Date: September 22, 2016

Subject: Public and Redacted Version of Request for Confidential Treatment and Complementary Exhibits

FCC File No: 1396-EX-ST-2016

To Whom It May Concern:

Google Inc. (Google), pursuant to 5 U.S.C. § 552 and Sections 0.457 and 0.459 of the Commission's Rules, 47 C.F.R. §§ 0.457, 0.459, hereby requests that certain information complementary to its above-referenced extension of Special Temporary Authority (STA Extension) be treated as confidential and not subject to public inspection. The designated information constitutes confidential and proprietary information that, if subject to public disclosure, would cause significant commercial, economic, and competitive harm. As described below, Google's request satisfies the standards for grant of such requests set forth in Sections 0.457 and 0.459 of the Commission's Rules.

In accordance with Section 0.459(b) and in support of this request, Google provides the following information:

1. Identification of the Information for Which Confidential Treatment is Sought:

Google's request for confidential treatment is limited to the following information that has been redacted from the STA Extension and complementary exhibits. Google does not seek to withhold from public inspection information in the STA Extension necessary for interference mitigation, including applicant name, contact information, test location, frequency, output power, effective radiated power, emission characteristics and modulation.

Exhibit A - Narrative Statement:

Google requests confidential treatment of the following underlined text from Exhibit A that contains confidential and proprietary information regarding the proposed tests/experiments:

> Consistent with the standards set forth in Section 5.61 of the Federal Communications Commission's (FCC's or Commission's) Rules, 47 C.F.R. § 5.61, Google Inc. (Google) outlines below its need for the requested extension of Special Temporary Authority (STA Extension) and the compelling reasons why 1396-EX-ST-2016 should be granted expeditiously.
>
> Google requests that the STA Extension be granted for a period of 180 days. The STA Extension is needed for continued development of [REDACTED]. Among other parameters, Google will continue to evaluate [REDACTED] on these links.

Consistent with 0234-EX-STA-2016 (Call Sign WJ9XPL), the equipment used will continue to include [REDACTED] radios at any given time, including [REDACTED] operating in the frequencies between 27.9 and 28.0 GHz and [REDACTED] operating in the frequencies between 31.0 and 31.3 GHz. The 27 GHz radio will continue to be used with one of three antennas with a gain not to exceed 18.8 dBi. The 31 GHz radio will continue to be used with one of three antennas with a gain not to exceed 19.6 dBi. For both types of radios, maximum EIRP will not exceed 27 dBW, regardless of the antenna used. While most of Google's testing will continue to use wideband transmissions, Google also seeks authorization to continue to conduct limited narrowband testing. Narrowband testing is expected to take place over no more than 12 hours in total during the pendency of the STA Extension.

Grant of this STA Extension will not adversely impact any authorized user of RF spectrum for the reasons stated below.

***27.9-28.0 GHz band users (the 27 GHz band)*:** Google's continued operations will not cause harmful interference to other users of the 27 GHz band.

- *Terrestrial licensees*: On Google's behalf, Comsearch identified 27 GHz band licensees in the common carrier fixed point-to-point microwave service, local television transmission service (LTTS), and local multipoint distribution service (LMDS) in the vicinity of the test area under Google's initial STA request.[1] Notification letters were sent to each of those licensees, informing them of the technical parameters of the proposed experimentation.[2] No licensee objected[3] and no interference has been reported.

- *Satellite operations*: Google's continued testing will not interfere with satellite receivers operating in the 27 GHz band. Google has conducted analyses evaluating the potential for interference to geostationary (GSO) satellites, medium-earth orbit (MEO) satellites, and low-earth orbit (LEO) satellites. Each of these analyses is described below.

  GSO satellites: To assess potential interference to GSO satellites, Google calculated interference levels from the sidelobes of its [REDACTED] antennas into the satellite receiver. The 27 GHz band is allocated for earth-to-space transmissions, so interference with ground station receivers is not a concern.[4] Moreover, the 27 GHz transmitter will continue to point roughly horizontally, so the main beam will never point toward the satellite receiver. In performing its analysis, Google relied on the technical parameters for GSO satellites set forth in ITU-R

[1] *See* Exhibit C (Frequency Coordination Report) to File No. 0234-EX-STA-2016 (Call Sign WJ9XPL).
[2] *Id.* at 2.
[3] *Id.*
[4] *See* 47 C.F.R. § 2.106.

