

**Written Testimony of Philip Straub  
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**Before the Transportation and Infrastructure Subcommittees on  
Aviation and Coast Guard and Maritime Transportation  
United States House of Representatives**

**Joint Hearing: "GPS Reliability: A Review of Aviation Industry Performance, Safety  
Issues, and Avoiding Potential New and Costly Government Burdens"**

**June 23, 2011**

My name is Philip Straub, and I am Vice President, Aviation Engineering, for Garmin International, Inc. ("Garmin"). Today, I would like to address the serious threats to the aviation and maritime industries' use of the Global Positioning System ("GPS") posed by the proposal of LightSquared Subsidiary LLC ("LightSquared") to offer a nationwide terrestrial broadband network. Garmin is not opposed to the roll-out of improved broadband service in this country. We just believe it should be done in other ways that will not eviscerate GPS service.

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

Garmin is the leading manufacturer of GPS products for the general aviation industry in the United States and is a leading supplier of GPS-enabled products for the maritime market. 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. Garmin provides a full suite of avionics for General Aviation aircraft, helicopters, and Part 25 business aircraft, including:

- 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 that 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<sup>®</sup> signals, and Cellular Data Link products.

## **II. GPS-Enabled Aviation Products Have Revolutionized Aviation Safety, Particularly for the General Aviation Market**

It is unquestioned that the introduction and use of GPS-enabled devices, like Garmin’s, have brought important advances in aviation safety, particularly for the General Aviation market. 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.<sup>1</sup> 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. As the Aviation Subcommittee knows, GPS is the foundation for the Federal Aviation Administration’s (“FAA’s”) new NextGen System. The existing uses of GPS that are described below 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 between airports. GPS also gives pilots the ability to immediately orient where an aircraft is located relative to terrain or obstacle features when the GPS position is paired with map details. This combination provides “instant” orientation without the mental gymnastics that were necessary before GPS was introduced into the cockpit. This is a significant safety enhancement because it frees the pilot to concentrate on flying the airplane 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.

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

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<sup>1</sup> 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/](http://www.faa.gov/data_research/aviation_data_statistics/general_aviation/CY2009/), Table 1.1 (last visited June 20, 2011).

navigation aids such as the Instrument Landing System ("ILS"). 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 the pilot to fly a stabilized approach to a safe landing. 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,<sup>2</sup> at roughly 3,000 airports and heliports across the 50 states and U.S. territories. 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 which shortens flight paths, requires less fuel burn, results in lower costs to operate, and creates a smaller carbon footprint. In summary, 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 wings, he or she must rely on the plane's navigation system to keep the aircraft in safe airspace. During an approach, the pilot works hard to follow the FAA-prescribed flight path to the runway and must be able to rely on the GPS and have confidence in the system. Improperly executed instrument approach accidents are consistently among the most common causes of lethal descent and approach accidents.<sup>3</sup> 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 benefits GPS brings to aviation safety. The FAA is in the process of implementing the NextGen program, which uses airborne GPS as an enabling technology for a new Air Traffic Control system. 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.

GPS is also used as an input to many traffic awareness systems, particularly those derived from ADS-B. These systems can enhance safety by providing pilots with timely alerts of potential collisions with other aircraft so that they can be avoided. Additionally, GPS supplies position, altitude, and velocity information to many terrain awareness systems. Such systems greatly reduce the likelihood of controlled-flight-into-terrain incidents by providing the pilot with audible alerts of potential terrain and obstacle conflicts along the flight path and a picture of

<sup>2</sup> See [http://www.faa.gov/about/office\\_org/headquarters\\_offices/ato/service\\_units/techops/navservices/gnss/approaches/index.cfm](http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/approaches/index.cfm), update effective June 2, 2011.

<sup>3</sup> Aircraft Owners and Pilots Association Air Safety Institute, *2010 Nall Report: The Joseph T. Nall Report of Accident Trends and Factors*, at 24, 26, <http://www.aopa.org/asf/publications/nall.html>.

the aircraft's position relative to the surrounding terrain and obstacles. GPS also enables synthetic vision systems to display external topography from the perspective of the flight deck, enhancing situational awareness when pilots are flying in instrument conditions.

Many aircraft are equipped with electronic multi-function displays that depict the aircraft's location on a map. GPS is a primary source of position data for these displays, which reduce pilot workload by improving situational awareness through pictures that show an aircraft's position on a map that can be overlaid with weather radar and traffic information while airborne. Other GPS-enabled map displays, such as Garmin's SafeTaxi<sup>®</sup>, provide the flight crew with a detailed picture of the runway and taxiway environment while on the ground to prevent runway incursions. When visibility is poor, it is difficult to remain oriented when taxiing. SafeTaxi<sup>®</sup>'s moving map display makes it easy.

