

**Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, DC 20554**

In the Matter of)	IB Docket No. 12-340
)	
LightSquared Request to Modify Its ATC)	IBFS File Nos. SAT-MOD-20120928-
Authorization)	00160; SAT-MOD-20120928-00161;
)	SAT-MOD-20101118-00239; SES-MOD-
)	20121001-00872; SAT-AMD-20180531-
)	00044; SAT-AMD-20180531-00045
)	
)	
LightSquared Technical Working Group)	IB Docket No. 11-109
Report)	

COMMENTS OF GARMIN INTERNATIONAL, INC.

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Dated: July 9, 2018

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SUMMARY

Garmin does not oppose the Ligado Modification Applications and recently filed Amendment, consistent with its settlement agreement with Ligado.

The aviation-related changes in the Amendment represent a positive advance on these issues. Ligado's proposed adoption of a 9.8 dBW power level, as suggested recently by the U.S. Department of Transportation, is a first step toward protecting certified aviation GPS devices. The proposal, however, does need to be accompanied with consideration and commitments regarding corollary restrictions on the spacing of towers/transmitters, as well as regarding certain antenna parameters – such as height, downtilt, and polarization.

Decreasing the power of individual ancillary terrestrial component base stations is only effective in lowering aggregate power levels if site spacing or tower density remains consistent with assumptions made in the original analysis. Antenna height, downtilt, and polarization are also critical variables in any power calculation. Variations from the Department of Transportation's assumptions must be considered in evaluation of a power level proposal. Without consideration and commitments regarding these issues, protection of Garmin's certified aviation GPS devices is not assured.

The effect of Ligado's proposals also needs to be considered with respect to helicopter operators' reliance on certified aviation GPS devices. Maximizing public availability of information about Ligado's proposed "standoff cylinders" is paramount to ensure safe implementation with respect to certified aviation GPS devices.

Garmin respects the FAA's jurisdiction and expertise regarding certified aviation issues, and grant of Ligado's Modified Applications and Amendment should be preceded by explicit

FAA determination and acknowledgement that operation of the proposed network is compatible with certified aviation devices.

Finally, Garmin remains a strong supporter of application of a 1 dB decrease in a GPS device's carrier-to-noise density ratio ("C/N₀") (the "1 dB Standard") as a threshold determinant of harmful interference to the device's operations. Use of any alternative measure based on only user experience will fail to consider the vast number of devices, uses, and environments in which GPS devices are deployed. The 1 dB Standard is very relevant and appropriate to this proceeding because the design changes ongoing at Garmin in connection with the settlement agreement itself are based on ensuring that its GPS products are not degraded by more than 1 dB C/N₀ in the presence of Ligado signals. Garmin agreed not to oppose the Ligado Modification Applications precisely because, speaking only for Garmin's devices, the technical parameters to which it agreed in the Settlement Agreement were based on its own testing using the 1 dB Standard.

The 1 dB Standard is also relevant to Garmin's certified aviation devices. As discussed in these comments, the receiver's C/N₀ link budget, used in the Radio Frequency Interference analysis that underpins receiver performance standards, at times has less than 1 dB of margin. As also discussed, these considerations are relevant as well to ensuring certified aviation devices' ability to process information from GPS augmentation systems.

GPS manufacturers in the U.S. need a consistent, universal, and quantifiable metric to incorporate into their product designs and testing. Absent that, future product development, innovation, and the country's GPS and GNSS technology lead will be adversely affected. The 1 dB Standard is vital to ensure such continued development and to ensure U.S. devices are internationally compatible and competitive.

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COMMENTS OF GARMIN INTERNATIONAL, INC.

Garmin International, Inc. (“Garmin”) files these comments in response to Ligado Networks LLC’s (“Ligado’s”) amended applications for modification of its Mobile Satellite Service (“MSS”) licenses.¹ As discussed in detail below, Garmin submits these comments to supplement the record on two points: (i) consideration of recommendations from aviation regulatory parties and aviation stakeholders related to continued safe operation of Garmin’s certified aviation products; and (ii) use of a 1 dB decrease in the Carrier-to-Noise Power Density Ratio (“C/N₀”) as a metric to measure interference to an affected GPS receiver (the “1 dB Standard”). In processing the Modification Applications and Amendment, it is important that the FCC take both points into account.

