

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

In the Matter of)	
)	
LightSquared Subsidiary LLC)	IB Docket No. 11-109
Request for Modification of its Authority)	
for an Ancillary Terrestrial Component)	
)	
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 TRIMBLE NAVIGATION LIMITED

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SUMMARY

Trimble Navigation Limited (“Trimble”) wholeheartedly endorses the Obama Administration’s and the FCC’s goal to repurpose underutilized spectrum and make more wireless broadband services available to Americans. As current Administration policy statements make clear, however, these objectives should not be achieved through actions that would cause a “loss of critical existing and planned Federal, State, local, and tribal government capabilities.” Among the most powerful existing capabilities at the disposal of all levels of government and the public today is the constellation of Global Positioning System (“GPS”) satellites launched and maintained by the Department of Defense. GPS has enabled an incredible variety of innovative uses which make government, private business, and the everyday activities of ordinary citizens more productive, easier, and, in many cases, more enjoyable. The GPS constellation is the fruit of investment of \$35 billion of taxpayer money, and further tens of billions of dollars of government and private investment, to exploit the many capabilities it enables.

In January 2011, in response to a request from Mobile Satellite Service (“MSS”) licensee LightSquared Subsidiary LLC (“LightSquared”), the Commission conditionally authorized operation of a high-powered terrestrial wireless network in the satellite band directly adjacent to the spectrum dedicated to the public and private uses of GPS. LightSquared’s filings made clear that the company’s primary business would be the sale (indirectly, through “wholesale” carrier customers) of terrestrial-only wireless data plans.

Parties from the GPS industry as well as essential government GPS users objected to LightSquared’s plan. They argued that because LightSquared’s proposal violated the Commission’s carefully-constructed limitation on permissible terrestrial services in the MSS band, its operations would create substantially increased interference to GPS and GPS users.

The Commission agreed on the first point, requiring it to grant a waiver of its rules to authorize the new terrestrial-only services, and deferred the second question to a “Technical Working Group” made up of LightSquared, GPS companies, users, and other interested parties. The Commission made clear, however, that LightSquared would not be permitted to commence operations until interference concerns had been resolved.

The Technical Working Group (“TWG”) fulfilled the Commission’s mandate, exhaustively studying the interference issues on an accelerated time frame to determine whether there were any possible solutions. More than 100 experts from all relevant industry segments and user groups devoted thousands of hours to these efforts, including many days of real-world and lab testing. The results confirm the concerns of the GPS parties and government users in full:

- **LightSquared’s original deployment plans submitted for review by the Technical Working Group, using two separate blocks in the MSS band (the “upper” portion of the band directly adjacent to GPS spectrum and a “lower” portion of the band which is 23 MHz away from the GPS spectrum) would cause massive, incurable interference to every kind of GPS device.** Notwithstanding LightSquared’s initial contentions to the contrary, the Commission now has hundreds of pages of technical data before it which leaves no doubt on this point.
- **There is no viable means to modify the hundreds of millions of existing GPS devices already in the hands of consumers, businesses, and government users in order to reduce their vulnerability to interfering transmissions.** LightSquared has not provided any evidence of currently available filters or other technology that could be used to retrofit existing devices. Even if such technology existed, a retrofit is simply not feasible. GPS receivers are deeply embedded in and integrated with the devices that utilize the location information the receivers generate, from cell phones to survey instruments, agricultural combines, and construction equipment, to name just a few. As a result, if LightSquared cannot completely eliminate harmful interference to GPS, commencement of its proposed operations in 2012, less than six months away, will cause immediate and tangible harm to existing GPS devices used for any number of critical economic and safety-of-life applications.
- **Essentially conceding the foregoing, LightSquared made a late-filed proposal**

to limit its operations to the lower L-Band for the time being, but this proposal does not eliminate harmful interference to a large portion of the 500 million GPS receivers in use. The only way LightSquared can claim that this is a “solution” is by using definitions of interference and supporting methodologies that have no precedent in any proceeding and are often based on its own subjective assessment of how levels of interference are “correlated with operational performance” based on the limited test data available. Using more conventional definitions of interference, the TWG members other than LightSquared concluded that lower band operations would interfere with a significant number of receivers in every category tested, including cell phones and general navigation devices in widespread use. And even LightSquared concedes that it will not resolve interference to high precision receivers, which drive critical United States industries and protect the safety of life and property.

With barely a passing acknowledgement of the complete failure of its original plan to pass muster, and the huge efforts undertaken to analyze these misguided plans, LightSquared used a two week extension of the original June 15 deadline to prepare its own “Recommendations” document, which provides its own unilateral view of the technical results and options to address the massive interference problem. In preparing this document LightSquared essentially opted out of the collaborative Technical Working Group effort, offering new proposals for mitigation never mentioned in months of deliberations.

A major thrust of LightSquared’s June 15 document is an attempt to shift the blame for the unanticipated failure of its original plans on the “commercial GPS industry” for allegedly failing to anticipate that someday, somehow the FCC would sanction plans for non-integrated, terrestrial-only wireless services in the MSS band, and design their products accordingly. This critique ignores and insults the many government engineers and experts in our nation’s finest institutions, from the Air Force to NASA, among many others, that played an integral role in the development and widespread deployment of GPS technology. It also ignores the role of the FCC itself, the expert agency responsible for managing spectrum, and the fact that in 2005, as part of the same proceedings that LightSquared cites, the FCC expressly committed to act on behalf of

the many government users to proactively protect GPS from interference by adopting whatever rules might be necessary in the future.

The Recommendations document also asserts that existing or future technology (it is often not clear which and LightSquared does not often attempt to be precise on the point) can be applied to GPS receivers to make them less vulnerable to interference from its unprecedented high-powered transmissions in adjacent spectrum.

In fact, LightSquared's claims that future technology will eliminate interference issues – either in the lower or upper portions of the L-Band – lack any meaningful corroboration beyond its own claims and predictions. Additional filtering, for example, simply does not exist today, other than for less precise “narrowband” receivers that are likely to be phased out as better GPS technology moves down the cost curve. For the future, and for what is likely to be the future industry standard – “wideband” GPS receivers – LightSquared could only provide vendor presentations with highly qualified statements of what might be possible at some unknown point in the future. Many other experts, however, have expressed doubts whether in fact this is a solvable engineering problem, or a fundamental problem of physics.

Trimble strongly believes it is the latter – there has simply never been a serious attempt to transmit radio signals billions of times more powerful in spectrum even 23 MHz away from spectrum where a huge embedded population of highly sensitive satellite receivers are in operation. Nor does Trimble believe this is an appropriate subject for “experiments” affecting the safety of life. In any case, additional filtering comes with a variety of performance penalties, and would hamper innovation and improvement of GPS technology going forward, all for an uncertain benefit in reducing interference.

Given the conflicting claims, how are these remaining contested points to be evaluated?

Several points are critical.

First, and most importantly, if there is any uncertainty relative to the technical evidence, the costs of being wrong if LightSquared's operations are allowed to move forward are extraordinarily high. These costs could come in many forms: the costs to LightSquared's investors resulting from further wasted capital if LightSquared is allowed to proceed with its aggressive buildout plans only to find that these operations cannot be allowed to continue due to damaging interference to critical applications; the costs associated with failure of these same critical applications, such as the failure of E911 calls or public safety "man down" signals to go through in life-threatening circumstances, or the loss of life in aviation, maritime, or other accidents that could have been avoided had GPS functioned properly but for harmful interference; and the costs to industry and government to attempt to minimize to the greatest extent possible the impact of LightSquared's operations on the many activities that rely on GPS, as well as the costs of foregone efficiency benefits due to degraded GPS. In short, this is simply not an area where one can split the difference and hope for the best.

Second, having already spent, according to its own claims, billions of dollars of its investors' money on a plan which, to say the least, has hit a major snag, at this point LightSquared has an overpowering economic incentive to make aggressive and optimistic assessments of the available data. The tendency to ignore or minimize facts that get in the way of one's plans is human nature, proven time and again, and cannot be lightly disregarded.

Third, the Commission should not base any decisions on the assumption that remaining problems or unresolved disagreements can be "worked out" if the parties just keep talking to each other and working in good faith. Trimble is prepared to continue to devote extraordinary efforts to assist the Commission in achieving its laudable objectives of maximizing the efficiency

of spectrum use and providing innovative broadband services to the American public. Trimble has already devoted substantial time of its best engineers, who normally spend their time developing new and innovative GPS products and technology, to the Technical Working Group process. This process has already entailed an unprecedented level of cooperative effort by private industry and government experts on an extremely accelerated time frame. Given this effort, it is not reasonable to assume that more of the same will produce solutions that have not achieved some level of technical consensus so far. There must also be some reasonable limit to the amount of attention, time, and resources of the many parties affected by LightSquared's plans that can be mandated to advance the plans of another private party. At some point LightSquared must go back in the normal queue with the many other companies whose businesses plans require Commission attention. Many affected users also do not have the technical resources or expertise to evaluate these impacts, and the many affected users at all levels of government are obviously laboring under severe financial constraints.

The bottom line is that LightSquared has been afforded an extraordinary opportunity to make the case that its proposed use of the MSS band is viable without causing harm and cost to government and private industry in excess of the benefits of its proposal. The FCC has given it the benefit of every doubt to this point, and has given this private proposal extraordinary priority among all the other pressing business before the Commission. LightSquared's original plans, which it claims have been in the works for nearly a decade, and which it no doubt represented to the Commission up to January 2011 to be workable, have been proven by overwhelming technical evidence to cause far more harm than the good which would come from additional broadband deployment. The condition set forth in the Commission's January 2011 order – that harmful interference to GPS must be resolved – has not been satisfied, and LightSquared cannot

be allowed to commence operations.

It is certainly unfortunate that things have come to this point. But at this difficult moment it is critical to separate the public interest and the public policy objectives of the Commission from the interests of a sophisticated, well-financed private party that had every opportunity to do due diligence on its plans and all of their implications before investing private capital in pursuit of these plans. It now appears that LightSquared did not truly appreciate the overwhelming magnitude of the collateral damage from its plans and also relied upon extremely debatable interpretations of prior Commission decisions.^{1/} Fundamentally, LightSquared made a bet and elected to spend substantial sums of money on its plans well before it had definitive authorization from the Commission for these plans through regular Commission decision-making processes, and well before it had fully evaluated and addressed the GPS interference issue that is now so problematic. That has turned out to be a bad bet. Like many others in the annals of financial and business history, it must accept the consequences, not try to shift them to the US government, private industry, and American consumers. Certainly the Commission should not view prior investments, undertaken at LightSquared's own risk, as equities entitling it to any special accommodation or treatment. Doing so would not only violate long-established Commission policy, but also introduce a very unhealthy moral hazard in critical matters of spectrum policy.

Going forward, we urge the Commission to return to the hard work of determining how best to repurpose underutilized satellite spectrum to increase the spectrum available for terrestrial

^{1/} Even the Commission's January 2011 decision establishes that LightSquared's view of Commission policies and decisions was wrong in a very fundamental way. While LightSquared believed that its business plans would satisfy the "integration" requirement under its Ancillary Terrestrial Component ("ATC") authorization, the Commission found otherwise, which is what necessitated the waiver the FCC granted.

wireless use, without causing collateral damage which exceeds the benefits of repurposing, based on full consideration of the public interest considerations and the facts about current uses of satellite spectrum. Trimble stands ready to support the Commission in these efforts.

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COMMENTS OF TRIMBLE NAVIGATION LIMITED

Trimble Navigation Limited (“Trimble”), by its attorneys and in response to the *Public Notice* released on June 30, 2011 in the above-referenced proceeding,^{2/} hereby submits its comments to the Federal Communications Commission (“FCC” or “Commission”) regarding the final report of the Technical Working Group (“TWG”),^{3/} which analyzed the potential for interference to Global Positioning System (“GPS”) receivers caused by the proposed high-power, stand-alone terrestrial network of LightSquared Subsidiary LLC (“LightSquared”), and LightSquared’s “Recommendations” document released concurrently with and in response to the findings in the TWG Report.^{4/} Trimble is a provider of high precision receivers, timing receivers, systems, networks, and other GPS devices and has been an active participant in these proceedings directly and through its affiliation with the United States GPS Industry Council.

^{2/} *Comment Deadlines Established Regarding the LightSquared Technical Working Group Report*, Public Notice, IB Docket No. 11-109, DA 11-1133 (rel. June 30, 2011) (“*Public Notice*”).

^{3/} *See* Technical Working Group Report, Final Report, IBFS File No. SAT-MOD-20101118-00239 (filed June 30, 2011) (“TWG Report”).

^{4/} *See* Recommendation of LightSquared Subsidiary LLC, IBFS File No. SAT-MOD-20101118-00239 (filed June 30, 2011) (“LightSquared Recommendations”).

BACKGROUND

The Instant Proceeding. In January 2011, the FCC’s International Bureau granted LightSquared – a Mobile Satellite Service (“MSS”) licensee operating in the 1525-1559 MHz and 1626.5-1660.5 MHz bands (the “L-Band”) – a waiver of its ancillary terrestrial component (“ATC”) integrated service rule.^{5/} The integrated service rule requires a licensee to integrate the terrestrial component of its service with the underlying satellite service, in order to ensure that any terrestrial service is truly ancillary to the satellite service. The *January 2011 Order* essentially eliminated this rule by permitting LightSquared to operate its proposed stand-alone, high-power terrestrial network separate and apart from any satellite service, allowing terrestrial-only service plans over a new, nationwide terrestrial broadband network. Due to concerns raised by government users and the GPS industry, among others, that LightSquared’s proposed operations would cause harmful interference to GPS, the *January 2011 Order* imposed a condition that LightSquared could not begin commercial operations until the FCC-mandated TWG process had found – to the Commission’s satisfaction, and based on input from the National Telecommunications and Information Administration (“NTIA”) – that such operations would not interfere with GPS.^{6/}

When it became apparent during the TWG testing that LightSquared’s proposed operations, as submitted by LightSquared for review by the TWG at the outset of the process, would in fact cause harmful interference to all types of GPS receivers, LightSquared unilaterally proposed a new “solution” to the interference problem, announcing that it would delay providing service using the upper segment of its allocation and instead initially would use only the lower

^{5/} *LightSquared Subsidiary LLC Request for Modification of its Authority for an Ancillary Terrestrial Component*, Order and Authorization, 26 FCC Rcd 566 (2011) (“*January 2011 Order*”).

^{6/} *Id.* ¶ 41.

10 MHz band, 1526-1536 MHz.^{7/} Even though LightSquared's lower 10 MHz "solution" was introduced late in the TWG process, several of the TWG sub-teams were still able to test the lower 10 MHz proposal. As described further herein, those sub-teams found either that the lower 10 MHz proposal would cause harmful interference to GPS or that further testing would be needed. None of the sub-teams were able to find that LightSquared's lower 10 MHz proposal cured the potential for harmful interference to GPS.

Concurrent with the release of the TWG test results, LightSquared issued a "Recommendations" document, which was completed outside of the TWG process, advocating for the adoption of its new lower 10 MHz plan along with other related proposals it claims will allow it to proceed without harming GPS reception.

Commercial Devices. The TWG testing process evaluated different types of equipment, grouped by application. Among the equipment tested were those using the following applications: high precision receivers, timing receivers, and networks.

High precision receivers use space- and terrestrial-based systems to provide highly accurate navigation and position services. According to the TWG Report, some of these receivers "routinely provide accuracies of 1-2 cm (centimeters), under one inch, and in some modes can measure to 1-2 mm (millimeters)."^{8/} Timing receivers provide precise time synchronization and high precision frequency references that are critical to the interoperability of communications networks and other critical infrastructure. They typically provide timing pulses accurate to under 20 nanoseconds and, in some cases, can provide a high precision frequency

^{7/} See Press Release, *LightSquared Solution to GPS Issue Will Clear Way for Nationwide 4G Network* (June 20, 2011).

^{8/} TWG Report at 183.

references accurate to ± 1 part per 100 billion.^{9/} Networks consist of a combination of high precision receivers. Because they include a group of high precision receivers, they can normally provide even greater accuracy and reliability for navigation and positioning applications.^{10/}

High Precision receivers are widely used in applications such as agriculture, surveying, construction, mining, energy, oil and gas, utilities, and monitoring of dams, structures, earthquakes, and volcanoes, as well as various government applications. Timing receivers are widely used in communications applications such as wireless, wireline, and fiber optic telecommunications networks.^{11/} They are also used in electric power grids, paging systems, public safety radio systems, and financial networks.^{12/} Networks such as StarFire, Omnistar, and Real Time Kinematic all feature high-precision equipment.^{13/}

About Trimble. Founded in 1978, Trimble is a leading provider of advanced positioning solutions using GPS, laser, optical and inertial technologies. Trimble applies such technologies to make field and mobile workers in businesses and government significantly more productive. Its solutions are focused on applications requiring position or location, including surveying, construction, agriculture, fleet and asset management, public safety and mapping. Trimble also integrates a wide range of positioning technologies with application software, wireless communications, and services to provide complete commercial solutions. Its integrated solutions allow customers to collect, manage and analyze complex information faster and easier, making them more productive, efficient and profitable.