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. 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 is a crucial technology for airborne search and rescue operators. 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 allow rescue personnel to quickly reach the correct location once the victim is found.

I use GPS in the personal and business sector and have become highly dependent upon the system. Our business uses many types of aircraft, from single-engine to light jet aircraft, to facilitate a broad range of business endeavors. These aircraft are predominantly utilized by working-level professionals and often carry these individuals to areas not well served by the airlines and locations lacking sophisticated infrastructure. To be valuable business tools, we expect these aircraft to complete their mission under a wide range of weather and operational conditions. GPS enables these aircraft to reach remote destinations under adverse weather conditions while enabling GPS-dependent safety technologies such as enhanced flight vision systems displays, terrain awareness and warning, runway incursion prevention and next generation traffic awareness systems. My personal single-engine airplane is based at an airport served only by a World War II era non-directional beacon ("NDB") circling approach. The GPS overlay capability for this approach provides incalculable safety enhancements over flying that approach with only an NDB receiver. My experience as a pilot is very typical.

### **III. GPS-Enabled Marine Products Have Brought Similar Improvements in Boating Safety**

The introduction and use of GPS-enabled devices have similarly enhanced safety in the operation of all types of watercraft. The United States Coast Guard mandates that most boats have on board a VHF radio that is enabled with Digital Selective Calling ("DSC"). DSC depends on GPS to send accurate position information over VHF frequencies in emergencies such as capsized, piracy, overboard loss of passengers, and numerous other situations. These

devices replace the need for boaters to rely on rough estimates of their position transmitted verbally over a radio.

GPS-enabled devices have become even more critical for marine safety with the United States Coast Guard's termination on February 8, 2010 of the Loran-C system, a low-frequency hyperbolic radionavigation system.<sup>4</sup> Established in 1957, the Loran-C system provided navigation, location, and timing services for both civil and military marine users. In decommissioning Loran-C service, the Department of Homeland Security and the Coast Guard noted that technological advancements and the emergence of GPS had rendered the system unnecessary.<sup>5</sup>

Like avionics, modern marine electronics, through GPS, are also able to expand a boater's situational awareness beyond knowledge of just the basics of a boat's location to provide additional information about its position relative to fixed hazards like rocks or shoreline. Dynamic weather overlays also provide information necessary to avoid hazardous situations, and GPS-enabled equipment informs the boater where he or she is relative to such disturbances.

When visibility is low, 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 enhance situational awareness and incorporate alerts that help prevent accidents when two vessels come within close proximity. To operate, these systems require the accurate position, speed, and course information that GPS provides.

As with aviation, GPS is also a crucial technology in facilitating rescue operations at sea, allowing rescue personnel to 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 (EPIRBs), DSC, and AIS.

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 vessels in question, but also to the nation's border security.

#### **IV. 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

<sup>4</sup> Navigation Center, U.S. Department of Homeland Security, United States Coast Guard, *Loran-C General Information*, <http://www.navcen.uscg.gov/?pageName=loranMain> (last visited June 19, 2011).

<sup>5</sup> Terminate Long Range Aids to Navigation (Loran-C) Signal, 75 Fed. Reg. 998 (Jan. 7, 2010).

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.<sup>6</sup>

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 the same way that standing next to a lawnmower makes it impossible to hear someone whispering in your ear. LightSquared’s proposal essentially is to start a lawnmower in a library. 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, although LightSquared initially plans a power level of +62 dBm. Earlier this week, LightSquared proposed a fifty percent (3 dB) reduction in its authorized transmitter power limit, lowering it from +72 dBm to +69 dBm; however, such a proposed reduction is immaterial as it does not affect the proposed deployed power level of +62 dBm, which has been conclusively shown to cause harmful interference for many GPS receivers.<sup>7</sup> 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 signal. GPS receivers of all types are not designed to exclude such strong signals, something never contemplated before LightSquared sought its waiver to offer its new terrestrial broadband service in an area of the spectrum historically reserved for weak space-to-earth signals.

## **V. LightSquared’s Threat to GPS**

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

As Garmin’s lawyers have explained to me, the Federal Communications Commission (“FCC”) International 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-power 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

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<sup>6</sup> 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.

<sup>7</sup> Press Release, LightSquared, Inc., *LightSquared Solution to GPS Issue Will Clear Way for Nationwide 4G Network*, June 20, 2011, <http://www.lightsquared.com/press-room/press-releases/> (“*LightSquared June 20, 2011 Press Release*”).