¹ See Applications of LightSquared Subsidiary LLC, Narrative, IBFS File Nos. SAT-MOD-20151231-00090, SAT-MOD-20151231-00091, and SES-MOD-20151231-00981 (“Modification Applications”); Ligado Networks LLC Amendment License Modification Applications, IBFS File Nos. SAT-AMD-20180531-00044 and SAT-AMD-20180531-00045 (“Amendment”). See also FCC, Satellite Policy Branch Information, Space Station Applications Accepted for Filing, Public Notice, Report No. SAT-01321, at 1 (rel. June 8, 2018). In these comments, Garmin uses the term “Ligado” to refer to Ligado’s predecessors.

I. INTRODUCTION

Garmin, along with its affiliates, is a leading, worldwide provider of navigation equipment, committed to making superior products for automotive, aviation, marine, outdoor, fitness, and sports uses that are an essential part of its customers' lives. Garmin has a long history of innovation and of working with the Federal Communications Commission ("FCC" or "Commission"), other agencies, and communications and navigation stakeholders on vital issues concerning spectrum use.

Since its founding almost 30 years ago, Garmin has evolved into a leading, worldwide provider of certified aviation devices, almost all of which are enabled by Global Positioning System ("GPS") technology. Garmin's broad, overall product portfolio serves a wide range of customers and brings critical safety-of-life applications to the global marketplace.

Garmin has long supported the development of new broadband services in this country; it believes, however, that broadband deployment generally should not come at the expense of harm to the nation's well-functioning, innovative, and economically important GPS service. With respect to the particular service put forward by Ligado, Garmin entered into a settlement agreement with Ligado in which Garmin agreed not to object to Ligado's proposals regarding Garmin's non-certified aviation and general location/navigation lines of business as long as certain technical parameters were met.² At the same time, Garmin reserved the right to comment on issues related to certified aviation devices.³ In addition, Garmin and Ligado did not reach an agreement about whether the 1 dB Standard was an appropriate metric to use to evaluate

² See Settlement Agreement and Releases, by and between Garmin International, Inc. and New LightSquared LLC and LightSquared Subsidiary LLC, at Paragraphs 9(a) & 10(a) (dated Dec. 16, 2015) ("Settlement Agreement"), attached to Letter from Gerard J. Waldron to Marlene H. Dortch, IB Docket Nos. 12-340 *et al.* (filed Dec. 17, 2015).

³ Settlement Agreement at Paragraphs 7(d) & 9(a).

interference, and Garmin continues to participate actively in discussions of the issue.⁴ Finally, the parties to the settlement agreed that Garmin's execution of the agreement did not constitute an endorsement by Garmin of Ligado's proposal, and Ligado agreed not to make any statement or representation to that effect.⁵ Garmin's agreement with Ligado addresses its own GPS devices and does not speak to protection for all GPS devices.

II. THE LIGADO MODIFICATION APPLICATIONS, AS AMENDED, DO NOT FULLY ADDRESS IMPORTANT CONSIDERATIONS AND RECOMMENDATIONS RAISED BY EXPERT AVIATION REGULATORY BODIES AND AVIATION PARTIES

The aviation industry overall has been one of the primary beneficiaries of the development of GPS, and the FCC must vigilantly continue to consider concerns regarding the potential impact of Ligado's proposed service on certified aviation devices. Given the essentiality of GPS for aviation, where safety-of-life is of paramount concern, certified aviation devices must continue to operate on an interference-free basis. As Ligado has recognized, evaluation of any interference must be based upon technical determinations by aviation safety experts at the Federal Aviation Administration ("FAA") and RTCA, Inc. Their expertise will help ensure interference-free operation.

