Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
LightSquared Subsidiary LLC	)	IB Docket No. 11-109
Technical Working Group Report	)	
In re the Application of	)	
LightSquared Subsidiary LLC	)	File No. SAT-MOD-20101118-00239
Request for Modification of its Authority for an Ancillary Terrestrial Component	)	

COMMENTS OF GARMIN INTERNATIONAL, INC.

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TABLE OF CONTENTS

Page

Summary

I. For Two Decades, Garmin Has Been Designing and Manufacturing Reliable GPS-Enabled Aviation, Maritime, and Consumer Products 4

II. GPS-Enabled Aviation, Maritime, and Consumer Products Are Essential To Ensuring Safety in the Air, at Sea, and on the Ground 7

A. Aviation 8

B. Maritime 12

C. Consumer 14

III. Given the Technical Characteristics of GPS Signals, Receivers Are Extremely Sensitive 17

IV. LightSquared's Threat to GPS 18

A. For Years, the Terrestrial Component of MSS Has Been Both Ancillary to and Integrated with MSS Operations 18

B. LightSquared's Terrestrial Proposal Is Anything But Ancillary 21

V. The Results Noted in the Public Notice and Detailed in the TWG Report Are Consistent with Testing Conducted on GPS Equipment Prior to the TWG Report, Which Had Conclusively Demonstrated Serious Problems with LightSquared's Proposed Operations, and Give Credence to Concerns Expressed by a Wide Array of Institutions 23

VI. The Report of the Aviation TWG Subgroup Shows That the FCC Should Not Allow LightSquared's Proposed Terrestrial Operations To Proceed, Even As Modified by the Recommendation Document 29

VII. The Report of the TWG General Location/Navigation Subgroup Also Reveals That Extensive Disruption of GPS Service Would Result from LightSquared's Terrestrial Network, and the Recommendation Document Does Nothing To Cure This Problem 38

VIII. LightSquared's Suggestion of Additional Filters for GPS Receivers Is an Impractical Solution That Does Not Resolve the Problems That Would Arise from Its Initiation of Service as Proposed in the Recommendation Document 50

IX. Conclusion 56

SUMMARY

In early June, a representative of LightSquared Subsidiary LLC ("LightSquared") told a meeting of the National Position, Navigation, and Timing Engineering Forum ("NPEF") that "[w]e always knew there would be interference. The hard question is how to mitigate it."[1] That statement contrasts sharply with those made by LightSquared to the Commission prior to the International Bureau's January 2011 grant to LightSquared of a conditional waiver to operate its proposed high-powered, broadband terrestrial network on spectrum adjacent to frequencies used by the Global Positioning System ("GPS"). At that time, LightSquared told the FCC "[t]o wit, while GPS interference is highly unlikely, even the possibility of such interference has nothing to do with LightSquared's integrated service showing."[2]

Now that, after a half year, the GPS industry and many other sectors have spent untold millions of dollars documenting, in the Technical Working Group Report ("TWG Report") and elsewhere, that LightSquared's proposed operation will cause such interference, the question becomes whether the FCC will accord the same credence to LightSquared's latest reformulated proposals for mitigation that it gave to LightSquared's pre-waiver representations.

At this point, Garmin International, Inc. ("Garmin") – one of those companies that in good faith over the past six months has redirected extensive resources from developing its own products to analyzing and testing LightSquared's proposed operations and its ever-evolving "solutions" – submits that the time has come for the FCC to acknowledge what LightSquared has failed to recognize from the beginning – that the laws of physics prevent the result LightSquared

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[1] Graham Warwick, *LightSquared Tests Confirm GPS Jamming*, AVIATION WEEK, June 9, 2011, *available at* http://www.aviationweek.com/aw/generic/story_channel.jsp?channel=busav&id=news/awx/2011/06/09/awx_06_09_2011_p0-334122.xml.

[2] *E.g.*, Letter from Jeff Carlisle, Executive Vice President, Regulatory Affairs & Public Policy, to Marlene H. Dortch, Secretary, FCC, SAT-MOD-20101118-00239, dated Dec. 20, 2011.

desires. Science has scuttled LightSquared's original proposals and shown that the collective exploration of mitigating solutions will continue to go nowhere.

As the FCC's own experts will find as they go through the 700^{+}-page TWG Report and the additional reports prepared by multiple federal agencies and other stakeholders, LightSquared's proposed operations, as originally planned and as now reconfigured in its June 30, 2011 "Recommendation," cannot coexist with GPS operations in adjacent frequencies. This is true even at the below-authorized power level tested for weeks in the TWG's studies as well as operation on the lower 10 MHz channel, which LightSquared suggested late in the testing process and now proposes for immediate use in its "Recommendation."

The results in the TWG Report are corroborated by, among other sources, the NPEF's own report, testing by the Air Force, and an "Impact Statement" recently released by the FAA. As discussed in detail in these comments, the FAA Impact Statement also documents the harm the likely interference would cause to implementation of the FAA's NextGen air traffic management system as well as more broadly to the aviation industry, lives of air passengers, and the overall economy.

The FCC, which to date has not frequently had to take transportation safety into account, should seriously consider, as also documented in these comments, the essential safety-of-life role that GPS plays in transport in the air, at sea, and on the ground. Due to a series of decisions from other federal agencies, GPS is increasingly replacing land-based safety systems in these various sectors.

With respect to aviation and general location/navigation GPS devices, in particular, which are Garmin's bailiwicks and areas of expertise, the TWG Report showed serious problems with LightSquared's proposed operations even with the parameters proposed in its June 30

"Recommendation." For aviation, the TWG Report, which built on earlier analyses conducted by RTCA, Inc. at the request of the FAA, showed operation on either an upper 5 or upper 10 MHz channel to be inconsistent with aviation use of GPS; it concluded that use of a lower 10 MHz channel required more study, but even that showed a negative margin for an aviation GPS receiver as it attempts to initially acquire signals. Only operation on a lower 5 MHz channel was deemed safe with aviation use of GPS.

For general location/navigation GPS devices, the TWG participants differed over appropriate technical metrics. When the GPS Industry representatives' definition of harmful interference, one with bases in well-documented domestic and international standards, is considered, jamming would occur for nearly seventy percent of the devices, even with operation on the lower 10 MHz channel. LightSquared's claims that "100 percent" will experience "no meaningful" interference can only be explained by its derivation, post-testing, of a novel interference metric which yielded the results it desires.

LightSquared's latest contention – that adding more filters to GPS devices will eliminate the serious problems with its proposed service – fails for a number of reasons, as discussed in these comments. First, no workable filters currently exist; the proposals that have been studied, based on the PowerPoint presentations LightSquared supplied, do not work. In filtering out the LightSquared signal, they reject so much of the GPS signal as to render many GPS devices unusable. Second, even if a suitable filter could be designed, it would take months, if not years, to develop, particularly for GPS aviation devices that must withstand extensive temperature variations, endure the rigors of intense vibration, survive electrostatic discharge and lightning events, and meet strict size and weight limitations applicable to aviation equipment. Finally, retrofitting the millions of existing GPS devices throughout the country with additional filters

raises innumerable challenges. In the aviation context, as the FAA Impact Statement notes, ten to fifteen years would be required to obtain necessary certifications and approvals. For the vast majority of general location/navigation devices which combine the GPS antenna and receiver into a single handheld package, retrofitting filters is simply not possible.

In short, technical solutions do not exist. The time has come for the FCC to rescind LightSquared's conditional waiver and engage in a review of whether any Ancillary Terrestrial Component ("ATC") operation in the MSS band can coexist with GPS.

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To: The Commission

COMMENTS OF GARMIN INTERNATIONAL, INC.

Garmin International, Inc., by its attorneys, hereby submits its comments in response to the Public Notice, "Comment Deadlines Established Regarding the LightSquared Technical Working Group Report," DA 11-1133, IB Docket No. 11-109, released by the Commission's International Bureau ("Bureau") on June 30, 2011 ("Public Notice").[3]

The Public Notice seeks comment on two documents. First, it seeks comments "generally" on the report submitted on June 30 by a technical working group co-chaired by LightSquared Subsidiary LLC ("LightSquared") and the United States Global Positioning System ("GPS") Industry Council ("GPSIC").[4] This Technical Working Group ("TWG") Report

[3] The Public Notice specified Saturday, July 30, 2011 as the response date for initial comments. These comments are being submitted on the next business day following July 30. *See* 47 C.F.R. §§ 1.4(e) and (j) (2010).

[4] *Id.* at 1.

was the culmination of months of testing and analysis of LightSquared's proposal to establish a terrestrial broadband network that would operate in the 1525-1559 MHz and 1626.5-1660.5 MHz bands.[5]

Given the very close proximity of these frequencies to the Radio Navigation Satellite Service ("RNSS") band where GPS operates, the Bureau earlier this year had granted LightSquared a waiver for its proposed operation of a terrestrial broadband network conditioned on the study and resolution of potential interference to GPS.[6] This condition required submission of a report including the TWG's "analysis of the potential for overload interference to GPS devices from LightSquared's terrestrial network of base stations, technical and operational steps to avoid any such interference, and specific recommendations going forward to mitigate potential interference to GPS devices."[7]

Second, the Public Notice seeks comment on a separate filing LightSquared submitted on June 30.[8] As the Public Notice acknowledges, the test results described in the TWG Report "demonstrated potentially significant interference between LightSquared operations in the upper [10 MHz] portion of the band and various GPS receivers" as well as "some interference issues in the lower 10 MHz portion of the band."[9] In an apparent attempt to address these problems, LightSquared on June 30 filed its own "Recommendation of LightSquared Subsidiary LLC"

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[5] Technical Working Group, Final Report, submitted June 30, 2011 ("TWG Report"). The TWG Report consists of an introduction, a description of the TWG's efforts, and five separate reports prepared by the TWG's seven substantive subgroups. (The High Precision, Timing and Networks Subgroups filed a single, combined report.)

[6] *LightSquared Subsidiary, LLC*, 26 FCC Rcd 566, 586 (Int'l Bur. 2011) ("*LightSquared Order*"), *review pending*.

[7] Public Notice at 1. *See also LightSquared Order*, 26 FCC Rcd at 586.

[8] Public Notice at 2.

[9] *Id.*

("Recommendation Document").[10] The Recommendation Document, which did not go through the expert peer review and consensus process of the TWG Report, sets forth three proposed mitigating steps related to LightSquared's own service: (i) operation at lower power than permitted by LightSquared's existing FCC authorization; (ii) a "standstill" of unspecified duration in terrestrial use of the upper 10 MHz frequencies immediately adjacent to the RNSS band; and (iii) commencement of terrestrial commercial operations only on the lower 10 MHz frequencies while it "coordinate[s] and share[s] the cost of underwriting a workable solution for the small number of legacy precision measurement devices that may be at risk."[11] In addition to seeking general comment on the TWG Report, the June 30 Public Notice sought comment on the Recommendation Document.

As shown and discussed in detail below, the TWG Report describes numerous operational scenarios in which GPS plays an essential role in the functioning of the U.S. economy and in ensuring safety-of-life in the air, on the sea, and on the ground. The TWG Report further documents that the possibility of harmful interference from LightSquared's proposed operation on an *upper* 10 MHz channel is much more than what the Public Notice describes simply as "potentially significant." Moreover, the interference potential from any LightSquared operation on a *lower* 10 MHz band will bring much more than what the Public Notice describes as "some interference issues." Indeed, as discussed at length below, the problems that the TWG Report identifies are so serious and so significant that, if LightSquared's

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[10] Letter from Henry Goldberg, counsel for LightSquared, to Marlene H. Dortch, Secretary, FCC, File No. SAT-MOD-20101118-00239, dated June 30, 2011 (transmitting Recommendation Document).

[11] Recommendation Document at 24.

new terrestrial broadband network is allowed to proceed, that operation should only be on frequencies far from those currently proposed by LightSquared.

Garmin believes that these problems are not unique to LightSquared's proposed operation but would result from any ancillary terrestrial component ("ATC") operating in the frequency ranges LightSquared has proposed. As a result, the Commission also should reevaluate and commence a rulemaking concerning its original adoption of rules permitting ATC operations adjacent to spectrum used by GPS. Allowing LightSquared's proposal to proceed would have drastic consequences in all of the important operational scenarios described in the TWG Report and highlighted below; similar proposals by other providers in the future would be likely to have the very same effect.

I. For Two Decades, Garmin Has Been Designing and Manufacturing Reliable GPS-Enabled Aviation, Maritime, and Consumer Products

In the past, except principally for certification of transmitting devices, the Commission has not regulated the provision of GPS devices or GPS service. Given this history, Garmin believes that any consideration of the results of the TWG Report and "next steps" requires a brief review of the GPS industry, the TWG Report's discussion of various GPS "operational scenarios" and the benefits GPS provides, and the specific context in which Garmin and other GPS companies operate. From this review, the seriousness and significance of any harmful interference from LightSquared's proposed terrestrial broadband network becomes obvious.

In the United States, Garmin is the leading manufacturer of GPS products for the General Aviation industry. It is also a leading supplier of GPS-enabled products for the maritime market and for general consumer use. It has been manufacturing GPS-enabled navigation devices since 1991.

Over the past two decades, Garmin's aviation business has grown, and today Garmin has a larger installed user base of GPS equipment than all other manufacturers combined. Two Garmin aviation devices were among those tested by the TWG's Aviation Subgroup, one of the seven substantive committees of the TWG.[12] A Garmin senior engineer served as a TWG member for the Aviation Subgroup, and he spent hundreds of hours this year participating in its work.[13] Garmin offers not just the two devices tested by the Aviation Subgroup but a full suite of avionics for General Aviation aircraft, helicopters, and Part 25 business aircraft, including the following:

- Fully integrated "Flight Decks," like the popular G1000®, which provide pilots with instrumentation, navigation, weather, terrain, traffic, and engine data on large-format, high-resolution displays;
- GPS navigation/communication devices, like the GNS™ 400 and 500 product lines involved in the TWG Aviation Subgroup tests, which have been the General Aviation standard since 1998 (over 115,000 sold), and their successors, the recently certified GTN™ 650 and 750. These aid pilots with high-resolution terrain mapping, graphical flight planning, geo-referenced charting, traffic display, and satellite weather;
- Mode S transponders which feature the extended squitter broadcast that enables the transponders to automatically transmit more accurate, and more useful, traffic surveillance data to support Automatic Dependent Surveillance-Broadcast ("ADS-B"), including aircraft flight identification, position, altitude, velocity, climb/descent, and heading information; and
- Many other GPS devices that assist pilots in monitoring every element of their flight conditions.

Garmin also manufactures a broad line of GPS-enabled products for the marine market. These include chartplotters, sounders, fishfinders, RADAR, autopilots, marine VHF communications, Automatic Identification System ("AIS") transceivers, products utilizing XM®

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[12] TWG Report at 32.

[13] TWG, Second GPS Working Group Progress Report, File No. SAT-MOD-20101118-00239, filed Apr. 15, 2011, Appendix A at 1 ("April 15 Report").

signals, and cellular data link products. Two Garmin marine devices were among those tested by TWG's General Location/Navigation Subgroup.[14]

In addition, Garmin's comprehensive line of consumer and commercial land navigation products provides individuals with information essential for efficient and safe travel by vehicle and on foot. The company's on-the-road navigation products include the following:

- The popular nüvi® series, which assists drivers with Garmin's signature mapping and direction functionality. The newest models in this series – like the nüvi 3790LMT – deliver features such as FM lifetime traffic, photo navigation, and ecoRoute™; the latter provides drivers with the most ecologically-friendly route to their destination;
- For motorcycle enthusiasts, Garmin offers the zūmo® series, which includes similar features as well as Bluetooth headset capability, waterproofing, and extended battery power; and
- For truckers, Garmin offers the dēzl™ series, with specially designed features like mapping of trucking routes for the lower 48 states and Canada, location of truck-specific points of interest, fuel logging capability based on the International Fuel Tax Agreement, drivetime tracking, repair information through the National Truck & Trailer Services Breakdown Directory, and extensive lists of services at highway exits (including food, lodging and rest areas).