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 an 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.

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.”<sup>8</sup>

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.” 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 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.”<sup>9</sup>

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

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<sup>8</sup> 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) (“MSS ATC Order”).

<sup>9</sup> *Id.* at 1965 & n.5.

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.<sup>10</sup>

In the same order, the Commission again explicitly stated that MSS ATC operators were required to “control self-interference sufficiently to maintain satellite service.”<sup>11</sup>

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 providers reasonably concluded that any power levels or filtering of the ATC service that was sufficient to protect the MSS component from interference would likewise be sufficient to protect GPS signals in the adjacent spectrum band.

#### **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. 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.

<sup>10</sup> 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).

<sup>11</sup> *Id.* at 4633, ¶ 46.

**C. The FCC Rushed To Allow LightSquared's Proposed New Service Without Evaluating Interference Concerns and Ignored Evidence of Interference and Numerous Objections, Including Those From Key Federal Offices**

The FCC's International Bureau responded to LightSquared's November 2010 letter by deeming it an application for a change in LightSquared's authorization, but the agency did not treat the letter according to the Commission's typical application processing policies. In place of the thirty days usually allowed for public comment and petitions to deny, followed by additional periods for oppositions and replies to those oppositions, the Bureau merely gave the public ten days to submit initial comments and an additional seven days for reply.<sup>12</sup> The Bureau surprisingly put the letter on public notice the very day after it was filed, meaning that, in this case, the comment period included the Thanksgiving holiday weekend. Ultimately, the Commission granted a very brief, three-day extension of the comment period, but the period was still much shorter than normal for an application of this consequence.<sup>13</sup>

Despite the truncated deadlines, a wide range of parties, including the U.S. GPS Industry Council, Verizon Wireless, AT&T, and CTIA-The Wireless Association filed comments discussing the massive problems that would be caused by LightSquared's proposed operations and arguing that such a wholesale rule change, as LightSquared was requesting, should more appropriately be handled in a broader rulemaking proceeding allowing opportunity for wide notice and comment. Following the comment deadline, oppositions continued to pour in from both individual GPS users and organizations representing them.

On January 12, 2011, the National Telecommunications and Information Administration ("NTIA") wrote the FCC, informing it that the Departments of Defense, Transportation, and Homeland Security had expressed concerns about LightSquared's impact on GPS and wanted the FCC to defer action on modifying LightSquared's authorization until the FCC evaluated the scope of the problem.<sup>14</sup> Attached to NTIA's letter was another letter from the Department of Defense requesting that NTIA oppose grant of LightSquared's request and suggesting that the FCC defer action until a rulemaking proceeding could be conducted. Rather than follow the Defense Department's recommendation, however, NTIA told the FCC Chairman that if the FCC intended to grant LightSquared's requested modification, it should simultaneously establish a process for analyzing the scope of the potential interference and establishing solutions before allowing LightSquared to commence operations.

On January 20, 2011, the U.S. GPS Industry Council filed test data compiled by Garmin demonstrating that LightSquared's proposed operations would cause harmful interference to GPS devices. In experimental testing using the technical details of the proposed LightSquared system, an FAA-certified Garmin aviation receiver experienced harmful interference at power

<sup>12</sup> Policy Branch Information, Applications Accepted for Filing, *Public Notice*, Report No. SAT-00378 (rel. Nov. 19, 2010).

<sup>13</sup> LightSquared Subsidiary LLC, *Order*, SAT-MOD-20101118-00239, DA 10-2243 (rel. Nov. 26, 2010).

<sup>14</sup> Letter from Lawrence E. Strickling, Assistant Secretary of Commerce for Communications and Information, to FCC Chairman Julius Genachowski, dated Jan. 12, 2011.

levels expected at a range of 13.8 miles and entirely lost its position at an estimated 5.6 miles from a LightSquared transmitter.

Despite this evidence and the growing opposition from private and government parties, the FCC's International Bureau granted LightSquared's request on January 26, 2011, subject to the condition that LightSquared engage in a process with interested parties to identify the scope of anticipated interference and propose solutions for mitigating it.<sup>15</sup> The Bureau directed LightSquared, as chair of the group, to make periodic reports to the Bureau on its progress, with a final report due by June 15, 2011. In essence, the FCC delegated its core function – expert interference analysis for purposes of spectrum allocation – to a LightSquared-led non-governmental group. Moreover, the Bureau's order did not require that GPS interference be solved before LightSquared begins offering service; it merely required that LightSquared complete the “process for addressing interference concerns related to GPS.”<sup>16</sup> The Bureau left itself the option of allowing LightSquared to commence service even if it turned out that GPS interference could not be remediated. In the view of Garmin and many other parties, this unprecedented action amounted to an abdication of the FCC's responsibilities to police interfering uses of spectrum.