^{9/} *See id.*

^{10/} *See id.*

^{11/} *See id.*

^{12/} *See id.*

^{13/} *See id.*

Trimble products are used in over 100 countries around the world, contributing to United States exports. It has employees in more than 21 countries, coupled with a highly capable network of dealers and distribution partners. Trimble's portfolio includes over 900 patents and serves as the basis for the broadest array of offerings in the industry.

Trimble, therefore, is particularly concerned with the massive interference LightSquared's proposed network would cause to GPS devices – particularly high precision GPS devices – both under LightSquared's initial proposal and the lower 10 MHz approach discussed in LightSquared's Recommendations document.

COMMENTS

I. LIGHTSQUARED'S CLAIM IN ITS RECOMMENDATIONS DOCUMENT AND THROUGHOUT THESE PROCEEDINGS THAT THE GPS INDUSTRY HAS KNOWN ABOUT AND ACQUIESCED TO LIGHTSQUARED'S BUSINESS PLAN HAS BEEN REFUTED NUMEROUS TIMES AND IS COMPLETELY BASELESS

In its Recommendations document, LightSquared again tries to shift responsibility for the massive interference its proposed operations admittedly will cause by claiming that the GPS industry has known about LightSquared's plans for years and either acquiesced or decided to do nothing about them.^{14/} First, the argument that the entire GPS ecosystem – made up of domestic and international players, both public and private, and manufacturers, service providers, government and United Nations organizations which set pertinent GPS standards for aviation and marine safety-of-life applications, and end users involved in dozens of industries – knew about LightSquared's operations and the impact they would have on GPS and yet sat idly by is incredible. Second, this argument has been disproven frequently throughout these proceedings

^{14/} LightSquared Recommendations at 16 (“The commercial GPS device industry is now complaining, at the eleventh hour, of plans about which it has had years of advance knowledge and of a technical issue it had more than sufficient time to resolve in its receiver designs.”).

without meaningful response from LightSquared, other than recitation of the same empty assertions or simplistic and self-serving summary of complex decisions.^{15/} Because LightSquared continues to present it to the Commission, however, Trimble responds yet again in these comments, in the hopes that this submission will finally put an end to these baseless claims.

A. LightSquared’s Recent Plans Are Not an Outgrowth of the Type of ATC Authority the FCC Contemplated

The FCC adopted the ATC regime in 2003 “to permit flexibility in the delivery of communications by MSS providers by enabling them to integrate ATC into their MSS networks.”^{16/} Specifically, the Commission in Section 25.149(b) of its rules requires an MSS operator seeking ATC authority to make certain demonstrations in order to “ensure that the added terrestrial component remains ancillary to the principal MSS offering.”^{17/} One of the primary ways by which the Commission historically ensured the ancillary nature of such terrestrial operations was to require the MSS licensee to show that its satellite service and terrestrial service would be “integrated.”^{18/} While LightSquared’s predecessors met the integrated service requirement by showing that they would offer handsets capable of receiving both the satellite and terrestrial signals, LightSquared’s November 2010 letter modified this prior commitment and explicitly stated its intentions to make available (indirectly through its

^{15/} See, e.g., Reply to Opposition, The U.S. GPS Industry Council, IBFS File No. SAT-MOD-20101118-00239 (filed March 29, 2011); Letter from James A. Kirkland, Vice President and General Counsel, Trimble Navigation Limited, to Julius P. Knapp, Chief Engineer, Office of Engineering and Technology, FCC, IBFS File No. SAT-MOD-20101118-00239 (filed June 14, 2011).

^{16/} *January 2011 Order* ¶ 14.

^{17/} See, e.g., *January 2011 Order* ¶ 15; *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 Bands*, Report and Order and Notice of Proposed Rulemaking, 18 FCC Rcd 1962 n.5 (2003) (“*2003 ATC Order*”) (“As we have repeatedly indicated, we intend to authorize ATC only as an ancillary service to the provision of the principal service, MSS.”).

^{18/} See, e.g., *Mobile Satellite Ventures Subsidiary LLC*, Order and Authorization, 19 FCC Rcd 22144 ¶ 19 (2004) (“An ATC applicant must demonstrate that it will integrate provision of ATC service with provision of MSS”).

wholesale carrier customers) terrestrial only data plans. The International Bureau in the *January 2011 Order* found that LightSquared failed to meet the integrated service rule and waived the rule instead.^{19/} As Trimble further explains in this Section I, the waiver of the integrated service rule was unprecedented, and was inconsistent with repeated Commission assurances that it would vigorously enforce the integration requirement and related “ancillary” status of any terrestrial operations in the MSS band. There was no way that the GPS industry could have reasonably anticipated that the FCC would waive the rule which serves as the foundation for ATC in the L-Band: that terrestrial services must be ancillary to and integrated with the primary satellite service.

In fact, LightSquared’s version of history is demonstrably wrong. LightSquared continues to assert that it was well known as early as 2003 that MSS spectrum could be used to provide a nationwide high-powered terrestrial broadband network that was not integrated with a satellite service in any meaningful sense. If this were true, then as of 2003, LightSquared’s predecessors were sitting on spectrum similar to spectrum which the FCC was in the process of auctioning for billions of dollars.^{20/} Yet, despite the value of the spectrum, as validated by the Commission’s auctions, LightSquared’s predecessors were unable to raise capital to actually do what LightSquared is now proposing to do and Harbinger Capital was able to purchase LightSquared’s predecessor, SkyTerra, for a small fraction of this spectrum value.^{21/} Given the

^{19/} *January 2011 Order* ¶¶ 24, 29.

^{20/} See, e.g., *Auction of Advanced Wireless Services Licenses Closes, Winning Bidders Announced for Auction No. 66*, Public Notice, DA 06-1882 (Sept. 20, 2006); *Auction of 700 MHz Band Licenses Closes, Winning Bidders Announced for Auction 73*, Public Notice, DA 08-595 (rel. March 20, 2008).

^{21/} In a moment of revealing candor, LightSquared itself recently estimated that its spectrum, if permitted to be used for terrestrial broadband wireless, is worth *\$12 billion*. See Coleman Bazelon, The Brattle Group, Inc., *GPS Inteference: Implicit Subsidy to the GPS Industry and Cost to LightSquared of Accommodation*, at 1 (June 22, 2011). In other words, under rule changes the FCC purportedly adopted dating back to 2003, LightSquared’s predecessors were owners of a \$12 billion dollar asset for which they

parade of owners of this MSS spectrum since 2003, and the many sophisticated investors that LightSquared's predecessors no doubt solicited in fund raising, it is remarkable that only Harbinger was able to uncover what LightSquared now characterizes as obvious from 2003.

Similarly, if LightSquared (or its predecessors) knew in 2003 that they were going to build a free-standing, nationwide broadband network, then its expert engineers and management irresponsibly sat by while hundreds of millions of GPS receivers – which LightSquared now claims (and all technical information confirms) to be clearly incompatible with these planned operations – were sold, and the U.S. government proceeded to invest tens of billions of dollars in GPS-dependent systems. If anyone ignored obvious facts that were inconsistent with its plans, it was LightSquared, not the GPS industry.

These reality checks make clear that in fact, *no one* thought the MSS license held by LightSquared's predecessors, under Commission policies in effect prior to 2011, conferred a right to build a free-standing nationwide terrestrial broadband wireless network. The most cursory review of Commission decisions up to 2011 completely confirms that no reasonable person could have come to the conclusion that LightSquared now has.

1. The GPS Industry Reasonably Expected ATC That Was “Ancillary”

As noted above, since 2003, the FCC has contemplated terrestrial operations as an *ancillary* enhancement to what all along had been a satellite-based service. LightSquared's November 18, 2010 letter^{22/} describes a new service that is completely inconsistent with this expectation. There, LightSquared states that “the capacity of its fully deployed terrestrial

had paid nothing. It would be a market failure of truly staggering proportions if the FCC had in fact authorized this use in 2003, but none of its predecessors, or anyone else, realized this until Harbinger came along in 2010.

^{22/} Letter from Jeffrey J. Carlisle, Executive Vice President, Regulatory Affairs & Public Policy, LightSquared, to Marlene H. Dortch, Secretary, FCC, SAT-MOD-20101118-00239, at 2 (Nov. 18, 2010) (the “November 18, 2010 Letter”).

network across all base stations will be *tens of thousands of times* the capacity of either of [its] satellites.”^{23/} Similarly, under the only combined satellite/terrestrial service plan described in the letter, an end user would be provided with basic usage (*i.e.*, usage before additional charges apply) of one *gigabyte* of terrestrial wireless broadband usage but only *500 kilobytes* of satellite data usage, less than what is needed to send a single email in many cases.^{24/} In fact, a LightSquared executive was quoted earlier this year as expressing “LightSquared’s hope that people would use its satellite coverage as a last resort, saying, ‘We’ve likened satellite coverage to gym membership. We want everyone to have it, but we don’t want people to go!’”^{25/}

LightSquared itself principally promotes its provision of terrestrial wireless broadband capacity, not of satellite capacity.^{26/} It has announced that it has entered into transactions with various companies in which LightSquared will make its terrestrial network available, so that its customers can compete with current wireless providers like mobile phone companies (and in some cases, LightSquared will provide those current wireless carriers with additional capacity to supplement existing spectrum).^{27/}

^{23/} November 18, 2010 Letter at 7 n.7.

^{24/} *Id.* at 6.

^{25/} Benny Har-Even, *LTE World Summit 2011*, TELECOMS.COM, May 20, 2011, <http://www.telecoms.com/27960/lte-world-summit-2011-tweets-from-the-floor/>.

^{26/} See, e.g., Press Release, LightSquared, *LightSquared and SI Wireless Announce They Have Entered Into a Bilateral Roaming Agreement* (Apr. 21, 2011) (“LightSquared’s mission is to revolutionize the U.S. wireless industry. . . . Through its wholesale-only business model, those without their own wireless network or who have limited geographic coverage or spectrum can develop and sell their own devices, applications, and services using LightSquared’s open 4G network – at a competitive cost and without retail competition from LightSquared.”).

^{27/} See, e.g., *id.*; *LightSquared Plans to Offer 4G Nationwide*, CNBC.COM, March 23, 2011 (reporting LightSquared’s plan to offer wholesale nationwide 4G networks to wireless phone service providers and quoting CEO Sanjiv Ahuja stating, “We are here to provide enough capacity to the wireless guys so that they can take it and in turn provide it to their customers”); Dan Jones, *LightSquared Leaps into Best Buy Deal*, LIGHT READING MOBILE, March 23, 2011 (reporting that LightSquared announced a deal with Best Buy where “the retailer will offer own-brand 4G service and devices with LightSquared running the network in the background”); Peter Svensson, *LightSquared Gets First Deal with a Phone*

This is precisely the opposite of what the FCC anticipated when it authorized ATC. Then, the FCC said that it did *not* expect ATC services to be comparable to and therefore competitive with the services of established consumer terrestrial services like cellular.^{28/} In fact, the FCC used the distinction between ATC and cellular-like services to justify the fact that the ATC spectrum should not be auctioned, as is most terrestrial wireless spectrum.^{29/}

Instead, both the FCC and LightSquared's predecessors expected ATC to be a means by which MSS operators could provide service in urban areas where satellite coverage would be difficult to achieve.^{30/} As the FCC noted in its original *Notice of Proposed Rulemaking* considering ATC authority in the MSS band:

Motient [LightSquared's predecessor] seeks authority to operate terrestrial base stations, as part of Motient's next-generation mobile satellite system in both the upper and lower L-band. The terrestrial base stations would be integrated with the satellite network and would enable co-channel reuse of the satellite service link frequencies in adjacent satellite antenna beams to provide coverage to areas where the satellite

Company, ABCNEWS.COM, March 22, 2011 ("LightSquared, a company building a new wireless broadband network to compete with those of AT&T Inc., Verizon Wireless and Clearwire Corp., announced Tuesday its first phone-company customer, Leap Wireless International Inc.").

^{28/} See *2003 ATC Decision* ¶¶ 39, 41 (2003) ("As a preliminary matter, terrestrial [Commercial Mobile Radio Service ("CMRS")] and MSS ATC are expected to have different prices, coverage, product acceptance and distribution; therefore, the two services appear, at best, to be imperfect substitutes for one another that would be operating in predominately different market segments. . . . MSS ATC is unlikely to compete directly with terrestrial CMRS for the same customer base . . .").

^{29/} *Id.* ¶¶ 220, 225.

^{30/} See, e.g., *id.* ¶ 24 (noting that "improved coverage in urban areas should significantly expand the consumer market that MSS is capable of serving"); *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 Bands*, Memorandum Opinion and Order and Second Order on Reconsideration, 20 FCC Rcd 4616, ¶ 27 (2005) ("*2005 ATC Decision*") ("On the contrary, the MSS/ATC operators' interest in avoiding unnecessary capital expenditures would deter them from installing ATC base stations in non-urban areas where traffic is light enough to be handled by MSS alone. Thus, we believe that MSS/ATC operators will only install ATC base stations in areas where the satellite signal is substantially affected by blocking or where consumers demand more communications paths than the satellite can provide. These are the precise situations for which we authorized ATC."); Comments of Motient Services Inc., TMI Communications and Company, Limited Partnership, and Mobile Satellite Ventures Subsidiary LLC, IB Docket 01-185, ET Docket No. 95-18, at 23 (filed Oct. 22, 2001) ("MSV 2001 Comments") ("MSV [LightSquared's predecessor] will not operate a terrestrial-only system; rather, terrestrial operations will only supplement the satellite service in urban and indoor environments with terrestrial extensions.").

signal is attenuated by foliage or terrain and to provide in-building coverage. The satellite path would be the preferred communications link, but if the user's satellite path is blocked, the communications link would be sustained via the fill-in base stations.^{31/}

LightSquared's planned network turns this original vision on its head. In September 2010, LightSquared, after stating that its "ancillary" terrestrial network would have "the capability to serve hundreds of millions of users," also noted that:

LightSquared will achieve these results while at the same time maintaining service to its existing MSS customer base of over 300,000 terminals used in rural and remote areas and by emergency service providers that need a reliable replacement service in the event terrestrial infrastructure is destroyed.^{32/}

Now, under LightSquared's plan, the purpose of the satellite service would be to provide ancillary service in remote areas not covered by the ubiquitous primary terrestrial network, or in the event that the terrestrial network is destroyed – exactly the opposite of what the FCC authorized and the GPS industry could have reasonably anticipated.

2. The GPS Industry Reasonably Expected ATC That Was "Integrated"

When the FCC adopted its ATC rules, it required that the terrestrial service be *integrated* with the satellite service.^{33/} GPS providers relied on this requirement and were satisfied that with

^{31/} 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*, Notice of Proposed Rulemaking, 16 FCC Rcd 15532, ¶ 15 (2001).

^{32/} Comments of LightSquared Subsidiary LLC, ET Docket No. 10-142, at 6-7 (filed Sept. 15, 2010) ("LightSquared 2010 Comments").

^{33/} See, e.g., *2003 ATC Decision* ¶¶ 87-88 ("MSS licensees must make an affirmative showing to the Commission that demonstrates that their ATC service offering is truly integrated with their MSS offering . . . This integrated service requirement and the other rules adopted today will help ensure that MSS remains first and foremost a satellite service and that the terrestrial component remains ancillary to the primary purpose of the MSS system."); *2005 ATC Decision* ¶ 19 (reiterating that to "ensure that ATC will be ancillary to provision of MSS . . . [w]e require[] the offer of MSS and ATC services to be integrated" and that MSS/ATC operators have to make a showing to that effect). In addition, the Commission further clarified the integrated nature of the service by prohibiting ATC-only subscriptions. See, e.g., *id.* ¶ 33 ("We reiterate our intention not to allow ATC to become a stand-alone system. The purpose of ATC is to enhance MSS coverage, enabling MSS operators to extend service into areas that they were previously

an ATC that was integrated with MSS, ATC would not be implemented in a way that would harm GPS reception, since the MSS licensee was obligated to avoid in-band interference with and disruption to the fully integrated mobile satellite service that was the basis for its license.^{34/} LightSquared's own filings with the FCC, as late as September 2010, indicate that it understood that ATC operations must be integrated with, and not independent of, the underlying MSS service.^{35/}

One long-established means of fulfilling the integrated service requirement was to offer dual-mode handsets – *i.e.*, handsets that were capable of receiving both satellite and terrestrial services.^{36/} LightSquared's November 18, 2010 Letter acknowledged this requirement when it stated:

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. We therefore clarify that 'integrated service' as used in this proceeding and required by 47 C.F.R. § 25.147(b)(4) forbids MSS/ATC operators from offering ATC-only subscriptions.”).

^{34/} See, e.g., 2003 ATC Decision ¶ 3 n.5 (“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.’”).

^{35/} LightSquared 2010 Comments at 12 (stating that at present, “ATC in the L-band, because it lacks a primary allocation in the United States, may have to protect other services and to accept interference from other services . . . The Commission could, however, make it substantially easier to implement ATC domestically in the future by expanding the definition of MSS in its rules to include ATC and thus rendering ATC a primary service.”).