Garmin's basic handheld GPS receivers provide outdoor enthusiasts with location functionality and 17-18 hour battery life. The devices include products like the eTrex® and the wrist-mounted Foretrex® series; the Montana™, Oregon™, and GPSMAP® handheld series, which offers mapping and additional features like cameras, barometric altimeters, and wireless data sharing; and the popular Rino® series, which combines GPS with two-way radio functionality permitting on-the-trail communications so groups can stay together and safe.

In addition to the two marine devices noted above, twelve other Garmin devices were among those tested by the General Location/Navigation Subgroup.[15] Five Garmin engineers served on the General Location/Navigation Subgroup, including one who served as "Lead" for

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[14] TWG Report at 131.

[15] *Id.* at 130-32.

that Subgroup.[16] Altogether, Garmin employees and representatives have devoted thousands of hours to the TWG process and the review of LightSquared's proposals.

II. GPS-Enabled Aviation, Maritime, and Consumer Products Are Essential To Ensuring Safety in the Air, at Sea, and on the Ground

As noted in the TWG Report, two of the "elements" of the "Work Plan" that guided the TWG's efforts were "[d]evelop[ing] operational scenarios," which involved charting likely use scenarios for the devices being tested, and "[a]ssess[ing] operational scenarios using analytics and test results," which involved evaluating the effect and significance of the test results for the various scenarios.[17] As the Aviation Subgroup Report noted, aviation use of GPS is not limited just to navigation; it is also used to support many other safety-of-life applications in aviation.[18] The Aviation Subgroup Report recognized that these applications greatly enhance aviation safety and operational capabilities.[19] Similarly, the General Location/Navigation Subgroup Report identified five "critical operational scenarios" and then described the economic and societal benefits, including safety-of-life applications, that flow from use of GPS-enabled products in these scenarios.[20] As demonstrated below, these scenarios from the TWG Report show how essential GPS devices have become to public and individual safety.

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[16] April 15 Report, Appendix B at 2.

[17] TWG Report at pp. 10-12.

[18] *Id.* at pp. 32-34.

[19] *Id.* at 32.

[20] *Id.* at 132-33 (presenting the combined perspective of LightSquared and the GPS Industry on five scenarios – suburban, urban canyon, golfing, deep forest, and arm swing environment) and 167-75 (presenting the GPS Industry perspective on the benefits of GPS as well as LightSquared's agreement that "GPS devices bring great benefits to their users"). The General Location/Navigation Subgroup Report, in places, had sections presenting the view of GPS Industry representatives and LightSquared separately.

A. Aviation.

As the Aviation Subgroup Report recognized, the introduction and use of GPS-enabled devices, like Garmin's, have brought important advances in aviation safety, particularly for the General Aviation market.[21] GPS has become ubiquitous and indispensable in the years since Garmin introduced its first aviation GPS receiver. Virtually all types of aircraft utilize GPS for navigation and approaches. Some 190,000 General Aviation aircraft are equipped with GPS, which represents over eighty percent of the active U.S. fleet.[22] For the majority of these aircraft, GPS is the *primary* means of navigation. Almost eighty percent of air carriers' planes utilize GPS. Nearly all military aircraft include GPS for navigation, weapon system integration, or command and control. Most foreign aircraft that enter U.S. airspace are fitted with GPS.

The position information computed by GPS receivers provides pilots with a reliable and accurate navigation source. When it is integrated with other systems in the cockpit, GPS enables a multitude of capabilities that enhance safety and improve operating efficiency. GPS is the foundation for the Federal Aviation Administration's ("FAA's") new NextGen System for air traffic management.[23] The existing uses of GPS that are described below and in the Aviation

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[21] *Id.* at 32. At this point in the report, LightSquared noted that "most operational cases . . . have existing available non-GPS alternatives to rely on traditional navigation systems (*e.g.*, ground-based navigation aids or instrument landing system (ILS) proceedings), and that aircraft can and do operate in the National Airspace System (NAS) without the use of GPS." *Id.* As noted at many other places in these comments, whether in-the-air, at sea, or on land, GPS is quickly replacing the use of many of these alternative systems; in many cases, they are being phased out pursuant to federal mandate. Even if some land-based systems remain, there is no reason to deny the American public the advanced safety benefits provided by the newer, "non-legacy" GPS systems, as opposed to the "legacy" ground-based systems.

[22] There were 223,877 total active General Aviation aircraft as of 2009. *See* http://www.faa.gov/data_research/aviation_data_statistics/general_aviation/CY2009/, Table 1.1 (last visited Aug. 1, 2011).

[23] TWG Report at 33.

Subgroup Report have made critical differences in the ability of pilots to ensure safety of life in the skies; proposed improvements in future devices will only enhance these benefits.

GPS provides pilots with the ability to fly point-to-point instead of following ground-based radio navigation aids that require longer flight paths and require more fuel in travel between airports. When GPS position information is paired with map details, it allows pilots to instantly determine – or orient – where an aircraft is located relative to terrain or obstacle features without having to go through the mental gymnastics required before GPS was introduced into the cockpit. This is a significant safety enhancement because it frees pilots to concentrate on flying their airplanes instead of working to stay oriented. During in-flight emergencies, GPS systems can provide immediate navigation to the closest airport, even in areas where there are no ground-based navigation aids.[24]

GPS-based instrument approach procedures, both standalone and those enhanced by the Wide Area Augmentation System ("WAAS") or Ground-Based Augmentation System ("GBAS"), allow aircraft to land safely at airports throughout the country. GPS approaches require substantially less ground infrastructure than those approaches utilizing ground-based navigation aids such as ILS.[25] GPS/WAAS-based Lateral Navigation ("LNAV")/Vertical Navigation ("VNAV"), Localizer Performance with Vertical guidance ("LPV"), and GBAS approaches provide both horizontal and vertical guidance that improve aviation safety by allowing pilots to fly stabilized approaches to safe landings.[26] There are, in fact, now more LPV approaches in the United States that require GPS/WAAS, than Category I ILS approaches. All told, the FAA has published over 10,000 approach procedures that use GPS, at roughly 3,000

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[24] *Id.* at 32.

[25] *Id.* at 33.

[26] *Id.*

airports and heliports across the 50 states and U.S. territories.[27] Over 900 of these airports and heliports have only GPS-based approaches; in other words, instrument approaches are not possible at these airports without GPS. GPS navigation also enables the use of repeatable curved approach and departure paths to and from airports, thus shortening flight paths, requiring less fuel burn, resulting in lower costs to operate, and creating a smaller carbon footprint. In short, GPS navigation improves airport capacity, access, and efficiency.

Availability, integrity, and accuracy are all necessary for GPS to function as a primary means of navigation and to ensure aviation safety. When weather is poor and a pilot cannot see outside the aircraft beyond the tips of the plane's wings, he or she must rely on the plane's navigation system to keep the aircraft in safe airspace. During an approach, the pilot must follow the FAA-prescribed flight path to the runway and needs to be able to rely on GPS and have confidence in the system. Improperly executed instrument approaches are consistently among the most common causes of lethal descent and approach accidents.[28] The loss of the GPS signal during this critical time is clearly a hazard to safety. Without it, pilots have to scramble to "stay ahead" of the airplane by tuning to the frequencies of alternate navigation equipment and shifting their mindset to alternate navigation methods instead of relying on GPS.

The federal government has recognized the extensive surveillance benefits GPS brings to aviation safety. The FAA is in the process of implementing the NextGen program, which uses

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[27] *See* FAA, *Navigation Services –Global Navigation Satellite System*, http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/approaches/index.cfm (update effective June 2, 2011) (last visited Aug. 1, 2011).

[28] Aircraft Owners and Pilots Association Air Safety Institute, *2010 Nall Report: The Joseph T. Nall Report of Accident Trends and Factors*, at 24, 26, *available at* http://www.aopa.org/asf/publications/nall.html.

airborne GPS as an enabling technology for a new air traffic management system.[29] ADS-B equipment broadcasts GPS-derived position reports to other aircraft in the vicinity and to air traffic control centers on the ground. ADS-B will enable increased safety, precision, capacity, and capability for air traffic control, with a reduced cost of operation since it is not dependent on ground-based radar systems. The FAA has mandated that all aircraft operating in class A, B, or C airspace be equipped with ADS-B by 2020.[30]

GPS is also used as an input to many traffic awareness systems, particularly those derived from ADS-B. These systems enhance aviation safety by providing pilots with timely alerts of potential collisions with other aircraft in time to avoid them.[31] Additionally, GPS supplies position, altitude, and velocity information to many terrain awareness systems. Such systems greatly reduce the likelihood of controlled-flight-into-terrain accidents by providing pilots with audible alerts of potential terrain and obstacle conflicts along a flight path as well as with a picture of the aircraft's position relative to the surrounding terrain and obstacles.[32] GPS also enables synthetic vision systems that display external topography from the perspective of the flight deck, enhancing situational awareness when pilots are flying in instrument conditions.[33]

Many aircraft are equipped with electronic multi-function displays that depict the aircraft's location on a map.[34] GPS is a primary source of position data for these displays; they reduce pilot workload by improving situational awareness with pictures that show an aircraft's

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[29] TWG Report at 33.

[30] *Id.*

[31] *Id.*

[32] *Id.*

[33] *Id.* at 34.

[34] *Id.* at 33.

position on a map and overlays of weather radar and traffic information while airborne. Other GPS-enabled map displays, such as Garmin's SafeTaxi®, provide the flight crew with a detailed picture of the runway and taxiway environment while a plane is on the ground, thus preventing runway incursions. Poor visibility makes it difficult to remain oriented when taxiing. The moving map feature in Garmin's SafeTaxi®, for instance, addresses that problem.

In General Aviation aircraft, GPS is also used in conjunction with low cost inertial sensors to provide reliable, inexpensive, and lightweight attitude and heading systems.[35] These devices replace spinning-mass gyroscopic instruments that have notoriously poor reliability and that otherwise would provide a pilot's primary means for determining attitude and heading during instrument flight.

Finally, GPS provides essential support for airborne search and rescue operations.[36] GPS allows search and rescue aircraft to fly precise, predetermined search patterns at any location, day or night, under all weather conditions. Accurate GPS position reports mean that rescue personnel can quickly reach a victim's correct location.

B. Maritime.

The introduction and use of GPS-enabled devices have similarly enhanced safety in the operation of all types of watercraft. Since 1999, the International Convention for the Safety of Life at Sea ("SOLAS") has mandated that passenger boats and other large ships on international voyages have on-board VHF radios equipped with Digital Selective Calling ("DSC") for emergency communications. DSC depends on GPS to send accurate position information over VHF frequencies in emergency situations such as boating capsizes, overboard losses of

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[35] *Id.*

[36] *Id.* at 34.

passengers, and pirate attacks. The United States Coast Guard recommends that most other boats have DSC functionality to ensure maximum interoperability and safety on the seas.[37] To ensure this system is used as widely as possible, the Coast Guard a decade ago petitioned the FCC to require all maritime radios sold in the U.S. to include DSC-capable radios.[38] The FCC adopted such rules in 1999, and they went into effect that year.[39] DSC-enabled devices remove the need for boaters to rely on rough estimates of their position transmitted verbally over radio frequencies.

GPS-enabled devices have become even more critical for marine safety with the United States Coast Guard's termination last year of the Loran-C system, a low-frequency hyperbolic radionavigation system.[40] Established in 1957, the Loran-C system had long provided navigation, location, and timing services for both civil and military marine users. In decommissioning it, the Department of Homeland Security and the Coast Guard explained that technological advancements and the emergence of GPS had rendered the system unnecessary.[41]

Modern marine electronics, through GPS, also expand a boater's situational awareness beyond knowledge of just the basics of the boat's location; they provide additional information about its position relative to fixed hazards like rocks or shoreline. In addition, dynamic weather overlays provide information necessary to avoid hazardous situations, and GPS-enabled equipment informs boaters as to where they are relative to such disturbances. In low visibility,

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[37] U.S. Dept. of Homeland Security, U.S. Coast Guard, *Navigation Center: Digital Selective Calling*, http://www.navcen.uscg.gov/?pageName=mtDsc (last visited Aug. 1, 2011).

[38] *Id.*

[39] *See* 47 C.F.R. § 80.1103.

[40] The termination took effect February 8, 2010. Navigation Center, U.S. Department of Homeland Security, United States Coast Guard, *Loran-C General Information*, *available at* http://www.navcen.uscg.gov/?pageName=loranMain.

[41] Terminate Long Range Aids to Navigation (Loran-C) Signal, 75 Fed. Reg. 998 (Jan. 7, 2010).

these marine surface radar overlays on charts allow boaters to differentiate between fixed (charted) obstacles and other vessels. Marine collision avoidance systems, such as the marine Automated Identification System ("AIS"), further improve situational awareness and incorporate alerts when two vessels come within close proximity of each other. To operate at all, these systems need the accurate position, speed, and course information that GPS provides.

In addition to collision avoidance, marine AIS facilitates the tracking and management of large international shipping vessels when they enter United States coastal waters. Any degradation to the GPS signals on which this system relies poses a serious threat not only to the safety of the particular vessels in question, but also to border security.

As with aviation, GPS is a crucial technology for rescue operations at sea, ensuring rescue personnel reach endangered craft and their passengers quickly. The Global Maritime Distress Safety System ("GMDSS") relies heavily on GPS position information as a primary feature in many of its component systems, including Emergency Position-Indicating Radio Beacons, DSC, and AIS. GPS has proven instrumental in advancing marine safety and, as federal changes have recognized, is now replacing older, non-space-based safety systems.

C. Consumer.

On the ground, consumer GPS devices play a key role in saving lives and property every day. These devices not only aid travelers exploring unfamiliar locales and help prevent risky situations from developing into crises, but they also aid in public safety search and rescue operations when full-fledged emergencies do result.

As the GPS Industry representatives on the General Location/Navigation Subgroup noted, one unique feature that many automotive GPS receivers offer is the ability to locate a

hospital or police station very quickly.[42] This section of the General Location/Navigation Report recounts one incident in which such a feature helped a woman save her husband's life when he suffered a heart attack while they were away on a short vacation. When her husband began suffering chest pains, the hospital locator led her to the best heart hospital in the unfamiliar city. Her husband underwent successful heart surgery less than an hour after the attack.[43] Other scenarios in this part of the TWG Report describe similar life-saving uses of GPS devices that have guided families to hospitals when loved ones suffered heart attacks or life-threatening allergic reactions to food.[44]

Similarly, this section of the General Location/Navigation Subgroup report describes the plight of a hiker, who after being chased by a bear, was lost in the woods as nightfall approached. With his GPS, he was able to locate and reach a ranger station in the most direct fashion possible.[45] In another incident, family members used their GPS devices to locate their elderly father who had chased wildlife into a canyon but then fell, hit his head, and suffered an asthma attack. Not only did the GPS device allow them to locate their father, but it then helped them navigate back to camp to obtain his asthma medicine, helping to save his life.[46]

The GPS Industry representatives on the General Location/Navigation Subgroup also noted how GPS devices have aided operators of emergency vehicles and first responders.[47] One

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[42] TWG Report at 168 (GPS Industry Perspective) supplemented by LightSquared agreement on existence of benefits, TWG Report at 175.