Ligado's latest filing proposes several aviation-related changes to its proposals and represents a positive advance on these issues.⁶ Specifically, Ligado suggests the following three changes: (i) lowering the power level of its ancillary terrestrial component ("ATC") base stations operating in the 1526-1536 MHz band to 9.8 dBW (10 W) with a +/- 45 degree cross-polarized

⁴ *Id.* at Paragraph 6(h).

⁵ *Id.* at Paragraph 12.

⁶ *See* Letter from Gerard J. Waldron *et al.* to Marlene H. Dortch, IB Docket No. 11-109 *et al.*, (filed May 31, 2018), with attached Amendment.

base station antenna; (ii) prohibiting any Ligado ATC base station antenna in this band from operating at a location less than 250 feet laterally or less than 30 feet below an obstacle clearance surface established by the FAA; and (iii) requiring Ligado to comply with reporting, notification, and monitoring obligations discussed in the Amendment.⁷

Ligado's proposed adoption of the 9.8 dBW power limit follows a recent recommendation to that effect put forward by the U.S. Department of Transportation in its "Final Report" issued after a multi-year "GPS Adjacent Band Compatibility Assessment."⁸ This decrease in power is a first step toward protecting certified aviation receivers; however, such a step by itself, absent consideration and commitments regarding corollary restrictions on the spacing of towers and transmitters – inter-site distances ("ISD's") between such locations – is insufficient to protect Garmin's certified aviation receivers. Similarly, without consideration and commitments regarding antenna parameters – such as height, downtilt, and polarization – protection of Garmin's certified aviation receivers is not assured.⁹

First, decreasing the power of individual ATC base stations, as Ligado has proposed, is only effective in lowering aggregate power levels if site spacing or tower density remains consistent with assumptions made in the original analysis.¹⁰ Changes in cell site density necessitate compensating adjustments in power levels. For instance, if tower density were to

⁷ *Id.* at 1-2 & Amendment.

⁸ U.S. Department of Transportation, *Global Positioning System (GPS) Adjacent Band Compatibility Assessment*, Final Report, at VI, 149 (Apr. 2018) ("DOT/ABC Final Report"), <https://www.transportation.gov/sites/dot.gov/files/docs/subdoc/186/dot-gps-adjacent-band-final-reportapril2018.pdf>.

⁹ As the DOT/ABC Final Report notes, the 9.8 dBW power level it recommended is highly dependent upon and sensitive to these antenna parameters. *Id.* at 148.

¹⁰ DOT assumed ATC base stations arranged in a hexagonal grid formation with 433 meter and 693 meter ISDs. *Id.* at Tables 5-5 & 5-9; 152-153.

increase beyond the level assumed in the DOT/ABC Final Report without any compensating adjustment to the power level, certified aviation devices would likely experience harmful interference.

Second, antenna height and antenna downtilt are critical variables in any power calculation, and variations from DOT/FAA assumptions must be considered in evaluation of a power level restriction. Ligado's publicly discussed proposals for its network include providing communications and data connectivity for unmanned aerial vehicles ("UAVs") or drones.¹¹ Tilting or turning antennas skyward to provide such connectivity for UAVs would likely cause harmful interference to certified aviation devices, without compensating changes, and must be taken into account in evaluating the Modification Applications and Amendment. Accordingly, FAA-sanctioned limits should be captured explicitly in FCC processing of the Modification Applications and Amendment.

In like manner, the polarization of transmitted signals must be explicitly addressed in evaluation of proposed power levels. Ligado's Amendment is insufficiently specific with respect to the issue of polarization. For instance, if its ATC base stations will only be cross-polarized at the degree specified in the Amendment, it needs to commit to that on the record. The 9.8 dBW power level recommended by the DOT/ABC Final Report only pertains to an analysis utilizing cross-polarized signals.¹² Because of the greater sensitivity of certified aviation devices to

¹¹ John Croft, *LightSquared Successor Fuses Space and Ground Networks for UAS*, *Aviation Week* (Apr. 18, 2017), <http://aviationweek.com/connected-aerospace/lightquared-successor-fuses-space-and-ground-networks-uas>; see also Press Release, Ligado Networks, *Remarks of Ligado Networks CEO Doug Smith at Politico Live "Spectrum, Innovation, and Infrastructure in the Trump Era,"* (June 15, 2017), <https://ligado.com/press/remarks-ligado-networks-ceo-doug-smith-politico-live-spectrum-innovation-infrastructure-trump-era/>.