^{36/} In furtherance of the integrated service requirement, the FCC adopted a safe harbor for MSS/ATC applicants to demonstrate that ATC would be integrated with the underlying MSS system where such applicants would have to show that they use a dual-mode handset to provide the proposed ATC service. See, e.g., 2003 ATC Decision ¶ 87. LightSquared's authorization was premised on its ability to meet this safe harbor. See *Mobile Satellite Ventures Subsidiary LLC Application for Minor Modification of Space Station License for AMSC-1, et al.*, Order and Authorization, 19 FCC Rcd 22144, ¶¶ 19-21 (2004) (“2004 ATC Decision”) (“MSV asserts that the handsets that will be used to access its ATC network will be dual-mode devices that can also be used for MSS communication . . . The ATC authorization granted by this order is conditioned accordingly.”).

At the time LightSquared's predecessor applied for ATC authority, the company, in order to demonstrate compliance with the Commission's integrated service requirements, planned to use dual-mode handsets *exclusively*.^{37/}

The November 18, 2010 Letter abandoned the concept entirely. Under LightSquared's proposal, its wholesale carrier customers are not required to offer satellite service to end customers, nor are they required to provide handsets that are capable of receiving satellite service. In other words, at that customer level, there is absolutely no integration of terrestrial and satellite service.^{38/} Under these circumstances, there can be no doubt, as LightSquared's public statements described above make clear, that terrestrial-only data usage will greatly predominate over time, rendering satellite service a distant second in LightSquared's business plans and priorities.

LightSquared's "integration" plans are thus the polar opposite of what the FCC and the GPS industry "anticipated" when the ATC rules were adopted and thereafter. In 2003, the Commission stated:

We will authorize MSS ATC subject to conditions that ensure that the added terrestrial component remains ancillary to the principal MSS offering. We do not intend, *nor will we permit*, the terrestrial component to become a stand-alone service.^{39/}

In 2004, the International Bureau reaffirmed the "integration" requirement, making clear that it was an essential part of ensuring that terrestrial operations remain truly "ancillary":

The Commission's decision to permit implementation of MSS ATC was based on the premise that ATC must be "ancillary" to MSS operation. To that end, the Commission established "gating" requirements for ATC authorization and operation

^{37/} November 18, 2010 Letter at 1.

^{38/} LightSquared's November 18, 2010 Letter attempts to claim that terrestrial and satellite services were "integrated" because the rate card it presented to its wholesale customers (who in turn resell the service to end customers) would only list combined satellite/terrestrial services. November 18, 2010 Letter at 6-7. These assertions cannot overcome the fact that these wholesale customers were not required to buy specialized dual-purpose handsets or sell them to their customers, or even tell their customers that satellite services were available.

^{39/} 2003 ATC Decision ¶ 1 (emphasis added).

to ensure that ATC will augment, rather than supplant, MSS. In order to satisfy the gating requirements, which are set forth in Section 25.149 of the Commission’s rules, an MSS-ATC licensee must, among other things, . . . integrate its offering of ATC services with its offering of MSS.^{40/}

Under these circumstances, it is not surprising that the International Bureau concluded in the *January 2011 Order* that “LightSquared fails to satisfy the integrated service rule.”^{41/} The Bureau nonetheless decided to waive the rule, despite repeated prior assurances that terrestrial service would not be allowed to supplant satellite service in the MSS band. There is simply *no language in prior Commission orders* that might have put the GPS community on notice that the integrated nature of an MSS’s provider’s terrestrial service could be changed in such a fundamental way.

B. The GPS Industry Could Not Reasonably Anticipate That LightSquared Would Abandon the Need to Protect Its Own MSS Operations

The Commission’s established policies requiring that terrestrial uses be strictly ancillary to primary satellite uses were a critical part of the spectrum plan for the L-Band, where GPS has historically operated. The spectrum plan grouped satellite operations with other satellite operations intentionally, to avoid the kinds of interference issues presented by inconsistent spectrum uses in adjacent frequency bands – in this case, to avoid the interference that would result when ubiquitous, high-powered terrestrial transmitters operate in spectrum directly adjacent to spectrum where highly sensitive GPS receivers attempt to detect faint satellite signals. The ancillary usage the FCC permitted in prior decisions was a limited accommodation

^{40/} *2004 ATC Decision* ¶ 18 (footnotes omitted) (emphasis added).

^{41/} *January 2011 Order* ¶ 24 (finding that LightSquared failed to satisfy the integrated service rule).

designed to enhance a *satellite service*. The limited accommodation of ATC did not represent a considered decision to allow ubiquitous high-powered use of the band.^{42/}

Notwithstanding the longstanding rationale for limiting ancillary operations, and clear Commission policy against free-standing terrestrial services, LightSquared points to a series of incremental modifications of the Commission's technical rules that it claims opened the door to its current business plans. Whether the modifications which came before it were incremental, the change which resulted from LightSquared's November 2010 filing – its plans to indirectly sell entirely free-standing terrestrial broadband services – was not. That required, as the International Bureau recognized, a reversal of longstanding Commission policy, which the Bureau elected to adopt by “merely” waiving its rules.^{43/}

Put another way, the earlier changes cited by LightSquared all occurred against the backdrop of the fundamental requirements that the terrestrial operations would be *ancillary to and fully integrated with*, a primary satellite service. The GPS community evaluated changes in the technical rules in this context and did its best to cooperate in technical modifications that would apply to terrestrial operations which were subject to these fundamental constraints. To now characterize the accommodations, cooperation, and even support given by the GPS industry to LightSquared in the past under the previously well-established regulatory backdrop as acquiescence to LightSquared's new plans that are so outside the realm of the current rules as to

^{42/} Trimble is not suggesting, nor is it the case, that terrestrial uses cannot ever coexist in or adjacent to satellite bands, and that policy makers are stuck with decisions made long ago. However, the FCC must engage in detailed consideration of the affected existing uses and the proposed new uses, and carefully craft rules to support coexistence. In this case, the TWG Report makes clear that an intensive, ubiquitous terrestrial use (LightSquared's terrestrial business plan) cannot be authorized adjacent to a satellite band that is intensively used on an even more ubiquitous basis (GPS). There are very few if any satellite uses comparable to GPS in ubiquity and importance (direct broadcast satellite being the only one that has substantial adoption), so the repurposing of alternative underutilized satellite bands should be less problematic.

^{43/} See Letter from Julius Genachowski, Chairman, FCC, to The Honorable Charles E. Grassley, United States Senate, at 1 (May 31, 2011) (“*Genachowski Letter*”).

require a waiver of the fundamental rule underpinning the Commission’s ATC’s regulatory regime is preposterous.^{44/}

Chairman Genachowski’s recent efforts to downplay the importance of the integrated service requirement misses the point.^{45/} The *January 2011 Order* did not “merely” waive the integrated service requirement. It eliminated a critical basis on which GPS protection rested. Similarly, the Chairman overstates the case when he says that the GPS industry sent a letter to the FCC in August 2009 “agreeing that the GPS interference issues *had been resolved*.”^{46/} The matters under discussion at the time were limited to out-of-band emission limits associated with femtocells and data cards.^{47/} It certainly had no reason to consider those, or any other issues, in the context of the potential elimination of the integrated service obligation.

From an interference standpoint, so long as LightSquared and its predecessors were obligated to provide ATC that was truly ancillary to and integrated with the primary MSS, they were necessarily compelled to protect their own primary satellite operations from interference. The same protection that the ATC operator’s own satellite operations required was needed to protect GPS receivers, as most recently proven by the TWG’s test results finding that

^{44/} LightSquared Recommendations at 13 (noting that the GPS industry “submitted a letter urging the Commission to grant [LightSquared’s] applications ‘as soon as possible’ and stating that LightSquared was ‘to be commended for its proposal to use its spectrum in a responsible manner.’”).

^{45/} *Genachowski Letter* at 1.

^{46/} *Id.* at 2 (emphasis in original).

^{47/} See Letter from Bruce D. Jacobs, Counsel for SkyTerra Subsidiary LLC and Raul R. Rodriguez, Counsel for The U.S. GPS Industry Council, to Marlene H. Dortch, Secretary, FCC, at 1 (Aug. 13, 2009) (“We are pleased to inform you that . . . the U.S. GPS Industry Council (‘Council’) and SkyTerra have agreed on out-of-band emissions (‘OOBE’) limits for the operation of low-power base stations with a maximum EIRP of -4 dBW/MHz that are intended to be deployed indoors (‘femtocells’) and personal computer (‘PC’) data cards communicating with such base stations.”).

LightSquared's proposed operations will not only interfere with GPS but with LightSquared's own satellite operations.^{48/}

The Commission and LightSquared's predecessors specifically recognized that ATC would be limited by the need to ensure that ATC operations did not cause harmful interference to LightSquared and its predecessors' own MSS operations.^{49/} Because of LightSquared's self-interest in protecting its own satellite signals in-band, the GPS industry focused its efforts on limiting out-of-band emissions from the anticipated ATC operations to GPS reception in the adjacent spectrum band, as evidenced by the agreements reached between the GPS industry and LightSquared. Now that LightSquared is no longer required to provide an integrated service, it is free to view mobile satellite service as important only in "remote" areas and when terrestrial facilities have been "destroyed."^{50/} Therefore, it has no incentive to protect its own MSS operations from interference from its core terrestrial operations, removing its fundamental motivation to engineer its own system in a manner that protected GPS reception as well.

As shown by the TWG Report and further explained in Sections II.B. and II.C. below, this is not a mere theoretical possibility. LightSquared's proposed services will not only interfere with GPS, they will also create massive interference to other users of satellite services, including LightSquared's own existing services in the MSS band, exactly the outcome the FCC sought to avoid through its repeated statements that terrestrial uses must remain ancillary and integrated with satellite services. This is highlighted by LightSquared's agreements with

^{48/} TWG Report at 22.

^{49/} See, e.g., MSV 2001 Comments at 17 ("Because MSV's own satellite system will be the most affected by signals generated by ancillary terrestrial operations, it will have every incentive to monitor and minimize these signal levels in order to ensure that the quality of its satellite service is not compromised."); *2003 ATC Decision* ¶¶ 130-188 (discussing, among other things, MSV's incentive and efforts to eliminate self-interference to its satellite operations caused by ATC).

^{50/} LightSquared 2010 Comments at 6-7.

Inmarsat, which shares the MSS band with LightSquared. When LightSquared negotiated with Inmarsat to obtain favorable concessions on spectrum use, LightSquared both acknowledged the substantial interference problems in the MSS band and provided Inmarsat with compensation as a result. As LightSquared admits in its Recommendations document, it agreed “to pay Inmarsat almost \$500 million (plus annual cash payments) to rationalize the L-band spectrum into frequency blocks that would be usable for a terrestrial network,”^{51/} and Inmarsat has publicly estimated that its costs to mitigate interference to its own operations, with 50,000 affected users, at approximately \$250 million dollars.^{52/} This transaction – designed to address the extensive interference issues between Inmarsat’s and LightSquared’s adjacent channel block operations – shows that LightSquared had to have known about the potentially devastating interference its proposed terrestrial operations would have on both in-band and adjacent band operations.

It also is unclear what, if any, provision LightSquared intends to make for its own MSS customers or the many thousands of other users of the MSS band who rely indirectly on MSS services provided by LightSquared or Inmarsat. Under LightSquared’s new business plan, in which its main revenue opportunity is with terrestrial services, this interference appears to be merely a cost of doing business or acceptable collateral damage. Private and government GPS users, who also relied upon and benefited from prior requirements and the resulting imperative to avoid MSS in-band interference, will also be swept into the collateral damage category. Worse, according to LightSquared, those other users are to be blamed for failing to foresee the eventual rollback by the FCC of rules protecting the integrity of what for decades was a satellite band.

^{51/} LightSquared Recommendations at 11.

^{52/} See, e.g., Peter B. de Selding, *Inmarsat Awaits Harbinger Payment for Interference Mitigation*, SPACE NEWS, May 13, 2010.

C. LightSquared's Plans Did Not Even Remotely Come to Light Until 2010

Earlier this year, Chairman Genachowski stated that it “should be no surprise to anyone involved in the LightSquared matter” that the terrestrial component of the network Harbinger planned would cover 90 percent of the United States.^{53/} To set the record straight, LightSquared's first, limited description of its new business model was included in the public record for the first time days before, and as a condition of, the release of the Commission's *March 2010 Order*.^{54/} Prior to March 2010, LightSquared's intentions were hardly longstanding or transparent. In response to Harbinger's application for transfer of control, the FCC's International Bureau asked Harbinger in 2009 how it planned to provide ATC. Much of Harbinger's response was provided in redacted format, hiding from the public how it intended to offer ATC.^{55/} Since Harbinger's commitment to cover 90 percent of the country was only made public days before the *March 2010 Order*, interested parties did not, as the Chairman asserts, have “ample time to comment in advance of [the March 2010] orders.”^{56/}

Moreover, the *March 2010 Order*, did not even consider, much less resolve possible GPS interference issues on its own motion either – neglecting its obligation to ensure that GPS remained protected from the new terrestrial network Harbinger envisioned, not to mention its

^{53/} *Genachowski Letter at 2.*

^{54/} Letter from Henry Goldberg and Joseph A. Godles, Counsel for the Harbinger Capital Partners Funds, to Marlene H. Dortch, Secretary, FCC, IB Docket No. 08-184 (Feb. 26, 2010) (*see* Attachment). Harbinger's business plan was also appended to the *March 2010 Order*. *SkyTerra Communications, Inc., Transferor, and Harbinger Capital Partners Funds, Transferee, Applications for Consent to Transfer of Control of SkyTerra Subsidiary, LLC*, Memorandum Opinion and Order and Declaratory Ruling, 25 FCC Rcd 3059 (2010) (“*March 2010 Order*”) (Appendix B – Harbinger Business Plan Letter of March 26, 2010 at Attachment 1).

^{55/} *See* Response of Harbinger, IB Docket No. 08-184 (filed Dec. 11, 2009).

^{56/} *Id.* Even if there was “ample time” to comment on the Harbinger plan to cover 90 percent of the United States, the *March 2010 Order* left in place the integrated service requirement, meaning that regardless of the scope of LightSquared's terrestrial coverage, it could not practically provide terrestrial service without harming its own satellite operations. Once the obligation to provide integrated service was eliminated, it was no longer so constrained.

2005 commitment, as described below, to proactively protect GPS from harmful interference by consulting with affected government users. Nor did the *March 2010 Order* purport to modify, or even suggest modification of, the Commission's policies requiring that terrestrial services be ancillary to and integrated with a primary satellite service, the fundamental requirements that the Commission decided to waive in January 2011.

After the *March 2010 Order*, in the next significant proceeding related to MSS, FCC Docket No. 10-142, the U.S. GPS Industry Council, in comments filed in September 2010, extensively discussed its concerns with "overload" of GPS receivers by the sort of dense, high-powered terrestrial network contemplated by LightSquared's business plan and the Commission's July 2010 *Notice of Proposed Rulemaking*.^{57/} The U.S. GPS Industry Council has consistently raised the overload issue since, as have the NTIA and other government users, especially following the November 18, 2010 Letter.

In short, LightSquared's assertion that it "made detailed disclosure of the technical characteristics of its planned terrestrial network in FCC application proceedings dating back to 2001" is wrong.^{58/} LightSquared's current plans only began to come to light in 2010. Moreover, if the FCC intended in its *March 2010 Order* to make a change in policy that substantially increased the risk of interference to GPS, it did this without saying so, the antithesis of reasoned decision making, and with no record to support it. For LightSquared or the FCC to suggest that these decisions, and the industry response to them, foreclose any future consideration of GPS interference issues impacting critical safety-of-life issues like aviation safety and E911, or justify imposing harmful interference, or mitigation costs on government and private GPS users is

^{57/} See Comments of The U.S. GPS Industry Council in Response to Notice of Proposed Rulemaking and Notice of Inquiry, ET Docket No. 10-142 (filed Sept. 15, 2010).

^{58/} LightSquared Recommendations at 12.

without basis in public policy and proper administrative procedure. Given the substantial government and private investment in GPS, the FCC owes much more to these parties than an admonition, much less the more serious consequences conclusively shown in the TWG test results, for supposedly failing to “read the tea leaves.”