Recommendation SF 1601-2.[5] This recommendation suggests a GSO satellite has a maximum receive antenna gain of 55 dBi and a system noise temperature of 500K.[6] To assess worst-case conditions, Google assumed that Google's ground transmitter was located directly in the spot beam of the satellite's receiver. Google made additional worst-case assumptions regarding its own antenna by assuming its antenna has +10 dBi gain in the direction of the GSO satellite receiver.[7] Assuming free space propagation between Google's transmitter and the satellite's receiver, Google's analysis showed that any signal received by the satellite from Google's transmitter would be at least 19.2 dB below the satellite receiver's thermal noise floor. This equates to at most 0.052 dB in degradation, which should have no impact on a data link. ITU Recommendation S.1323-2 recommends that internetwork interference caused by the earth and space station emissions of any one other GSO FSS network operating in the same frequency band or bands be limited to 6% of the total system noise power under clear-sky conditions.[8] Link degradation of 0.052 dB corresponds to 1.2% of total system noise power.

In reality, the received signal at the GSO satellite is likely is to be even weaker than the worst-case analysis suggests, because any satellite antenna pointed at an associated satellite earth station necessarily will be pointing substantially away from Google's transmitter location. A search of the FCC's IBFS database shows that there are no GSO earth stations registered in California. Therefore, the closest earth station to Google's continued operation can be no closer than the Nevada border, roughly 257 kilometers away from Google's test location. As a result, any satellite receiver operating in this band will be pointed at a terrestrial location *at least* 257 kilometers away from Google's test location, ensuring that its receiver will be a minimum 0.41 degrees off-boresight from the Google transmitter.

MEO and LEO satellites: Google's continued testing will not interfere with MEO or LEO satellites. A search of the FCC's IBFS database shows that there are no MEO or LEO earth stations registered in California. Therefore, the closest earth station to Google's continued operation can be no closer than the Nevada border, roughly 257

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[5] ITU-R Recommendation SF 1601-2, *Methodologies for Interference Evaluation from the Downlink of the Fixed Service Using High Altitude Platform Stations to the Uplink of the Fixed-satellite Service Using the Geostationary Satellites Within the Band 27.5-28.35 GHz* (2007), *available at* http://www.itu.int/rec/R-REC-SF.1601-2-200702-I (ITU-R Recommendation SF 1601-2).

[6] *Id.* at 8.

[7] [REDACTED].

[8] ITU-R Recommendation S.1323-2, *Maximum Permissible Levels of Interference in a Satellite Network (GSO/FSS; Non-GSO/FSS; Non-GSO/MSS Feeder Links) in the Fixed-satellite Service Caused by Other Codirectional FSS Networks Below 30 GHz* (2002), *available at* https://www.itu.int/rec/R-REC-S.1323/en (ITU-R Recommendation S.1323-2).

kilometers away from Google's test location. If a MEO satellite operates at roughly 8,000 kilometers above the earth's surface[9] and points at an earth station at least 257 kilometers from the edge of Google's testing area, the MEO satellite's receive antenna will be off axis from Google's transmitter by at least 1.8 degrees. Relying on the antenna patterns recommended in ITU-R Recommendation F.699-7,[10] the satellite receive antenna gain in the direction of Google's continued operation is at most 30 dBi for MEO satellites. Using a worst case antenna gain of +10 dBi in the direction of the satellite, and a satellite receiver noise temperature of 500K,[11] the signal received by a MEO satellite from Google's transmitter will be at least 28 dB below the noise floor. As noted above, ITU Recommendation S.1323-2 recommends that internetwork interference caused by the earth and space station emissions of any one other GSO FSS network operating in the same frequency band or bands be limited to 6% of the total system noise power under clear-sky conditions.[12] Transmissions at 28.3 dB below the noise floor correspond to 0.16% of total system noise power and will not cause harmful interference to MEO satellites.

To assess potential interference to LEO satellites, Google assumed that such satellites would operate at orbital heights between 500 and 2,000 kilometers above mean sea level and conducted the same analysis described above.[13] Google's results are summarized in the table below:

[9] O3b Networks operates a MEO satellite in this band, and that satellite operates at an orbital height of 8062 kilometers.

[10] ITU-R Recommendation F.699, *Reference Radiation Patterns for Fixed Wireless System Antennas for Use in Coordination Studies and Interference Assessment in the Frequency Range From 100 MHz to About 70 GHz* (2006), *available at* https://www.itu.int/rec/R-REC-F.699/en.

[11] ITU-R Recommendation SF 1601-2.

[12] ITU-R Recommendation S.1323-2. The ITU has not issued similar recommendations for MEO and LEO satellites, so Google has assumed that the system noise temperature and antenna gain characteristics for LEOs and MEOs are similar to those provided in the ITU-R Recommendation S.1323-2.

[13] Mark A. Sturza, LEOs: The Communications Satellites of the 21st Century 1, IEEE Technical Applications Conference Northcon/96 Conference Record (1996), *available at* http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=564754&tag=1.