Following the decision, numerous parties, including Garmin, asked the full FCC to review the Bureau's order. On March 25, 2011, the Departments of Defense and Transportation also wrote FCC Chairman Genachowski objecting to the lack of inclusion of federal agencies in the LightSquared-led working group process and advising that a comprehensive study of “all the potential interference to GPS is needed.”<sup>17</sup>

At today's hearing, Garmin fully expected to be able to discuss with the Subcommittees the final working group report to the FCC. Unfortunately, on the day the report was due, LightSquared sought and was granted an extension of time until July 1, 2011 to file the report, despite the GPS Industry Council's comments, on the part of its members who had been actively involved for months in the working group process, that the group's technical report was final and ready for submission.<sup>18</sup>

This month, both the International Civil Aviation Organization (“ICAO”) and the International Air Transport Association (“IATA”) have notified the FCC Chairman that they have serious concerns about LightSquared's proposed service. IATA expressed “strong opposition” to any waiver of the Integrated Service Rule for LightSquared, particularly because

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<sup>15</sup> LightSquared Subsidiary, LLC, *Order and Authorization*, 26 FCC Rcd 566, 586-87, ¶¶ 41-43 (2011).

<sup>16</sup> *Id.* at 588, ¶ 48.

<sup>17</sup> Letter from William J. Lynn III, Deputy Secretary of Defense, and John D. Porcari, Deputy Secretary of Transportation, to FCC Chairman Julius Genachowski, dated Mar. 25, 2011.

<sup>18</sup> Comments of the U.S. GPS Industry Council, File No. SAT-MOD-20101118-00239, filed June 15, 2011.

of the threat it creates for NextGen.<sup>19</sup> 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.”<sup>20</sup>

## **VI. Testing Conducted on Aviation GPS Equipment Conclusively Demonstrates Serious Problems**

Given the potentially devastating consequences that the LightSquared system poses for the aviation industry, multiple groups have conducted tests -- besides those done by the LightSquared-led working group -- to assess the true impact. All of the testing performed to date confirms that the LightSquared system, as currently proposed, will result in a widespread degradation of GPS receiver performance and severely limit the GPS utility as we now know it.

At the request of the FAA, RTCA, Inc. (“RTCA”), a standards setting body for the aviation community, performed tests and analysis to assess the impact of the LightSquared system on aviation GPS operations. The results of this effort were published on June 3 as RTCA/DO-327<sup>21</sup> and showed a severe impact to aviation GPS operations. The tests included a set of four aviation receivers from both the General Aviation and Air Transport sectors. All of the tested receivers experienced significant degradation when exposed to the LightSquared signals. Every receiver was significantly degraded at interfering signal levels that will be seen within 1.1 kilometer of a single LightSquared transmitter, but some receivers were impacted 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 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 the upper LightSquared channel is incompatible with aviation GPS operations. Until this week, all of the proposed LightSquared deployment phases included the use of the upper channel. 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<sup>th</sup> of its authorized power limit. RTCA did not reach any conclusion on the compatibility of a single lower 10 MHz channel with aviation use; it said further study was needed.

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<sup>19</sup> Letter from Giovanni Bisignani, Director General and CEO of the International Air Transport Association, to FCC Chairman Julius Genachowski, dated June 5, 2011.

<sup>20</sup> 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.

<sup>21</sup> RTCA/DO-327, Assessment of LightSquared Ancillary Terrestrial Component Radio Frequency Interference Impact on GNSS L1 Band Airborne Receiver Operations, June 3, 2011.

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. 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. 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.

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.<sup>22</sup> 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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<sup>22</sup> 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.govexec.com/pdfs/061711bb1.pdf> (last visited June 19, 2011). 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.