D. The GPS Industry Reasonably Relied on the FCC’s Affirmative Obligation to Protect GPS as a Critical Government Spectrum Use and Investment

The many public statements to date about what the GPS industry knew or should have known would happen in the future simply miss the point – *the FCC itself has an affirmative duty to proactively protect critical government spectrum uses and investments*. In fact, in its 2005 *ATC Decision*, the FCC explicitly undertook to do exactly that. In discussing a proposal to codify certain emission limits in the FCC rules, the FCC stated:

While we agree with the GPS Industry Council, NTIA, and other government agencies that it is essential to ensure that GPS does not suffer harmful interference, it is also important to ensure that new technologies are not unnecessarily constrained. In this regard, we recognize that the President’s new national policy for space-based positioning, navigation, and timing (PNT) directs the Secretary of Commerce to protect the radio frequency spectrum used by GPS and its augmentations through appropriate domestic and international spectrum management regulatory practices Furthermore, the President’s PNT policy calls for the establishment of an inter-agency Executive Committee, on which the Chairman of the FCC will be invited to participate as a liaison, and a National Space-Based PNT Coordination Office. It is our intention to establish discussions with other agencies, through the PNT Executive Committee and Coordination Office as appropriate, to better understand what protection levels for GPS are warranted. The results of those discussions may lead to future rulemaking proposals in order to ensure that all FCC services provide adequate protection to GPS, and produce a more complete record upon which to establish final GPS protection limits for MSS ATC licensees.^{59/}

The Presidential policy that the Commission committed to implement in 2005 has been followed and amplified by the present Administration. The June 28, 2010 *National Space Policy of the United States* provides that the United States “must maintain its leadership in the service,

^{59/} 2005 *ATC Decision* ¶ 70 (emphasis added).

provision, and use of global navigation satellite systems” and lists as a critical objective “invest[ing] in domestic capabilities and support[ing] international activities to detect, mitigate, and increase resiliency to harmful interference to GPS.”^{60/} Similarly, this Administration’s policy statements on spectrum policy make clear that advancing broadband deployment and competition should not come at the expense of critical government assets such as GPS. The June 2010 Presidential Memorandum directing the Department of Commerce to work with the FCC to develop a plan to make available additional spectrum for broadband services states that any such plan “must take into account the need to ensure no loss of critical existing and planned Federal, State, local, and tribal government capabilities.”^{61/}

The FCC’s commitment to protect the GPS industry is not surprising, in light of the significant investment that the Federal government has made in GPS. The GPS satellite constellation was launched as a *Federal government initiative* and represents a national asset paid for by American taxpayers. The Federal government has a significant investment in the GPS constellation and is the authorized user of the spectrum allocated for radio transmissions by GPS satellites. One official recently estimated that investment to be \$35 billion dollars in the constellation alone.^{62/} In recent testimony, the CIO of the Defense Department stated that the Department spends \$1.7 billion per year maintain the constellation.^{63/} The Federal government’s

^{60/} *National Space Policy of the United States of America*, at 5, June 28, 2010, available at http://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf.

^{61/} White House Office of the Press Secretary, *Presidential Memorandum: Unleashing the Wireless Broadband Revolution*, § 1, June 28, 2010, available at <http://www.whitehouse.gov/the-press-office/presidential-memorandum-unleashing-wireless-broadband-revolution>.

^{62/} Peter B. de Selding, *LightSquared Plans Hinge on Outcome of GPS Interference Debate*, SPACE NEWS, March 4, 2011 (reporting U.S. Air Force estimates of the U.S. government’s GPS investments).

^{63/} *GPS Reliability: A Review of Aviation Industry Performance, Safety Issues, and Avoiding Potential New and Costly Government Burdens Before the Subcomm. on Aviation of the H. Comm. on Transportation and Infrastructure*, 112th Cong. (June 23, 2011), available at <http://www.militaryaerospace.com/index/display/avi-wire-news-display/1443949270.html> (“To deliver

investment in GPS-related systems and equipment are estimated to amount to many additional billions.

Instead of diligently and proactively protecting GPS in regulating use of the MSS band, it appears that the FCC simply ignored GPS interference considerations in the *March 2010 Order* that first sanctioned LightSquared's plans to build extensive terrestrial facilities and approved the transfer of control to Harbinger. The decision did not purport to change the Commission's prior policies requiring that any terrestrial service in the MSS band be *ancillary to and integrated with* primary satellite operations, the policies that provided fundamental protections to private and government users of GPS. To the extent that the Commission contemplated, in March 2010, or at any time prior to that, different types of operations that presented "significant interference concerns" or which created a "new and more challenging interference environment," as NTIA described LightSquared's November 2010 proposal,^{64/} it was clearly incumbent upon the FCC itself to proactively evaluate interference issues in accordance with, among others, its 2005 commitment. The Commission cannot now, as LightSquared would have it, attempt to revise history and shift its own obligation to protect GPS to the private sector. In any case, the Commission's *January 2011 Order* represented a fundamental change in Commission policy regarding ancillary terrestrial operations in the MSS band, and so could not have reasonably been foreseen by either the GPS industry or knowledgeable GPS experts in the U.S. government.

GPS service to all DOD and civil and commercial users who rely upon it, DOD maintains and continuously upgrades a constant constellation of 24 satellites composed of a minimum of four satellites in each six planetary orbits at a very cost-effective budget currently of \$1.7 billion annually.").

^{64/} Letter from Lawrence E. Strickling, Assistant Secretary for Communications and Information, U.S. Department of Commerce, to Julius Genachowski, Chairman, FCC, at 1-2 (filed January 12, 2011).

E. Under Longstanding Commission Precedent, LightSquared Has an Obligation to Eliminate, or Bear All Costs of Eliminating, Harmful Interference to GPS

Whatever the history, or debatable assertions about it, the responsibility for eliminating interference to GPS, or bearing the costs of eliminating it, rests squarely with LightSquared.

When the FCC authorized ATC, it made it clear that in the event that services in bands adjacent to ATC operations, like GPS, suffered harmful interference, it would be *the responsibility of the ATC operator*, not the GPS provider, to cure that interference.^{65/} The FCC’s rules are crystal clear on this point – Section 25.255 of the Commission’s rules states:

If harmful interference is caused to other services by ancillary MSS ATC operations, either from ATC base stations or mobile terminals, the MSS ATC operator must resolve any such interference.^{66/}

No Commission decision, in March 2010, January 2011, or otherwise, has modified this rule. All of the rule changes and waivers described by LightSquared that purportedly authorized its November 2010 business plan, or any other business plan for that matter, were expressly limited by this rule. Quite simply, LightSquared has never been permitted to interfere with other services such as GPS through terrestrial operations, whatever the number of allowed ground stations or permitted maximum power levels.

The other critical part of this rule is that LightSquared, as the ATC licensee, must either take action itself (such as discontinuing the offending transmissions) or otherwise takes steps on its own account to “resolve” the interference. LightSquared has already acknowledged this by

^{65/} 2003 ATC Decision ¶ 183 (requiring L-band ATC base stations and mobile terminals to meet certain out-of-band emission levels and requiring MSV to operate its ATC base stations with a maximum transmit power of 23.9 dBW EIRP, per sector, and incorporate a 1.2 MHz guard band “in order to demonstrate that its base stations will be capable of meeting the -70 dBW/MHz and -80 dBW for discrete spurious emissions measured in a 700 Hz bandwidth to protect GPS”); *id.* ¶ 188 (requiring L-band ATC operators to maintain records and submit reports to the Commission in order to resolve interference complaints received from other operators and to ensure compliance with interference rules).

^{66/} 47 C.F.R. § 25.255.

agreeing to pay Inmarsat for the costs of protecting Inmarsat's customers from interference within the MSS band. The same obligation applies to government and private industry users of GPS, who have invested many billions of dollars in GPS long before Harbinger arrived on the scene in March 2010. The Commission has provided no sound basis for deviating from that approach – that burden remains squarely with LightSquared.

II. THE TWG TEST RESULTS CONFIRM THAT LIGHTSQUARED'S PROPOSED TERRESTRIAL OPERATIONS WILL CAUSE DEVASTATING INTERFERENCE TO GPS DEVICES, INCLUDING HIGH PRECISION GPS DEVICES, EVEN UNDER LIGHTSQUARED'S PROPOSED LOWER 10 MHZ PLAN

As required by the International Bureau as a condition to its approval of LightSquared's waiver, the TWG reviewed LightSquared's proposal and conducted extensive testing of all types of GPS receivers (including narrowband, wideband, and integrated MSS-GPS receivers), and all types of interference (including receiver overload, intermodulation, and co-channel interference). The TWG's test results, contained in the TWG Report, confirm that LightSquared's proposal would cause devastating interference to hundreds of millions of GPS receivers.

A. The TWG Engaged in Rigorous Testing of All Types of GPS Receivers

The TWG tests were designed to measure the interference effects on GPS users of LightSquared's originally proposed deployment of cell towers in the MSS band operating on spectrum immediately adjacent to the Radio Navigation Satellite Services ("RNSS") band, in which GPS signals are transmitted. In addition to LightSquared's original plan, the TWG and its sub-teams assessed the lower 10 MHz channel alternative deployment scenario.

1. Testing Environments

Testing was conducted in both a controlled anechoic chamber environment and in a "live sky" environment, where a sample of actual cell towers were set up and operated in the Las

Vegas area. A limited number of GPS receivers were also tested in a laboratory environment, where the GPS and interference signals were directly injected into the GPS receiver.

In the carefully controlled chamber tests, an equivalent simulation of the GPS signals was transmitted, along with an equivalent simulation of the LightSquared interference signal. The power of the LightSquared signal was slowly increased from a very low level, up to the range of power levels that would actually be found in the LightSquared network as deployed. Measurements in the chamber of each power level were taken until a power level was reached where the GPS receiver lost all ability to acquire or track satellites and provide the user with a position.

The “live sky” tests were used to measure the actual power levels seen on the ground at various distances from actual cell towers in different rural, suburban, and urban settings. This allowed an assessment of the radius from each tower at which harmful interference or complete jamming could be expected.

Finally, testing of GPS receivers was conducted in a facility at the Jet Propulsion Laboratory in Pasadena, California. The TWG conducted tests in the laboratory were designed to determine, among other things, the LightSquared power levels that would result in degradation to GPS signal tracking, the range from LightSquared’s stations where power levels would exceed acceptable values, and the impact on users in practical terms.

2. Power Levels Utilized

While LightSquared’s *authorized* power is 15,850 watts of emitted power, all tests were conducted at much lower power levels. LightSquared stated from the beginning of the tests that it would not use a total radiated power level of more than 1,600 watts per carrier. Because LightSquared, however, was unable to supply cell site transmitters for the “live sky” tests that were capable of reproducing its stated network deployment plans of 1,600 watts per carrier, the

test were conducted at half the stated power.^{67/} Therefore, LightSquared’s actual network as deployed at either its authorized or announced power levels would likely cause even greater interference than that observed in “live sky” tests.

3. Types of GPS Receivers: Narrowband, Wideband, and Integrated

Testing results varied based on the different types of GPS receivers: narrowband, wideband, and integrated MSS-GPS receivers. Narrowband GPS receivers only use a small fraction of the GPS spectrum, typically just 6 percent or 2 MHz of the 32 MHz GPS signal. These receivers, such as those used in cell phones, do not produce high accuracy (they are typically accurate only to less than 100 feet). Using only a fraction of the GPS band provides some additional resistance to interference – the 94 percent of the RNSS band they do not use provides additional separation from the interfering signal in the adjacent band where LightSquared proposes to operate. Thus, narrowband receivers may be able to withstand higher interference levels before malfunctioning.

Wideband GPS receivers use the full 32 MHz signal transmitted by the government-owned GPS satellites, and some use the full 51 MHz RNSS band to receive signals from other, non-U.S.-based, satellite navigation systems. These receivers are designed to take advantage of the full 32 MHz signal in order to improve location accuracy for users, and are used in commercial, industrial, professional, and scientific applications. They can provide positions accurate to one or two inches, which makes them critical in many public and private sector applications. Because wideband GPS receivers utilize the full GPS band, however, there is no

^{67/} The recently announced 50 percent power “reduction” presented by LightSquared as an accommodation to reduce interference was to its “maximum authorized power” (15,850 Watts), which in fact represents no reduction at all from the power levels tested, which were 90 percent lower than the authorized levels.

“unused” portion of the GPS band that can act as protection from very high-powered adjacent signals, unlike narrowband GPS receivers.

Integrated MSS-GPS receivers are designed to receive satellite communications in the MSS L-Band, including services provided by LightSquared through its satellites and GPS signals. MSS-GPS equipment is used in many safety-of-life and other critical applications, including Global Maritime Distress and Safety Systems built to International Maritime Organization standards, as well as for precision agriculture, construction, surveying, and mapping, and many other professional and industrial applications. Many integrated MSS-GPS receivers are sensitive to interference throughout the entire 1525-1559 MHz band and will suffer from interference to both the MSS band satellite communications and the GPS signals.

4. Types of Interference Observed

The TWG observed three main categories of interference to GPS during the testing of the effects of LightSquared’s transmissions: GPS receiver overload, intermodulation, and co-channel interference. GPS receiver overload is interference caused by massively stronger signals from nearby transmitters in adjacent channels overwhelming components or circuits in GPS receivers. GPS receivers are designed to listen for very faint and distant GPS signals from space. Extremely powerful adjacent signals can “drown out” the faint GPS signals, causing receiver “desensitization” or “overload.” Intermodulation results from having not just one, but also multiple, high-powered signals in adjacent channels. These signals can interact to create unwanted harmonic signals *inside* the GPS band. Finally, co-channel interference pertains to interference to the MSS communications component of integrated MSS-GPS real-time differential receivers.

B. The TWG Report Demonstrates That LightSquared’s Proposal Would Result in Extremely High Levels of Harmful Interference to All Types of GPS Receivers

The TWG Report concluded that LightSquared’s proposed network, which is expected to utilize typical cell tower spacing^{68/} and to cover 92 percent of the population within four years,^{69/} would result in extremely high levels of interference to GPS receivers, including, for example, those used in aviation, mobile phones, and general location and navigation, such as automotive, public safety, personal, and marine navigation. Receivers used for GPS timing in communications and broadcast networks, power grids, and timing of financial transactions, as well as satellite services within the MSS band, were also found to be affected.^{70/}

In all of the test environments,^{71/} the TWG recorded power levels from LightSquared’s operations that were hundreds of billions of times stronger than the GPS signal, even though LightSquared was utilizing drastically reduced emitted transmission levels. For instance, at the Las Vegas “live sky” test, the TWG observed power levels of up to *hundreds of billions of times* the received GPS signal,^{72/} even though the GPS receivers were approximately 500 feet from the single cell tower and LightSquared was using power levels that were at a 90 percent reduction from the almost 16,000 watts that are authorized in the FCC’s rules.^{73/} At one mile from the cell

^{68/} See TWG Report at 259, Table 13.

^{69/} See *id.* at 279.

^{70/} See *id.* at 6.

^{71/} The TWG tested over 100 different GPS devices in the calibrated laboratories, anechoic chambers, and “live sky” test environments.

^{72/} See TWG Report at 276, Figure 58.

^{73/} See *id.* at 48 (using EIRP 62 dBm per channel per sector instead of the authorized power of 72 dBm).

tower, power levels of up to 400 million times the GPS signals were also recorded.^{74/} Even GPS receivers in outer space, over 500 miles in orbit, would not escape harmful interference.^{75/}

LightSquared's operations were also found to cause substantial interference to other satellite services within the MSS band as well as LightSquared's own satellite service.^{76/} Such satellite services are often used in land- and marine-based commercial and critical safety-of-life applications, such as maritime distress systems.

None of the TWG's sub-teams – Aviation, Cellular, General Location/Navigation, High-Precision, Timing, Networks, and Space – could conclude that LightSquared would be able to operate without causing significant widespread harmful interference to all types of GPS receivers, even under its new proposal to use only the lower 10 MHz of the L-Band allocation.

For instance, the Cellular sub-team found that LightSquared's proposed operations would cause “GPS failure for a significant number of the tested devices,”^{77/} even if LightSquared operated only in the lower 10 MHz channel. The Cellular sub-team test results show that potentially up to 10 out of 41 GPS receivers inside cell phones had failed to pass its defined test in lower band only operations.^{78/} The General Location and Navigation sub-team similarly concluded that several GPS devices, many of which are used in public safety, navigation, and other applications, would also suffer “from harmful interference from the lower 10 MHz

^{74/} See *id.* at 276, Figure 58 (reporting power levels at 1.6km or 1 mile = -45dBm or 400 million times GPS -131dBm).

^{75/} See *id.* at 24, 300.

^{76/} See *id.* at 22.

^{77/} *Id.* at 16-17.

^{78/} *Id.* at 78, Figure 3.2.2 (showing 6 devices failing at -25 dBm or lower (power levels that would be seen inside the network even after removing 5 dB for antenna gain) and a further 4 devices failing at power levels between -15 and -20 dBm (power levels which could be experienced in practice depending on antenna gain, proximity to tower, and other parameters)).

channel.”^{79/} Further, the Space-based sub-team reported that LightSquared’s network, even if limited to the lower 10 MHz of the L-Band, would cause harmful interference to GPS receivers several hundreds of miles up in orbit.^{80/}

Despite LightSquared’s arguments to the contrary, even the Aviation sub-team could not conclude that operations in the lower 10 MHz channel would result in substantially reduced interference. The sub-team merely found a small positive margin for GPS positioning under the lower 10 MHz proposal.^{81/} Such a margin, however, would not be enough for an initial acquisition by a GPS receiver.^{82/} Thus, the Aviation sub-team ultimately held that “[c]ompatibility of aviation GPS operations with a single lower 10 MHz channel could not be determined definitively without additional study.”^{83/}

C. High Precision Receivers Would Suffer Particularly Devastating Interference

As described above, “narrowband” GPS receivers used in many mass market devices such as cell phones use only a small portion of the GPS signal centered in the middle of the GPS frequencies. These receivers are more resistant to interfering signals in the adjacent MSS band because the unused portion of the GPS band provides additional separation from the interfering signals. They are also less accurate because they do not process most of the data in the GPS signal, with accuracies in the range of 100 feet.

