Date: February 22, 2016

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

FCC File No: 0234-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 application for Special Temporary Authority (STA) 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 and complementary exhibits. Google does not seek to withhold from public inspection information 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) requests Special Temporary Authority (STA) to conduct demonstrations of experimental transmitters. The STA is sought for a period of 180 days beginning on March 28, 2016. Google outlines below its need for the requested STA and the reasons that the STA should be granted expeditiously.

The STA is needed for development of [REDACTED]. Among other parameters, Google will evaluate [REDACTED] on these links.

The equipment used will 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 be used with one of three antennas with a gain not to exceed 18.8 dBi. The 31 GHz radio will 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 use wideband transmissions, Google also seeks authorization 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.

Grant of this STA 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 operations will not cause harmful interference to other users of the 27 GHz band.

- *Terrestrial licensees*: On Google's behalf, Comsearch identified in the vicinity of Google's proposed testing 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).[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]

- *Satellite operations*: Google's proposed 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 be pointing roughly horizontally, so the main beam will never be pointing toward the satellite receiver. In performing its

[1] *See* Exhibit C (Frequency Coordination Report).
[2] *Id.* at 2.
[3] *Id.*
[4] *See* 47 C.F.R. § 2.106.

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 proposed 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 proposed operation can be no closer than the Nevada border, roughly 257 kilometers away from Google's proposed operation. 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.

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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).

MEO and LEO satellites: Google's proposed 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 proposed operation can be no closer than the Nevada border, roughly 257 kilometers away from Google's proposed operation. 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 proposed testing area, the MEO satellite's receive antenna will be off axis from Google's transmitter in California 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 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 2000 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 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 proposed 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 grain silo.[15] The transmit antennas of these radars are oriented downward.[16] Google's proposed operation will transmit roughly horizontally, and will 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.

[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).

- *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 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*: Google's operations also will not cause harmful interference to other users of the 31 GHz band. On Google's behalf, Comsearch also identified the common carrier fixed point-to-point microwave service, LTTS, and LMDS licensees operating in this band in the vicinity of Google's proposed test area.[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]

  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.

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[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.
[20] *See* Exhibit C at 2.
[21] *Id.*
[22] *Id.*
[23] *Id.* at 5.
[24] *Id.*
[25] *Id*. at 5-7.

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

The proposed experimental operations in the 27 and 31 GHz bands accordingly will be conducted without harmful interference to other authorized users. For these reasons, Google requests approval of this STA request.

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	Aparna Sridhar
Contact Details	Counsel 25 Massachusetts Avenue NW, Ninth Floor Washington DC 20001

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 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 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. These Exhibits were filed with the Office of Engineering and Technology on February 22, 2016. For additional information, please see File No. 0234-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 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 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 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,

Aparna Sridhar

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) requests Special Temporary Authority (STA) to conduct demonstrations of experimental transmitters. The STA is sought for a period of 180 days beginning on March 28, 2016. Google outlines below its need for the requested STA and the reasons that the STA should be granted expeditiously.

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[1] *See* Exhibit C (Frequency Coordination Report).
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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 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 proposed 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 grain silo.[15] The transmit antennas of these radars are oriented downward.[16] Google's proposed operation will transmit roughly horizontally, and will 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

[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.

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 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*: Google's operations also will not cause harmful interference to other users of the 31 GHz band. On Google's behalf, Comsearch also identified the common carrier fixed point-to-point microwave service, LTTS, and LMDS licensees operating in this band in the vicinity of Google's proposed test area.[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]

  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 proposed test area is more than 700 kilometers away from U.S. borders, no international coordination is required.

The proposed experimental operations in the 27 and 31 GHz bands accordingly will be conducted without harmful interference to other authorized users. For these reasons, Google requests approval of this STA request.

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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 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	Aparna Sridhar
Contact Details	Counsel 25 Massachusetts Avenue NW, Ninth Floor Washington DC 20001

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)[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 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 test three different antennas during the course of experimentation, only one antenna will be used with any given transmitter at a particular time.

EXHIBIT C – FREQUENCY COORDINATION REPORT

Experimental Operation

Mountain View, CA

Frequency Coordination Report – 27 & 31 GHz

Prepared on Behalf of
Google Inc.