Satellite height	**500 km**	**1000 km**	**2000 km**
Minimum angle off-boresight from Google operations	27 degrees	14 degrees	7 degrees
Maximum receive antenna gain in direction of Google operations	10 dBi	15.3 dBi	21.4 dBi
Maximum power of Google signal received by satellite	27.7 dBm below noise floor	28.2 dBm below noise floor	27.7 dBm below noise floor

Based on this analysis, the signal received by a LEO satellite from Google's continued operation will be at least 27 dB below the receiver noise floor. This interference level, too, is undetectable on a data link. As noted above, ITU Recommendation S.1323-2 recommends that internetwork interference caused by the earth and space station emissions of any one other GSO FSS network operating in the same frequency band or bands be limited to 6% of the total system noise power under clear-sky conditions.[14] Transmissions at 27 dB below the noise floor correspond to 0.2% of total system noise power and will not cause harmful interference to LEO and MEO satellites.

- *Unlicensed operations -- level probing radars*: Google's continued testing will not interfere with unlicensed users of the 24.05-29.00 GHz band. Level probing radars use this band to measure the level, or relative height, of various substances in man-made or natural containers. For example, they may be used to measure levels water basin levels, coal piles, or grain levels in a silo.[15] The transmit antennas of these radars are oriented downward.[16] Google's continued operation will transmit roughly horizontally, and will continue to be limited to locations [REDACTED] in Mountain View, California. [REDACTED], further shielding any potentially affected receivers from interference. Moreover, many level probing radars are used in confined spaces where Google's signal will be further attenuated by additional obstructions.

- *Unlicensed operations -- automotive radars*: Unlicensed vehicular radar is also permitted in the 27.9-28.0 GHz band.[17] A search of the FCC's

[14] ITU-R Recommendation S.1323-2.
[15] *In the Matter of Amendment of Part 15 of the Commission's Rules To Establish Regulations for Tank Level Probing Radars in the Frequency Band 77-81 GHz, et al.*, Report and Order and Order, 29 FCC Rcd. 761 ¶ 1 (2014).
[16] 47 C.F.R. §15.256(b).
[17] See 47 C.F.R. §§ 15.252, 15.515.

equipment authorization database reveals one vehicular radar certified for operation between 22 and 29 GHz,[18] but the test results submitted in support of that equipment authorization demonstrate that the radar's highest operating frequency is 25.050 GHz.[19] Because Google's continued testing will take place at frequencies that are 2.85 GHz above those used by the radar, there is no risk of harmful interference to the radar's operation.

***31.0-31.3 GHz band users (31 GHz band)*:**

- *Terrestrial licensees*: On Google's behalf, Comsearch also identified the common carrier fixed point-to-point microwave service, LTTS, and LMDS licensees operating in the 31 GHZ band in the vicinity of the test area under Google's initial STA request.[20] Notification letters were sent to each of the licensees, informing them of the technical parameters of the proposed experimentation.[21] No licensee objected[22] and no interference has been reported.

  Comsearch also identified site-based licenses in the microwave public safety and industrial/business pool services.[23] It then performed an analysis to assess the interference into all potentially affected site-based 31 GHz stations in the microwave public safety and industrial/business pool services.[24] This analysis shows that there is no risk of harmful interference to incumbent fixed operations.[25]

- *Federal operations*: The Table of Frequency Allocations reflects a federal allocation for standard frequency and time signal-satellite (space-to-earth) operations. Google is not aware of any federal standard frequency and time signal-satellites using the 31 GHz band, but is prepared to coordinate with such satellite operations as necessary.

***International users*:** Because the test area is more than 700 kilometers away from U.S. borders, no international coordination is required.

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[18] *See* FCC ID L2C0030TR.
[19] See University of Michigan Radiation Laboratory, *Test Report: Delphi UWB 24 GHz Automotive Radar Model(s): 12237659* (2005), at 7. This report can be accessed via the list of exhibits supporting Delphi Electronics & Safety's application for equipment authorization for FCC ID L2C0030TR.
[20] *See* Exhibit C (Frequency Coordination Report) to File No. 0234-EX-STA-2016 (Call Sign WJ9XPL) at 2.
[21] *Id.*
[22] *Id.*
[23] *Id.* at 5.
[24] *Id.*
[25] *Id*. at 5-7.

Finally, as noted, Google has already been conducting similar tests in this area under a grant of Special Temporary Authority, and no disruptions have been noted.