Wideband high precision receivers, on the other hand, are far more susceptible to interference because they are appropriately designed to receive the entire GPS signal transmitted

^{79/} *Id.* at 19, 123 (finding that 20 out of 29 receivers tested experienced harmful interference from LightSquared’s proposed operations in the lower 10 MHz channel.)

^{80/} *See id.* at 24, 300.

^{81/} *See id.* at 50.

^{82/} *See id.* (stating that “[t]he lower 10 MHz channel shows compatibility with a small margin for tracking functions, but not necessarily for initial acquisition”).

^{83/} *Id.* at 15.

out to the GPS band edge, and therefore do not have the de facto additional “guard band” of which narrowband receivers can take advantage. The use of the full GPS band signals are necessary for multipath reduction and other requirements of high precision GPS. The high powered LightSquared terrestrial facilities transmit signals billions of times stronger in frequencies much closer to the frequencies where wideband receivers attempt to detect very faint satellite signals, with far greater potential for overload at greater distances.

The other category of high precision receivers described in Section II.A.3. above are integrated MSS-GPS receivers which have additional vulnerability because they are intentionally, and appropriately, designed to receive commercial augmentation services that are transmitted and received (for a fee) in the MSS band, including both the upper and lower MSS bands that LightSquared proposes to use for high powered terrestrial transmissions. These integrated MSS-GPS receivers are even more susceptible to interference from LightSquared’s transmissions, since they also experience in-band interference from the high power terrestrial signals LightSquared will transmit in the MSS band.

High precision GPS receivers are ubiquitous and economically critical – they are embedded in commercial and professional equipment used in crop agriculture, mapping, and Geographic Information Systems (“GIS”) data collection for government, public safety, and commercial applications, construction and civil engineering, dredging operations in ports, harbors, and navigable waterways, marine and near-shore construction, and various operations in oil and gas both land and marine, including pipeline management, and offshore and near-shore platform positioning.

High precision differential GPS systems, which also use the MSS band, provide real-time submeter- or decimeter-level (*i.e.*, measuring within approximately 4 to 40 inches) positioning

through the combination of a wideband design to utilize the full GPS signal and a real-time stream of correction data from fixed reference stations or networks which are used to remove GPS system errors which are spatially correlated, such as satellite orbit and clock errors and atmospheric propagation delays. These MSS based augmentation services are used to provide the continuous communications link for the differential GPS correction messages essential to the real-time operations of these systems. Reference stations capable of receiving MSS and GPS are used for system integrity monitoring and performance measurement and may also form part of the reference network used to generate the DGPS data sent via the MSS link.

LightSquared has consistently confused and obfuscated the distinction between wideband GPS receivers and integrated MSS-GPS receivers. For example, in its press release announcing its new “solution” to the interference problem released on June 20, before the TWG report had even been filed, LightSquared claimed that use of the lower block of frequencies “is largely free of interference issues with the exception of a limited number of high precision GPS receivers that are specifically designed to rely on LightSquared’s spectrum.”^{84/} Contrary to LightSquared’s suggestion that only integrated MSS-GPS receivers (i.e. those “specifically designed” to use LightSquared’s MSS frequencies) experience interference from lower band operations, in fact both categories of high precision receivers experience substantial interference.

This obfuscation is a serious distortion of the record because wideband high precision receivers represent a far larger universe of receivers (so LightSquared’s estimates of the affected receiver population are wildly inaccurate), and, over time, inferior and less accurate narrowband receivers will be increasingly replaced in all GPS applications as the costs of wideband receivers come down. This is obviously a positive technology trend – all GPS users should enjoy the most

^{84/} See Press Release, *LightSquared Solution to GPS Issue Will Clear Way for Nationwide 4G Network* (June 20, 2011).

accurate GPS readings possible. But it also means that the small sliver of good news in the TWG study results, that narrowband receivers suffer less interference, particularly when operations are confined to the lower MSS band, and will benefit from additional filtering, will become increasingly irrelevant as technology and GPS products advance.

Not surprisingly given the higher susceptibility of all high precision receivers to interference, the High Precision, Networks, and Timing sub-team, which issued a joint report, found that LightSquared's original configuration would cause substantial harmful interference to high precision receivers and networks.^{85/} Under LightSquared's original configuration, harmful interference to high precision, wideband GPS receivers were observed at distances well over 2 km (1.25 miles) from the cell towers.^{86/} The sub-teams also observed harmful interference to receivers that were at 1.2 km (.75 miles) or more from each tower, as well as a complete loss of high accuracy positioning for receivers that were within 0.5 miles of any tower.^{87/}

At the Las Vegas "live sky" environment, 100 percent of the high precision receivers that were tested were found to have suffered detrimental interference, even under the lower 10 MHz proposal. Data from the TWG testing demonstrated a severe impact to GPS receivers even at long distances from LightSquared's base stations, with tracking losses recorded at up to 15 km from LightSquared's sites.^{88/} In addition, 31 out of the 33 high precision and network GPS

^{85/} See TWG Report at 22, 180 (concluding that "[t]he LightSquared Base Station 4G LTE signals harmfully interfere with High-Precision, Timing, and Network GPS receivers over long ranges.")

^{86/} See *id.* at 277.

^{87/} See *id.*

^{88/} See *id.* at 254-55.

receivers tested using the lower 10 MHz configuration were found to have lost all ability to provide high precision positioning.^{89/}

The joint sub-teams concluded by noting that “[w]e know of nothing feasible that can be done to make currently fielded wide band High Precision, Timing, and Network receivers and augmentation systems operate properly when in the vicinity of a LightSquared base station, with respect to either GPS or augmentation systems,” under any of LightSquared’s proposed operations,^{90/} and concluded that LightSquared should be required to utilize a different frequency band for its terrestrial network.^{91/}

The TWG results were confirmed by Trimble test data from a critical safety of life application. Trimble and all other interested parties were invited by the U.S. Government to participate in the “live sky” testing of a cell tower of the type proposed by LightSquared. These tests included two types of integrated MSS-GPS receivers – a Global Maritime Distress and Safety System (“GMDSS”) used in maritime safety-of-life at sea applications and an integrated MSS-GPS device used in various land-based or marine applications. The integrated MSS-GPS receivers tested are representative of a class of user equipment that has been deployed over many years to take advantage of both L-Band MSS communications and the GPS radionavigation service, which exist in immediately adjacent and contiguous bands, in a single integrated device.

The measured power levels from the LightSquared’s transmitter during the tests described were between –66 dBm to –47 dBm at various frequencies. The Trimble GMDSS

^{89/} See *id.* at 22, 180 (adding that “high precision receivers fielded today would experience harmful interference at up to 5km from a single LightSquared base station.”)

^{90/} *Id.* at 181.

^{91/} See *id.*

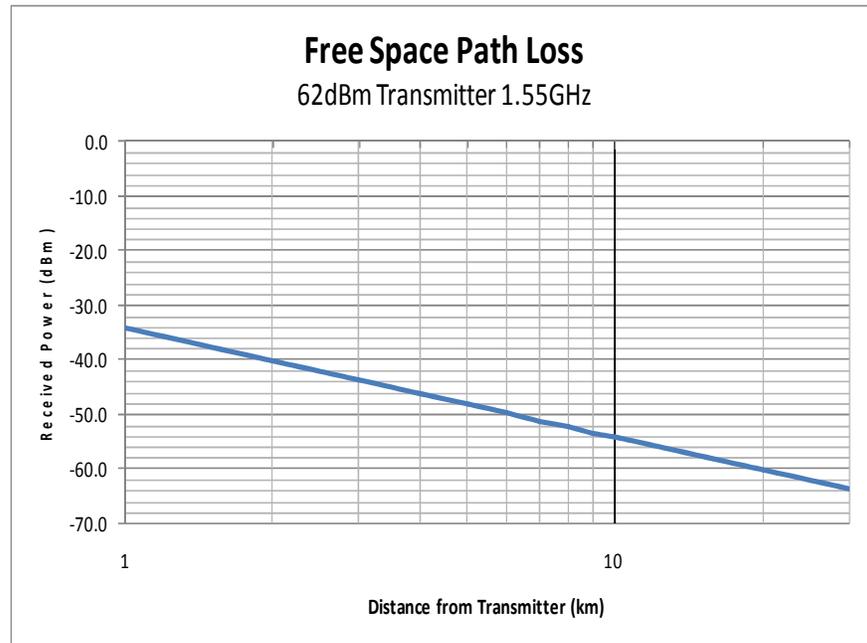
receiver was unable to track either L-Band MSS communications or GPS signals at the following received power levels:

- Minimum power at -66.0 dBm -- unit stopped tracking at -61.5 dBm
- Minimum power at -66.8 dBm -- unit stopped tracking at -64.5 dBm
- Minimum power at -65.8 dBm -- unit stopped tracking at -65.8 dBm
- Minimum power at -66.2 dBm -- unit stopped tracking at -66.2 dBm

The second design of integrated MSS-GPS receiver tested was unable to receive MSS transmissions above -63 dBm in the single configuration tested.

A free space path loss approximation demonstrates a theoretical range of approximately 30 km at which loss of both MSS communications and GPS positioning could be expected for the GMDSS

receiver based on measurements observed at the sky test.



the live

These results are based on transmitters with 62 dBm EIRP, which is only approximately one tenth of LightSquared's currently licensed power. The expected result of LightSquared's operations is severe harmful interference and loss of primary device function in all ports and

harbors across the United States where such transmitters and GMDSS receivers could be deployed.

International standards require that shipboard communications equipment be either integrated with a suitable electronic position fixing aid, or interfaced to one.^{92/} The GMDSS receiver tested is representative of an integrated L-Band satellite communications system and GPS receiver originally designed to meet those international standards. These integrated GMDSS systems are used in large numbers in maritime operations in the Gulf of Mexico and elsewhere, on both U.S. registered vessels and on foreign vessels visiting U.S. ports or working in U.S. waters.^{93/} The system is designed so that a GPS-derived position can be transmitted via L-Band satellite as a recognized distress call in the event of an emergency. Receivers of the same design may also be used on land, for example, in long-haul truck tracking applications.

D. There Are No Filter Solutions for High Precision Receivers, Now or For the Foreseeable Future

The TWG analyzed and rejected the use of additional filtering as a mitigation technique. The TWG noted that filters capable of reducing harmful interference from LightSquared's operations simply do not exist, and therefore could not be tested. The only filter that could be

^{92/} See International Maritime Organization Resolution A.807(19) – MSC 68/23/Add.1 ANNEX 10 at 5 (June 6, 1997).

^{93/} The importance of potential interference near navigable waterways and runways is recognized in Section 25.253(d)(5),(6), and (7) of the rules, which establish ATC aggregate power levels from multiple transmitter sources in those areas. Although not analyzed by the TWG, it appears that LightSquared's operations will require a separation of approximately 3-5 kilometers from any navigable waterways, including those in New York, Chicago, Los Angeles and San Francisco, in order to meet the requirements of the current regulations. Although SkyTerra received a waiver of the PFD limit applicable to operations near airports, the rule is still applicable with respect to navigable waterways. See *SkyTerra Subsidiary LLC Application for Modification Authority for an Ancillary Terrestrial Component*, Order and Authorization, 25 FCC Rcd 3043 (2010). Moreover, that waiver was conditioned on the replacement of Inmarsat terminals that would have been affected by SkyTerra operations near airports. However, there are GMDSS terminals that are not manufactured by either party to the FCC's decision – Inmarsat and SkyTerra. There has been no replacement or modification of those devices, which will receive harmful interference under LightSquared's plan and are unprotected by the waiver.

tested was for narrowband GPS receivers only, and would cause a loss of over 96 percent of the GPS signal, leaving large portions of the GPS community without adequate GPS service. Several of the sub-teams noted that even if a filter existed that could substantially reduce or eliminate harmful interference to GPS receivers, it would simply not be feasible to retrofit existing GPS devices with such a filter.^{94/}

In addition, the TWG specifically reviewed and rejected several potential filters for high precision receivers and networks. For instance, the TWG explained that it investigated the use of Surface Acoustic Wave (“SAW”) filter technology as a possible mitigation strategy.^{95/} The TWG, however, determined that a state-of-the-art SAW filter designed to operate pursuant to LightSquared’s proposal would not be feasible.^{96/} Although the TWG also found that cavity filter technology could be utilized as an interference mitigation mechanism, it concluded that “the physics of cavities at these frequencies result in a filter of very large size – larger and more expensive than the rest of GPS receiver – which would not be appropriate for portable equipment.”^{97/} However, the vast majority of GPS receivers are deployed in portable devices as those are the kind of devices that need to determine their position dynamically.

These findings decisively refute LightSquared’s repeated suggestions that the harmful interference problem is a result of the GPS industry using substandard filters. GPS receivers use state-of-the-art radio filters that can resist signals in the adjacent band tens of thousands or even millions of times more powerful than the GPS signal from space. Nonetheless, even these high

^{94/} See, e.g., TWG Report at 28 (noting that “aviation representatives have stated that they believe that pursuing the filter strategy will be expensive to implement”).

^{95/} See *id.* at 289.

^{96/} See *id.* at 289.

^{97/} *Id.*

quality filters were overwhelmed in the presence of interfering signals that were recorded to be up to hundreds of billions of times the power of the GPS signal.

With respect to the testing of integrated MSS-GPS devices in particular, there similarly is no current or future technology that would successfully mitigate interference on the receiver side, for either the existing user installed base of integrated MSS-GPS equipment, or for future designs of such equipment. While the existing satellite communications component of the LightSquared network, capable of serving public safety users and remote rural areas outside of terrestrial cellular coverage already co-exists with other L-Band MSS and GPS users and does not cause harmful interference, deployment of the new proposed terrestrial component of this network would.

E. Commencing Operations as LightSquared Initially Proposed or Even in the Lower 10 MHz Band Would Disrupt Critical Sectors of the U.S. Economy

The TWG Report indicates that LightSquared's proposed deployment, either in the upper or lower MSS band, would have a detrimental effect on both the public and private sectors in the U.S. Not surprisingly, thousands of individuals across all sectors as well as national and international organizations have expressed their concerns over LightSquared's plans. Studies have also shown devastating effects on the U.S. economy from degraded or reduced use of high precision GPS technologies.

1. Several Sectors in the U.S. Have Voiced Their Concerns About LightSquared's Proposed Operations and Its Potentially Devastating Impact on Critical GPS Services

As the Commission is well aware, thousands of individuals and organizations have already filed comments in this proceeding, the overwhelming majority of which seek to protect GPS signals and oppose LightSquared's proposed service. The commenting parties include aircraft pilots, land surveyors, ship captains and sailors, farmers, city officials, public safety

entities, and private citizens. Almost all of the commenting parties agree that LightSquared's service will cause harmful interference to GPS signals necessary for many occupations and critical safety-of-life operations.

For instance, aircraft pilots and sailors assert that they utilize GPS systems to avoid navigational errors and collisions in the air and on the sea.^{98/} Surveyors argue that they need GPS applications with great precision and reliability, as well as horizontal and vertical control, in order to develop map designs and locations of topographic features.^{99/} Farmers argue that they rely on GPS systems to produce more food more efficiently for the world, such as by allowing the placement of fertilizer in strips for maximum dispensation of nutrients and by allowing accurate placement of crops.^{100/} Moreover, hundreds of private citizens argue that they rely on accurate GPS reception for personal use and recreation, such as automobile navigation and hiking.

Large national and international organizations have also expressed their concerns over LightSquared's proposal.^{101/} The European Commission, for example, submitted comments

^{98/} See, e.g., Letter from T.W. Knorr Construction, LLC, to the Federal Communications Commission, IB Docket No. 11-109 (filed July 18, 2011).

^{99/} See, e.g., Letter from Dennis R. Baker, PLS, Director of Land Surveying Services, J.W. Morrisette & Associates Inc., P.S., to the Federal Communications Commission, IBFS File No. SAT-MOD-20101118-00239 (filed July 20, 2011); Letter from Don K. Roundy, Dominion Engineering Associates, L.C., to the Federal Communications Commission, IB Docket No. 11-109 (filed July 14, 2011).

^{100/} See, e.g., Letter from Andrew Moore, Executive Director, National Agricultural Aviation Association, to Julius Genachowski, Chairman, Federal Communications Commission, IB Docket No. 11-109 (filed July 20, 2011); Letter from Mark Maslyn, Executive Director, Public Policy, American Farm Bureau Federation, to Marlene H. Dortch, Secretary, Federal Communications Commission, IB Docket No. 11-109 (filed July 21, 2011).