January 29, 2016

COMSEARCH®
A CommScope Company

Table of Contents

1. Summary of Results

In support of experimental operations at 27 and 31 GHz[1], Comsearch performed a frequency search considering all existing and proposed incumbent licenses within an appropriate coordination distance of the experimental system. The search results identified licensees in the common carrier fixed point-to-point microwave service, local television transmission service (LTTS) and local multipoint distribution service (LMDS). Prior notification letters were sent to the licensees and a summary of the notification data is provided in section four of this report.

No objections were received from any of the incumbent licensees. Our notification to the LMDS incumbents was performed under the assumption that the experimental stations would be operating on a secondary basis to LMDS operations and a point of contact at Google has been provided in case any concerns may arise in the future.

[1] The experimental system will operate in the 27.9 – 28.0 GHz and 31.0 – 31.3 GHz portions of the 28 GHz / 31 GHz / LMDS band.

2. Coordination Data

This section presents the data pertinent to the experimental system in Mountain View, California. This data was circulated to all incumbent licensees in the shared 27 and 31 GHz frequency ranges.

Administrative Information	**MTNVIEW1 CA**	**MTNVIEW2 CA**
Status / License Basis	Proposed / Non-Interference	Proposed / Non-Interference
Licensee Name	GOOGLE INC.	GOOGLE INC.
Radio Service / Station Class	XT - Experimental	MO - Mobile

Site Information
Latitude (NAD 83)
Longitude (NAD 83)

The operating area is within the polygon with vertices at the following GPS coordinates:

Location Name	GPS Coordinates
Rengstorff and 101	37° 25' 15.9" N 122° 05' 33.0" W
Shoreline and 101	37° 24' 43.3" N 122° 04' 41.4" W
Moffett and 101	37° 24' 05.2" N 122° 02' 14.0" W
Moffett / Bay	37° 25' 37.2" N 122° 02' 16.2" W
Shoreline Park	37° 26' 08.9" N 122° 05' 05.2" W

Ground Elevation (m/ft-AMSL)	Various
Path Azimuth (°)	Various: 0° to 360°
Path Length (km / miles)	Various

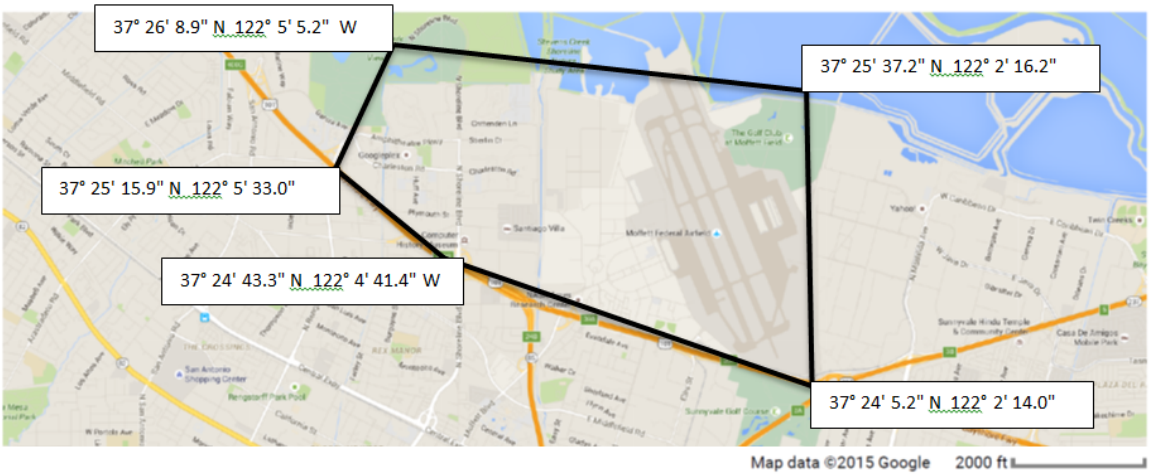
Antenna #1 †	Directional Antenna	Directional Antenna
Gain (dBi)	18.8	19.6
Beamwidth (°)	20.0	19.5
Elevation Angle (°)	-30 to +20.0	-30 to +20.0
Centerline (m / ft - AGL)	1.0 to 20.0m / 3.3 to 65.6 ft	1.0 to 20.0m / 3.3 to 65.6 ft