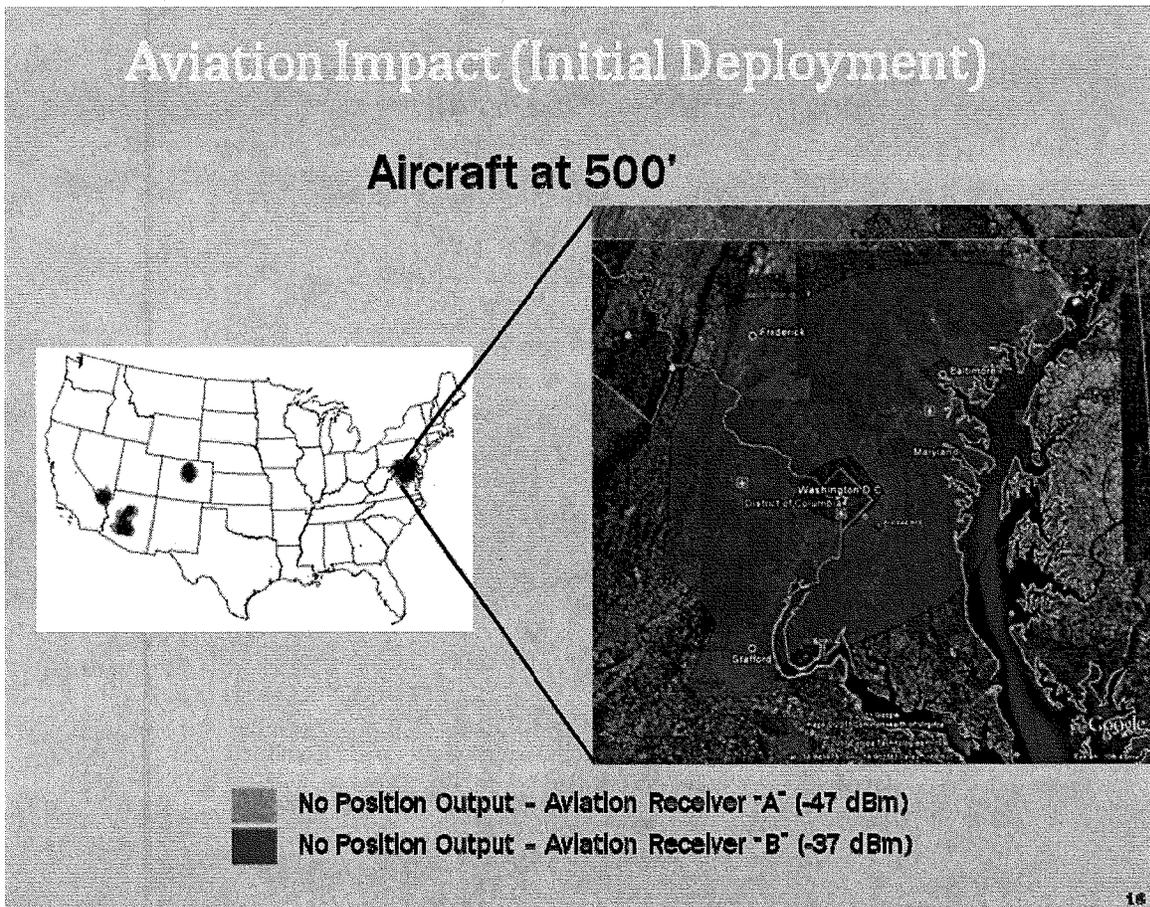


Figure 1

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 excessively costly and likely to sacrifice the levels of performance achieved by existing GPS equipment. The 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 in the lower portion of the LightSquared band was also evaluated. The NPEF noted that while some applications such as aviation may be compatible with this strategy, it will not work universally across the wider range of GPS applications. The only mitigation strategy that the NPEF identified as compatible with all GPS applications was the relocation of LightSquared to another band more suitable for high power terrestrial operations (*i.e.*, not the MSS band).

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

1. Move to rescind the FCC conditional waiver (FCC Order DA 11-133) of January 26, 2011 authorizing terrestrial only ATC operation in the Mobile Satellite Service (MSS) 1525 - 1559 MHz Band.

2. The U.S. Government should conduct more thorough studies on the operational, economic and safety impacts of operating the LightSquared Network, to include additional ATC signal configurations not currently in LightSquared planned spectrum phases, effects on timing receivers, as well as transmissions from LightSquared handsets.
3. Based on testing of representative ATC equipment which became available for the first time during this NPEF evaluation, it strongly recommended the FCC revisit and readdress the effects of the 2003-2010 ATC authorizations within the MSS L-Band spectrum on GPS applications.

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 dangerous threat to the continued operation of GPS.

## VII. The Concept of Mitigation Cannot Be Supported

The aviation and GPS communities themselves have invested a significant amount of time, effort, and money not only in testing the effect of LightSquared's proposed service but investigating potential mitigations that might allow GPS to coexist with LightSquared transmissions in the MSS L-Band. They have found that the concept of mitigation cannot be supported.