^{101/} See, e.g., Letter from Michael Toscano, President and CEO, Association for Unmanned Vehicle Systems International, to Julius Genachowski, Chairman, Federal Communications Commission, IB Docket No. 11-109 (filed July 14, 2011) (arguing that "lack of a reliable GPS signal poses a serious threat to our public safety and national defense, and the potential cost of retrofitting or replacing affected GPS receivers would be an undue burden.").

expressing “deep concerns” about the LightSquared system.^{102/} Moreover, the European Commission letter clearly refers to the first stage of the revised deployment plan in the lower 10 MHz channel – LightSquared’s current “solution.” The International Civil Aviation Organization also submitted a letter stating that “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,” not only in the United States, but also abroad.^{103/} Both the National Space-Based Positioning, Navigation, and Timing Systems Engineering Forum (“NPEF”) and the National Public Safety Telecommunications Council (“NPSTC”) also prepared and submitted reports that LightSquared’s proposed configuration would result in significant harmful interference to several GPS applications in the U.S.^{104/} In light of the TWG test results, these concerns regarding the impact LightSquared’s proposed network would have on GPS, which have been expressed by numerous parties representing both the public and private sectors, are

^{102/} See Letter from Heinz Zourek, Director General, European Commission, to Julius Genachowski, Chairman, Federal Communications Commission, IB Docket No. 11-109 (filed July 19, 2011).

^{103/} See Letter from Robert Kobeh Gonzalez, President of Council, and Raymond Benjamin, Secretary General, International Civil Aviation Organization, to Julius Genachowski, Chairman, Federal Communications Commission, IBFS File No. SAT-MOD-20101118-00239 (filed June 13, 2011); see also Letter from Giovanni Bisignani, Director General & CEO, International Air Transport Association, to Julius Genachowski, Chairman, Federal Communications Commission, IBFS File No. SAT-MOD-20101118-00239 (filed June 5, 2011).

^{104/} See *Assessment of LightSquared Terrestrial Broadband System Effects on GPS Receivers and GPS-dependent Applications*, IBFS File No. SAT-MOD-20101118-00239 (filed June 13, 2011) (“*NPEF Report*”) (finding “significant detrimental impacts to all GPS applications assessed,” including U.S. government and commercial GPS applications); Letter from Ralph A. Haller, Chair, National Public Safety Telecommunications Council, to Julius Genachowski, Chairman, Federal Communications Commission, IBFS File No. SAT-MOD-20101118-00239 (filed June 15, 2011); see also Letter from Lawrence E. Strickling, Assistant Secretary for Communications and Information and Administrator, National Telecommunications and Information Administration, to Julius Genachowski, Chairman, Federal Communications Commission, IBFS File No. SAT-MOD-20101118-00239 (filed July 6, 2011) (noting that the *NPEF Report* “clearly demonstrate[s] that implementing the LightSquared Subsidiary LLC (LightSquared) planned deployment for terrestrial operations poses a significant potential for harmful interference to Global Positioning System (GPS) services”).

clearly valid, and cannot be dismissed as simply a “vitriolic lobbying campaign” by the “commercial GPS industry” against LightSquared.^{105/}

2. The Disruption to High Precision GPS Devices Would Create Extreme Disturbances to Critical U.S. Industries, Such as Farming, Construction, Surveying, and Transportation, as well as to Critical Government Activity at the Federal, State, and Local Government Levels

In addition to the problems caused by disruption to other types of GPS devices, the disruption to high precision GPS devices would have a severe economic impact on critical U.S. industries, such as farming, construction, surveying and transportation. A recent study suggests that the aggregated benefits of GPS technology in these three industries total approximately \$39.4 billion per year, with a potential benefit of \$71.3 billion per year.^{106/} Pursuant to the TWG Report, given the investment in high precision GPS across several sectors of the U.S., the economic impact that could be expected from LightSquared’s deployment would be devastating, with estimated total economic costs over ten years summing to almost \$1 trillion.^{107/}

In addition, today there are more than 3.3 million jobs that rely on GPS technology, including approximately 130,000 jobs in GPS manufacturing industries and 3.2 million jobs in downstream commercial GPS-intensive industries, such as precision agriculture, engineering construction, and commercial surface transportation, among others.^{108/} When penetration of GPS technology reaches an expected 100 percent in commercial GPS-intensive industries, the number

^{105/} See LightSquared Recommendations at 10.

^{106/} See Nam D. Pham, Ph.D., *The Economic Benefits of Commercial GPS Use in the U.S. and the Costs of Potential Disruption*, NDP Consulting, at 9 (June 2011) (“*NDP Study*”), attached hereto as Exhibit A.

^{107/} See TWG Report at 282.

^{108/} See *NDP Study* at 1.

of jobs in these industries directly affected by GPS will exceed 5.8 million.^{109/} In the event GPS is disrupted, these jobs would be significantly threatened.

In the farming sector, which employs more than half a million people in the U.S., high precision GPS technologies are utilized for the accurate placement of pesticides, herbicides, and fertilizers.^{110/} According to census data from the U.S. Department of Agriculture, the value of crop farm production in the United States averages \$169.1 billion per year.^{111/} Studies show that disruption to GPS applications could adversely impact the benefits of GPS to crop farming, which has accounted for 11.8 percent of total U.S. crop production per year.^{112/} One of the largest manufacturers of high precision GPS devices for the agriculture, construction, and surveying industries has estimated that the “degradation of high-precision GPS signals could result in a negative impact to U.S. farmers of \$14 billion to \$30 billion annually.”^{113/}

High precision GPS technologies similarly increase production in the construction industry by increasing accuracy in activities such as surveying, excavating, grading, subgrading, transportation management, facility delivery, urban planning, and jobsite safety monitoring.^{114/} It is also used in construction to help improve efficiency, reduce costs and increase profits.^{115/} Such services have produced annual revenues of \$260 million per year.^{116/} Studies suggest that

^{109/} *See id.*

^{110/} *See id* at 6.

^{111/} *See id.*; TWG Report at 278.

^{112/} *See NDP Study* at 7 (calculating the total annual benefits of GPS to crop farming at \$19.9 billion per year.)

^{113/} *See* Letter from Barry Schaffter, Senior Vice President, Intelligent Solutions Group and Chief Information Officer, Deere & Company, to Marlene H. Dortch, Secretary, Federal Communications Commission, IBFS File No. SAT-MOD-20101118-00239, at 5 (filed July 5, 2011).

^{114/} *See NDP Study* at 7.

^{115/} *See id.*

^{116/} *See* TWG Report at 282.

GPS technologies generate approximately \$9.2 billion of cost savings for heavy and civil engineering construction, or 3.8 percent of annual production, with potential benefits reaching up to \$23 billion per year, or 9.4 percent of the annual production.^{117/} The vast majority of the land and hydrographic surveyors in the United States have invested heavily in high precision GPS, as have those engaged in surveying, mapping and geographical information systems in the public sector and across industries such as mining, domestic natural resources, energy including clean domestic energy, electric, water and gas utilities, land management, land transactions and mapping and charting for land, aeronautical and waterways. High precision GPS is deeply embedded in tens of billions of dollars worth of capital equipment in the United States, including in agricultural and construction plant and machinery, special purpose aircraft and vehicles used in high precision surveying, mapping and three dimensional modeling, and heavy vehicles using GPS lane guidance systems, among others.

Further, businesses across all sectors use GPS applications in vehicles to carry out several different types of transportation functions.^{118/} Studies have shown that between 50 percent and 86 percent of organizations that utilize and manage vehicle fleets have adopted GPS technologies for that purpose,^{119/} and have spent approximately \$126.4 billion annually on transportation related expenditures.^{120/} The total benefits of GPS applications to the transportation industry are estimated at \$10.3 billion per year, or 8.1 percent of annual U.S. expenditures on commercial

^{117/} See *NDP Study* at 8.

^{118/} See *id.*

^{119/} See *id.*

^{120/} See *id.* at 9.

surface transportation activities, with potential benefits reaching up to \$15.1 billion per year, or 12 percent of annual U.S. transportation activities.^{121/}

These economic figures relating to the costs and benefits of the provision of GPS service are real and verifiable. This is in stark contrast to the \$120 billion in alleged benefits that LightSquared alleges its terrestrial network will deliver to consumers.^{122/} As further shown in the economic analysis by the NDP Consulting Group appended to the comments submitted today in this proceeding by the Coalition to Save Our GPS, this \$120 billion is an arbitrary figure appearing in an economic study sponsored by LightSquared, which was calculated by multiplying an unsupported estimate of the value of LightSquared's L-Band spectrum of \$12 billion by ten.^{123/} LightSquared also cites this same economic study to support its accusation that the GPS industry has been the beneficiary of an "implicit subsidy" of \$18 billion in the form of free access to the government's GPS satellite infrastructure and frequencies.^{124/} As also discussed in detail in the economic study appended to the Coalition Comments, the government's investment in GPS does not amount to a subsidy any more than the transportation industry's use of the U.S. highway system amounts to a government subsidy.^{125/} This country's ability to leverage significant government GPS-related investments to benefit both the public and also the private sectors is evidence of sound public policy, and nothing more. In fact, if the definition of "subsidy" is applicable to any context in these proceedings, it would be applicable to

^{121/} *See id.*

^{122/} LightSquared Recommendations at 20.

^{123/} *See* Comments of the Coalition to Save Our GPS, IB Docket No. 11-109, IBFS File No. SAT-MOD-20101118-00239, Appendix B at 2 (filed Aug. 1, 2011) ("Coalition Comments").

^{124/} LightSquared Recommendations at 6.

^{125/} Coalition Comments, Appendix B at 3-4.

LightSquared's acquisition of its L-Band spectrum, which was not subject to the Commission's traditional spectrum auction processes.^{126/}

III. LIGHTSQUARED'S PACKAGE OF "SOLUTIONS" IN ITS RECOMMENDATIONS IS LACKING IN SUBSTANCE AND SUBSTANTIATION AND CANNOT PROVIDE A BASIS FOR DEPLOYMENT AT ANY TIME IN THE FORESEEABLE FUTURE

In its Recommendations, LightSquared proposes various "solutions" to the interference problems it previously claimed did not exist or were vastly overstated. The document uses a combination of sweeping unsupported generalizations, repackaged rhetoric, creative interpretation of data and optimistic predictions about present and future technology to support its overall claim that the massive interference found in the TWG Report can be solved. Taken individually and as a whole, the claims in the document do not survive even minimal scrutiny. One key feature of the purported solutions – LightSquared's proposal to confine its operations to the lower MSS band for some undefined period of time – has already been discussed at length, and contrary data has been highlighted previously.^{127/} Here, LightSquared can only support its claim that operations in this band will not cause interference by adopting an unprecedented and unsupported definition of what constitutes "harmful interference." Applying more standard benchmarks to the available data, the number of receivers that will suffer harmful interference increases dramatically. LightSquared's remaining suggestions rest on similarly slim reeds, and do not provide a basis to allow it to commence operations.

^{126/} *Id.* at 5.

^{127/} *See supra* Sections II.B. and II.C.

A. LightSquared’s Attempt To Define Away Harmful Interference by Adoption of Arbitrary and Unsupported Thresholds for Harmful Interference Must Be Rejected

LightSquared and all the rest of the Technical Working Group reach fundamentally different conclusions about the extent of harmful interference created by LightSquared’s proposed operations in the lower MSS band. The body of LightSquared’s Recommendations document repeats time and again that lower MSS band only operation solves the interference problem for 99% of GPS receivers without ever citing any detailed industry data or stating the critical assumptions underlying this claim. The linchpin of this claim is LightSquared’s own idiosyncratic definition of harmful interference, based on its own subjective evaluation of the levels of signal degradation that are “correlated with receiver performance.” The use of unproven, unsubstantiated standards to resolve an interference issue involving safety of life and a wide variety of other adverse consequences must be rejected.

Many of the sub-groups – including the High Precision, Timing and Networks sub-team – adopted the well-established threshold for harmful interference as a 1 Decibel (dB) degradation in the Carrier-to-Noise ratio of the received GPS signal.^{128/} LightSquared, on the other hand, takes the position that “a 1 dB reduction in the [Carrier-to-Noise ratio] may be unduly conservative,” further stating its unilateral belief that “the test results have shown no correlation of the 1 dB reduction to an impact on the end-user’s experience.”^{129/} Instead, LightSquared argues for a 6 dB degradation standard, and bases its conclusion that lower band operations do not cause interference on this much more lax standard.

The Carrier-to-Noise ratio measures the ratio between the “desired” signal a receiver is trying to receive and process and the “noise” that a receiver detects from both background

^{128/} See, e.g., TWG Report at 129, 187-188.

^{129/} *Id.* at 188.

“thermal” noise and from unwanted, interfering signals. If the “noise” in the ratio increases, the ability to receive the desired signal decreases, by an equivalent amount. A 1 dB degradation is equivalent to a 20 percent loss in the received signal power in a GPS receiver as a result of the jamming transmitter being present.

In the GPS context, loss in power of the desired GPS signal can be the difference between receiving or not receiving a signal from one or more of the GPS satellites above the horizon for a particular receiver on Earth, and therefore a reduction in accuracy of the location produced by the receiver (since the greater number of satellite signals received produces higher accuracy), and even the inability of the receiver to produce a location at all. Other effects of interference include loss of accuracy due to degraded signals, loss of sensitivity, loss of ability to perform initial acquisition of GPS satellites, and increased Time to First Fix (“TTFF”).

The 1 dB degradation threshold is well-established. This threshold has been adopted by the International Telecommunications Union and other international bodies. Specifically, and as mentioned in the TWG Report, the use of a 1 dB threshold “as a quantification of harmful interference to GPS has a well-recognized basis in the products of seven years of technical work on protection of radionavigation-satellite service receivers, which are now up for final approval within the ITU’s Radiocommunication Sector.”^{130/} The Asia-Pacific Telecommunity has similarly found that in order not to cause harmful interference to terrestrial networks, mobile phone onboard aircraft systems “shall not cause more than a 1 dB rise in the effective noise floor

^{130/} *Id.* at 129 (“The protection levels for various types of receivers that operate with RNSS systems, including GPS, in the 1559–1610 MHz band that are provided in Draft New Recommendation ITU-R .[1477_New] are based (in combinations of technical parameters such as – “system noise temperature” and “acquisition mode threshold power density level of aggregate wideband interference at the passive antenna output”) on a maximum permissible increase in the noise floor from interferers of 1 dB.”).

of the receiving ‘victim’ terminal receiver on the ground.”^{131/} The *NPEF Report*, submitted by NTIA, similarly endorsed use of the 1 dB threshold, finding that 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.”^{132/} For example, “some tested aviation receivers could not meet their WAAS word error rate requirements” in the presence of LightSquared interference even at the 1 dB threshold.^{133/} The FCC also has used the 1 dB degradation threshold to evaluate interference in a variety of proceedings.^{134/}

In fact, degradation to GPS performance may occur well before the point where 20 percent of the signal power is lost, so 1 dB is arguably too high a threshold. Despite this, LightSquared suggests – particularly in the context of the General Location and Navigation sub-team test results – that a 6 dB loss in the Carrier-to-Noise ratio is acceptable, providing no sound basis in accepted technical literature or engineering for this 6 dB standard.^{135/} A 6 dB degradation threshold, however, translates into a 75 percent reduction in the ability of GPS receivers to receive the desired GPS signals.

^{131/} Asia-Pacific Telecommunity, 5th Meeting of the APT Wireless Forum, *Guidelines on Technical Conditions for the Use of Mobile Phones Onboard Aircraft*, Document AWF-5/OUT-04 (rel. Aug. 27, 2008) (noting that the international standards organization 3GPP “endorsed the criteria of a 1 dB increase in the effective noise floor for the definition of harmful interference”).

^{132/} *NPEF Report* at 4.

^{133/} *Id.*

^{134/} See, e.g., *Revision of Part 15 of the Commission’s Rules Regarding Ultra-Wideband Transmission Systems*, Memorandum Opinion and Order and Further Notice of Proposed Rulemaking, 18 FCC Rcd 3857, ¶ 12 (2003) (evaluating harmful interference from ultra wideband transmissions “based on a 1 dB increase in the noise floor of the GPS receiver”); *Allocations and Service Rules for the 71-76 GHz, 81-86 GHz and 92-95 GHz Bands*, Report and Order, 18 FCC Rcd 23318, ¶ 91 (2003) (adopting an interference threshold-to-interference ratio that would cause no more than 1 dB of degradation to the static threshold of a protected receiver); *Allocations and Service Rules for the 71-76 GHz, 81-86 GHz, and 92-95 GHz Bands*, Memorandum Opinion and Order, 20 FCC Rcd 4889 (2005) (reiterating the Commission’s adoption of a 1 dB degradation limit); *Amendment of the Commission’s Rules to Establish Part 27, the Wireless Communications Service*, Memorandum Opinion and Order, 12 FCC Rcd 3977, ¶ 29 (1997) (basing calculations of permissible interference on a 1 dB allowable rise in the noise floor).

^{135/} TWG Report at 130.