Antenna #2 †	Directional Antenna	Directional Antenna
Gain (dBi)	14.3	15.8
Beamwidth (°)	34.0	31.0
Elevation Angle (°)	-30 to +20.0	-30 to +20.0
Centerline (m / ft - AGL)	1.0 to 20.0m / 3.3 to 65.6 ft	1.0 to 20.0m / 3.3 to 65.6 ft

Antenna #3 †	Directional Antenna	Directional Antenna
Gain (dBi)	10.0	10.0
Beamwidth (°)	50.0	50
Elevation Angle (°)	-30 to +20.0	-30 to +20.0
Centerline (m / ft - AGL)	1.0 to 20.0m / 3.3 to 65.6 ft	1.0 to 20.0m / 3.3 to 65.6 ft

Radio Information	**#1**	**#2**	**#3**	**#1**	**#2**	**#3**
Modulation	QAM	BPSK	CW	QAM	BPSK	CW
Emission Bandwidth	100 MHz	15 MHz	100 Hz	300 MHz	15 MHz	100 Hz
Max EIRP (dBm) (Ant1/Ant2/Ant3)	46/51/56	46/51/56	46/51/56	46/51/56	46/51/56	46/51/56
Transmit Frequencies (MHz)	27,900-28,000			31,000-31,300		

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



3. Common Carrier and LTTS Coordination

In accordance with FCC Rules and Regulations, the 27/31 GHz experimental system in Mountain View, California was prior-coordinated by Comsearch. Notification letters for this system were sent to the following common carrier fixed microwave licensees. These licensees are authorized to operate temporary fixed operations over a designated geographic area.

Licensee	Band	Authorized Geographic Area
AT&T	28 GHz, 31 GHz	Continental US
California, State of	31 GHz	Limited Area in California
M.U.T. Licensing, LLC	28 GHz	Statewide: California
Verizon	28 GHz, 31 GHz	Continental US

A notification letter and datasheet for the experimental system were also sent to the following 28/31 GHz local television transmission licensees. These licensees are authorized to operate temporary fixed operations on a nationwide basis.

Licensee	Band	Authorized Geographic Area
AT&T	31 GHz	Continental US
Information Super Station, LLC	28 GHz, 31 GHz	Continental US
NSM Surveillance	31 GHz	Continental US
Remote Facilities Consulting Services	31 GHz	Nationwide

No objections were received from the common carrier or local television transmission service incumbents.

4. LMDS Coordination

A Notification letter was sent to the following 28/31 GHz LMDS licensees. The proposed experimental system will operate on frequencies that overlap Block A and Block B of the LMDS service. The total frequency allocation for each block of the LMDS spectrum appears below.

Block A: 27.500-28.350 GHz
29.100-29.250 GHz
31.075-31.225 GHz

Block B: 31.000-31.075 GHz
31.225-31.300 GHz

Licensee	Block	Market	Market Name
Nextlink/XO	B	BTA404[2]	San Francisco-Oakland-San Jose, CA
Straight Path Spectrum	A	BTA404	San Francisco-Oakland-San Jose, CA
T-Mobile[3]	A	BTA404	San Francisco-Oakland-San Jose, CA

No objections were received from the LMDS incumbents.

5. Interference Analysis into Site-Based Licenses

Comsearch performed interference calculations to determine the potential for interference from Google's proposed 31 GHz experimental transmitter into site-licensed 31 GHz microwave public safety and industrial/business incumbent receivers.

As input to the interference study, Comsearch retrieved data for potentially affected 31.0 - 31.3 GHz microwave public safety and industrial/business pool systems from the FCC ULS database. The systems selected for the analysis include 25 duplex fixed links (50 receivers) in ULS as well as point-radius licenses west of 110 degrees longitude. The distance limit imposed by this geographic selection is more than sufficient to ensure that harmful interference with systems to the east would not occur.

Standard direct interference calculations were used to predict the interference level into each receiver in the selected data.

[2] The proposed experimental system will be located inside BTA404.

[3] T-Mobile has acquired LMDS spectrum from Straight Path in the San Francisco-Oakland-San Jose, CA BTA.