[43] *Id.*

[44] *Id.* As the TWG Report describes, in these instances, it is important that GPS users obtain quick and ready access to GPS signals. *Id.* at 169 (GPS Industry Perspective).

[45] *Id.* at 173 (GPS Industry Perspective).

[46] *Id.*

[47] *Id.* at 170-71 (GPS Industry Perspective).

GPS user, described in this part of the report, used a GPS device to help locate individuals waiting to be rescued from the rubble following last year's earthquake in Haiti.[48] As the report noted, "inaccuracies of more than a few meters would likely mean death" for some of the victims.[49]

Another first responder quoted in the report explained how GPS helps his search and rescue team conduct "search grids" for injured individuals in a much more effective fashion. As he noted,

> GPS also provides a standard to communicate position when our search subject is found and emergency air evacuation is critical to our subject's survival. Without an accurate location source, errors from map and compass on the ground, and navigation in the air would severely diminish our ability to command a life-flight air ambulance directly to our location.[50]

As all members of the General Location/Navigation Subgroup acknowledged, "GPS devices bring great benefits to their users."[51] The common theme that runs through the reports in the TWG Report is that GPS devices dependably put their users in the right place at the right time to save lives and protect property. Any degradation of GPS signals will compromise that dependability and significantly hamper public safety and individual rescue efforts. GPS consumer devices are not just for recreation.

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[48] *Id.* at 171 (GPS Industry Perspective).

[49] *Id.*

[50] *Id.* at 172 (GPS Industry Perspective).

[51] *Id.* at 175 (LightSquared Perspective). *See also id.* at 167-174 (GPS Industry Perspective) for more details on operational scenarios in which General Location/Navigation devices deliver safety-of-life and other benefits to public safety officials, law enforcement personnel, and other individuals.

III. Given the Technical Characteristics of GPS Signals, Receivers Are Extremely Sensitive

The GPS signals used by civilian receivers are transmitted in the GPS L1 Band, located at 1559-1610 MHz. This band is directly adjacent to the L-Band frequencies LightSquared is proposing to use at 1525-1559 MHz. Both of these bands historically have been reserved for space-to-earth signal transmissions.

Space-to-earth transmissions need a very quiet interference environment because the signals reach earth at extremely low power levels. The only means of powering GPS signals from satellites is via solar panels, and GPS signals are sent out from satellites using 50 or fewer watts, about the same wattage it takes to power a light bulb. The GPS signal then travels 12,600 miles before being received. GPS receivers must be designed to be very sensitive in order to pick up these weak signals, in some instances using a wide bandwidth to improve measurement accuracy. For example, FAA-certified GPS/WAAS equipment is allowed to receive satellite signals across 20 MHz of bandwidth.[52]

GPS receivers are extremely sensitive to strong signals operating on nearby frequencies. The GPS receivers are "listening" very hard for relatively weak GPS signals, so strong signals overload their capacity to "hear" those signals. At ground level, GPS signals have a minimum guaranteed strength of -128.5 dBm; LightSquared signals, on the other hand, are authorized at +72 dBm (or 42 dBW), although LightSquared told the TWG and repeated in the Recommendation Document that it initially plans a power level of +62 dBm (32 dBW). At 800 meters from its transmitters, LightSquared's power is predicted to be 96 dB higher than GPS. That translates to a LightSquared signal that is four billion times stronger than a GPS

[52] RTCA/DO-229D, Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne Equipment, December 13, 2006, sections 2.1.4.5.1 and 2.1.4.5.2.

signal.[53] GPS receivers of all types are not designed to exclude such strong signals because, as explained in the next section, such operation was not and could not have been contemplated before LightSquared in November 2010 filed its modified proposal for a new high powered terrestrial broadband service using spectrum adjacent to frequencies historically reserved for weak space-to-earth signals.

IV. LightSquared's Threat to GPS

A. For Years, the Terrestrial Component of MSS Has Been Both Ancillary to and Integrated with MSS Operations.

The Bureau's January 26, 2011 decision granting LightSquared a waiver to offer a widespread terrestrial broadband service represented a fundamental change in FCC policy. LightSquared proposes to operate its high powered terrestrial broadband network in spectrum historically allocated to the Mobile Satellite Service ("MSS"), which is located at 1525-1559 MHz and 1626.5-1660.5 MHz. These frequency ranges in the "L-Band" are adjacent to or near the frequency band used for low power GPS signals. MSS carriers provide satellite communications services that are interconnected to the public switched telephone network in rural areas unserved by terrestrial commercial wireless telephone services. MSS signals are characterized by very low power at ground level, which makes them entirely compatible with other satellite services like GPS that operate in adjacent spectrum. The low power MSS signals, however, typically make the service unsuitable for voice communications in densely populated urban areas that are the most profitable to serve.

[53] The LightSquared signal will be attenuated by 94.5 dB at 800 meters from the transmitter. LightSquared's proposed deployment is to transmit at 62 dBm. Thus, the power at a GPS device 800 meters from the transmitter is 62 minus 94.5, or -32.5 dBm. This is 96 dB (4 billion times) more than the minimum guaranteed GPS power of -128.5 dBm.

In 2003, the FCC sought to make offering MSS in underserved areas more attractive by permitting MSS carriers to use L-Band frequencies to provide an "Ancillary Terrestrial Component" ("ATC") to their satellite service that would "fill-in" gaps in geographic areas where the satellite service would not work. The FCC made clear that it was not seeking to reallocate MSS to terrestrial service. Instead, it was trying to strengthen MSS by allowing add-on terrestrial service in limited areas. The FCC explicitly stated in this 2003 action that "[w]e do not intend, nor will we permit, the terrestrial component to become a stand-alone service."[54]

To ensure that the ATC portion of the service remained truly "ancillary," the FCC adopted what is known as the Integrated Service Rule, requiring any MSS carrier offering ATC service to do so only by offering "an integrated service of MSS and MSS ATC."[55] In other words, if an MSS operator offers a service plan that includes ATC service, the FCC's rules require that plan to include satellite service as well. To make absolutely clear what this integrated service requirement meant, the FCC adopted a "safe-harbor" rule providing that the integrated service requirement would be satisfied if the MSS used a "dual-mode" receiver capable of communicating using both the satellite and ATC components of the service.

As a final warning to service providers who might see the ATC component as a back-door way of providing competitive terrestrial wireless service, the Commission stated that:

> [W]e intend to authorize ATC only as an ancillary service to the provision of the principal service, MSS. We have established a number of gating requirements to ensure that ATC may only operate after the provision of MSS has commenced and during the period in which MSS

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[54] *See* Flexibility for Delivery of Communications by Mobile Satellite Service Providers in the 2 GHz Band, the L-Band, and the 1.6/2.4 GHz Band, *Report and Order and Notice of Proposed Rulemaking*, 18 FCC Rcd 1962, 1964-65, ¶ 1 (2003) ("*First ATC Order*"). The Commission also established that ATC service is secondary to satellite service by rule, adopting Section 25.255 of its rules, 47 C.F.R. § 25.255, which makes ATC operators responsible for resolving interference to any other service.

[55] 47 C.F.R. § 25.149(b)(4).

> continues to operate. . . . While it is impossible to anticipate or imagine every possible way in which it might be possible to "game" our rules by providing ATC without also simultaneously providing MSS and while we do not expect our licensees to make such attempts, we do not intend to allow such "gaming."[56]

No one could read these unequivocal FCC statements as anything other than assurances to operators in the L-Band and adjacent bands that the agency was absolutely committed to maintaining a spectrum environment hospitable to low power satellite services like MSS and GPS.

In 2005, the FCC reiterated that "ancillary" must remain "ancillary":

> The purpose of ATC is to enhance MSS coverage, enabling MSS operators to extend service into areas that they were previously unable to serve, such as the interiors of buildings and high-traffic density urban areas. We will not permit MSS/ATC operators to offer ATC-only subscriptions, because ATC systems would then be terrestrial mobile systems separate from their MSS systems.[57]

In the same order, the Commission again explicitly stated that MSS ATC operators were required to "control self-interference sufficiently to maintain satellite service."[58]

Given this history and the underlying rules, other users of the MSS and adjacent spectrum, such as GPS providers, had every reason to expect that ATC operations would enhance – not interfere with – MSS operations. The Integrated Service Rule assured that any ATC service provider would, through its use of dual-mode or integrated handsets, protect against "self-interference" to the integrated MSS component. GPS manufacturers reasonably concluded that any power levels or filtering of the ATC service that was sufficient to protect the MSS

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[56] *First ATC Order* at 1965 & n.5.

[57] Flexibility for Delivery of Communications by Mobile Satellite Service Providers in the 2 GHz Band, the L-Band, and the 1.6/2.4 GHz Band, *Memorandum Opinion and Order and Second Order on Reconsideration*, 20 FCC Rcd 4616, 4628, ¶ 33 (2005).

[58] *Id.* at 4633, ¶ 46.

component from interference would likewise be sufficient to protect GPS signals in the adjacent spectrum band, and the very complex designs of their products have been premised on this reasonable condition.

B. LightSquared's Terrestrial Proposal Is Anything But Ancillary.

On November 18, 2010, LightSquared filed a letter with the FCC that fundamentally undercut these expectations.[59] In its filing, LightSquared informed the FCC that it had developed a new business plan that would involve offering ATC service on a wholesale basis to retail wireless providers. LightSquared's proposed network would operate from 40,000 terrestrial transmitters located nationwide. Most importantly, LightSquared would no longer commit to satisfying the Integrated Service Rule by offering service only for use with "dual mode" handsets. Instead, it contended that it would be offering an "integrated service" merely because it would continue to offer MSS in the rural and sparsely populated areas where its ATC service would be unavailable.

Without the provision of "dual mode" handsets, LightSquared would no longer need to avoid self-interference, a crucial requirement basic to the GPS industry's willingness on several prior occasions to work with MSS applicants to ensure their ATC service did not result in harmful out-of-band emissions. LightSquared's November 2010 filing transformed its proposed service into an offering that would severely degrade GPS service for the millions of individuals, businesses, and government agencies that rely upon it.

Within the last two months, the Directorate General for Enterprise and Industry of the European Commission ("EC"), the International Civil Aviation Organization ("ICAO"), and the

[59] Letter from Jeffrey J. Carlisle, Executive Vice President, Regulatory Affairs and Public Policy, to Marlene H. Dortch, Secretary, FCC, File No. SAT-MOD-20101118-00239, filed Nov. 18, 2011.

International Air Transport Association ("IATA") have commented on this potential for serious degradation, notifying the FCC Chairman that they have serious concerns about LightSquared's proposed service. The EC noted that the LightSquared proposal "would completely change the nature of radio transmissions in the MSS band" and reported on its own technical analysis of the "considerable potential to cause harmful interference" and the "potential impacts to safety critical to aviation applications."[60] IATA expressed "strong opposition" to any waiver of the Integrated Service Rule for LightSquared, particularly because of the threat it creates for NextGen.[61] ICAO, terming its concern "grave," discussed the "far-reaching impact on current and future aviation operations" caused by the LightSquared proposal and urged that the United States government's long-standing commitment to provide GPS Standard Positioning Service for aviation throughout the world not be "jeopardized by the introduction of the LightSquared system and the ensuing impact on GPS use by aviation."[62] The deep concern expressed in these letters is strong proof that, contrary to LightSquared's statements in its Recommendation Document,[63] the potential impact of LightSquared's proposals on GPS is not something that should have been foreseen by anyone, including GPS manufacturers.[64]

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[60] Letter from Heinz Zourek, Director General, EC Directorate for Enterprise and Industry, to Julius Genachowski, dated July 19, 2011, attached as Appendix A.

[61] Letter from Giovanni Bisignani, Director General and CEO of the International Air Transport Association, to FCC Chairman Julius Genachowski, dated June 5, 2011, attached as Appendix B.

[62] Letter from Raymond Benjamin, Secretary General, and Robert Kobeh González, President of the Council, International Civil Aviation Organization, to FCC Chairman Julius Genachowski, dated June 13, 2011, attached as Appendix C.

[63] Recommendation Document at 1-2.

[64] For a lengthy analysis of the history of the ATC and why the potential harm from LightSquared became apparent only recently, *see* Letter from F. Michael Swiek, Executive Director, U.S. GPS Industry Council, to Marlene H. Dortch, Secretary, FCC, File No. SAT-MOD-20101118-00239, dated June 30, 2011 (transmitting letter from James A. Kirkland, Vice President and General Counsel, Trimble Navigation Limited, to Julius P. Knapp, Chief Engineer,

V. The Results Noted in the Public Notice and Detailed in the TWG Report Are Consistent with Testing Conducted on GPS Equipment Prior to the TWG Report, Which Had Conclusively Demonstrated Serious Problems with LightSquared's Proposed Operations, and Give Credence to Concerns Expressed by a Wide Array of Institutions

Given the potentially devastating consequences that the LightSquared system poses for GPS, multiple groups have conducted analyses and tests – besides those done by the TWG – to assess the proposed service's true impact. All of this actual study, which predated release of the TWG Report, shows that the LightSquared system, as proposed in the November 2010 filing, will result in a widespread degradation of GPS receiver performance and severely limit, if not eviscerate, GPS utility as it currently exists.

At the request of the Federal Aviation Administration, RTCA, Inc. ("RTCA"), a standards setting body for the aviation community, assessed the impact of the LightSquared system on aviation GPS operations. The results of this effort were published on June 3, 2011 as RTCA/DO-327 and showed a severe impact to aviation GPS operations.[65] This review included a set of four aviation receivers from both the General Aviation and Air Transport sectors. All of the receivers under review experienced significant degradation when exposed to the LightSquared signals. Every receiver was significantly degraded at interfering signal levels that would be seen within 1.1 kilometer of a single LightSquared transmitter, but some receivers were affected at interfering signal levels corresponding to ranges of 6.2 or 25.8 kilometers. Several of the tested receivers experienced a loss of satellite tracking in the presence of LightSquared signal

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Office of Engineering and Technology, File No. SAT-MOD-20101118-00239, dated June 14, 2011).

[65] Letter from Margaret Jenny, President, RTCA, to Marlene H. Dortch, Secretary, FCC, File No. SAT-MOD-20101118-00239, dated June 16, 2011(transmitting RTCA/DO-327, *Assessment of LightSquared Ancillary Terrestrial Component Radio Frequency Interference Impact on GNSS L1 Band Airborne Receiver Operations*, June 3, 2011 ("RTCA Report")).

levels that would be expected during routine low altitude operations such as during instrument approaches to landing. The RTCA analysis considered the effects of multiple LightSquared transmitters and showed that significant degradation would be experienced at aircraft altitudes below 18,000 feet over large regions of the country where LightSquared plans to deploy. In light of these findings, the RTCA Report concluded that use of an upper channel deployment is incompatible with aviation GPS operations. While the RTCA report stated that the operation of a single lower 5 MHz channel might be compatible with aviation GPS operations, the statement was based on an assumption that LightSquared would operate at $1/10^{th}$ of its authorized power limit. RTCA did not reach any conclusion on whether operation on a single lower 10 MHz channel would be compatible with aviation use; it said further study was needed.

Separate from the RTCA effort, the Department of Defense coordinated two sets of tests to assess the LightSquared impacts. The first of these was a series of laboratory tests conducted at White Sands Missile Range, New Mexico, from April 4 to April 7, 2011. Simulated LightSquared signals were broadcast to the GPS receivers being tested in an anechoic chamber, which is specially designed to eliminate reflecting signals. The tests included filters on the broadcast signal that were provided by LightSquared. LightSquared's engineers were present to assess the test setup, and they concurred that it was appropriate. These tests included FAA-certified aviation receivers, all of which demonstrated a complete loss of function with interfering signal levels that would typically be seen in airborne operations.