Exhibit B - Technical Information:

Google requests confidential treatment of the following underlined text from Exhibit B that contains confidential and proprietary information regarding the proposed tests/experiments:

Applicant Name: Google Inc.
Applicant FRN: 0016069502

Legal Contact Details

Name of Contact	Stephanie Selmer
Contact Details	Associate Corporate Counsel 25 Massachusetts Avenue NW, Ninth Floor Washington DC 20001 Email: selmer@google.com

Technical Contact Details

Name of Contact	Chris White
Contact Details	1600 Amphitheatre Parkway Mountain View, CA 94043 Phone: (650) 214-0860 Email: cjwhite@google.com

Ka-Band Transmitter Equipment and Station Details

Transmitter Equipment (27 GHz band)

Equipment	[REDACTED]
Number of Terminals	[REDACTED]
Station Class	Mobile
Location	The operating area is a polygon with vertices at the following GPS coordinates: (1) 37° 25' 15.9" N 122° 5' 33.0" W (2) 37° 24' 43.3" N 122° 4' 41.4"W (3) 37° 24' 5.2" N 122° 2' 14.0" W (4) 37° 25' 37.2" N 122° 2' 16.2" W (5) 37° 26' 8.9" N 122° 5' 5.2" W

Frequency Range	**Low (GHz)**	**High (GHz)**
[REDACTED]	27.900	28.000

Radio	**Modulation**	**Emission Designator**	**Modulation Bandwidth**	**Maximum Power Out**	**Maximum EIRP/ERP**
[REDACTED]	QAM	100MD1D	100 MHz	5 W	26 dBW/ 231 W
[REDACTED]	BPSK	15M0G1D	15 MHz	5 W	26 dBW/ 231 W
[REDACTED]	Continuous Waveform	100HK0N	100 Hz	5 W	26 dBW/ 231 W

Antenna Information (27 GHz band)[26]

Antenna #1	[REDACTED]
Type	[REDACTED]
Quantity	[REDACTED]
Gain	18.8 dBi
Beam Width at Half-Power Point	20 degrees
Orientation in Horizontal Plane	0 degrees to 360 degrees
Orientation in Vertical Plane	-30 degrees to +20 degrees from horizontal
Antenna Height (AGL)	1 m to 20 m

Antenna #2	[REDACTED]
Type	[REDACTED]
Quantity	[REDACTED]
Gain	14.3 dBi
Beam Width at Half-Power Point	34 degrees
Orientation in Horizontal Plane	0 degrees to 360 degrees
Orientation in Vertical Plane	-30 degrees to +20 degrees
Antenna Height (AGL)	1 m to 20 m

Antenna #3	[REDACTED]
Type	[REDACTED]
Quantity	[REDACTED]
Gain	10 dBi
Beam Width at Half-Power Point	50 degrees
Orientation in Horizontal Plane	0 degrees to 360 degrees
Orientation in Vertical Plane	-30 degrees to +20 degrees
Antenna Height (AGL)	1 m to 20 m

[26] While Google will continue to test three different antennas during the course of experimentation, only one antenna will be used with any given transmitter at a particular time.

Transmitter Equipment (31 GHz band)

Equipment	[REDACTED]
Number of Terminals	[REDACTED]
Station Class	Mobile
Location	The operating area is a polygon with vertices at the following GPS coordinates: (1) 37° 25' 15.9" N 122° 5' 33.0" W (2) 37° 24' 43.3" N 122° 4' 41.4" W (3) 37° 24' 5.2" N 122° 2' 14.0" W (4) 37° 25' 37.2" N 122° 2' 16.2" W (5) 37° 26' 8.9" N 122° 5' 5.2" W

Frequency Range	**Low (GHz)**	**High (GHz)**
[REDACTED]	31.000	31.300

Radio	**Modulation**	**Emission Designator**	**Modulation Bandwidth**	**Maximum Power Out**	**Maximum EIRP/ERP**
[REDACTED]	QAM	300MD1D	300 MHz	5 W	27 dBW/ 278 W
[REDACTED]	BPSK	15M0G1D	15 MHz	5 W	27 dBW/ 278 W
[REDACTED]	Continuous Waveform	100HK0N	100 Hz	5 W	27 dBW/ 278 W

Antenna Information (31 GHz band)[27]

Antenna #1	[REDACTED]
Type	[REDACTED]
Quantity	[REDACTED]
Gain	19.6 dBi
Beam Width at Half-Power Point	19.5 degrees
Orientation in Horizontal Plane	0 degrees to 360 degrees
Orientation in Vertical Plane	-30 degrees to +20 degrees
Antenna Height (AGL)	1 m to 20 m

Antenna #2	[REDACTED]
Type	[REDACTED]
Quantity	[REDACTED]
Gain	15.8 dBi
Beam Width at Half-Power Point	31 degrees
Orientation in Horizontal Plane	0 degrees to 360 degrees
Orientation in Vertical Plane	-30 degrees to +20 degrees
Antenna Height (AGL)	1 m to 20 m

Antenna #3	[REDACTED]
Type	[REDACTED]
Quantity	[REDACTED]
Gain	10 dBi
Beam Width at Half-Power Point	50 degrees
Orientation in Horizontal Plane	0 degrees to 360 degrees
Orientation in Vertical Plane	-30 degrees to +20 degrees
Antenna Height (AGL)	1 m to 20 m

[27] While Google will continue to test three different antennas during the course of experimentation, only one antenna will be used with any given transmitter at a particular time.

2. Identification of the Commission proceeding in which the information was submitted or a description of the circumstances giving rise to the submission.