LightSquared has suggested that filters might effectively protect GPS receivers from its transmissions. There are no filters in existence that would protect aviation GPS receivers from LightSquared's proposed transmissions. Since no filters exist – not even prototypes – the aviation community has not been able to test this mitigation proposal; however, as filter proposals surface, it is important to evaluate them in light of the stringent requirements imposed on products installed in aircraft. In addition to the challenging filter selectivity constraints required to reject LightSquared signals adjacent to the GPS band, aviation filters must reliably preserve the GPS spectrum, 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. To achieve the high level of rejection required to eliminate the high power LightSquared transmissions from the GPS receiver, any potential filter must necessarily reject some of the GPS signal as well. Improving out-of-band signal rejection comes at the cost of other performance requirements that are critical to the operation of the GPS receiver.

LightSquared has stated that there are companies willing to build filters that meet the aforementioned constraints. The aviation and GPS communities have only received one proposal thus far. The proposal was comprised of two facets; it was evaluated carefully and found to be completely infeasible. First, this proposal suggested the use of an in-line cavity filter. The insertion loss of this cavity filter is much too large for use as an antenna preselect filter, and it does not provide sufficient protection against 3<sup>rd</sup> order intermodulation when installed in-line after the antenna module. In addition, the size and weight of the cavity filter present 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 requires converting GPS signals to another frequency, filtering them, and then

converting them back to the GPS frequency. It 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 3<sup>rd</sup> order intermodulation concerns. In addition, it draws 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 filters needed to protect GPS from LightSquared do not exist. There are no commercially available parts that will work. We have yet to even see a prototype. Furthermore, many of the proposals that have surfaced reject a large portion of the GPS signal in order to sufficiently attenuate LightSquared's powerful signal. Meanwhile, LightSquared continues to make claims that GPS receivers "look into its spectrum." Essentially, LightSquared is instead proposing that the GPS community add filtering to GPS receivers that would restrict them to using 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, it would take many years to obtain all of the necessary certifications and approvals.<sup>23</sup> Furthermore, the task of retrofitting the entire fleet of GPS-enabled aircraft in the United States would take years.<sup>24</sup> Any 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 filters would be required to meet the needs of various aviation GPS receivers.

In summary, there are numerous obstacles to filter-based mitigations that lead Garmin to conclude that such a proposal is completely impractical. Specifically, these obstacles are:

**Technical obstacles:**

1. Appropriate filters do not exist. All discussions in the FCC-mandated technical working group process have focused on proposals derived from simulations.
2. Proposed filters reject portions of the GPS signal in addition to the LightSquared signal.

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<sup>23</sup> 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)"), [http://www.jpdo.gov/library/20101008\\_ARM\\_v\\_1.2.pdf](http://www.jpdo.gov/library/20101008_ARM_v_1.2.pdf).

<sup>24</sup> 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).

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. Proposed filters are considerably larger than existing ones, making any retrofitting of existing receivers virtually impossible.
5. Handheld units would have to be scrapped because the antenna is integral to the unit.
6. The proposed filters do not address third-order intermodulation issues.
7. Proposed 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 different aviation receivers.
2. The time required to obtain necessary certifications and approvals.
3. The time, expense, and feasibility of retrofitting the entire fleet of aircraft in the U.S. and aircraft flying here from other nations.
4. The loss of revenue and impact on jobs while aircraft are out of service for the installation and retrofit.
5. 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 remaining mitigation discussions with LightSquared focused on modifications to its deployment plans that would move it to spectrum further away from the GPS band. One proposal discussed the possibility of LightSquared only utilizing its lower 10 MHz channel, centered at 1531 MHz. RTCA has concluded that not enough information exists today to decide whether this option is viable and that more study is needed.

Earlier this week, LightSquared issued a press release setting forth what it termed a “comprehensive solution” to the problem of interference with GPS receivers.<sup>25</sup> While the details remain vague, this solution involves initially limiting LightSquared to using the lower 10 MHz channel, along with, as noted above, a 3 dB (50%) reduction in its maximum authorized transmit power of 42 dBW. This proposal is no solution at all, given that the RTCA analysis was unable to show that the lower 10 MHz channel is compatible with aviation GPS operations due to a negative margin for initial GPS signal acquisition. The proposed reduction in power is an illogical conclusion given that the RTCA analysis was based on LightSquared’s previously stated plan to limit base station transmissions to 1/10<sup>th</sup> (32 dBW) of its authorized transmit power. LightSquared’s latest proposal would allow it to transmit at five times the power levels assumed in the RTCA analysis. Moreover, this “comprehensive solution” conveniently ignores much of the existing user base, especially users of high precision GPS equipment.

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<sup>25</sup> *LightSquared June 20, 2011 Press Release, supra, n. 7.*

The only fail-safe mitigation strategy proposed to date is for LightSquared to move to entirely different frequencies outside of the MSS L-band, away from GPS.