¹² DOT/ABC Final Report at 149. As the DOT/ABC Final Report itself recommends, "a requirement for cross-polarization emissions from the base stations must be captured in any

vertical polarization, Ligado needs to be explicit about its plans with respect to polarization, so power levels can be assessed accurately.

III. CONCERNS ABOUT HARMFUL INTERFERENCE TO HELICOPTER USE OF CERTIFIED AVIATION DEVICES, ALREADY DOCUMENTED IN THE RECORD, REMAIN UNADDRESSED

Various parties have raised concerns, in particular, about the effect of Ligado's proposed ATC base stations on the safety of helicopter operations that rely upon certified aviation devices for navigational guidance.¹³ In the Amendment, Ligado assumes aircraft will be 250 feet from one of its ATC base stations – a “standoff cylinder” of that radius.¹⁴ Yet, helicopter operators have raised concerns about their ability, when operating near such proposed standoff cylinders, to rely on GPS-based navigation and GPS-enabled capabilities for obstacle/terrain avoidance and position reporting with other air bound operations.¹⁵

license application or issuance. A vertical polarization (only) based limit must be significantly lower than 9.8 dBW.” *Id.*

¹³ See, e.g., Letter from Capt. Tim Canoll, President, Air Line Pilots Association, International (“ALPA”), *et al.*, to Daniel K. Elwell, IB Docket Nos. 12-340 *et al.*, at 2 (filed June 18, 2018) (“Aviation Parties’ June 2018 Letter”) (The letter was filed on behalf of ALPA, Airborne Public Safety Association, Aircraft Owners and Pilots Association, Airlines for America, Association of Air Medical Services, Helicopter Association International, Helicopter Safety Advisory Conference, National Agricultural Aviation Association, National Business Aviation Association, National EMS Pilots Association, and Professional Helicopter Pilots Association.); Letter from Edward A. Yorkgitis, Jr., Counsel for Aviation Spectrum Resources, Inc. (“ASRI”), to Marlene H. Dortch, IB Docket Nos. 12-340 *et al.*, at 2-3 & Attachment B (filed June 20, 2017) (“ASRI June 20, 2017 Letter”) (The letter reflected participation also by Airlines for America, Helicopter Association International, and Aerospace Industries Association.)

¹⁴ Amendment at 1-3.

¹⁵ Aviation Parties’ June 2018 Letter at 2; RTCA, Inc., “Operational Review of Ligado Networks Proposal for Standoff Cylinders (Approved by the Tactical Operation Committee December 2016),” Dec. 2016 (“RTCA TOC Report”), at 5, available at http://prod-ha.rtca.org.373elwb11.blackmesh.com/sites/default/files/toc_dec_2016_summary.pdf (“Attachment 4”); ASRI June 20, 2017 Letter at 2-3.

These concerns about aviation safety arise for a number of reasons. First, there currently is no codified aviation prohibition on rotorwing aircraft entering such standoff cylinders.¹⁶ Second, contrary to support for the concept in RTCA participants' review of Ligado's proposals, there is no indication that information on the location of Ligado's ATC base station towers and their related standoff cylinders will be made publicly available.¹⁷ As aviation parties have recommended, "if such information is provided in a database to the operational community, and the obstacle data was [sic] incorporated into equipment performing TAWS/HTAWS function, this would begin to help ensure safety."¹⁸ Without publicly available information, a large question remains as to how helicopter pilots using certified aviation equipment will know whether or not they are operating within a standoff cylinder.¹⁹

On the other hand, making standoff cylinders part of the FAA's Digital Obstacle File database or other publicly available sources would go a long way to support compliance with flight planning requirements, help operators avoid standoff cylinders, and reduce the potential for inadvertent flights across or into cylinders with the attendant possibility of flight accidents.²⁰

¹⁶ See, e.g., 14 C.F.R. § 91.119, setting forth a helicopter exemption related to minimum safe altitudes, which relies on publicly available FAA information and parameters in the rule, but makes no reference to standards akin to Ligado's proposal.