The above-referenced Exhibits were submitted to the Commission in support of the STA Extension. These Exhibits were filed with the Office of Engineering and Technology on September 22, 2016. For additional information, please see File No. 1396-EX-ST-2016.

3. Explanation of the degree to which the information is commercial or financial or contains a trade secret or is privileged.

The information requested to be kept confidential has significant commercial value. The details of the STA Extension tests/experiments may include trade secret information. The Commission has clarified that confidential treatment should be afforded to trade secrets.[28] Google's tests/experiments and proprietary wireless applications using particular radio frequency equipment represent a "secret commercially valuable plan" within the meaning of a trade secret as recognized by the Commission.

In addition, agreements entered into between Google and any parties that provided equipment for testing or will provide analysis of test results require that confidential information of the parties be held in strict confidence, and that such information not be disclosed to any third party (with limited exceptions not applicable to this request). The manufacturer name and model number constitutes confidential trade secrets, technical information, and business information under the agreements.

4. Explanation of the degree to which the information concerns a service that is competitive.

The services and technologies that are the subject of this STA Extension have not yet been fully developed but are expected to lead to material developments in markets subject to competition from multiple U.S. and non-U.S. third parties.

5. Explanation of how disclosure of the information could result in substantial competitive harm.

The technology under development is highly sensitive and confidential in nature. The release of such information would provide valuable insight into Google's technology innovations and potential business plans and strategies. Public disclosure would jeopardize the value of the technology under examination by enabling others to utilize Google's information to develop similar products in a similar time frame.

[28] *Examination of Current Policy Concerning the Treatment of Confidential Information Submitted to the Commission*, Report and Order, GC Docket No. 96-55, at para. 3, (released Aug. 4, 1998) (defining "trade secrets" for purpose of Commission rules on confidential treatment).

6. Identification of any measures taken by the requesting party to prevent unauthorized disclosure.

Google has taken steps to keep confidential the information set forth in the confidential exhibits by limiting the number of people involved in the tests/experiments to only those on a "need to know" basis, and by requiring any third parties involved in the testing process to execute robust nondisclosure agreements.

7. Identification of whether the information is available to the public and the extent of any previous disclosures of the information to any third parties.

The information contained in the confidential exhibits is not available to the public, and has only been disclosed to third parties pursuant to restrictive safeguards.

Google voluntarily provides the information to the Commission at this time with the expectation that it will be treated confidentially in accordance with the Commission's rules. *See Critical Mass Energy Project v. Nuclear Regulatory Comm'n*, 975 F.2d 871, 879 (D.C. Cir. 1992) (commercial information provided on a voluntary basis "is 'confidential' for the purpose of Freedom of Information Act (FOIA) Exemption 4 if it is of a kind that would customarily not be released to the public by the person from whom it was obtained.")

8. Justification of the requested period of confidentiality.

Google expects that confidential treatment will be necessary for the length of the proposed experiment and thereafter in order to protect its evolving business and technology strategies.

9. Any other information that would be useful in assessing whether this request should be submitted.

The information subject to this request for confidentiality should not be made available for public disclosure at any time. There is nothing material that public review of this information would add to the Commission's analysis of Google's request for an experimental authorization.

Moreover, public disclosure of the sensitive information in the confidential exhibits to the STA Extension after the Commission has ruled on the Request for Confidentiality is not necessary for the Commission to fulfill its regulatory responsibilities.

Consistent with 47 C.F.R. § 0.459(d)(l), Google requests notification if release of the information subject to this request is requested pursuant to the FOIA or otherwise, so that Google may have an opportunity to oppose grant of any such request.

Sincerely yours,

Stephanie Selmer

EXHIBIT A – NARRATIVE STATEMENT

Consistent with the standards set forth in Section 5.61 of the Federal Communications Commission's (FCC's or Commission's) Rules, 47 C.F.R. § 5.61, Google Inc. (Google) outlines below its need for the requested extension of Special Temporary Authority (STA Extension) and the compelling reasons why 1396-EX-ST-2016 should be granted expeditiously.

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Grant of this STA Extension will not adversely impact any authorized user of RF spectrum for the reasons stated below.