### **VIII. Allowing LightSquared To Proceed Will Have Profound Consequences for Aviation and Marine Safety, As Well As Harmful Economic and International Implications**

*Aviation Safety of Life.* Given the way that GPS-enabled aviation products have revolutionized aviation safety, it is not an understatement to say that allowing the LightSquared proposal to proceed, in any form within the identified spectrum, will have serious implications for aviation safety of life. To ensure their products consistently meet safety objectives, Garmin and others in the industry design their devices to not only meet minimum requirements but also include margins, redundancy, and other backup design elements. Any threatened erosion of these critical elements, as would occur with LightSquared's proposed operation, would produce extremely serious consequences for integrity and availability of GPS service. Not only is NextGen likely to be seriously delayed, if not compromised entirely by any roll-out of LightSquared's proposed network, the possibilities in individual circumstances are alarming:

- 1) NextGen would be slowed or stopped completely if the GPS signal does not meet the availability and integrity requirements of the National Airspace System. NextGen programs at risk include ADS-B, Required Navigation Performance ("RNP")/Area Navigation ("RNAV"), WAAS, GBAS, and Cockpit Display of Traffic Information ("CDTI"). These programs already have proven extremely beneficial to aircraft operators because of the GPS-based capabilities bring improved safety and airspace/airport capacity and reduced passenger delays, carbon emissions, and noise impact.
- 2) Losing GPS while on approach would be more than an inconvenience; it would cause significant distraction and require pilots to revert to a less precise ground-based navigation system that has few of the capabilities of GPS. Furthermore, loss of GPS would deny approach coverage at hundreds of airports and heliports that previously had no instrument approach because they were not in proximity to a ground-based navigation aid and could not afford to purchase a standalone instrument approach system of their own.
- 3) The inability of GPS to acquire position while on the ground would prevent the functioning of SafeTaxi<sup>®</sup> and similar applications, increasing the probability of runway incursions.
- 4) Without GPS, the Terrain Awareness and Warning System ("TAWS") will not work for General Aviation, and Air Transport TAWS effectiveness will be degraded, increasing the likelihood of controlled flight into terrain.
- 5) Loss of GPS means that, for General Aviation, cockpit displays of aircraft position would be gone, and, therefore, a pilot would lose the very valuable situational awareness associated with a moving map display and a relative display of weather and traffic.
- 6) Loss of GPS would disable a synthetic vision system's ability to display external topography from the perspective of the flight deck, thus reducing a pilot's situational awareness.

- 7) Poor GPS availability would preclude low cost AHRS systems and promote the return to spinning mass gyroscope instruments with their notoriously poor reliability and safety record.
- 8) Without GPS, pilots would lose the ability to fly precise predetermined search patterns at any location night or day under all weather conditions.
- 9) Loss of GPS would mean rescue personnel could not determine a precise location for rendering emergency help and would greatly delay their ability to save lives.

Marine Safety of Life. Equally concerning is the effect that impairment of GPS service would have on safety of operations on the nation's lakes and waterways and along its coasts. Any degradation or interruption of GPS signals would erode the integrity and availability of critical positional information. Again, the possibilities are alarming:

- 1) Losing GPS-enabled DSC service would mean boaters would have to return to reliance on rough estimates of location conveyed verbally over a radio.
- 2) Without GPS, boaters who depend on marine surface radar overlays with their GPS components to supply information on hazards instead would have to rely simply on visual identification, which becomes impossible at night or in fog.
- 3) Loss of GPS would render boaters unable to make the decisions necessary to avoid weather squalls based on marine weather information geo-located via GPS.
- 4) Without GPS, marine collision avoidance systems such as DSC and AIS (Class B) for small vessels, and AIS (Class A) for large vessels would be rendered useless.
- 5) Loss of GPS would cripple GMDSS component systems (e.g. EPIRB, DSC, and AIS) and make marine search and rescue efforts much less likely to reach emergency locations and stranded individuals or vessels.
- 6) Without GPS, marine AIS (Class A) used to track large international shipping vessels would be unavailable, affecting national security.

Other Serious Implications. Disruption of GPS has profound economic and international implications. The GPS community, the aviation industry, and numerous other business sectors have already spent significant resources over the last half year to analyze LightSquared's proposed broadband terrestrial network to compensate for the FCC's failure to do so prior to its issuance of the LightSquared waiver on January 26, 2011. The distraction from the business of developing, designing, and implementing new products has diminished economic competitiveness. In the event that any aspect of LightSquared's proposal is allowed to proceed, these businesses will be forced to expend critical resources continuing to study this issue while facing diminishing profit margins due to degradation in GPS receiver performance. The cumulative effect is a massive delay in the development of new GPS technology beneficial to consumers, businesses, governments, and the safety of life. Some parties have even begun to harbor concerns that, because of LightSquared, GPS users in the U.S. may actually find it more cost effective to switch to other global navigation systems, such as Russia's GLONASS, given

the different frequencies that system uses, further eroding American leadership in space-based navigation and timing.