¹⁷ Exhibit 1 to the Amendment provides for base station data to be submitted to the FCC and FAA with public availability of the information allowed only through the FCC's codified confidentiality procedures, which permit very limited access to confidential information.

¹⁸ RTCA TOC Report at 6.

¹⁹ "Operators remain concerned that 10,000 – 20,000 Standoff Cylinders may be in the [National Airspace System] and pilots may not know where they are. There is interest in understanding how operators may know where these cylinders are, and operators should be engaged to provide input into how this information would be made available to aviation stakeholders." *Id.*

²⁰ See FAA, Digital Obstacle File (DOF), https://www.faa.gov/air_traffic/flight_info/aeronav/digital_products/dof/ (last visited July 9, 2018), which includes the following description: ("The Digital Obstacle File (updated every 56 days) describes all known obstacles of interest to

Maximizing publicly available information is paramount because, as the DOT/ABC Final Report noted, aviation community concerns include the possibility that, even with full public access, “pilot workload, confusion, or error could lead to aircraft inadvertently entering an assessment zone [or Standoff Cylinder] and losing needed GPS functionality.”²¹

The FCC, working closely with the FAA, needs to focus on, and exhaustively review, these safety-related concerns. Not only did the DOT/ABC Final Report catalog them, but, as recently as several weeks ago, a large number of aviation industry stakeholders, having had an opportunity to review the DOT/ABC Final Report and Ligado’s latest filing, concluded that “the concerns and safety issues of the industry have NOT been addressed.”²² Similarly, the DOT/ABC Final Report itself acknowledged that “[t]he FAA has not completed an exhaustive evaluation of the operational scenarios in developing the assessment zone[s]” or standoff cylinders.²³ In addition, the Report noted that “the current analyses do not include an operational

aviation users in the United States, with limited coverage of the Pacific, the Caribbean, Canada, and Mexico. ...”)

FAA helicopter air ambulance flight planning regulations require consideration of terrain and obstacles, and similar steps could be taken with regard to this information to ensure aviation safety. *See* 14 C.F.R § 135.615(a), which with respect to visual flight rules (“VFR”) flight planning provides for a number of requirements, including the following: “Prior to conducting VFR operations, the pilot in command must (1) Determine the minimum safe cruise altitude by evaluating the terrain and obstacles along the planned route of flight; (2) Identify and document the highest obstacle along the planned route of flight.”

²¹ DOT/ABC Final Report at VII. The DOT/ABC Final Report summarized the following additional concerns regarding standoff cylinders: “technical and human factors issues associated with re-initialization of GPS after loss of the signal or when the signal reception is intermittent; workload and human factors impacts on pilots to monitor and track assessment zone locations; ... and impacts to onboard and ground systems that are dependent upon GPS, such as Automatic Dependent Surveillance (ADS) Broadcast/Contract (B/C), or fixed-wing and helicopter terrain awareness warning system including obstacle alerting.” *Id.*

²² Aviation Parties’ June 2018 Letter at 2.

²³ DOT/ABC Final Report at VII.

assessment of the impact of the assessment zone[s] in densely populated areas, which may present additional variables, including the risk posed to people and property for operations such as UAS using certified avionics which may be required to operate within the assessment zone.”²⁴

Garmin respects the FAA’s jurisdiction and expertise regarding certified aviation issues and related safety concerns and reiterates that grant of Ligado’s Modified Applications and Amendment should be preceded by explicit FAA determination and acknowledgement that operation of the proposed network is compatible with certified aviation devices.