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[1] *See* Exhibit C (Frequency Coordination Report) to File No. 0234-EX-STA-2016 (Call Sign WJ9XPL).
[2] *Id.* at 2.
[3] *Id.*

transmissions, so interference with ground station receivers is not a concern.[4] Moreover, the 27 GHz transmitter will continue to point roughly horizontally, so the main beam will never point toward the satellite receiver. In performing its analysis, Google relied on the technical parameters for GSO satellites set forth in ITU-R Recommendation SF 1601-2.[5] This recommendation suggests a GSO satellite has a maximum receive antenna gain of 55 dBi and a system noise temperature of 500K.[6] To assess worst-case conditions, Google assumed that Google's ground transmitter was located directly in the spot beam of the satellite's receiver. Google made additional worst-case assumptions regarding its own antenna by assuming its antenna has +10 dBi gain in the direction of the GSO satellite receiver.[7] Assuming free space propagation between Google's transmitter and the satellite's receiver, Google's analysis showed that any signal received by the satellite from Google's transmitter would be at least 19.2 dB below the satellite receiver's thermal noise floor. This equates to at most 0.052 dB in degradation, which should have no impact on a data link. ITU Recommendation S.1323-2 recommends that internetwork interference caused by the earth and space station emissions of any one other GSO FSS network operating in the same frequency band or bands be limited to 6% of the total system noise power under clear-sky conditions.[8] Link degradation of 0.052 dB corresponds to 1.2% of total system noise power.

In reality, the received signal at the GSO satellite is likely is to be even weaker than the worst-case analysis suggests, because any satellite antenna pointed at an associated satellite earth station necessarily will be pointing substantially away from Google's transmitter location. A search of the FCC's IBFS database shows that there are no GSO earth stations registered in California. Therefore, the closest earth station to Google's continued operation can be no closer than the Nevada border, roughly 257 kilometers away from Google's test location. As a result, any satellite receiver operating in this band will be pointed at a terrestrial location *at least* 257 kilometers away from Google's test location, ensuring that its receiver will be a minimum 0.41 degrees off-boresight from the Google transmitter.

MEO and LEO satellites: Google's continued testing will not interfere with MEO or LEO satellites. A search of the FCC's IBFS database shows that there are no MEO or LEO earth stations registered in California. Therefore, the closest earth station

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[4] *See* 47 C.F.R. § 2.106.

[5] ITU-R Recommendation SF 1601-2, *Methodologies for Interference Evaluation from the Downlink of the Fixed Service Using High Altitude Platform Stations to the Uplink of the Fixed-satellite Service Using the Geostationary Satellites Within the Band 27.5-28.35 GHz* (2007), *available at* http://www.itu.int/rec/R-REC-SF.1601-2-200702-I (ITU-R Recommendation SF 1601-2).

[6] *Id.* at 8.

[7] [REDACTED].

[8] ITU-R Recommendation S.1323-2, *Maximum Permissible Levels of Interference in a Satellite Network (GSO/FSS; Non-GSO/FSS; Non-GSO/MSS Feeder Links) in the Fixed-satellite Service Caused by Other Codirectional FSS Networks Below 30 GHz* (2002), *available at* https://www.itu.int/rec/R-REC-S.1323/en (ITU-R Recommendation S.1323-2).

to Google's continued operation can be no closer than the Nevada border, roughly 257 kilometers away from Google's test location. If a MEO satellite operates at roughly 8,000 kilometers above the earth's surface[9] and points at an earth station at least 257 kilometers from the edge of Google's testing area, the MEO satellite's receive antenna will be off axis from Google's transmitter by at least 1.8 degrees. Relying on the antenna patterns recommended in ITU-R Recommendation F.699-7,[10] the satellite receive antenna gain in the direction of Google's continued operation is at most 30 dBi for MEO satellites. Using a worst case antenna gain of +10 dBi in the direction of the satellite, and a satellite receiver noise temperature of 500K,[11] the signal received by a MEO satellite from Google's transmitter will be at least 28 dB below the noise floor. As noted above, ITU Recommendation S.1323-2 recommends that internetwork interference caused by the earth and space station emissions of any one other GSO FSS network operating in the same frequency band or bands be limited to 6% of the total system noise power under clear-sky conditions.[12] Transmissions at 28.3 dB below the noise floor correspond to 0.16% of total system noise power and will not cause harmful interference to MEO satellites.

To assess potential interference to LEO satellites, Google assumed that such satellites would operate at orbital heights between 500 and 2,000 kilometers above mean sea level and conducted the same analysis described above.[13] Google's results are summarized in the table below:

Satellite height	**500 km**	**1000 km**	**2000 km**
Minimum angle off-boresight from Google operations	27 degrees	14 degrees	7 degrees
Maximum receive antenna gain in direction of Google operations	10 dBi	15.3 dBi	21.4 dBi
Maximum power of Google signal received by satellite	27.7 dBm below noise floor	28.2 dBm below noise floor	27.7 dBm below noise floor

[9] O3b Networks operates a MEO satellite in this band, and that satellite operates at an orbital height of 8062 kilometers.

[10] ITU-R Recommendation F.699, *Reference Radiation Patterns for Fixed Wireless System Antennas for Use in Coordination Studies and Interference Assessment in the Frequency Range From 100 MHz to About 70 GHz* (2006), *available at* https://www.itu.int/rec/R-REC-F.699/en.

[11] ITU-R Recommendation SF 1601-2.