Moreover, any FCC decision that allows or promotes GPS degradation will affect foreign aircraft operating in affected U.S. airspace. If LightSquared is allowed to proceed, these aircraft will require the same costly retrofit (if adequate mitigation is technically possible) with whatever new system U.S. aircraft will be forced to employ to retain GPS functionality. Complex U.S.-based standards for GPS-enabled aviation devices are harmonized with other countries and through international organizations, like ICAO, and accepted abroad. Any necessary modification of U.S. standards for GPS-enabled avionics means that the whole system of worldwide standards would need to be revised.

Similar problems will occur in the marine context. Marine GPS receivers used in safety-of-life applications such as AIS are required to undergo international GPS receiver certification per International Electrotechnical Commission (“IEC”) 61108-1.<sup>26</sup> Furthermore, many agencies, including the US Coast Guard and the FCC, rely on international standards written by the Radio Technical Commission for Maritime Services (“RTCM”) to regulate GPS performance as it relates to AIS, DSC, and EPIRB, to name a few. Modification of these standards due to harmful interference from LightSquared would have far reaching international consequences for other countries that adopt these same standards.

## **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 original tests 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, Congress should put an end to this dysfunctional exercise and, as NPEF recommended, work to ensure the FCC’s rescission of LightSquared’s conditional waiver and an overall review of the effects of Ancillary Terrestrial Component operations in L-Band spectrum. At a minimum, LightSquared’s proposed operations should be moved to entirely different frequencies outside of the MSS L-Band, away from GPS.

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<sup>26</sup> IEC 61108-1 Ed. 2.0 en: 2003, Maritime navigation and radiocommunication equipment and systems - Global navigation satellite systems (GNSS) - Part 1: Global positioning system (GPS) - Receiver equipment - Performance standards, methods of testing and required test results.



## Philip Straub

### Education.

1990 - 1992

#### **University of Missouri at Kansas City**

Graduated magna cum laude with a Bachelor of Science in Electrical Engineering.

1986 - Present

#### **Flight Training**

Presently holds an Airline Transport Pilot (ATP) with a King Air 350 Type Rating. Flight Instructor Certificate with single-engine, multi-engine and instrument privileges.

### Professional Experience.

1987 - 1993

#### **Baker Aircraft Center and Executive Beechcraft**

Worked as a pilot and flight instructor. Developed and utilized pilot training curriculum. Conducted pilot proficiency reviews in accordance with FAA regulations.

1993 - Present

#### **Garmin International**

Has held a variety of positions of increasing responsibility in the Aviation Engineering department contributing to the development of Garmin's core aviation products, including embedded software development and certification flight testing. Currently oversees all Garmin aviation engineering activities, including design, software, program management, flight operations, and systems and aircraft certification.

### Achievements.

Served as Vice President of Theta Pi Chapter of Eta Kappa Nu, honors electrical engineering association. Was also a member of Tau Beta Pi, honors engineering association.

Initial Flight instructor certification at the age of nineteen.

COMMITTEE ON TRANSPORTATION AND INFRASTRUCTURE  
*Truth in Testimony Disclosure*

Pursuant to clause 2(g)(5) of House Rule XI, in the case of a witness appearing in a nongovernmental capacity, a written statement of proposed testimony shall include: (1) a curriculum vitae; and (2) a disclosure of the amount and source (by agency and program) of each Federal grant (or subgrant thereof) or contract (or subcontract thereof) received during the current fiscal year or either of the two previous fiscal years by the witness or by an entity represented by the witness. Such statements, with appropriate redaction to protect the privacy of the witness, shall be made publicly available in electronic form not later than one day after the witness appears.

(1) Name:

Philip Straub

(2) Other than yourself, name of entity you are representing:

Garmin International

(3) Are you testifying on behalf of an entity other than a Government (federal, state, local) entity?

YES

If yes, please provide the information requested below and attach your curriculum vitae.

NO

(4) Please list the amount and source (by agency and program) of each Federal grant (or subgrant thereof) or contract (or subcontract thereof) received during the current fiscal year or either of the two previous fiscal years by you or by the entity you are representing:

Garmin does not benefit from any Federal grant or contract at this time.

Signature

Philip Straub

Date

6/16/2011