IV. THE UNIVERSALLY RECOGNIZED 1 dB STANDARD IS THE PROPER METRIC FOR ASSESSING INTERFERENCE

In its Amendment, Ligado again criticizes the use of a standard metric – a 1 dB decrease in a GPS device’s carrier-to-noise-density ratio (“C/N₀”) (the “1 dB Standard”) – as a threshold determinant of harmful interference to a GPS receiver’s operation.²⁵

Ligado’s position overlooks the critical differences between navigation and communication systems and the underlying engineering concepts that govern their operation. As Garmin has documented extensively in the record, the 1 dB Standard is the long-established and appropriate determinant of harmful interference to GPS and other Radio Navigation Satellite Service (“RNSS”) receivers. As Garmin also recently highlighted, this is the case whether the 1 dB Standard is applied to out-of-band emissions (“OOBE”) that emanate from services in adjacent bands but fall within the RNSS band or overload interference that emanates from services in adjacent bands and overpowers receivers in the RNSS band.²⁶ This metric is the

²⁴ *Id.*

²⁵ Amendment at n.9.

²⁶ Letter from M. Anne Swanson to Marlene H. Dortch, IB Docket Nos. 11-109 *et al.*, at 2-5 (filed May 16, 2018) (“Garmin May 2018 Letter”), *citing* U.S. Air Force, SMC/GP (GPS Directorate), *Background Paper on Use of 1-dB decrease in C/N₀ as GPS Interference Protection Criterion*, at

appropriate standard for evaluating harmful interference from adjacent band services because it successfully aggregates increases in the noise floor from OOB E alongside degradation from overload interference, and it does so in a manner even more generous than some existing recommendations cited by the Air Force analysis endorsing use of the 1 dB Standard.²⁷ As Garmin has noted, a holistic approach is a more effective and reasonable regulatory approach to resolving this issue than a piecemeal regime, which focuses separately on different types of interference affecting the same devices.²⁸

As noted above, Garmin's Settlement Agreement with Ligado specifically provides that the parties did not reach an agreement about whether the 1 dB Standard was an appropriate metric to use to evaluate interference. That agreement also provides for specified temporal periods during which Ligado will operate its network at reduced power levels to permit time for the design and development of hardened receivers that will be able to tolerate interference at the levels specified in the Settlement Agreement. The 1 dB Standard is very relevant and appropriate to this proceeding because that design change, which is ongoing at Garmin, is itself based on ensuring that its GPS products are not degraded by more than 1 dB C/N_0 in the presence of Ligado signals. Garmin agreed not to oppose the Ligado Modification Applications precisely because, speaking only for Garmin's devices, the technical parameters to which it agreed in the Settlement Agreement were based on its own testing using the 1 dB Standard.

2, 6-9 (June 2017), www.gps.gov/spectrum/ABC/1dB-background-paper.pdf; and also citing HEGARTY & KAPLAN EDS., *Understanding GPS, Principles and Applications*, Section 5.11.1 (Artech House, Boston, 2nd Ed. 2006).

²⁷ Garmin May 2018 Letter at 4.

²⁸ *Id.*; see also Letter from F. Michael Swiek to Marlene H. Dortch, IB Docket Nos. 12-340 *et al.*, at 2-11 (filed July 13, 2017); Comments of Garmin International, Inc., IB Docket Nos. 12-340 *et al.*, at 8-19 (filed May 23, 2016).

Without use of the universal and objective 1 dB Standard, Garmin’s testing to ensure compliance with the Settlement Agreement would devolve into an administratively unproductive and ineffective exercise. The same is true for testing interference to GPS devices in other contexts: without use of the 1 dB Standard, individual and unique test scenarios would need to be developed for thousands of use cases – whether in automotive, aviation, marine, outdoor, fitness, or sports applications. The extensive volume of testing required across a host of subjective measurements of user-experienced “accuracy,” when multiplied by the plethora of test scenarios, would yield a vast amount of data that would simply be administratively staggering – and unlikely to demonstrate any universal trend or establishment of any other reliable metric. Regulators who reject use of the 1 dB Standard would face a daunting task and likely one that would prove inconclusive and unproductive in the end.