[12] ITU-R Recommendation S.1323-2. The ITU has not issued similar recommendations for MEO and LEO satellites, so Google has assumed that the system noise temperature and antenna gain characteristics for LEOs and MEOs are similar to those provided in the ITU-R Recommendation S.1323-2.

[13] Mark A. Sturza, LEOs: The Communications Satellites of the 21st Century 1, IEEE Technical Applications Conference Northcon/96 Conference Record (1996), *available at* http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=564754&tag=1.

Based on this analysis, the signal received by a LEO satellite from Google's continued operation will be at least 27 dB below the receiver noise floor. This interference level, too, is undetectable on a data link. As noted above, ITU Recommendation S.1323-2 recommends that internetwork interference caused by the earth and space station emissions of any one other GSO FSS network operating in the same frequency band or bands be limited to 6% of the total system noise power under clear-sky conditions.[14] Transmissions at 27 dB below the noise floor correspond to 0.2% of total system noise power and will not cause harmful interference to LEO and MEO satellites.

- *Unlicensed operations -- level probing radars*: Google's continued testing will not interfere with unlicensed users of the 24.05-29.00 GHz band. Level probing radars use this band to measure the level, or relative height, of various substances in man-made or natural containers. For example, they may be used to measure levels water basin levels, coal piles, or grain levels in a silo.[15] The transmit antennas of these radars are oriented downward.[16] Google's continued operation will transmit roughly horizontally, and will continue to be limited to locations [REDACTED] in Mountain View, California. [REDACTED], further shielding any potentially affected receivers from interference. Moreover, many level probing radars are used in confined spaces where Google's signal will be further attenuated by additional obstructions.

- *Unlicensed operations -- automotive radars*: Unlicensed vehicular radar is also permitted in the 27.9-28.0 GHz band.[17] A search of the FCC's equipment authorization database reveals one vehicular radar certified for operation between 22 and 29 GHz,[18] but the test results submitted in support of that equipment authorization demonstrate that the radar's highest operating frequency is 25.050 GHz.[19] Because Google's continued testing will take place at frequencies that are 2.85 GHz above those used by the radar, there is no risk of harmful interference to the radar's operation.

***31.0-31.3 GHz band users (31 GHz band)*:**

- *Terrestrial licensees*: On Google's behalf, Comsearch also identified the common carrier fixed point-to-point microwave service, LTTS, and LMDS licensees operating in the 31 GHZ band in the vicinity of the test area under Google's initial

[14] ITU-R Recommendation S.1323-2.
[15] *In the Matter of Amendment of Part 15 of the Commission's Rules To Establish Regulations for Tank Level Probing Radars in the Frequency Band 77-81 GHz*, *et al.*, Report and Order and Order, 29 FCC Rcd. 761 ¶ 1 (2014).
[16] 47 C.F.R. §15.256(b).
[17] See 47 C.F.R. §§ 15.252, 15.515.
[18] *See* FCC ID L2C0030TR.
[19] See University of Michigan Radiation Laboratory, *Test Report: Delphi UWB 24 GHz Automotive Radar Model(s): 12237659* (2005), at 7. This report can be accessed via the list of exhibits supporting Delphi Electronics & Safety's application for equipment authorization for FCC ID L2C0030TR.

STA request.[20] Notification letters were sent to each of the licensees, informing them of the technical parameters of the proposed experimentation.[21] No licensee objected[22] and no interference has been reported.

Comsearch also identified site-based licenses in the microwave public safety and industrial/business pool services.[23] It then performed an analysis to assess the interference into all potentially affected site-based 31 GHz stations in the microwave public safety and industrial/business pool services.[24] This analysis shows that there is no risk of harmful interference to incumbent fixed operations.[25]

- *Federal operations*: The Table of Frequency Allocations reflects a federal allocation for standard frequency and time signal-satellite (space-to-earth) operations. Google is not aware of any federal standard frequency and time signal-satellites using the 31 GHz band, but is prepared to coordinate with such satellite operations as necessary.

***International users*:** Because the test area is more than 700 kilometers away from U.S. borders, no international coordination is required.

Finally, as noted, Google has already been conducting similar tests in this area under a grant of Special Temporary Authority, and no disruptions have been noted.

[20] *See* Exhibit C (Frequency Coordination Report) to File No. 0234-EX-STA-2016 (Call Sign WJ9XPL) at 2.
[21] *Id.*
[22] *Id.*
[23] *Id.* at 5.
[24] *Id.*
[25] *Id*. at 5-7.