The White Sands testing was followed by open-air tests at Holloman Air Force Base in New Mexico from April 14 to April 17, 2011. As with the White Sands tests, LightSquared was

an active participant; it provided representative LightSquared transmitter equipment, and its engineers were on site to support the tests.[66]

The data from these two Defense-coordinated tests, along with the results from RTCA, were analyzed by the National Space-Based Positioning, Navigation, and Timing Systems Engineering Forum ("NPEF"), which recently released its own assessment of the LightSquared effects on GPS.[67] The data showed that significant degradation of aviation GPS performance will occur at distances up to 27.2 kilometers from a single LightSquared base station and that a complete loss of service can be expected at distances up to 12.2 kilometers. As shown in Figure 1 below, when the data are superimposed against a proposed deployment in the greater District of Columbia metropolitan area, they show a denial of aviation GPS service over the entire area.

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[66] While the Holloman tests were directed by the Department of Defense, and Garmin does not have access to the results, the letter attached as Appendix D from the State of New Mexico's E-911 Program Director reports on the negative effect during the testing of the LightSquared transmissions on GPS general location/navigation devices. As the letter and its attached reports make clear "the LightSquared network will cause interference to GPS signals and jeopardize 911 and public safety nationwide."

[67] National Space-Based Positioning, Navigation, and Timing Systems Engineering Forum ("NPEF"), *Assessment of LightSquared Terrestrial Broadband System Effects on GPS Receivers and GPS-dependent Applications*, *available at* http://www.ntia.doc.gov/files/ntia/publications/ligtsquared_assessment_report_07062011.pdf ("NPEF Report"). The National Space-Based Positioning, Navigation, and Timing Systems Engineering Forum is a multi-agency technical forum that supports policy and managerial decisions regarding the evolution of GPS. The NPEF is co-chaired by the Department of Defense (Air Force) and the Department of Transportation (Federal Aviation Administration) and comprised of representatives from various government agencies. The NPEF Report was transmitted to the FCC by NTIA on July 6, 2011. *See* Letter from Lawrence E. Strickling, Assistant Secretary for Communications, Department of Commerce, to FCC Chairman Julius Genachowski, dated July 6, 2011, *available at* http://www.ntia.doc.gov/files/ntia/publications/ntia_fccletter_lightsquared_gps_07062011.pdf.

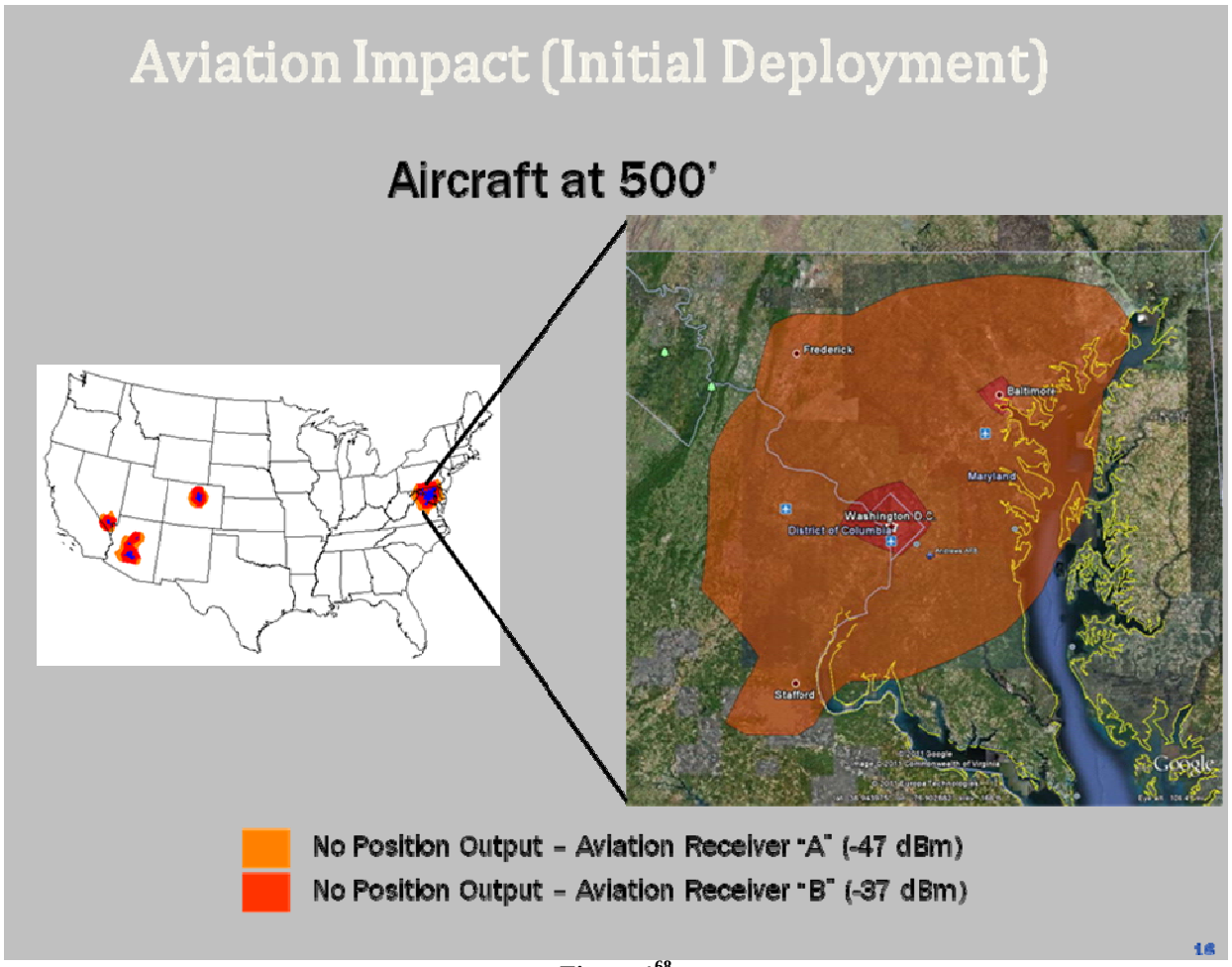

Figure 1[68]

The NPEF Report looked at potential mitigations that might allow GPS to coexist with the LightSquared system. The addition of filtering was considered and was determined to be

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[68] D. Bunce, NPEF Co-Chair, "National PNT Systems Engineering Forum (NPEF) – LightSquared Effects on GPS Test and Analysis Results," Jun. 9, 2011, Slide #16, *available at* http://www.pnt.gov/advisory/2011/06/bunce.pdf.

At the same sessions at which this slide was presented, Jeff Carlisle, executive vice president of regulatory affairs and public policy for LightSquared, also spoke. At the session he noted, "We always knew that there would be interference. The hard question is how to mitigate it." *LightSquared Tests Confirm GPS Jamming,* AVIATION WEEK, June 9, 2011, *available at* http://www.aviationweek.com/aw/generic/story_channel.jsp?channel=busav&id=news/awx/2011/06/09/awx_06_09_2011_p0-334122.xml (last visited Aug. 1, 2011), *contrast* Letter of Jeff Carlisle, Executive Vice President, Regulatory Affairs & Public Policy, to Marlene H. Dortch, dated Dec. 20, 2010, in FCC File No. SAT-MOD-20101118-00239 ("To wit, GPS interference is highly unlikely, even the possibility of such interference has nothing to do with LightSquared's integrated service showing.").

excessively costly and likely to sacrifice the levels of performance achieved by existing GPS equipment. The NPEF Report stated that, for many applications of GPS that require the use of a wide pass-band, a practical receiver design with sufficient filtering will not be possible. The potential for mitigation by limiting LightSquared to operations using a single 5 MHz or 10 MHz channel in the lower portion of the LightSquared band was also evaluated. The NPEF Report noted that while some applications such as aviation might be compatible with this strategy, it will not work universally across the wider range of GPS applications.

Based on these findings the NPEF Report made the following recommendations to the National Executive Committee for Space-Based Positioning, Navigation, and Timing:

1. LightSquared should not commence commercial service per its planned deployment for terrestrial operations in the 1525 – 1559 MHz Mobile-Satellite Service (MSS) Band due to harmful interference to GPS operations.

2. The U.S. Government should conduct more thorough studies on the operational, economic and safety impacts of operating the LightSquared Network, to include compatibility of ATC architectures in the MSS L Band with GPS-dependent applications, signal configurations not currently in LightSquared planned spectrum phases, effects on timing receivers, and transmissions from LightSquared handsets.[69]

These recommendations, made by the U.S. government's own experts on GPS and its critical importance to the nation's infrastructure, clearly show that LightSquared poses a significant and serious threat to the continued operation of GPS.

In a very recent report on LightSquared's Recommendation Document, the FAA also addressed the threat LightSquared poses to the safety of the nation's aviation system.[70] The FAA Impact Statement catalogued many of the same safety gains the TWG had reported that the

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[69] NPEF Report at i, ii, 12.

[70] Federal Aviation Administration, *LightSquared Aviation Impacts* at 3 (July 12, 2011), *available at* http://www.amerisurv.com/docs/07122011FAA-LightSquaredAviationImpacts.pdf ("FAA Impact Statement").

aviation industry has realized since the advent of GPS. These included the following: (1) the diminished frequency of approach and landing accidents due to GPS's ability to allow an aircraft "to identify its precise location relative to a precisely located touchdown point"; (2) the reduced risk of controlled flights into terrain due to the GPS-dependant Enhanced Ground Proximity Warning System, which provides "look-ahead terrain information to the flight crew . . [to] . . . give the crew time to avoid impact; and (3) decreased incidence of runway collisions because of the use of GPS-reliant "moving map" displays available to pilots.[71] The FAA's analysis showed that, if LightSquared's proposed operations impaired the accuracy and dependability of GPS systems, these improvements would disappear, resulting in the loss of 794 additional lives over the next ten years.[72] The FAA also noted that its multi-year, multibillion dollar transition to the NextGen air traffic management system, which is intended to take full advantage of the increased safety opportunities offered by GPS, would be delayed for a decade or more while the entire U.S. air fleet has to be retrofitted with GPS devices accommodating LightSquared's proposed operations – presuming that such devices can even be designed.[73]

The FAA's Impact Statement notes that these negative consequences, along with significant economic costs, would occur if LightSquared is permitted to implement the proposal

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[71] *Id.* at 3.

[72] *Id.* at 3-4.

[73] *Id.* at 4, 5-6, 7. The FAA Impact Statement also expressed grave doubts about the feasibility of LightSquared's proposed filtering solutions. The FAA Impact Statement assesses "LightSquared's proposal for in-line filter . . . as high risk and not feasible" because it will result in degraded performance in the presence of high-power LightSquared signals and because the filters would force rejection of too much of the GPS signal. The FAA's analysis ascribed a "medium risk" to the other alternative of replacing both the GPS receiver and antenna with redesigned equipment to accommodate LightSquared. The FAA noted, however, that this potential solution was entirely hypothetical because no such equipment has yet been designed, and presuming it would be accomplished would introduce the additional risk of undermining international confidence in GPS if LightSquared is allowed to deploy and efforts to develop safe equipment fail. *Id.* at 7.

in the Recommendation Document.[74] "Use of the LightSquared upper channel is unacceptable at any power level," the FAA explained, "since the LightSquared upper channel interference exceeds the GPS receiver MOPS [Minimum Operational Performance Standards]-related environmental limit by a factor ranging from 4,000-80,000, depending upon the assumed operational scenario."[75] Because retrofitting the air fleet would take a decade or more, LightSquared's offer to delay use of the upper channel until 2014 would not preserve any GPS-derived safety benefits for the aviation industry, the FAA concluded. Moreover, as the FAA Impact Statement noted, existing technical data do not support LightSquared's proposed use of its lower 10 MHz channel. Not only are current studies insufficient to show that LightSquared's proposed lower 10 MHz operations protect aviation-specific GPS receivers, the FAA emphasized that the aviation industry relies heavily on high-precision GPS devices that unquestionably would be affected by use of the frequencies.[76]

VI. The Report of the Aviation TWG Subgroup Shows That the FCC Should Not Allow LightSquared's Proposed Terrestrial Operations To Proceed, Even As Modified by the Recommendation Document.

Just like the studies that preceded it, the work of the TWG Aviation Subgroup, in which Garmin actively participated, showed serious problems with LightSquared's proposed terrestrial deployment. Its conclusion was clear: "[A]ll three phases of the currently proposed LightSquared deployment plan are incompatible with aviation GPS operations absent significant mitigation and would result in complete loss of GPS operations below 2000 feet above ground level (AGL) over a large radius from the metro deployment center."[77] All three deployment

[74] *Id.* at 6-7.
[75] *Id.* at 6.
[76] *Id.* at 6-7.
[77] TWG Report at 27.

plans under study in the RTCA and Aviation Subgroup analyses included either an upper 5 or 10 MHz channel.[78] Even when operation on a lower 10 MHz channel is considered, however, the analysis showed a negative margin for initial acquisition of the GPS signal.[79] LightSquared has proffered no "significant mitigation" proposals that would meet these serious concerns. As discussed below, Garmin, based on the thousands of hours its experts have devoted to good faith study of this issue, does not believe a practical technical solution exists to resolve the serious harm that LightSquared's proposed terrestrial operations would cause to GPS use in aircraft.

The TWG Aviation Subgroup's review closely paralleled the work done by RTCA, with many overlapping members participating in each group. RTCA's approach used analyses, supported by tests of four airborne receivers, to determine the potential for interference,[80] and, just as RTCA had, the Aviation Subgroup proceeded on a consensus basis. The Aviation Subgroup Report's findings note that the FCC's rules define "harmful interference" as "interference which endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radio communication service operating in accordance with [the ITU] Radio Regulations."[81] The Aviation Subgroup Report then defined harmful interference as any unwanted signal that prevents airborne GPS receivers from meeting all of RTCA's Minimum Operation Performance Standards as invoked by FAA Technical Standard Orders, plus an extra 6 dB safety margin and, for applicable operational

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[78] *Id.* at 49.

[79] *Id.* at 48-49.

[80] *Id.* at 27, 39.

[81] *Id.* at 28 (citing 47 CFR § 2.1: No. 1.169 of ITU Radio Regulations).

scenarios, 6 dB for initial acquisition.[82] The analyses were performed based on a maximum LightSquared base station effective isotropic radiated power ("EIRP") of 32 dBW per LTE channel per sector, "significantly lower" than its FCC authorized power of 42 dBW.[83]

The results depicted in Figure 2 below show that, applying these principles, the aggregate interference power levels that would be experienced at 1756 feet (535.3 meters) above ground level ("AGL"), which is typical of low-altitude aircraft operations, as a result of use of either of the two upper channels "vastly exceeds the levels that current GPS equipment is required to withstand."[84] The negative margins in the far right column show the extent to which the interfering signals exceed the satellite tracking interference limits of GPS receivers built to well defined and longstanding FAA and international standards.

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[82] TWG Report at 28. To maintain the high safety standards required for air travel, the FAA requires that all aircraft components – particularly crucial components like navigation systems – be consistent with exacting specifications, embodied in Technical Standard Orders ("TSOs") and type certifications. The FAA typically formulates TSOs based on recommendations from collaborative industry organizations – most frequently RTCA – which produce Minimum Operational Performance Standards ("MOPS") that are then incorporated by reference in the TSOs.

[83] *Id.* at 29, 38.

[84] *Id.* at 49.