LightSquared’s unilateral suggestion that a seventy five percent degradation in the ability of GPS receivers to receive GPS signals is not “correlated” with a degradation in day to day performance of GPS devices, based on its interpretation of test data, simply defies credulity. With hundreds of millions of receivers in use in critical applications every day, gambling that this incredible claim is correct is reckless. Indeed, LightSquared appears to have selected the 6 dB threshold because it successfully “defines away” observed harmful interference by “moving the goal posts,” for example, by allowing LightSquared to announce that harmful interference was shown in only 1 of the 29 devices tested instead of 20 of the 29 devices actually found by the General Location and Navigation sub-team to suffer harmful interference.^{136/}

Similarly, the Technical Appendix attached to LightSquared’s Recommendations includes a drive test graphic, which LightSquared characterizes as showing that even with “a 6 dB drop in [the Carrier-to-Noise ratio], the receiver performance continues to be almost indistinguishable from the case in which there is no potentially interfering signal.”^{137/} Even a casual inspection of LightSquared’s graphic indicates a one to two city block error for the 6 dB case when compared with the no-interference case.^{138/} This is not “almost indistinguishable” performance. In any case, it is remarkable technical naiveté to suggest that the selection of the appropriate threshold for determining harmful interference involving safety of life and hundreds of billions of dollars of economic benefits or harms should be based on a limited set of observed “drive test data,” as opposed to the expected statistical effects of a 75% degradation in the ability to receive GPS signals applied to hundreds of millions of receivers and more conventional industry benchmarks.

^{136/} *Id.* at 177.

^{137/} LightSquared Recommendations, Technical Appendix at 11-12.

^{138/} TWG Report at 157-159 (Figures 3.3.20 – 3.3.23).

Selection of the appropriate standard for GPS interference should also take into account prior compromises affecting the level of noise in the relevant interference environment. The GPS community has engaged in good faith efforts over many years to accommodate uses in the adjacent MSS band, agreeing to reduced received signal power and increased noise for GPS users in order to provide reasonable compromises to interference problems. For example, the previously agreed out of band emission limits already allow LightSquared to increase the noise within the GPS band by around 20 percent, as a result of its transmissions “bleeding over” into the GPS band. In addition, use of the 1 dB threshold for measuring interference here would allow LightSquared to reduce signal power by a further 20 percent due to the receiver overload caused by its high powered network proposal. Both the 20 percent increase in the noise and the 20 percent decreased signal power would affect the Carrier-to-Noise ratio equally. The testing clearly demonstrates that these limits would be far exceeded by both LightSquared’s initial proposal and lower 10 MHz proposal.

LightSquared takes a similar idiosyncratic and unfounded view of how harmful interference should be defined for GPS receivers in cell phones, which, not surprisingly, allows LightSquared to claim that no interference occurs. The main damage is done by the use of theoretical propagation models that systematically understate the size of the geographic area where cellular GPS receivers would be exposed to power levels all parties (including LightSquared) agree would constitute harmful interference and result in degraded performance, and extremely selective use of actual data.

LightSquared and the TWG members agree on the power levels where the cellular devices studied would fail the TWG interference tests in the lower MSS band scenario. Of the 41 devices tested, 6 failed the defined and agreed tests at power levels between -25 dBm and -45

dBm. A further 4 devices failed at -15 dBm.^{139/} LightSquared attempts to dismiss these results by stating in the Recommendations document that:

The data collected by the TWG process during the Las Vegas tests, as well as independent studies by LightSquared, demonstrate that, when considered over its entire network comprising the full range of tower heights, the LightSquared lower channel signal will be at levels of -20 dBm in no more than roughly 0.1 percent of its service area, -25 dBm in no more than 0.5 percent of its service area, and -30 dBm in no more than 1.0 percent of its service area. This is based on the Korowajczuk model simulations for Washington DC [TWG Final Report, Section 3.3.9.1.1] and additional independent simulation work performed by LightSquared.^{140/}

LightSquared's casual dismissal of interference occurring even in one percent of a network footprint that will cover 92 percent of the US population is disturbing, and would no doubt provide little solace to those who try to place E911 calls from that portion of its footprint.

Moreover, this claim simply does not hold up, and the TWG data in fact show interfering power levels in a far greater geographic area than LightSquared states. LightSquared's own measured and reported data from the Las Vegas site 53, Sector 1 shows power levels as high as -12 dBm measured on the ground (Fig 3.2.31 p110).^{141/} From the same tower, power levels of -40 dB

^{139/} TWG Report at 76-77 (Table 3.2.4, Figure 3.2.1, Figure 3.2.2).

^{140/} LightSquared Recommendations, Technical Appendix at 5.

^{141/} The same graph also shows that the majority of measured power levels were greater than those predicted by the one theoretical model favoured by LightSquared, the WILOS model, clearly demonstrating that this model substantially underestimates the power levels seen in practice and is therefore wholly inappropriate for interference analysis. As is pointed out in the TWG report, TWG Report at 124, WILOS obscures the effects of unobstructed or complementary propagation paths which are critical when designing or investigating interference to products with safety of life applications. Free Space Path Loss also underestimates the effects of complementary propagation paths in some cases but is a more reliable indicator of power levels that can be observed in practice, thus it is the de facto standard to be used in interference studies such as this. The data clearly shows that the WILOS model invariably underestimates the power observed on the ground when validated against actual measurements, for example by a factor of 50, or 17 dB. See TWG Report at 102 (showing power levels at 60m predicted by WILOS were -33 dBm while actual measurements were as high as -16 dBm, an error which is a of a factor of 50 times). Similarly, LightSquared does not even attempt to justify the extrapolation of the "Korowajczuk model simulations for Washington DC" to its entire footprint, nor is there any sound basis for assuming that such an extrapolation would produce reliable results. In addition, the key cited passage in LightSquared's technical appendix refers to "independent studies by LightSquared" and "additional independent simulation work performed by LightSquared." Since LightSquared does not disclose either the methodology or the results of these studies, they should be dismissed.

were observed to 1.4 km or almost a mile (TWG Fig 3.2.31 p110), -25 dBm to 700 meters, -20 dBm to 450 meters (TWG Fig 3.2.31 p110). In other words, using the live sky test data, six of the tested cellular devices would fail within 1.4 km to 700 meters from the tower. Given that the furthest distance from a tower in the network ranges from 0.2km in dense urban areas to 4km in very rural areas, with a typical average of around 1.5-2km, this equates to interfering signal strengths in a much higher percentage of its coverage area than LightSquared reports using its own faulty “simulation” data.

Once appropriate standards agreed upon by all of the members of the TWG other than LightSquared are used, rather than LightSquared’s unilateral and unsupported standards, the number of receivers that would suffer harmful interference if its lower band “solution” were deployed increases dramatically. Taking just the mass market devices into consideration, over 140 million devices used by consumers every day would suffer interference.

- The Cellular sub-team reported results that showed that at least 6 and potentially up to 10 out of 41 GPS receivers inside cell phones, or fifteen to twenty four percent, had failed to pass its defined interference test in lower MSS band only operations.^{142/} Applying this percentage to LightSquared’s estimate of 300 million cell phones with GPS receivers,^{143/} *44 million to 73 million cell phones currently in use would suffer harmful interference.*
- The General Location and Navigation sub-team found that 20 of the 29 devices tested, or sixty nine percent, would suffer harmful interference from lower MSS band operations.^{144/} Applying this percentage to LightSquared’s estimate of 100

^{142/} See TWG Report at 78, Figure 3.2.2.

^{143/} LightSquared Recommendations, Technical Appendix at 2.

^{144/} TWG Report at 19, 123.

million general navigation devices,^{145/} *69 million general navigation devices currently in use would suffer harmful interference.*

In short, what LightSquared is advocating with its solution is that the Commission should gamble with the lives and livelihoods of tens of millions of people that its unilateral technical views, contradicted by every other participant in the TWG and government testing process, are correct. A far more prudent approach would be to conclude that LightSquared has fallen far short of proving even that it is more likely than not, much less conclusively demonstrated, that its solution will work in a huge number of cases.

B. The Recommendations' Analysis of the Interference Problem for High Precision Receivers Is Deeply Flawed

1. LightSquared Grossly Underestimates the Number of High Precision GPS Devices in Use

LightSquared acknowledges, as it must, that it will create harmful interference to high precision receivers even if it confines its operations to the lower MSS band, for reasons explained above.^{146/} In order to minimize this unavoidable problem with its proposals, LightSquared grossly underestimates the number of high precision GPS receivers in the installed user base. Without citing any industry or other sources, LightSquared estimates the number of precision and network GPS devices is “approximately 200,000,” which it asserts represents “approximately 0.05 percent of the total installed base of commercial GPS receivers.”^{147/} To the contrary, Trimble’s sales of high precision GPS devices alone exceeds this number, and Trimble competes with more than ten other high precision GPS providers in the United States market, making this figure clearly grossly inaccurate. While exact data is not available, a further

^{145/} LightSquared Recommendations, Technical Appendix at 2.

^{146/} LightSquared Recommendations at 29; *supra* Sections II.B and II.C.

^{147/} *Id.* at 32 n.42.

indication of the magnitude of LightSquared's error is provided by data compiled in an economic study commissioned by the Coalition to Save Our GPS. This data (from public analyst reports cited in the study) shows that 769,000 GPS receivers have been sold in the last five years alone in the categories of construction machine control, precision agriculture and survey and mapping, all high precision applications.^{148/} The total number of high precision receivers in use is likely to be significantly higher once high precision receivers in other fields are taken into account.

LightSquared's attempt to minimize the high precision problem also falsely equates extremely high value high precision GPS systems costing tens of thousands of dollars each to extremely low cost embedded consumer GPS components costing just a few dollars, allowing LightSquared to claim that if it addresses interference to consumer GPS devices, it has solved 99% of the problem. That approach is inaccurate and overlooks, among other things, the relative impact on the economy, the comparative replacement cycle, and the different impact to safety of life and property of high precision and other GPS devices. As demonstrated in the *NDP Study*, precision construction and agriculture uses alone contribute almost \$30 billion dollars in economic benefits annually.^{149/}

2. LightSquared Falsely Suggests That the High Precision Interference Problem Arises from Poor Design Decisions by GPS Manufacturers

Throughout its Recommendations, LightSquared asserts that the GPS industry is to blame for the interference caused to GPS by LightSquared's operations because "GPS receivers do not adequately reject base station transmissions in the adjacent band,"^{150/} and high precision devices

^{148/} *NDP Study* at 5 (Table 1b).

^{149/} *NDP Study* at 6-8.

^{150/} *Id.* at 17.

in particular “deliberately use LightSquared’s L-band frequencies”^{151/} and even claims that the high precision receivers’ receipt of MSS signals is “unauthorized.”^{152/} LightSquared also criticizes GPS manufacturers for these choices, attributing them to their attempts to “minimize cost.”^{153/}

As a general matter, these claims suffer from the same fatal flaw as LightSquared’s broader claims that the GPS industry should have anticipated its plans and taken action accordingly. These claims assume that LightSquared’s current plans were actually contemplated at any point prior to January 2011, which is a false assumption. They also assume that there was available alternative technology that eliminated the interference problem, or that such technology can be developed in the future. This point too is wholly uncorroborated, at best unproven, and in Trimble’s view, just plain wrong.

In this context LightSquared’s claims are also disingenuous, as LightSquared itself, and its predecessors, have sold and profited from the very augmentation services that it now criticizes GPS manufacturers for designing its receivers to take advantage of. LightSquared also fails to disclose that its own service agreements for augmentation services specify that the services can be transmitted anywhere in the MSS band at the provider’s discretion, which means that such devices must be able to receive signals in the entire MSS band.^{154/} For LightSquared to characterize this capability as a GPS industry “design flaw” when it not only requires high

^{151/} *Id.* at 18.

^{152/} *Id.* at 36.

^{153/} *Id.* at 30.

^{154/} In proposing mitigation options for future high precision GPS receivers, LightSquared notes that one of its options would remove “the uncertainty that precision receiver manufacturers currently have regarding the frequency used to receive their MSS augmentation signals.” *Id.* at 34. Such assertions are particularly audacious given that LightSquared itself created such “uncertainty” by requiring GPS devices to be able to receive MSS augmentation services throughout the entire MSS band.

precision GPS receivers to be built with such capability but also collects ongoing payments by providing service to such receivers is remarkable. LightSquared's offer to fix this problem going forward by working with Inmarsat to specify more limited bands for transmission of augmentation signals in the future^{155/} is hardly a meaningful accommodation, since this is a problem of LightSquared's own creation.

LightSquared's related suggestion to move augmentation signals closer to the GPS band does not represent a sustainable solution until LightSquared definitively commits that it will not use its upper 10 MHz channel in the future. LightSquared has proposed only to delay, and not abandon entirely, use of its upper 10 MHz channel. In the absence of such a commitment, these related proposals are simply irresponsible – in essence LightSquared is proposing that GPS manufacturers redesign expensive integrated MSS-GPS equipment to tune only to a portion of the band which LightSquared ultimately will try to reclaim for terrestrial use, rendering all equipment in the field obsolete yet again, and all related investment a waste of time, money and effort.

LightSquared's self serving account of this issue raises further troubling questions. If LightSquared did not know that it was specifically requiring GPS devices to be designed in a way that would be incompatible with LightSquared's proposed terrestrial network, then it has yet again failed to do even the most minimal diligence regarding its spectrum neighbors and customers. On the other hand, if LightSquared knew all along that it was eventually planning to roll out terrestrial service completely incompatible with GPS augmentation services, then it has shown irresponsible disregard for its own customers.

Last, LightSquared's Recommendations document focuses almost entirely on integrated MSS-GPS devices, implying that these devices are the only high precision devices that will

^{155/} LightSquared Recommendations at 33-34.

suffer interference from lower MSS band operations. This is simply not the case – virtually all wideband high precision receivers will suffer destructive interference in this scenario, whether they are designed to receive services in the MSS spectrum or not, as noted in Section II.C. herein.

As also noted there, incorporating wideband technology into GPS devices is becoming increasingly common as it allows for the GPS device to optimize use of the spectrum and improve positioning, navigation, and timing (“PNT”) accuracy. Moving from narrowband to wideband GPS technologies is a trend that is critical in terms of improving location accuracy for a host of applications, including location based services used by first responders. So the high precision problem is not going to go away, and will only become more pronounced in the future.

C. LightSquared’s Proposed Solutions for High Precision Receivers Are Mere Window Dressing, and Do Not Reduce the Problem in Any Meaningful Way

The centerpiece of LightSquared’s recommended “solutions,” temporary operation on the lower MSS band only, is clearly not a solution at all. Another solution in the Recommendations document, LightSquared’s offer to “reduce” its power levels, is mere public relations spin, no doubt intended to create the impression that LightSquared is offering to reduce power levels relative to the levels that tests showed would produce harmful interference. In fact, the power levels already tested and evaluated by the TWG were at or below the power levels at which LightSquared commits to operate in its proposal.^{156/} As discussed in Section II.B. above, the TWG found overwhelming evidence that operating at such power levels would create substantial harmful interference to GPS. LightSquared’s specific proposals to resolve the high precision GPS interference problem are no better.

^{156/} LightSquared Recommendations at 25.

1. LightSquared’s Promise to Share the Cost of Underwriting a Workable Solution for High Precision Receivers Assumes an Engineering Solution That Does Not Exist and Does Not Address the Substantial Base of Existing Receivers

While even LightSquared cannot deny the fact that its proposed operations will cause extensive interference to high precision devices under its lower 10 MHz proposal, it has promised to “coordinate and share the cost of underwriting a workable solution for the small number of legacy precision measurement devices that may be at risk.”^{157/} As an initial matter, the number of high precision GPS devices at risk is not “small.” As discussed in Section III.B.1. above, LightSquared has grossly underestimated the number of high precision devices currently in use. Similarly, characterizing such devices as “legacy” connotes outdated receivers and not the advanced technology widely used and relied upon by both the public and private sector today. These mischaracterizations alone demonstrate LightSquared’s limited understanding of the magnitude of the high precision interference problem it has agreed to “solve.”

The usefulness of this proposal, however, hinges entirely on the truth of LightSquared’s contention that “there appear to be a number of mitigation options available to manufacturers of precision GPS receivers.”^{158/} There is simply no supporting evidence for this contention. As discussed above, the TWG Report evaluated mitigation measures and all parties involved in the TWG process except LightSquared concluded that viable mitigation options generally were not available, particularly for wideband and integrated MSS-GPS receivers.^{159/} As the TWG test results have also shown, filters that can block out high power signals in close by spectrum either do not exist or have not been tested or shown as effective. Consequently, such mitigation measures are pure technical speculation at the outset.

^{157/} *Id.* at 24.

^{158/} *Id.* at 32.

^{159/} TWG Report at 181.

The lack of proven technology also highlights the lack of any basis for LightSquared's assertion that GPS device manufacturers "must begin the process of improving their equipment by adding . . . appropriate filtering and other technology necessary to reject signals that operate outside the GPS frequencies."

This is simple wishful thinking and potentially harmful and wasteful. In the absence of credible, independent evidence that changes in GPS receivers can eliminate interference problems, there is no public policy rationale for forcing major redesign of GPS products at substantial expense to government and private purchasers of GPS equipment and systems, even if LightSquared were to fully underwrite the costs of developing them.