EXHIBIT B - TECHNICAL INFORMATION

Applicant Name: Google Inc.
Applicant FRN: 0016069502

Legal Contact Details

Name of Contact	Stephanie Selmer
Contact Details	Associate Corporate Counsel 25 Massachusetts Avenue NW, Ninth Floor Washington DC 20001 Email: selmer@google.com

Technical Contact Details

Name of Contact	Chris White
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Ka-Band Transmitter Equipment and Station Details

Transmitter Equipment (27 GHz band)

Equipment	[REDACTED]
Number of Terminals	[REDACTED]
Station Class	Mobile
Location	The operating area is a polygon with vertices at the following GPS coordinates: (1) 37° 25' 15.9" N 122° 5' 33.0" W (2) 37° 24' 43.3" N 122° 4' 41.4"W (3) 37° 24' 5.2" N 122° 2' 14.0" W (4) 37° 25' 37.2" N 122° 2' 16.2" W (5) 37° 26' 8.9" N 122° 5' 5.2" W

Frequency Range	**Low (GHz)**	**High (GHz)**
[REDACTED]	27.900	28.000

Radio	**Modulation**	**Emission Designator**	**Modulation Bandwidth**	**Maximum Power Out**	**Maximum EIRP/ERP**
[REDACTED]	QAM	100MD1D	100 MHz	5 W	26 dBW/ 231 W
[REDACTED]	BPSK	15M0G1D	15 MHz	5 W	26 dBW/ 231 W
[REDACTED]	Continuous Waveform	100HK0N	100 Hz	5 W	26 dBW/ 231 W

Antenna Information (27 GHz band)[1]

Antenna #1	[REDACTED]
Type	[REDACTED]
Quantity	[REDACTED]
Gain	18.8 dBi
Beam Width at Half-Power Point	20 degrees
Orientation in Horizontal Plane	0 degrees to 360 degrees
Orientation in Vertical Plane	-30 degrees to +20 degrees from horizontal
Antenna Height (AGL)	1 m to 20 m

Antenna #2	[REDACTED]
Type	[REDACTED]
Quantity	[REDACTED]
Gain	14.3 dBi
Beam Width at Half-Power Point	34 degrees
Orientation in Horizontal Plane	0 degrees to 360 degrees
Orientation in Vertical Plane	-30 degrees to +20 degrees
Antenna Height (AGL)	1 m to 20 m

Antenna #3	[REDACTED]
Type	[REDACTED]
Quantity	[REDACTED]
Gain	10 dBi
Beam Width at Half-Power Point	50 degrees
Orientation in Horizontal Plane	0 degrees to 360 degrees
Orientation in Vertical Plane	-30 degrees to +20 degrees
Antenna Height (AGL)	1 m to 20 m

[1] While Google will continue to test three different antennas during the course of experimentation, only one antenna will be used with any given transmitter at a particular time.

Transmitter Equipment (31 GHz band)

Equipment	[REDACTED]
Number of Terminals	[REDACTED]
Station Class	Mobile
Location	The operating area is a polygon with vertices at the following GPS coordinates: (1) 37° 25' 15.9" N 122° 5' 33.0" W (2) 37° 24' 43.3" N 122° 4' 41.4" W (3) 37° 24' 5.2" N 122° 2' 14.0" W (4) 37° 25' 37.2" N 122° 2' 16.2" W (5) 37° 26' 8.9" N 122° 5' 5.2" W

Frequency Range	**Low (GHz)**	**High (GHz)**
[REDACTED]	31.000	31.300

Radio	**Modulation**	**Emission Designator**	**Modulation Bandwidth**	**Maximum Power Out**	**Maximum EIRP/ERP**
[REDACTED]	QAM	300MD1D	300 MHz	5 W	27 dBW/ 278 W
[REDACTED]	BPSK	15M0G1D	15 MHz	5 W	27 dBW/ 278 W
[REDACTED]	Continuous Waveform	100HK0N	100 Hz	5 W	27 dBW/ 278 W

Antenna Information (31 GHz band)[2]

Antenna #1	[REDACTED]
Type	[REDACTED]
Quantity	[REDACTED]
Gain	19.6 dBi
Beam Width at Half-Power Point	19.5 degrees
Orientation in Horizontal Plane	0 degrees to 360 degrees
Orientation in Vertical Plane	-30 degrees to +20 degrees
Antenna Height (AGL)	1 m to 20 m

Antenna #2	[REDACTED]
Type	[REDACTED]
Quantity	[REDACTED]
Gain	15.8 dBi
Beam Width at Half-Power Point	31 degrees
Orientation in Horizontal Plane	0 degrees to 360 degrees
Orientation in Vertical Plane	-30 degrees to +20 degrees
Antenna Height (AGL)	1 m to 20 m

Antenna #3	[REDACTED]
Type	[REDACTED]
Quantity	[REDACTED]
Gain	10 dBi
Beam Width at Half-Power Point	50 degrees
Orientation in Horizontal Plane	0 degrees to 360 degrees
Orientation in Vertical Plane	-30 degrees to +20 degrees
Antenna Height (AGL)	1 m to 20 m

[2] While Google will continue to test three different antennas during the course of experimentation, only one antenna will be used with any given transmitter at a particular time.