Center Frequency (MHz)	Carrier Bandwidth (MHz)	Maximum Received Interference level (dBm)	Interference Limit, Tracking (dBm)	Margin, Tracking (dB)
1550.2	10	-36.6	-85.6	-49.0
1552.7	5	-36.6	-92.4	-55.8
1528.8	5	-36.6	-28.2	8.4
1531.0	10	-36.6	-34.1	2.5

Figure 2: Comparison of Aggregate Power Seen by Airborne GPS Receiver in the Low Altitude (535.3 meters AGL) vs Interference Limits[85]

For instance, on the top line showing transmissions using an upper 10 MHz channel, the standards would be exceeded by 49 decibels (dB). Since decibels are logarithmic, this represents a factor of almost 80,000 times (actually 79,433). Said another way, the expected interference power levels of -36.6 dBm (third column) were almost 80,000 times more powerful than the -85.6 dBm limit (fourth column) that an aviation receiver is required to withstand. This -85.6 dBm limit itself is about 20,000 times the power of the distant GPS signal, meaning that an aviation GPS receiver is already required to withstand signals 20,000 times more powerful in the immediately adjacent band. The LightSquared signal, however, is almost an additional 80,000 times stronger, meaning it is more than 1.55 billion times more powerful than the GPS signal (79.433 times 19,498 equals 1,548,784,634).

These data illustrate just how overwhelmingly powerful LightSquared's proposed adjacent signals would be. They also should dispel any argument that current GPS receivers have "poor" and inadequate filters. Figure 2 shows that the aggregate interference that would be experienced at 1756 feet would overwhelm a GPS device operating consistently with the FAA-

[85] *Id.* at Table 3.1.9.

specified satellite tracking interference limits.[86] The Aviation Subgroup, noting that RTCA indicated an airborne receiver will experience peak interference levels at an altitude between 1756 feet and 3281 feet, concluded that "a complete loss of aviation GPS operations at altitudes below 2000 feet . . . AGL is possible over a large radius from cities where LightSquared plans to deploy, if such deployment includes a channel in the upper part of LightSquared's band."[87]

Equally important, the Aviation Subgroup Report pointed out that the margins would diminish by 6 dB for initial acquisition with negative margins for all LightSquared configurations, except the lower 5 MHz channel. This means that, when initial acquisition is considered, there is a negative margin – or loss of operation – *even for* LightSquared transmissions on a *lower* 10 MHz channel.[88] "Initial acquisition" of GPS satellites involves situations, such as initial GPS receiver power-up or "cold start," normal satellite rising and setting, GPS receiver restart after a power interruption, or regaining a satellite fix after an abrupt aircraft maneuver.[89]

As the Aviation Subgroup also emphasized, both the satellite tracking and initial acquisition margins would be negative for *all* channels – whether upper or lower – if the LightSquared base stations operated at the FCC authorized maximum power of 42 dBW, rather than the lower power of 32 dBW at which the tests were run.[90] In short, operation on a lower 10 MHz channel would cause serious issues for key performance indicators premised on initial

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[86] *Id.* at 49.

[87] *Id.*

[88] *Id.* at 48-49.

[89] RTCA Report at Section 3.1.1.1.

[90] TWG Report at 48.

acquisition and would cause serious problems across the board at power levels in excess of the 32 dBW on which the analyses were premised.

For aircraft operating at a higher altitude of 18,012 feet (5,490 meters) above mean sea level (MSL), typical of en route flight, the results for LightSquared base station transmissions on the two upper channels present only slightly less severe problems. Figure 3 below shows the aggregate interference that would be seen by an airborne receiver operating at such altitude above the Mid-Atlantic region of the nation.

Center Frequency (MHz)	Carrier Bandwidth (MHz)	Maximum Received Interference level (dBm)	Interference Limit, Tracking (dBm)	Margin, Tracking (dB)
1550.2	10	-49.6	-85.6	-36.0
1552.7	5	-49.6	-92.4	-42.8
1528.8	5	-49.6	-28.2	21.4
1531.0	10	-49.6	-34.1	15.5

Figure 3: Comparison of Aggregate Power Seen by Airborne GPS Receiver in the High Altitude Scenario (5490 m MSL) vs Interference Limits[91]

As with the lower altitude results that were shown in Figure 2, the signal levels of LightSquared base stations transmitting on either the upper 5 or 10 MHz channel, as shown by the top two lines of Figure 3, would exceed the limit for harmful interference by more than 36 dB. "Based on this analysis, GPS-based operations could be unavailable over entire regions of the country at

[91] *Id.* at Table 3.1.10.

any normal aircraft altitude if LightSquared were to deploy with a channel in the upper part of its spectrum band."[92]

Based on all its work, the Aviation Subgroup, citing RTCA, noted that "a shift to using only a lower 5 MHz channel . . . may be compatible with aviation GPS operations" provided ATC transmissions are kept at or below the 32 dBW level at which tests were conducted and below LightSquared's authorized power.[93] Use of the lower 10 MHz, the Aviation Subgroup stated, "shows compatibility with a small margin for tracking functions, but not necessarily for initial acquisition."[94] As a result, both RTCA and the Aviation Subgroup said that they could not conclude that use of even the lower 10 MHz channel would be compatible with aviation GPS operations, and that further study was required.[95]

The results from the Aviation Subgroup Report show that LightSquared's three recommendations in the Recommendation Document do not offer any effective mitigation. As a first mitigating approach, the Recommendation Document suggests simply operating "at lower power than permitted by its existing FCC authorization," specifically 32 dBW EIRP per sector per carrier.[96] The RTCA/Aviation Subgroup analyses were already conducted at this proposed 32 dBW power and shown to cause problems for all but operations on the lowest 5 MHz channel, so this first proposal is a non-starter. In addition, the Aviation Subgroup Report emphasized that any consideration of reduced power would need to consider the number of deployed base

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[92] TWG Report at 50. As with the lower altitude results from Figure 1, the Subgroup noted that an increase in power to LightSquared's authorized level would not be compatible with aviation GPS operations. *Id.*

[93] *Id.*

[94] *Id.*

[95] *Id.*

[96] Recommendation Document at 25. Notably, LightSquared does not indicate whether this power level would apply to any future operations on an upper 10 MHz channel.

stations. "[A] reduction in the transmit EIRP would not be an effective mitigation if it is accompanied by an increased number of ATC base stations visible to the aircraft, because the airborne receiver is affected by the aggregate power within its line of sight."[97] The Recommendation Document is silent on this issue.

Second, it is not clear how LightSquared's next proposal – a "standstill" during which it refrains from use of its upper 10 MHz channel, particularly one of only six-month duration as LightSquared hints may be the case in the Recommendation Document[98] – offers any form of a realistic solution. For aviation in particular, even the Recommendation Document itself cited RTCA's recommendation for more study to consider "how much if any additional margin is required for cold start acquisition" for operation using the *lower* 10 MHz channel.[99] While LightSquared said it "is optimistic that this further analysis can be concluded in the next few weeks," such optimism is completely unfounded and not at all realistic. In the four weeks since the Recommendation Document's filing, Garmin and other GPS aviation representatives have heard nothing further from LightSquared on this point.[100] Moreover, the RTCA and Aviation Subgroup Reports were completed in what aviation representatives thought was "record" time –

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[97] TWG Report at 52.

[98] Recommendation Document at 25.

[99] *Id.* at 31. LightSquared's statement understates the extent of the recommended study. As noted above at page 33, the Aviation Subgroup Report pointed out a negative margin not only for "initial acquisition," which includes "cold start acquisition," but for many other situations as well.

[100] Despite the extensive resources that all the GPS Industry representatives have devoted to helping to solve LightSquared's problems over the last half year, it is unclear what role LightSquared envisions for these experts going forward. During the period that LightSquared is operating on the lower 10 MHz channel and waiting to bring the upper 10 MHz operations on line, LightSquared says it "will work with the FCC, NTIA, and other government agencies to explore all options for using a full complement of terrestrial frequencies at appropriate power levels needed to provide LTE capacity and service levels to the public." Recommendation Document at 5.

from early March (when FAA requested study) until June 3, in the case of RTCA, and from early March (when the first TWG meeting was held) until June 30, in the case of the Aviation Subgroup. As the time required to prepare these reports demonstrates, resolution of the initial acquisition issue involving LightSquared operation on a *lower* 10 MHz will require months and months, and more likely years, of study. With regard to resolving the more serious problems associated with use of the *upper* 10 MHz channel, any suggestion of a "standstill" of any duration but years simply ignores the science.

Third, RTCA's and the Aviation Subgroup's calls for further study on use of a lower 10 MHz channel, even at the proposed 32 dBW power, makes obvious that LightSquared's final proposed mitigation recommendation – that it be allowed to commence operation on the lower 10 MHz *now* – is a complete non-starter because of the problems it would entail for aviation use of GPS and the resulting danger to safety of flight. The Recommendation Document offers no ground for the FCC to proceed to authorize commencement of LightSquared's terrestrial broadband service in any form.

In the Recommendation Document, LightSquared claims that the actual testing shows that "all" the tested receivers performed at least 25 dB better than the FAA's minimum standard.[101] This is not correct. The data show the receivers that were studied exhibited 20+ dB of tracking margin between the 1 dB degradation in C/N_0 (carrier to noise ratio) and the FAA-specified satellite tracking interference limits.[102] This, however, does not represent all the results. Two of the same tested receivers failed to satisfy WAAS message-loss rate requirements

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[101] *Id.* at 3 & Technical Appendix at 16.

[102] TWG Report at 50. The carrier-to-noise ratio measures the ratio between the "desired" signal a receiver is trying to receive and process and the noise that the receiver detects from both background "thermal" noise and from unwanted, interfering signals.

at the 1 dB degradation in C/N_0.[103] The Aviation Subgroup Report concluded that a 1 dB degradation in C/N_0 "is unacceptable for the certified WAAS receivers."[104]

Neither LightSquared's criticisms nor the proposed changes to its own operations suggested in the Recommendation Document refute RTCA's and the Aviation Subgroup's conclusions that LightSquared's proposed terrestrial operations are completely incompatible with GPS use in aircraft, on anything but the lower 5 MHz channel. As shown below in Section VIII, LightSquared's remaining mitigation suggestion – adding more filters to GPS receivers – does not provide a practical or effective solution.

VII. The Report of the TWG General Location/Navigation Subgroup Also Reveals That Extensive Disruption of GPS Service Would Result from LightSquared's Terrestrial Network, and the Recommendation Document Does Nothing To Cure This Problem.

As was true for the TWG Aviation Subgroup, Garmin engineers took an active and good faith role in the work of the TWG General Location/Navigation Subgroup, and the results produced by this work showed equally serious problems with LightSquared's proposed operations. One of the Garmin engineers, as noted above, even devoted the extensive time necessary to be the "Lead" or chair of the General Location/Navigation Subgroup.

Initially, the General Location/Navigation Subgroup identified a wide range of GPS devices to be tested – in all, some 53 devices in 10 different categories ranging from outdoor to marine to fleet management.[105] Testing took place 16 hours a day at two Alcatel-Lucent/Bell

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[103] *Id.* at 41, 50. Lost WAAS messages mean diminished safety and reduced access to airports not served by commercial service. WAAS is essential for LPV – Localized Performance with Vertical guidance – approaches; it aids pilots by providing horizontal and vertical guidance that allows pilots to fly stabilized approaches to safe landings. In addition, LPV approaches facilitate better access to airports that are not served by the type of ground-based navigation aids that LightSquared claims can make up for any degradation in GPS performance. *See* discussion, *supra*, at nn.25-27.

[104] *Id.* at 45.

[105] *Id.* at 130-132.

Labs facilities ("Bell Labs") in New Jersey and Illinois from May 9, to June 3, 2011.[106] Bell Labs required manufacturers with devices being tested to be on-site throughout the process. Engineers from the companies, including Garmin, were present throughout the testing; LightSquared representatives were present for portions of the testing.[107]

Bell Labs conducted a series of static and dynamic tests, which evaluated performance when GPS devices were stationary and when they were moving. Unfortunately, given the large number of devices and the short amount of time available, some 29 – rather than 53 – devices were tested. At the beginning of the exercise, LightSquared had stated that deployment of its terrestrial broadband network would take place using an upper 5 MHz and a lower 5 MHz channel – 1526.3-1531.3 MHz and 1550.2-1555.2 MHz – and employing power levels of 32 dBW (1,585 watts) per channel per sector, well below its authorized power of 42 dBW (15,849 watts). At LightSquared's request, the General Location/Navigation tests were conducted using these parameters called "Phase 1" for purposes of this Subgroup. On May 17, 2011, LightSquared announced a change to a deployment utilizing a lower 10 MHz channel at the same 32 dBW power and requested testing at those parameters (dubbed "Phase 0B") by this Subgroup.[108] The late change, however, meant there was only time to perform a limited subset of tests at these new parameters. For instance, Bell Labs was not able to conduct dynamic tests on the lower 10 MHz channel for any devices. In fact, there is very little data in the TWG

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[106] *Id.* at 134. Originally, testing had been scheduled for two eight-hour shifts per day at a single lab. As the large scope of the test plan became apparent, a second laboratory was added.

[107] *Id.* at 134.

[108] *Id.* at Appendix G.1, p. 10, n.1.

General Location/Navigation Subgroup report overall regarding proposed use of the lower 10 MHz channel. Only an "Interference Susceptibility Test" was run for the lower 10 MHz channel configuration.[109]

From the numerous tests on the 29 devices that were completed, however, the GPS Industry representatives in the Subgroup saw a clear and consistent conclusion emerge: "all phases of the LightSquared deployment plan will result in widespread harmful interference to GPS signals and service and . . . mitigation is not possible."[110] Even for use of only a lower 10 MHz channel, the General Location/Navigation Subgroup determined that 20 of the 29 tested devices would experience harmful interference.[111]

In the Recommendation Document, LightSquared offers a very different picture of the results, particularly those regarding its proposed operation on the lower 10 MHz channel. LightSquared claims that "well over 99 percent, including 100 percent of GPS-enabled mobile phones and general location and navigation devices, can be expected to experience no meaningful interference from LightSquared operations in the lower 10 MHz channel."[112] Most surprising is LightSquared's assertion that "[t]he results from static *and dynamic tests* show that none of the devices experienced harmful interference from LightSquared's lower 10 MHz channel,"[113] since absolutely no dynamic tests at all were performed on General Location/Navigation devices based on use of that lower channel.

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[109] *Id.* at Appendix G.3 (GPS Industry Perspective).

[110] *Id.* at 18, 122 (GPS Industry Perspective).

[111] *Id.* at 19, 123 (GPS Industry Perspective).

[112] Recommendation Document at 10. Later in the same document, LightSquared makes a similarly sweeping claim that "practically all mobile phones and personal navigation devices can be expected to function without any appreciable impact from the planned LightSquared terrestrial development in the lower 10 MHz." *Id.* at 27.

[113] *Id.* at 29 (emphasis supplied).

The only way LightSquared can make these broad and sweeping claims of "no interference" is by abandoning a conventional and supportable interference metric in favor of a *post hoc* measure it constructs, post-testing, to rationalize the data and by relying upon an unrealistic propagation model. The GPS Industry and LightSquared representatives on the General Location/Navigation Subgroup agreed that an appropriate starting point in defining harmful interference is the FCC's definition as "interference which endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radio communication service operating in accordance with [the ITU] Radio Regulations."[114]

Beyond that, however, there was no agreement. The GPS Industry representatives on the General Location/Navigation Subgroup adopted the definition of a 1 Decibel – or 1 dB – degradation in the carrier-to-noise ratio (C/N_0) of the received GPS signal.[115] Such a 1 dB degradation is equivalent to a twenty percent reduction in the effective received signal power in the GPS receiver. Degradation to GPS performance may occur, however, well before the point at which twenty percent of signal power is lost. Indeed, as other agencies of the federal government have recognized, even the 1 dB degradation point "is not necessarily a tolerable level of degradation from LightSquared emissions but is useful to highlight the onset of severity associated with these emissions. For example, some tested aviation receivers could not meet

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[114] TWG Report at 129 (GPS Industry Perspective), 130 (LightSquared Perspective) (citing 47 C.F.R. § 2.1: No. 1.169 of the ITU Radio Regulations).