For line-of-sight propagation, the interference level at the input to a 31 GHz band receiver is calculated as:

$$I = EIRP - FSL - ABS + G_r(\delta) - L_{fixed}$$

Where:

EIRP	=	The EIRP of the experimental transmitter
FSL	=	The free-space path loss from experimental transmitter to the receiver (dB)
ABS	=	The oxygen and water vapor absorption loss for the path from experimental transmitter to receiver (dB)
G_r	=	The receiver antenna gain (dBi) as a function of the off-axis angle δ
δ	=	The receiver antenna off-axis angle (deg)
L_{fixed}	=	The receiver common and receive-side fixed losses (dB)

Absorption losses were calculated according to the methods of Annex 2 of Recommendation ITU-R P.676-10. The temperature, atmospheric pressure, and water vapor density parameters that are required as inputs to the P.676 algorithms were determined at each receiver location using the methods of Recommendation ITU-R P.835-5 and the associated ITU data banks.

Specific attenuation values (dB/km) for oxygen and water vapor absorption were calculated for each 31 GHz band receiver in the data set based on the location and antenna height. The total absorption loss was calculated as the total (water vapor plus oxygen) specific attenuation for the receiver location times the length of the interference path.

Consistent with FCC rules Section 101.105 and TIA TSB10-F, interference low enough to degrade the performance of a 31 GHz receiver by less than 1 dB is considered not to be harmful. The interference objective used in the analysis to satisfy this condition was determined as follows.

The thermal noise power level in a receiver is:

$$N = -114 + 10 * log_{10}(BW) + NF\ (dBm)$$

Where:

BW	=	The receiver bandwidth in MHz
NF	=	The receiver noise figure (dB)

The receiver bandwidth is estimated to be the same as the transmitter emission bandwidth indicated on the license. The receiver noise figure is estimated to be 3 dB.

By power addition, interference at 6 dB below the receiver thermal noise power level would result in 1 dB degradation of the receiver performance. The interference objective for this condition is:

$$I_{max} = -114 + 10 * log_{10}(BW) + NF - 6\ (dBm)$$

Based on the assumption of a typical 3 dB noise figure, the interference objective for this analysis is:

$$I_{max} = -114 + 10 * log_{10}(BW) - 3\ (dBm)$$

For each receiver, the predicted interference level under the assumption of line-of-sight propagation was compared to the 1 dB threshold degradation (TD) objective to determine whether harmful interference could occur.

Interference Analysis Results

The interference level under the assumption of line-of-sight propagation was calculated into each 31 GHz band receiver in the selected data. This analysis showed that the interference into all receivers except WNTY579 (Sacramento, CA license of State of California) meets the 1 dB TD objective. Further calculations for WNTY579 taking into account the intervening terrain showed sufficient over-the-horizon losses to resolve the potential interference into this system as well.

Thus Google's proposed experimental operations are not predicted to cause interference to any of the incumbent site-based systems at 31 GHz.

Example analysis results to illustrate the calculations are listed in Table 1 below.

Call Sign	Receiver Site Name	Receiver Frequency (GHz)	Experimental Transmitter Site Name	Distance from Experimental Transmitter to Receiver (km)	Experimental Transmitter EIRP	Free-Space Loss plus Absorption Loss (dB)	Receiver Antenna Off-Axis Angle (deg)	Receiver Antenna Gain at Off-Axis Angle (dBi)	Interference Level (dBm)	Over-the-Horizon Path Loss (dB)	Margin to 1 dB TD Objective (dB)
WNTY579[4]	SACRAMENTO	31.1625, 31.0125	MTNVIEW2	123.1	56.0	176.9	N/A (Omni)	38.2	-82.7	72.2	44.9

Table 1: Example Interference Analysis Calculation into 31 GHz Site-Based License

[4] Due to the distance from WNTY579 to the experimental transmitter (123.1 km), Comsearch sent a notification letter to the incumbent licensee. The incumbent responded that they have no objection to Google's proposed system. All other call signs were of sufficient distance to preclude coordination.

6. Contact Information

For questions or information regarding the 27 and 31 GHz Frequency Coordination Report, please contact:

Contact person:	Peter Young
Title:	Principal Engineer
Company:	Comsearch
Address:	19700 Janelia Farm Blvd., Ashburn, VA 20147
Telephone:	703-726-5764
Fax:	703-726-5599
Email:	pyoung@comsearch.com
Web site:	www.comsearch.com