Indeed, the volume of data accumulated in the NASCTN testing of just a select few devices, which relied on an approach other than the 1 dB Standard, was extensive.²⁹ As Garmin has previously discussed, these results actually provide direct and indirect support for use of the 1 dB metric: “direct” support because the NASCTN test data showed a direct correlation between a 1 dB drop in C/N_0 and degradation of the key performance indicators that were analyzed; “indirect” support by highlighting the extreme complexity of an approach like NASCTN’s, which focused only on measuring the effect of interfering signals on selected key performance indicators of the GPS devices under test.³⁰

²⁹ William F. Young, *et al.*, *LTE Impacts on GPS; Final Test Report*, National Advanced Spectrum and Communications Test Network (“NASCTN”) (Feb. 15, 2017), <https://nvlpubs-nist.gov/nistpubs/TechnicalNotes/NIST.TN.1952.pdf>.

³⁰ Garmin May 2018 Letter at 4-5.

The 1 dB Standard is also relevant to Garmin’s certified aviation devices, and Ligado’s implication to the contrary in its Amendment is overly simplistic. There are numerous instances in which use of the 1 dB Standard is very relevant to designing and assessing the performance of Garmin’s certified aviation devices.

The 1 dB Standard is relevant to certified aviation devices precisely because the receiver’s C/N_0 link budget is used in the Radio Frequency Interference analysis that underpins the receiver performance standards considered by RTCA and the FAA.³¹ For instance, in the Wide Area Augmentation System (“WAAS”), there is less than a 1 dB of margin available for additional interference beyond that which was envisioned in the existing standard.³² With WAAS, “even small changes in the C/N_0 link margin can have significant adverse consequences on receiver and ultimately navigation system performance.”³³ As little as “a 0.4 to 0.6 dB difference in link margin, under certain scenarios, can change the WAAS word error rate by an order of magnitude. Loss of continuity probability is closely tied to this and certain other key

³¹ The link budget is a foundational equation amalgamating all system gains and losses (including interference) from the GPS satellite to the receiver. The link budget allows system designers to ensure sufficient link margin (and safety margin) exists to accommodate the known losses the system will encounter (*e.g.*, path loss, interference, etc.).

³² WAAS is a regional space-based augmentation system operated by the FAA to provide extremely accurate navigation information for civil aircraft operating throughout North America. *See* FAA, Satellite Navigation – Wide Area Augmentation System (WAAS), https://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/waas (last visited July 9, 2018); *see also* GPS, Augmentation Systems... Wide Area Augmentation System (WAAS), <https://www.gps.gov/systems/augmentations> (last visited July 9, 2018). (Although WAAS is “designed primarily for aviation users, WAAS is widely available in receivers used by other positioning, navigation, and timing communities.”).

³³ RTCA, Inc., *Assessment of Radio Frequency Interference Relevant to the GNSS L1 Frequency Band*, RTCA/DO-235B, prepared by RTCA SC-159, Mar. 13, 2008 at §2.6.3, at 23.

receiver performance measures (e.g. carrier phase error).”³⁴ Contrary to Ligado’s contention, the 1 dB Standard is relevant to certified aviation safety concerns as well.

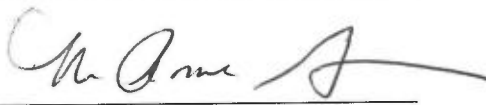
GPS manufacturers in the U.S. need a consistent, universal, and quantifiable metric to incorporate into their product designs and testing. Without that, future product development, innovation, and the U.S. lead in GPS and other Global Navigation Satellite System (“GNSS”) technologies will be adversely affected. The 1 dB Standard is vital to ensure such continued development and to ensure U.S. devices are internationally compatible and competitive.

V. **CONCLUSION**

Garmin does not object to the Modification Applications and Amendment, consistent with the terms of its Settlement Agreement, which permit it to make comments on issues related to certified aviation devices and the 1 dB Standard. Garmin respectfully requests that these comments be taken into account as the FCC reviews the Modification Applications and Amendment.

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³⁴ *Id.*