[115] TWG Report at 129 (GPS Industry Perspective). As noted in the last section of these Comments, the carrier-to-noise ratio measures the ratio between the "desired" signal a receiver is trying to receive and process and the noise that the receiver detects from both background "thermal" noise and from unwanted, interfering signals.

their WAAS word error rate requirements in the presence of LightSquared interference that caused a 1 dB degradation in C/N_0."[116]

The use of 1 dB reduction in effective C/N_0 as a quantification of harmful interference to GPS has a well recognized basis in the results from seven years of technical work on protection of radionavigation satellite receivers, which are now pending final approval with the ITU's Radiocommunication Sector. Such internationally recognized protection levels for various types of receivers, like GPS devices, that operate with RNSS systems in the 1559-1610 MHz band are based on a maximum permissible increase in the noise floor from interferers of 1 dB.[117]

Applying this 1 dB standard, the Interference Susceptibility Tests – or degradation of C/N_0 – that were performed by the General Location/Navigation Subgroup showed severe jamming of GPS, even in the lower 10 MHz configuration. Figure 4 below shows the distance (in meters) from the LightSquared transmitter tower at which a General Location/Navigation device suffered harmful interference for operation on a lower 10 MHz channel:

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[116] NPEF Report, Task 5, p. 4.

[117] TWG Report at 129. *See* Draft New Recommendation ITU-R.[1477_New].

The 1 dB measure also has precedent in the domestic regulatory context. Over eight years ago, the FCC adopted a model based on a 1 dB increase in the noise floor of the GPS receiver – that is, a 1 dB reduction in C/N_0 – in evaluating the appropriate interference criteria to protect GPS from ultra-wideband transmissions. *Revision of Part 15 of the Commission's Rules Regarding Ultra-Wideband Transmission Systems*, Memorandum Opinion & Order and Further Notice of Proposed Rule Making, 18 FCC Rcd 3857, 3863 (2003). In that decision, the FCC deemed the approach "conservative."

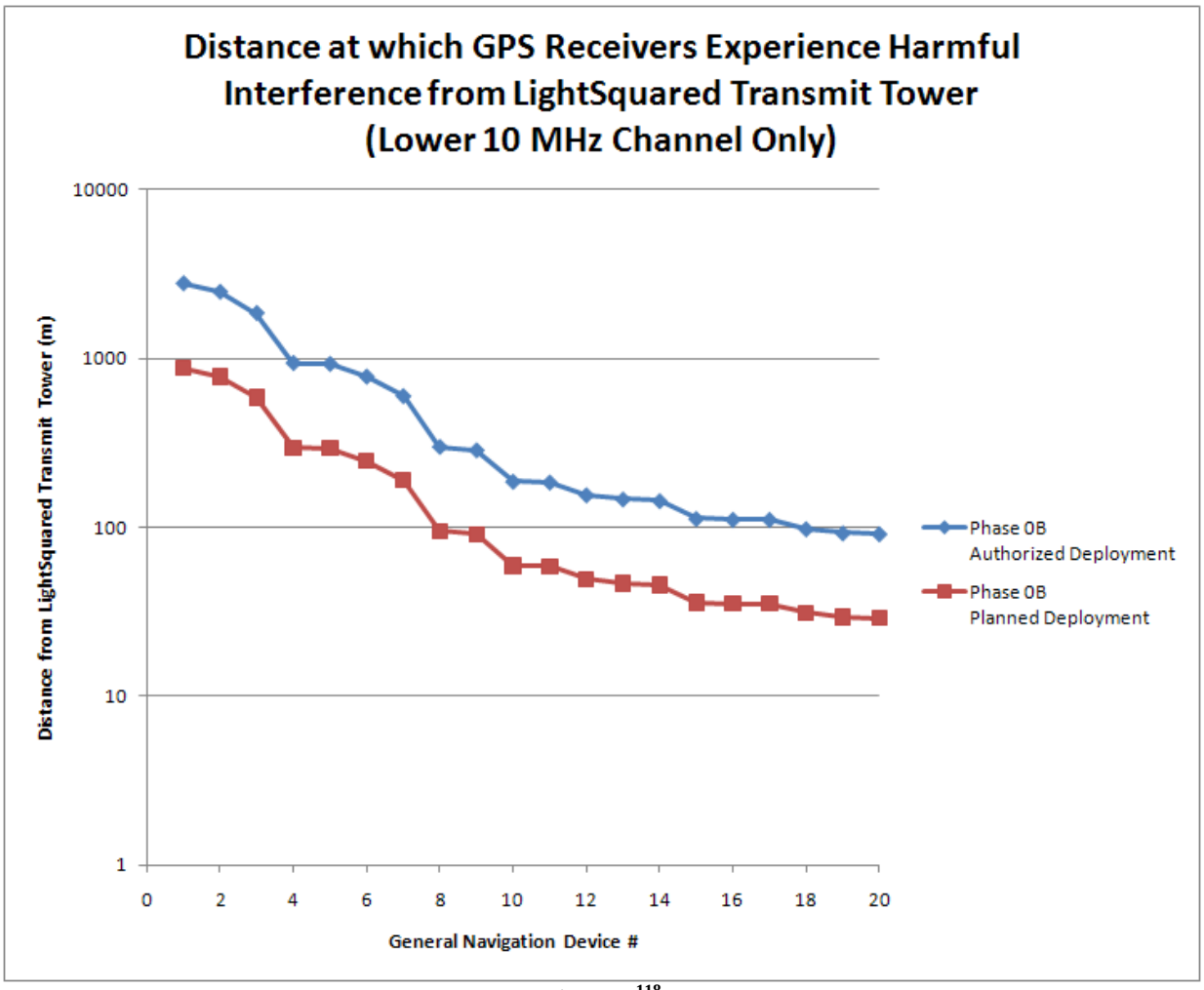

Figure 4[118]

The upper line represents deployment on such channel at LightSquared's FCC authorized power of 42 dBW, the lower line deployment on such channel at 32 dBW, the level LightSquared specified for the conduct of the tests. As even the lower line – operation at reduced power – demonstrates, devices are jammed at distances up to 1 km from the transmission tower. The devices shown in this plot represent the 20 of 29 devices tested that experienced such jamming from operation of the LightSquared transmitters on a 10 MHz lower channel.[119]

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[118] TWG Report, Appendix G.3 (GPS Industry Perspective).

[119] As the GPS Industry representatives explained in the TWG Report, the real world implications posed by the distances at which jamming occurred became apparent during the Las Vegas "live sky" testing. There, observers noted that a fire station tower was located only

Figure 5 below shows the distances at which jamming occurred under the LightSquared deployments that involved an upper 5 or 10 MHz channel or combinations thereof:

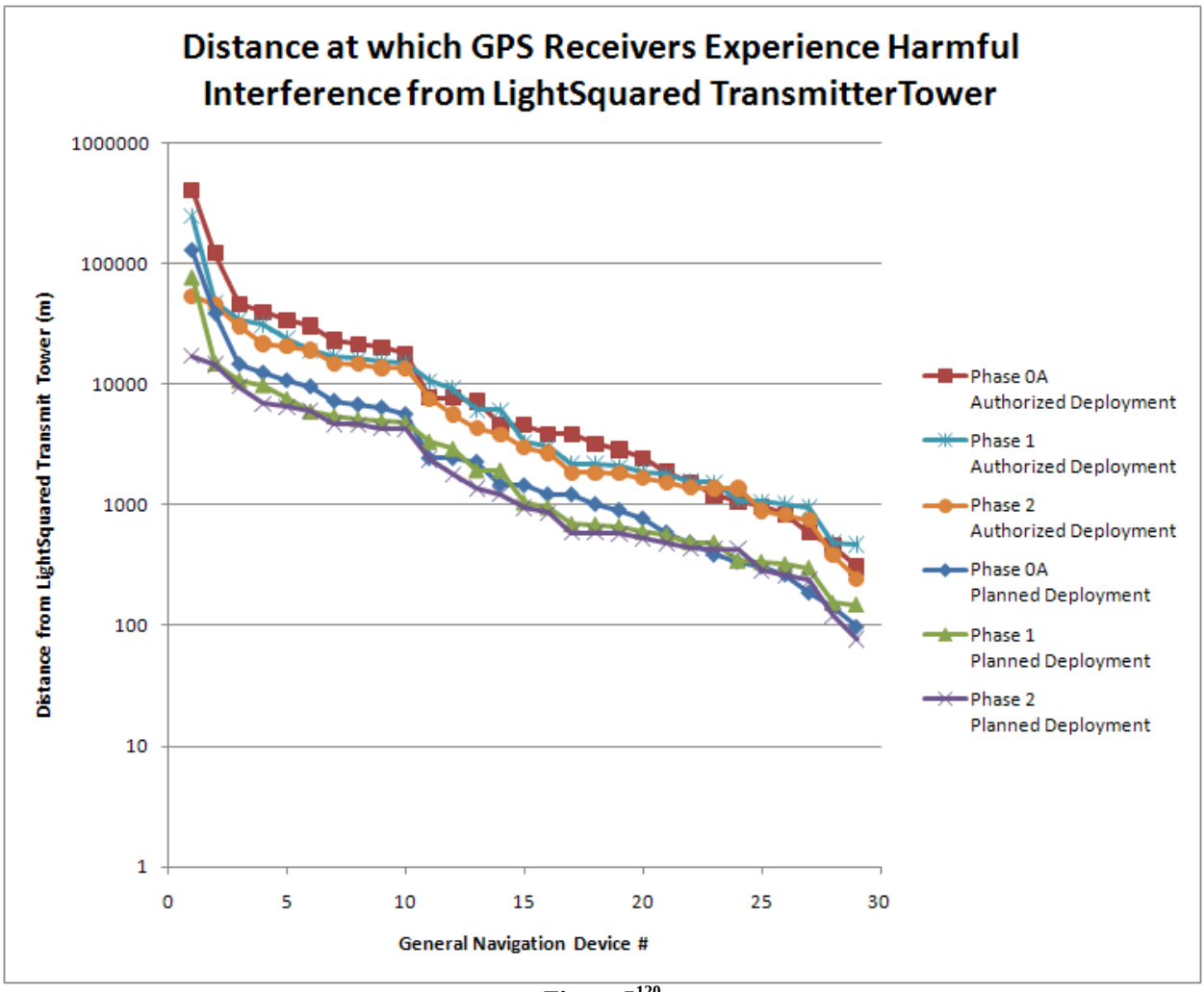

Figure 5[120]

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50 meters from the station itself, and rescue vehicles and fire trucks passed within just a few meters of the tower in the parking lot. *Id*. Similarly, LightSquared towers in Las Vegas were located just 30 meters from the side of a prominent road. *Id.* Both of these distances are sufficiently small that jamming of GPS receivers in the public safety vehicles or in cars passing on the highway would be expected.

[120] TWG Report at Figure 3.3.6 (GPS Industry Perspective). "Phase 0A" envisions use of a single upper 5 MHz channel; "Phase 1" would utilize an upper and a lower 5 MHz channel, and "Phase 2" would represent an upper and a lower 10 MHz channel. "Authorized Deployment" is at 42 dBW; "Planned Deployment" is at 32 dBW. Analysis of the test results allows predictions of results at additional parameters, even if not specifically tested.

Based on this chart, jamming would occur for about half the devices at over 1 kilometer from a base station transmitter, even at the lower power represented by the lines labeled "Planned Deployment."

LightSquared bases its own Panglossian interpretation of the results of the General Location/Navigation Subgroup testing on an interference criteria of 6 dB degradation and use of a probalistic propagation model.[121] The 6 dB standard that LightSquared suggests represents a full seventy-five percent degradation in the C/N_0 ratio, yet LightSquared provides no citation from accepted technical literature or engineering texts for its novel approach. Even at LightSquared's suggested threshold of 6 dB degradation in the C/N_0 ratio, however, the test results show that harmful desensitization of GPS occurs with respect to a number of key performance indicators. First, as illustrated by the 6 dB "Interference Level" line in Figure 6 below, there was a complete denial of service of WAAS TTFF for all five WAAS-enabled devices being tested – five out of five.

WAAS TTFF Analysis		
Interference Level	**Harmful Interference Observed**	**No Fix Within Five Minutes One or More Trials**
1 dB	1/5	1/5
3 dB	3/5	2/5
6 dB	5/5	5/5
10 dB	5/5	5/5

Figure 6[122]

This means that WAAS service, which many users utilize to improve positional accuracy, would be completely unavailable at all times for GPS receivers experiencing 6 dB of harmful interference from LightSquared transmissions in the upper or lower 10 MHz bands. Second, at the same 6 dB measure, as Figure 7 below shows, tests revealed that 6 of 25 devices being tested

[121] *Id.* at 153-57, 165-66 (LightSquared Perspective).

[122] *Id.* at Table 3.3.4 (GPS Industry Perspective).

could establish no fix within three minutes in one or more trials of the Cold Start TTFF Analysis, and 11 of 25 experienced more than a thirty-second delay in acquiring a signal.[123]

Cold Start TTFF Analysis		
Interference Level	**Harmful Interference Observed**	**No Fix Within Three Minutes One or More Trials**
1 dB	0/25	0/25
3 dB	5/25	2/25
6 dB	11/25	6/25
10 dB	23/25	15/25
20 dB	25/25	25/25

Figure 7[124]

Third, as shown by the two blanks in the 6 dB column of Figure 8 below, two of 24 devices under test failed to acquire GPS signals at all even when using LightSquared's 6 dB of C/N_0 degradation standard in the Acquisition Sensitivity test:

Acquisition Sensitivity with Static Susceptibility C/N_0 Degradation Level						
Receiver #	**Baseline**	**1 dB**	**3 dB**	**6 dB**	**10 dB**	**20 dB**
G18062	-146.5	-145.5	-141.5	-137.5	-132.5	
G10607	-132.5	-130.5	-129.5			
G18161	-144.5	-142.5	-141.5	-134.5	-131.5	
G14298	-139.6	-137.6	-135.6	-129.6		
G16382	-143.5	-143.5	-138.5	-135.5	-131.5	NO FIX
P18892	-143.5	-139.5	-137.5	-130.5		
G14666	-143.5	-139.5	-136.5	-132.5	NO FIX	NO FIX
P14949	-139.5	-137.5	-135.5	-132.5	-128.5	
G16382	-138.5	-137.5	-132.5	-131.5		
G16534	-147.5	-145.5	-143.5	-140.5	-135.5	NO FIX
G11207	-132.6	-132.6	-128.6			
P17655	-138.5	-137.5	-134.5	-132.5	-128.5	
G17783	-153.5	-151.5	-148.5	-144.5	-141.5	NO FIX
G15343	-145.5	-143.5	-140.5	-137.5	-133.5	
P13275	-149.5	-148.5	-137.5	-130.5		
G18696	-139.5	-139.5	-137.5	-133.5	-129.5	

[123] *Id.* at 145-46 (GPS Industry Perspective). TTFF is the "Time to First Fix" and describes the time it takes for a GPS receiver to compute its location from startup based on signals received from the GPS satellites. A "Cold Start" implies that the GPS receiver does not know its current location or time, and it does not know any of the information broadcast by the satellites necessary to compute its location—in colloquial terms, it is starting from scratch.

[124] *Id.* at Table 3.3.2 (GPS Industry Perspective).

