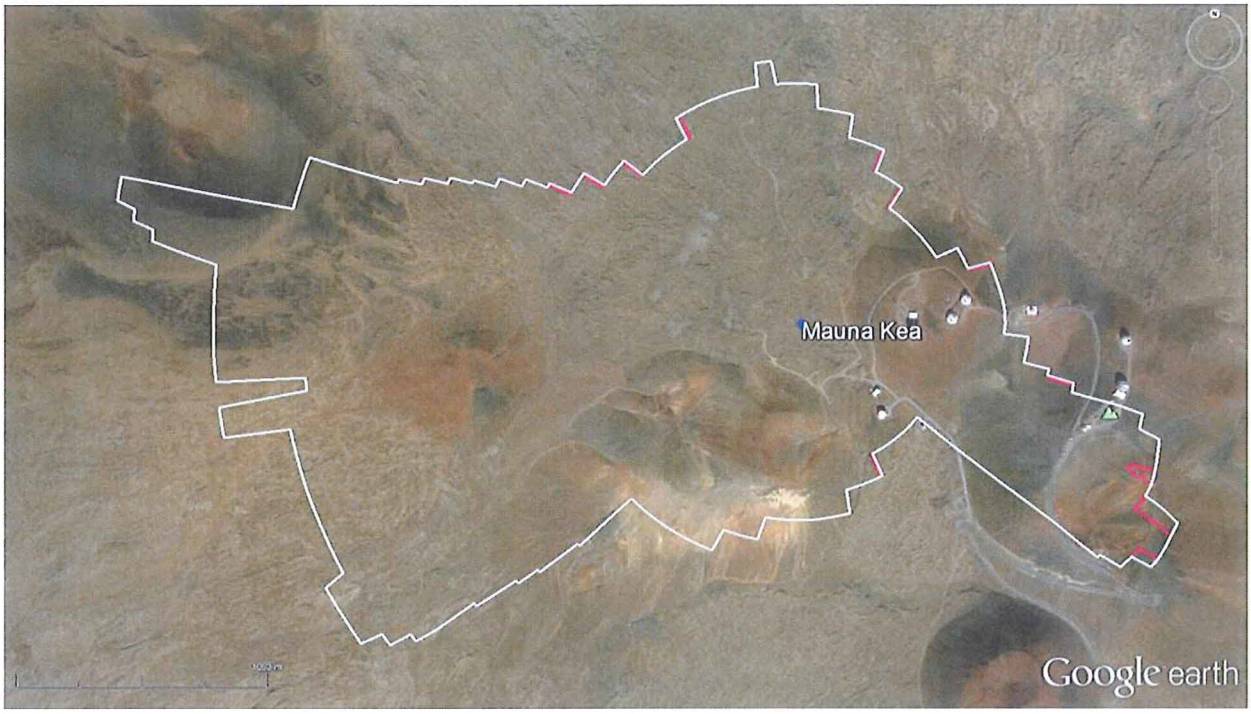

Figure 3. Mauna Kea, HI (White Contour - 135 GHz, Red Contour - 203 GHz)

The areas around the three RAS sites where there is a potential for the interference protection criteria to be exceeded are not populated.[3] Given the location of the three RAS sites the potential for interference from unlicensed devices with emission levels that comply with the FCC Section 15.255 limit is highly unlikely. For sites in more populated areas, further study would be necessary to determine whether the Section 15.255 emission limits for second and third harmonics are adequate to protect RAS observations in the 128-142 GHz and 192-213 GHz bands.

[3] The 2010 U.S. Census database shows no population around the Kitt Peak, AZ, Mount Graham, AZ, and Mauna Kea, HI sites.