Acquisition Sensitivity with Static Susceptibility C/N_0 Degradation Level						
Receiver #	**Baseline**	**1 dB**	**3 dB**	**6 dB**	**10 dB**	**20 dB**
G15028	-137.6	-136.6	-134.6	-131.6	-128.6	
G16449	-139.5	-138.5	-135.5	-132.5	-129.5	NO FIX
G12867	-146.5	-144.5	-139.5	-136.5	-133.5	NO FIX
G13445	-139.6	-139.6	-138.6	-132.6	-130.6	
G12586	-144.6	-143.6	-140.6	-137.6	-133.6	
G17641	-138.6	-136.6	-134.6	-131.6		
G10968	-140.6	-140.6	-136.6	-132.6		
G15448	-143.6	-142.6	-138.6	-133.6	-127.6	NO FIX

Figure 8[125]

All of these tests clearly demonstrate that LightSquared's proposed definition of "harmful interference" as a 6 dB of degradation in C/N_0 ignores clear and convincing evidence that harmful interference is actually experienced at a level of 1 dB. Furthermore, there is absolutely no evidence to support the LightSquared assertion that 100 percent of GLN devices experienced no problem with LightSquared's use of a lower 10 MHz channel.

LightSquared also tries to invalidate the General Location/Navigation Subgroup's demonstration of substantial interference, even for LightSquared's operation only on a lower 10 MHz channel, by claiming that the GPS Industry representatives improperly used a free-space propagation model in their analyses, rather than LightSquared's preferred "probalistic" interference analyses.[126] LightSquared contends that the free-space propagation model "radically overstates the probability of interference."[127] The models LightSquared posits, however, are drawn from the cellular industry, where they are used for cellular link-budget analysis to

[125] *Id.* at Table 3.3.1 (GPS Industry Perspective). Acquisition Sensitivity measures the lowest GPS signal level (signal strength) at which a GPS receiver can operate and successfully compute its position. As Figure 8 shows, increased amounts of interference require a stronger GPS signal; otherwise, the receiver cannot determine its location.

[126] *Id.* at 125, 153-56 (LightSquared Perspective).

[127] *Id.* at 153 (LightSquared Perspective).

determine the probability of dropped calls. Such an approach is totally inappropriate when accuracy of GPS and all the attendant safety concerns are at issue. With GPS and its essential safety-of-life role, users need a guarantee that their receivers will function as expected, whenever and wherever they need them.[128] These safety-of-life features require reliability and an interference-free environment, both of which are only ensured by the already established, accepted, and well recognized standards employed in the GPS Industry representatives' analytic approach.

From the test results, it is obvious that the three recommendations LightSquared puts forward in its Recommendation Document – operation at a lower power of 32 dBW per sector per carrier, a "standstill" of as short as six months in deployment on the *upper* 10 MHz channel, and initial operations only on a lower 10 MHz channel – offer absolutely no effective mitigation that would permit its proposed operation to proceed without disastrous results for General Location/Navigation GPS devices. As noted above, the General Location/Navigation Subgroup was able to accommodate in its Interference Susceptibility tests LightSquared's tardy request that operations on the *lower* 10 MHz be tested. As the plots in Figure 4 show, operation at reduced power of 32 dBW per sector per carrier even on the lower 10 MHz channel would cause 20 of 29 GPS devices (nearly 70 percent) to suffer harmful interference. The proposed lower power and initial deployment on the lower channel are not mitigating solutions. Similarly, the results of the tests set forth in Figure 5, which also included analysis at the same reduced power, showed harmful interference would occur on all studied channels if LightSquared were to operate on the upper and lower 10 MHz channels, as it implies, as soon as its self-enforced "standstill" ends.

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[128] Dropping a call is one thing; losing an ambulance or the location of a "man down" is another. *See* Letter from New Mexico first responder, attached as Appendix D.

The FCC must also consider the potential interference to GPS receivers not just from LightSquared's base stations, but also from LightSquared handsets. Despite the absence of prototypes available for testing, simulated handset interference analyses show service degradation at distances of over one meter from a LightSquared handset. Figure 9 below shows the interference from a single LightSquared handset:

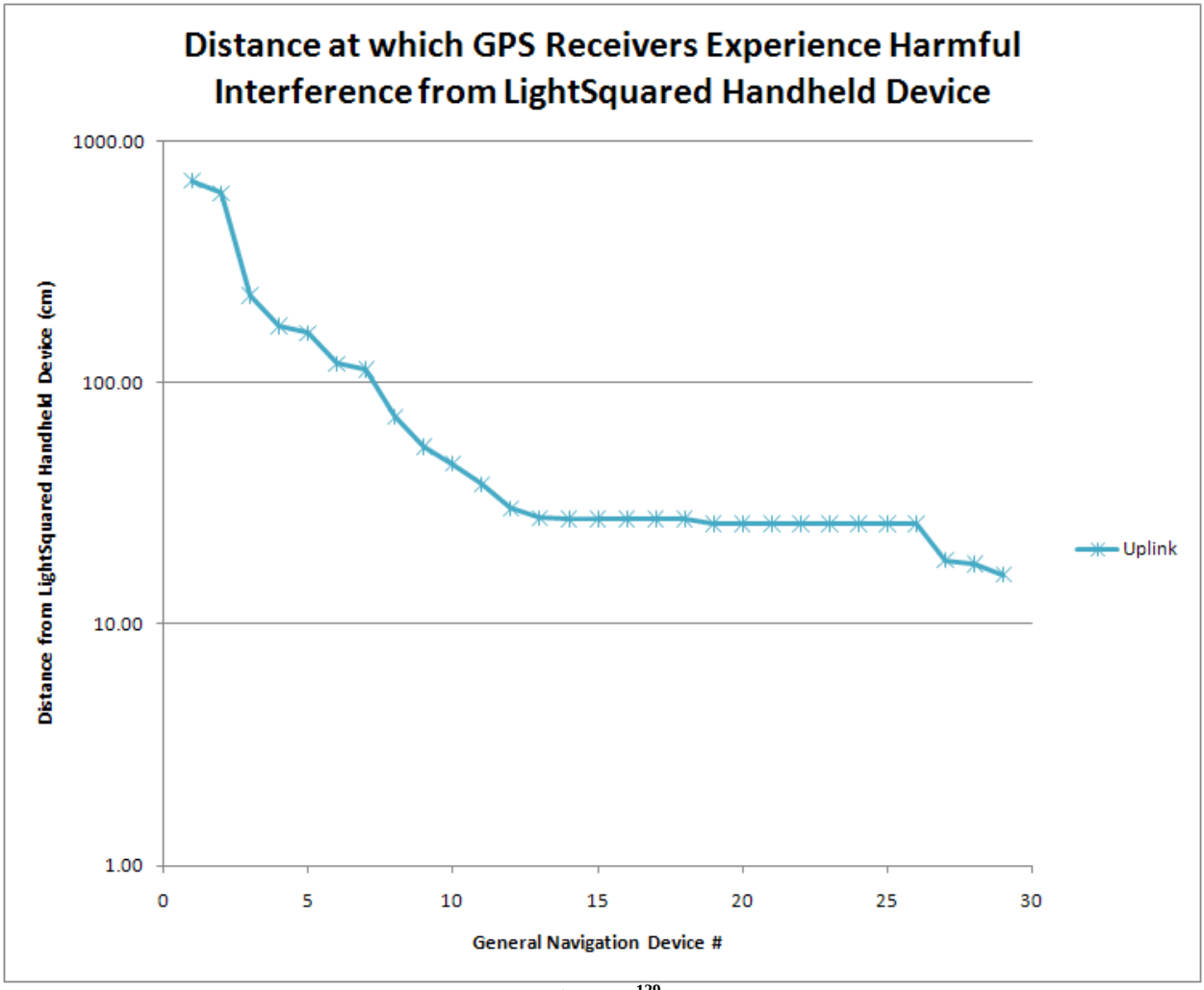

Figure 9[129]

These results mean that GPS receivers located in close proximity to a LightSquared handset – such as in the same vehicle, aircraft, or even in a person's hand or pocket – will experience

[129] TWG Report at Figure 3.3.8 (GPS Industry Perspective).

harmful interference from LightSquared handheld devices. It is certainly possible that, if the expansive need LightSquared describes for its service materializes, there frequently could be multiple handsets in close proximity to each other – say, two passengers in a car or aircraft each with LightSquared handsets. No analysis was done by the General Location/Navigation Subgroup to study the increased potential in interference from a scenario involving multiple LightSquared handsets. If LightSquared is permitted to proceed *now*, as it would like, with operation on a lower 10 MHz channel, that approach guarantees use of the handset (or uplink) frequencies closest to those used by GPS, raising additional serious concerns that have not been studied.[130]

In short, the General Location/Navigation Subgroup's test results showed disruption to the availability and accuracy of GPS signals under many scenarios, including those proposed in the Recommendation Document. The potential interference, even under these proposals, is sufficiently likely – nearly seventy percent of all GPS devices affected – that interim operation even under these latest parameters should not be allowed to proceed. As shown below in the next section, LightSquared's remaining mitigation suggestion – adding more filters to GPS receivers – does not represent a practical or effective solution.

VIII. LightSquared's Suggestion of Additional Filters for GPS Receivers Is an Impractical Solution That Does Not Resolve the Problems That Would Arise from Its Initiation of Service as Proposed in the Recommendation Document.

Rather than simply attempting to adjust its own proposed parameters to address the potential harmful interference its service is likely to cause, LightSquared has also stated that the GPS industry needs to redesign its devices to accommodate LightSquared's problems –

[130] TWG Report at Appendix O.1, 3-4 (identifying 1627.5-1637.5 MHz as handset uplink frequencies for lower 10 MHz downlink deployment). *See also* NPEF Report at ii (Recommendation 2), 12 (same) (calling for further study of potential interference to GPS from LightSquared handsets).

principally through additional filters to protect GPS receivers from LightSquared's transmissions.[131] Both the Aviation and General Location/Navigation Subgroups investigated the availability of filters for their respective types of devices. In each case, the conclusion was virtually the same: there are no filters in existence that would protect either aviation or general location/navigation GPS receivers from LightSquared's proposed transmissions. Since no filters exist – not even prototypes – neither subgroup was able actually to test this mitigation proposal. Both the Aviation Subgroup and the GPS Industry representatives on the General Location/Navigation Subgroup concluded that the concept of mitigation through filters cannot be supported at this time and that significant obstacles exist for filtering to ever be realized as a viable mitigation strategy.

As filter proposals surface, it is important to evaluate them in light of the specific performance characteristics that need to be maintained for each GPS device as well as the practical constraints and limitations of introducing filters. The stringent requirements, such as those from the FAA, imposed on products installed in aircraft present special challenges for designing filters for aviation GPS receivers; any filtering proposal for such devices would need to meet these requirements for both new aircraft designs and for retrofitting the large installed user base.[132] Similarly as GPS Industry representatives on the General Location/Navigation Subgroup noted, GPS devices have an installed user base of over one billion devices worldwide; any filtering mitigation proposal for existing handheld devices needs to consider the difficulty of retrofitting these devices, which are not "user-serviceable" or capable of even being

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[131] *See*, *e.g.*, Recommendation Document at 18, 19, 26, 31.

[132] TWG Report at 53. At one point in the Recommendation Document, LightSquared suggests "additional analysis needs to be done by the FAA with respect to airborne receiver standards." Recommendation Document at 10. Garmin questions LightSquared's qualifications for suggesting improvements in the FAA's work.

retrofitted.[133] Many, if not most, of the general location/navigation devices are in the hands of consumers and are effectively beyond the reach of the companies that have sold them.

To achieve the high level of rejection required to eliminate the high powered LightSquared transmissions from a GPS receiver, any potential filter must necessarily reject some of the GPS signal as well. The challenge comes in designing filters that would be sufficiently selective to reject LightSquared signals in the band adjacent to GPS frequencies while at the same time preserving their ability to receive GPS signals. Improving signal rejection can also come at the cost of other performance requirements that are critical to the operation of the GPS receiver. Aviation receivers have the added challenge of needing to be able to withstand extreme temperature variations, endure the rigors of intense vibration, survive electrostatic discharge and lightning events, and meet strict size and weight limitations.

LightSquared has stated that there are companies willing to build filters that would meet these various constraints.[134] The Aviation Subgroup only received one proposal for a filter suitable for use in aircraft, and that proposal was analyzed and found unsuitable and infeasible, as noted in the TWG Final Report.[135] The proposal was comprised of two independent aspects. First, the proposal suggested the use of an in-line cavity filter. The insertion loss of this cavity filter was much too large for use as an antenna preselect filter, and it did not provide sufficient protection against 3rd order intermodulation when installed in-line after the antenna module. In addition, the size and weight of the cavity filter presented serious challenges for airframe certification. Second, this proposal suggested an unconventional antenna module with an up-conversion approach to reduce the filter size. This approach required converting GPS signals to

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[133] *Id.* at 177 (GPS Industry Perspective).

[134] *Id.* at 53, 179.

[135] *Id.* at 53.

another frequency, filtering them, and then converting them back to the GPS frequency. This proposal would significantly increase the complexity of the antenna design with an unconventional approach that may not be well suited to the stringent operational requirements described above. It also would fail to address the 3rd order intermodulation concerns. In addition, it would draw significantly more power than conventional aviation antenna modules and would, therefore, require a re-design and re-certification of the GPS receiver in addition to the antenna. The Aviation Subgroup found that this proposal was complex, power intensive, and still failed to achieve the level of pre-selection improvement necessary to eliminate interference from LightSquared.[136]

The General Location/Navigation Subgroup evaluated proposals for three filters LightSquared suggested for use with general location/navigation receivers that might be manufactured in the future.[137] As the GPS Industry representatives noted in the TWG Final Report, none of the "proposed filter simulations yield[ed] sufficient rejection to protect against" interference from LightSquared.[138]

Despite LightSquared's claims to the contrary, the filters that would be needed to protect GPS against the harmful interference that would be caused by LightSquared's proposed operations simply do not exist. There are no commercially available parts that will work. LightSquared has yet to produce a prototype that passes even initial review – only the PowerPoints appended to the TWG Report.[139]

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[136] *Id.*

[137] *Id.* at 178 (GPS Industry Perspective).

[138] *Id.*

[139] *Id.* at Appendices A.3, G.4, and G.5.

The PowerPoint proposals that have surfaced reject a large portion of the GPS signal in order to attenuate LightSquared's powerful signal sufficiently. Meanwhile, LightSquared continues to make claims that GPS receivers look into its spectrum.[140] Essentially, LightSquared is proposing that the GPS community include additional filtering in GPS receivers to restrict their use to only a fraction of the frequency band allocated to GPS. These proposed filters actually filter out much of the desired GPS signals. This is hardly an acceptable compromise.

Even if a suitable filter could be developed, the one hundred million general location/navigation GPS devices in the U.S. that cannot be retrofitted would become obsolete in the face of LightSquared interference. For aviation GPS receivers, whether existing or future models, it would take many years to obtain all of the necessary certifications and approvals to install filters if they could even be designed.[141] Furthermore, the task of retrofitting the entire fleet of GPS-enabled aircraft in the United States would take years.[142] Aircraft from other countries flying to U.S. destinations would also need to be retrofitted. Equally important, there is no one-size-fits-all solution to this problem, so numerous different filters would be required to meet the needs of the large array of aviation GPS receivers.

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[140] *E.g.*, Recommendation Document at 18.

[141] Joint Planning and Development Office, NextGen Avionics Roadmap, Version 1.2, September 21, 2010) at 3 (under heading "System Safety – Avionics Constraints: *Historical* Communication Navigation and Surveillance (CNS) Lead-Times" states "it is important to highlight that many past efforts involving avionics system upgrades have spanned long periods (15-25 years with an average of 18 Years - as shown in the figure below)"), *available at* http://www.jpdo.gov/library/20101008_ARM_v_1.2.pdf.

[142] For example, the FAA's ADS–B Out Performance Requirements to Support Air Traffic Control Service Discussion of the Final Rule, Section II.N.1 includes the following statement: "[a]fter reviewing all the comments, the FAA finds that a 2020 compliance date remains appropriate because [National Airspace System ("NAS")] . . . users need time to equip to the requirements of the rule." Automatic Dependent Surveillance – Broadcast (ADS-B) Out Performance Requirements to Support Air Traffic Control (ATC) Service, 75 Fed. Reg. 30176 (May 28, 2010).

As the Aviation Subgroup Report and the GPS Industry representatives to the General Location/Navigation Subgroup recognized, the many obstacles to filter-based mitigations that exist make a filtering proposal not only completely impractical but totally unavailable. Garmin's own experience supports this conclusion. In summary, these obstacles are as follows:

Technical obstacles:

1. Appropriate filters do not exist. All discussions in the FCC-mandated TWG process focused on proposals derived from simulations set forth in PowerPoint presentations.
2. Proposed filters reject portions of the GPS signal in addition to the LightSquared signal.
3. The physics of filter design make it virtually impossible to reject a signal four billion times stronger than and closely proximate to the very weak GPS signal without harming the GPS signal to some degree.
4. The proposed filters are considerably larger than existing ones, making any retrofitting of existing receivers virtually impossible.
5. Many portable units would have to be scrapped because the antenna and filter are integral to the unit.
6. The proposed filters do not address 3rd order intermodulation issues.
7. Proposed aviation filters would require a different power design than presently exists, requiring new receiver designs to power the filter and antenna.
8. It is impossible to design one filter that will address all of the diverse requirements of the existing GPS user base.

Cost and time obstacles:

1. The time and expense of developing numerous filters to meet the needs of a very wide variety of different receivers, whether for aviation, general location/navigation, or other uses.
2. The impossibility of retrofitting the hundreds of millions of general location/navigation devices that are already in the hands of purchasers in the United States.
3. For aviation, the time required to obtain necessary certifications and approvals.
4. The time, expense, and feasibility of retrofitting the entire fleet of aircraft in the U.S. and aircraft flying here from other nations.
5. The loss of revenue and impact on jobs while aircraft are out of service for the installation and retrofit.
6. The difficulty in determining who would be responsible for funding the extensive development and retrofit costs when the changes offer no improved benefit or greater operational capabilities.

The GPS Industry has cooperated in good faith in assessing the many changing proposals LightSquared has put forward for its own proposed operations. The GPS Industry has also devoted extensive time to analyzing whether LightSquared's suggestions of additional filters for GPS devices bear any technical promise whatsoever. Again, both science and practical considerations show that they do not.

IX. Conclusion

Garmin's experience based on its participation in the GPS industry's review of LightSquared's operations over the past half year confirms what its testing it first conducted in January 2011 showed: operation of LightSquared's proposed broadband terrestrial network will cause catastrophic harm to GPS service, and this potential harm cannot be mitigated in any practical manner. Garmin and numerous other companies have cooperated in good faith to evaluate these concerns, spending millions of dollars that should have been more productively directed toward increasing jobs and advancing their own business goals and objectives. At this point, the FCC should put an end to this exercise.

For the foregoing reasons, Garmin requests that the Commission rescind LightSquared's conditional waiver and commence a rulemaking to consider modification of the rules allowing ATC operation in frequencies adjacent to GPS.

Respectfully submitted,

GARMIN INTERNATIONAL, INC.

By _____

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of
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Its Attorneys

August 1, 2011

APPENDIX A

EUROPEAN COMMISSION
DIRECTORATE GENERAL FOR ENTERPRISE AND INDUSTRY

Director general

Brussels, 19. 07. 2011
ENTR/GP1/PF/DH/ses ARES (2011) 800745

Mr Julius Genachowski
Chairman
Federal Communications Commission
445 12th Street, SW
Washington, DC, 20554
United States of America

Dear Mr Genachowski,

I am writing to express our deep concerns about the LightSquared system that is proposed for operation in frequencies immediately below the radionavigation-satellite service (RNSS) allocation at 1559-1610MHz. This band is the core band used by global satellite navigation systems including GPS and you are no doubt aware that Europe is at the advanced planning stage for its own system, Galileo, which will be operational by 2014/15, and that will also use this RNSS allocation.

The band immediately below 1559MHz, allocated by the Radio Regulations to the mobile-satellite service (MSS), has been used for satellite based transmissions for many years and has proved to be broadly compatible with RNSS systems above 1559MHz. The LightSquared proposal for a terrestrial network deployment in MSS spectrum would completely change the nature of radio transmissions in the band. What are now neighbour MSS transmissions at similar receive power levels to RNSS would in future be many orders of magnitude higher and with the potential to severely disrupt reception of RNSS signals.

Analysis carried out in Europe, including by our own technical partner the European Space Agency, has shown that transmissions from LightSquared base-stations do indeed have considerable potential to cause harmful interference to Galileo receivers operating in the United States. Interference effects have been determined to occur in the range 100m to almost 1000km, depending on the type of receiver being used. This obviously presents a grave threat to the viability of providing a Galileo service covering US territory – a service which many studies have shown will not only benefit Galileo users, but those of GPS too as the two systems will be interoperable through a common signal design providing significantly improved coverage and accuracy in urban environments.

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The European Commission is also concerned about potential impacts to safety critical aviation applications. Europe is covered by the EGNOS system, which is equivalent and interoperable with the US WAAS, and so it is vital that EGNOS/WAAS receivers fitted to aircraft entering US airspace do not suffer degradation to the availability and reception of their navigation signals.

The Galileo system will also contribute to the global COSPAS-SARSAT system through the MEOSAR programme and includes a dedicated space-to-Earth link in the band 1544-1545MHz acting as a return channel to distress beacons, in accordance with Article 31 of the Radio Regulations. Intended for the maritime and aviation sector the possibility of disruption to this safety related application within US territory should not be ignored.
Whilst recognising that the rules governing worldwide radio usage, enshrined in the ITU Constitution and the Radio Regulations, allow the USA freedom to decide on spectrum matters within its own territory, Article 4 of the Radio Regulations makes it clear that ITU Members States are expected not to cause harmful interference to systems of another country that operate in accordance with the Radio Regulations.

We are confident that the process put in place by the FCC to deal with internal US concerns about the threat to GPS reception will reach appropriate conclusions and that these will take into account our own concerns about reception of Galileo signals. However, the receivers may not have identical characteristics and therefore we would be grateful that Galileo and EGNOS receivers will also be taken into account within the FCC's decision making process, thus giving us sufficient assurance that users will be able to receive Galileo and WAAS signals in US territory without risk of harmful interference.

Yours sincerely,

Heinz Zourek

APPENDIX B

IATA

Giovanni Bisignani
Director General & CEO

5 June 2011

The Honorable Julius Genachowski
Chairman
Federal Communications Commission
445 12th Street, SW
Washington, D.C. 20554
United States of America

Dear Mr. Chairman:

On behalf of the 230 member airlines of the International Air Transport Association (IATA), I am writing to express our strong opposition to the waiver of the "integrated service" rule granted to LightSquared Subsidiary LLC (LightSquared) for its Mobile Satellite Service license in the L Band.

Specifically, we are concerned that interference from the proposed LightSquared system will impact Global Positioning System (GPS) frequencies, which are used by airline operations around the world for critical navigation, communication, and surveillance services that are essential for aviation safety.

We are particularly alarmed that interference to GPS signals will directly impact the U.S. Next Generation Air Transportation System (NextGen), an air traffic modernization effort strongly endorsed by the Obama Administration, which uses the GPS as the basis of its technology.

IATA is a strong proponent of NextGen and endorses its implementation to improve safety, increase efficiency, and reduce aviation's environmental footprint. We urge the Commission to take all necessary steps to ensure that GPS service provision is not compromised in any way by the LightSquared system.

Sincerely,

International Air Transport Association

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APPENDIX C

International Civil Aviation Organization | Organisation de l'aviation civile internationale | Organización de Aviación Civil Internacional | Международная организация гражданской авиации | منظمة الطيران المدني الدولي | 国际民用航空组织

Ref: AN 7/5 – CNS41541

13 June 2011

Mr. Julius Genachowski
Chairman
Federal Communications Commission (FCC)
445 12th Street, SW
Washington, DC 20554
United States

Dear Mr. Genachowski,

We are writing to you about an issue of grave concern to the international civil aviation community, in connection with Federal Communications Commission (FCC) Order and Authorization DA 11-133, adopted on 26 January 2011.

As you are aware, the Order granted LightSquared Subsidiary LLC a conditional waiver of FCC rules, enabling the company to use terrestrial-only devices in a band adjacent to that in which the global positioning system (GPS) operates.

Subsequent to the Order being issued, studies have shown that LightSquared transmissions would have a dramatic impact on aviation GPS receivers. Specifically, the conclusion reached by an authoritative aviation industry body (RTCA, Inc.), after an exhaustive technical investigation, is that the proposed LightSquared operation would be incompatible with the current aviation use of GPS.

The safety and efficiency of aviation operations today are already, to a substantial extent, reliant on the invaluable position, navigation and timing service provided by GPS. Ongoing aviation developments, such as those being undertaken in the framework of United States NextGen programme and the European SESAR programme, will place even more emphasis on the central role of GPS and other satellite navigation systems in aviation operations.

Therefore, the potential disruption to aviation use of GPS caused by the LightSquared system would have a far-reaching impact on current and future aviation operations. The impact would not only be limited to the United States. The international aircraft fleet flying into the United States would be directly affected and also similar developments could arise elsewhere and propagate the disruption beyond their borders.

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In September 2007, the United States Government reaffirmed its commitment to provide the GPS Standard Positioning Service (SPS) for aviation throughout the world.

This commitment, first expressed in 1994, was the foundation for the development of key GPS aircraft navigation applications, based on ICAO international standards and procedures, which today support safer and more efficient aviation operations worldwide.

We urge you to ensure that this vital commitment is not unintentionally jeopardized by the introduction of the LightSquared system and the ensuing impact on GPS use by aviation.

Yours sincerely,

Roberto Kobeh González
President of the Council

Raymond Benjamin
Secretary General

cc: Mr. Raymond H. LaHood
United States Secretary of Transportation
U.S. Department of Transportation

Mr. J. Randolph Babbitt
Administrator
Federal Aviation Administration (FAA)

Representative of the United States
on the Council of ICAO

APPENDIX D

SUSANA MARTINEZ
GOVERNOR

RICHARD E. MAY
CABINET SECRETARY

SAMUEL L. OJINAGA
ACTING DIRECTOR

STATE OF NEW MEXICO
DEPARTMENT OF FINANCE AND ADMINISTRATION
LOCAL GOVERNMENT DIVISION
Bataan Memorial Building, Suite 201 ♦ Santa Fe, New Mexico 87501
(505) 827-4950 ♦ FAX No. (505) 827-4948

May 11, 2011

Bernard J. Gruber, Col, USAF
Director
Global Positioning Systems Directorate
Front Office
483 N. Aviation Blvd.
Los Angeles AFB, CA 90245-2808

Karen Van Dyke
Director, Positioning, Navigation, and Timing (Acting)
DOT/Research and Innovative Technology Administration (RITA)
1200 New Jersey Avenue, SE
Washington, DC 20590

Thomas J. Nagle, SMC/GPC
Program Manager, Civil Applications
GPS Directorate, Los Angeles AFB
Building 271, Room B2-548
483 North Aviation Blvd.
El Segundo, CA 90245-2808

Dear Colonel Gruber, Ms. Van Dyke and Mr. Nagle:

In March 2011 I was informed of a company called LightSquared that is asking for FCC approval to build a nationwide 4G wireless network. There is concern from major GPS providers that LightSquared's frequency interferes with GPS signals necessary for routine 911 caller location.

I was asked by the Federal Aviation Agency (FAA) to coordinate first responder representatives from fire, EMS and law enforcement for testing of the LightSquared network in a live sky testing environment at Holloman AFB, New Mexico on April 15 – 16, 2011. The objective of the test was to determine if any level of interference to GPS signals were a result of LightSquared testing.

The attached reports are provided by law enforcement, EMS and fire first responders who participated in the field test. Law enforcement was represented by New Mexico State Police personnel Mike De Fausell and Officer Daniel Vaughan of New Mexico State Police District 4 office in Las Cruces. Mike is a subject matter expert in communications technology with an emphasis on radio. The attached reports verify there was a negative effect on the GPS equipment.

EMS and Fire reports are from local government first responders from Otero County. They represent typical fire and EMS field equipment. See the attached report from Otero County Emergency Manager Paul Quairoli detailing anomalies in GPS reception.

In conclusion the attached reports substantiate concerns that the LightSquared network will cause interference to GPS signals and jeopardize 911 and public safety nationwide.

If you have any questions, please feel free to contact me at 505-827-4804 or bill.range@state.nm.us.

Sincerely,

Bill Range

Bill Range, ENP, PMP
New Mexico E-911 Program Director
Department of Finance and Administration, Local Government Division

Attachments

LightSquared Test

On April 15, 2011, at approximately 2354, we experienced system failure when we parked under the LightSquared tower. Once the power was shut off at the tower, we left the tower site. When we got to the turn off for the dirt road, the system came back up and the Alamogordo office was able to see us moving again.

Our system has cell phone connectivity, radio connectivity, and satellite connectivity. Our mobile data terminal will automatically select and connect to the strongest signal. The GPS is only over the satellite transceiver.

When the tests were started again our GPS positions were skewed. When the LightSquared tower was turned off the system would normal out.

I believe it was approximately 0400 when they began the high dual five test, the GPS positions were skewed and remained skewed even after power was turned off. As they began the next tests, we started getting GPS reading from the Alamogordo office every ten minutes. These GPS readings continued to be incorrect the rest of the test period. We asked the Alamogordo office to send the GPS readings with the time via the MDC so there would be a record of the information.

We were unable to get the system to normal out until we were leaving Holloman AFB on April 16, 2011 at approximately 0700; we did another reset of the equipment. At that point the system began to function correctly.

My times and GPS reading were given to Captain Justin Deifel, USAF at the closing briefing.

Submitted by:

Mike De Fausell
New Mexico State Police
District Four Communications

These were the results of the LightSquared testing on equipment used by Otero County's emergency responders:

1. Testing on the AVL used on ambulances was in some test modes not affected, but in most modes affected by either showing a stationary vehicle in motion at 9 mph, 16 mph or losing track of the vehicle in its entirety. As the vehicle locating system does not have high resolution or "in detail" zoom features, the vehicle appears to stay at one location. The closer the vehicle is moved toward the Lightsquared antenna, effects of the 4G network on the system get worse.

2. Trimble GPS equipment tested was found to be the most susceptible to the 4G signal and almost from the moment the system was turned on seemed to be compromised. During the testing process the unit was limited to only being able to see 7 satellites at any location and upon moving just 50 yards from our position at the test site towards the tower were diminished to 3 or 4 satellites and at 60 yards unable to establish any satellite connections. (This is still approximately 1/8 of a mile from the tower)

3. Several Garmin hand held devices were tested with varying results, but all were affected as follows:
    a. Garmin Nuvi 255 – retained contact with most satellites but had a very difficult time establishing elevations, most fluctuations were in the decimal second range but showed during path tracking that the device was moving up to 200 feet in a random "figure 8" pattern. When approaching the tower, the signal eventually is lost.
    b. Garmin Etrex - Same results as above but path tracking on this model show a "U" shaped pattern.

Paul Quairoli
Emergency Services Director
Otero County Office of Emergency Services
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Alamogordo, NM 88310