Nor would underwriting development costs "solve" the harmful interference to high precision devices on any time frame that is meaningful given LightSquared's immediate deployment plans. Even if adequate technology did become available at some future date, high precision systems are routinely deployed for a useful life of ten to fifteen years. From the date such technology became available, a fifteen year period would be required to complete a normal replacement cycle. Anything less would render worthless a settled capital equipment investment in high precision GPS user systems across the public and private sectors identified above amounting to between \$5 and \$10 billion dollars, in addition to the costs associated with replacing embedded systems and the lost production costs and social costs of disruption, including potentially safety of life and property. Of course, LightSquared does not offer to bear any of these costs. Shifting them to government purchasers in these days of yawning budget deficits, and to private industry and consumers, would be unconscionable.

2. Frequency Coordination Is Not a Viable Mitigation Option for the Installed Base of High Precision Receivers

LightSquared believes that the massive interference that its proposed operations would cause to the high precision GPS industries' installed user base of millions of GPS receivers should be handled by frequency coordination.^{160/} While LightSquared asserts that frequency coordination is “an especially appropriate solution” because it believes that many high precision receivers are used for applications “such as surveying, construction, and snowplowing that tend to be time-limited in nature,”^{161/} it provides no data to back up this broad generalization. This suggestion is a mere fig leaf.

LightSquared does not explain exactly how this coordination process would work. This is no doubt because coordination is simply not workable for spectrum uses involving hundreds of thousands if not millions of government users, small businesses and individuals. Frequency coordination is employed almost exclusively between parties with experience operating radio transmission facilities as part of their everyday businesses. It is also generally used to coordinate sustained use of frequencies at fixed locations, such as microwave links or cellular base stations. In those circumstances, coordination is a useful element of permanent network planning. This is the complete opposite of the way high precision devices are typically used. GPS users operate receivers, not transmitters, and will have no native competence or even knowledge of frequency matters. It is also unrealistic, to say the least, for LightSquared to expect a municipality to arrange for coordination prior to sending out their snowplows during a snowstorm. Similarly, imagine requiring every construction contractor and surveyor to contact a frequency coordinator before surveying a job site or operating precision machine controlled construction equipment to

^{160/} *Id.* at 35-36.

^{161/} *Id.* at 35.

build a building, and then waiting for an answer before proceeding with its activities. Or requiring a farmer to contact a frequency coordinator before plowing his fields, planting seed or harvesting.

We could go on with many other examples, but the absurdity of the idea should be apparent. Recognizing that LightSquared has committed to cover 92 percent of the US population with its terrestrial network, the frequency coordination bureaucracy would be overwhelming, and the requirement to coordinate itself would be one of the most intrusive regulatory burdens ever adopted, affecting an extraordinary amount of productive activity.

As if this were not bad enough, LightSquared completely ignores the crucial question of who has superior rights in the coordination process. When a construction contractor working in downtown Manhattan calls the new frequency coordination bureaucracy to notify it that he will be operating precision GPS machine control construction equipment on a construction site, what happens next (hopefully after a reasonably short hold time)? Will LightSquared then shut down its cell sites serving the relevant area? That seems unlikely, and would no doubt be of concern to LightSquared's customers in the area. Or will the contractor simply be told that his plans conflict with LightSquared's existing operations and that he will have to forego use of high precision GPS on this job? Or, for that matter, any other job where LightSquared has a network, *i.e.* the vast majority of the United States, according to LightSquared? In other words, the coordination process would accomplish exactly nothing, but at the cost of tremendous effort and disruption of productive activity.^{162/}

^{162/} LightSquared's proposal to use a cellular or Personal Communications Service band modem for the augmentation link, *id.* at 33, is also unhelpful and also reflects ignorance of how GPS augmentation/corrections are used. This "solution" is by definition limited to places where there is terrestrial network coverage. And it ignores that fact that precision users who purchase satellite based augmentation obviously have a need for satellite coverage or they would not be buying the service in the first place. LightSquared's proposal would necessarily force these users to purchase two different

augmentation services rather than the one they have now that works perfectly well. And of course LightSquared provides no details about how and when LightSquared would offer such a service, its cost, or other relevant details, which are critical to evaluate the viability of this “solution.”

IV. CONCLUSION

Having received the TWG's Report, the FCC must now conclude that the condition in its *January 2011 Order*, which required demonstration that LightSquared's proposed use of the MSS L-Band for a densely deployed, high powered terrestrial network will not interfere with GPS, has not been met, and that LightSquared cannot be permitted to commence operations in this band. The TWG report and independent studies leave no doubt that GPS receivers will suffer devastating interference from LightSquared's system – whether as originally conceived or in its latest “hail Mary” configuration. While the United States must have additional spectrum for terrestrial wireless broadband systems, sound spectrum management policy dictates that the MSS L-Band cannot be the home for those systems. GPS is too important to the United States economy, government operations and consumers for the FCC to try to fit the LightSquared round peg into the satellite band's square hole.

Respectfully submitted,

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EXHIBIT A

The Economic Benefits of Commercial GPS Use in the U.S. and the Costs of Potential Disruption

NDP Consulting Group Study

The Economic Benefits of Commercial GPS Use in the U.S. and The Costs of Potential Disruption

June 2011

Nam D. Pham, Ph.D.

The Economic Benefits of Commercial GPS Use in the United States and the Costs of Potential Disruption

Nam D. Pham, Ph.D.¹

Background and Summary

LightSquared is a company with plans to build a nationwide 4G-LTE wireless broadband network utilizing spectrum allocated for Mobile Satellite Service. The base stations of the LightSquared network will transmit signals in a radio band immediately adjacent to the Global Positioning System (GPS) frequencies, which has caused a great deal of concern that GPS signals may be desensitized, resulting in jamming and other forms of interference that will affect the reliability and functionality of GPS equipment.

If the LightSquared network is deployed on this spectrum, it is very likely that all GPS signal-receiving equipment will suffer signal degradation ranging from mild to severe. In response to concerns voiced from the military, industry and others, the Federal Communications Commission mandated tests be conducted and any conflicts resolved before LightSquared can begin operations. At present, the Technical Working Group, comprised of LightSquared members of the U.S. GPS Industry Council and other affected GPS users, is conducting tests of various GPS equipment under different operating scenarios to determine the depth and breadth of potential signal degradation.

The commercial stakes are high. The downstream industries that rely on professional and high precision GPS technology for their own business operations would face serious disruption to their operations should interference occur, and U.S. leadership and innovation would suffer. Although recreational and military applications for GPS equipment are larger in terms of equipment sales volume, commercial applications generate a large share of economic benefits for society. As shown later in this report, the direct economic benefits of GPS technology on commercial GPS users are estimated to be over \$67.6 billion per year in the United States. In addition, GPS technology creates direct and indirect positive spillover effects, such as emission reductions from fuel savings, health and safety gains in the work place, time savings, job creation, higher tax revenues, and improved public safety and national defense. Today, there are more than 3.3 million jobs that rely on GPS technology, including approximately 130,000 jobs in GPS manufacturing industries and 3.2 million in the downstream commercial GPS-intensive industries. The commercial GPS adoption rate is growing and expected to continue growing across industries as high financial returns have been demonstrated. Consequently, GPS technology will create \$122.4 billion benefits per year and will directly affect more than 5.8 million jobs in the downstream commercial GPS-intensive industries when penetration of GPS technology reaches 100 percent in the commercial GPS-intensive industries.

As is the case in all other innovative industries, the GPS industry directly creates jobs and economic activities, which spur economic growth. Evidence shows that innovative industries, such as the GPS industry, create both high- and low-skilled jobs during economic expansions and downturns, pay their employees higher-than-national-average wages, raise output and sales per employee, increase U.S. competitiveness, which is reflected in increased exports and reduced U.S. trade deficits, and spend large sums on R&D and capital investment. In addition to creating these direct economic benefits, innovative industries create productivity benefits to the downstream industries, including increased sales, profits, and investment returns. Empirical studies have shown sustained productivity benefits support further growth and job creation in downstream industries and the U.S. economy as a whole.²

¹ This research received support from Coalition to Save Our GPS. The research team of this project includes Nam D. Pham, Daniel Ikenon, Mark Schmidt, Dylan Fox, Erin Fisher, and Tatiana Nikiforova. The analysis and views expressed here are solely those of the author.

² Pham, Nam D. 2010. "The Impact of Innovation and the Role of Intellectual Property Rights on U.S. Productivity, Competitiveness, Jobs, Wages, and Exports." NDP Consulting publication.

This analysis focuses exclusively on the direct economic benefits of GPS technology to commercial GPS users and, consequently, the economic costs of GPS signal degradation to commercial GPS users and GPS manufacturers. The full quantitative results presented, therefore, underestimate the economic benefits of the GPS to the U.S. economy, as they do not include the benefits that accrue to personal consumers or other noncommercial (consumer oriented) or military users.

The direct economic costs of full GPS disruption to commercial GPS users and GPS manufacturers are estimated to be \$96 billion per year in the United States, the equivalent of 0.7 percent of the U.S. economy. This annual total cost is the sum of \$87.2 billion and \$8.8 billion imposed on commercial GPS users and commercial GPS manufacturers, respectively. GPS user costs consist of \$67.6 billion per year in foregone GPS benefits—increased productivity and input cost savings—and another \$19.6 billion book value of investment losses in GPS equipment. GPS manufacturer costs consist of \$8.3 billion per year in foregone commercial GPS equipment sales and an additional \$0.55 billion per year in R&D spending and associated costs to attempt to mitigate the “LightSquared Problem.”

If the operation of LightSquared will disrupt 50 percent of commercial GPS equipment, the direct economic impacts are expected to be \$48.3 billion per year. Except the R&D spending and the opportunity cost of R&D spending performed by GPS manufacturers to find attempt to mitigate interference, direct economic costs to commercial GPS users and foregone GPS equipment sales are assumed to be half of total direct costs under the scenario of 100 percent degradation. In addition to direct economic impacts, there are other forgone direct and indirect economic and social benefits that are threatened by the LightSquared Problem. On the macroeconomic level, GPS disruption would reduce productivity and, consequently, hinder the competitiveness of GPS downstream users (Summary Table).

Summary Table. Estimated Annual Economic Costs of GPS Signal Disruption

	100 percent Degradation (in \$ billions)	50 percent Degradation (in \$ billions)
<i>DIRECT ECONOMIC IMPACTS</i>		
Commercial GPS Users	<u>\$87.2</u>	<u>\$43.6</u>
Foregone increased in productivity and cost-savings	\$67.6	\$33.8
Precision agriculture (crop farming)	\$19.9	\$10.0
Engineering Construction (heavy & civil, and surveying/mapping)	\$ 9.2	\$ 4.6
Transportation (commercial surface transportation)	\$10.3	\$ 5.1
Other commercial GPS users	\$28.2	\$14.1
Investment losses in GPS equipment	\$19.6	\$ 9.8
GPS Manufacturers	<u>\$ 8.8</u>	<u>\$ 4.7</u>
Foregone GPS equipment sales	\$ 8.3	\$ 4.1
R&D spending	\$ 0.5	\$ 0.5
Opportunity costs of R&D spending	\$ 0.1	\$ 0.1
<u>TOTAL</u>	<u>\$96.0</u>	<u>\$48.3</u>
<i>OTHER DIRECT & INDIRECT IMPACTS</i>		
Emission reductions from fuel savings		
Health and safety gains in work place		
Worker time savings		
Public safety and emergency response times		
Employment in GPS-related industries and supporting industries		
Quality-of-life improvements from noncommercial (consumer) GPS products and services		
Military, national defense, and public safety		
Large tax base to fund federal and local government expenditures		

The Development of Commercial GPS and Its Economic Benefits to the U.S. Economy

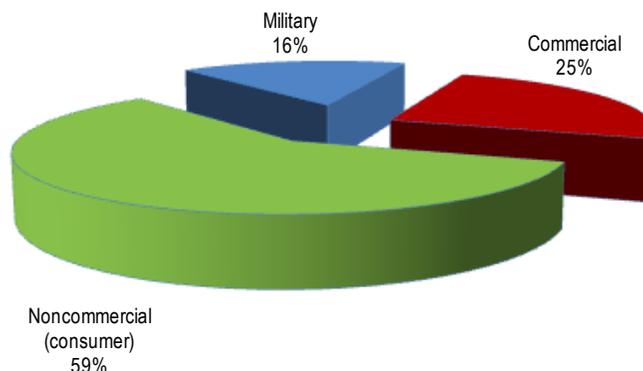
The Global Positioning System (GPS) is a U.S. government-owned technology that provides military and civilian users with positioning, navigation, and timing (PNT) services. The system was developed by the U.S. Department of Defense in 1978 strictly for military use, and played an important role in the 1991 Gulf War, as U.S. troops used it for navigation on land, sea and in the air for targeting of bombs and for on-board missile guidance. Following the Korean Airlines disaster in 1987, President Reagan announced that GPS would be available for civilian use once fully operational, which was initially established with a deliberate degradation of user position accuracy. On May 1, 2000, President Clinton announced the permanent end of the intentional degradation of the GPS signal to the public. Today, the GPS system consists of three components: the space component, the control component, and the user component. The space component consists of 30 operating satellites that transmit one-way signals that give the current GPS satellite position and time. The control component consists of worldwide monitor and control stations. And, the user component consists of GPS receiver equipment, which receives the signals from the GPS satellites and uses the transmitted information to calculate the user's three-dimensional position and time.³

During the past twenty years, GPS technology has transformed American businesses and lifestyles with myriad commercial applications across industries and spheres of life. GPS applications have improved business operations and best practices in a range of industries, including farming, construction, transportation, and aerospace. In addition to creating efficiencies and reducing operating costs, the adoption of GPS technology has improved safety, emergency response times, environmental quality, and has delivered many other less-readily quantifiable benefits. Although the market for GPS is already a multi-billion dollar industry, the future potential is still far reaching.

Market segments

Annual GPS equipment revenues in North America averaged \$33.5 billion during the period 2005-2010.⁴ The GPS market can be divided into three broad categories: commercial, noncommercial (consumer), and military. During the period, commercial equipment sales accounted for 25 percent of the total, while noncommercial and military equipment accounted for 59 percent and 16 percent, respectively (Figure 1).

Figure 1. Revenue Shares of GPS Equipment, 2005-2010⁵



Although a couple of industries dominate the commercial category, GPS technology is rapidly developing new applications across industries from construction to agriculture. During the period 2005-2010, commercial automobile

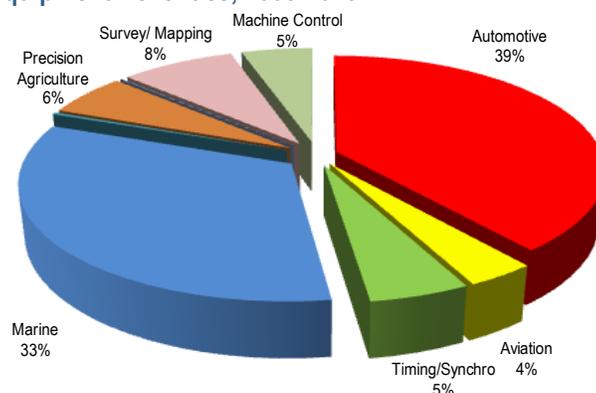
³ GPS.gov.

⁴ Bone, Dominique and Stuart Carlaw. 2009. "Global Navigation Satellite Positioning Solutions." ABI Research; and authors' estimates. North America consists of the United States, Canada, and Greenland. The U.S. markets are estimated to account for more than 90 of North America. Since disaggregated data is not available, we use North America data for this analysis.

⁵ Bone, Dominique and Stuart Carlaw. 2009. "Global Navigation Satellite Positioning Solutions." ABI Research; and authors' estimates.

and marine industries accounted for 39 percent and 33 percent of commercial GPS equipment sales, respectively. The remainder of the commercial market comprises surveying/mapping (8 percent), precision agriculture (6 percent), machine control (5 percent), timing/synchronization (5 percent), and aviation (4 percent) (Figure 2).

Figure 2. Commercial GPS Equipment Revenues, 2005-2010⁶



GPS equipment revenues increased more than 55 percent from \$25.5 billion in 2005 to \$39.6 billion in 2010. Revenues generated from the commercial segment increased by 120 percent from \$4.7 billion in 2005 to \$10.3 billion in 2010, and accounted for nearly 26 percent of total revenues in 2010. The noncommercial (consumer) segment, which includes passenger cars, recreational products (handhelds, fitness, and sports hardware solutions), and converged solutions (mobile handsets and portable consumer electronics devices) accounted for nearly 60 percent of total GPS equipment revenues during the period 2005-2010. Revenues generated from noncommercial (consumer) segments increased by 22 percent from \$17.6 billion in 2005 to \$21.3 billion in 2010. The military segment increased by 147 percent from \$3.2 billion to \$8.0 billion in 2010 (Table 1a).

Table 1a. GPS Equipment Revenues by Segment, 2005-2010 (in \$ billions)⁷

	2005	2006	2007	2008	2009	2010	Growth
Commercial	\$4.686	\$6.538	\$8.719	\$9.980	\$9.353	\$10.298	120%
Ground transport.	1.205	2.145	3.479	4.233	4.085	4.213	250%
Aviation	0.209	0.278	0.314	0.361	0.271	0.325	56%
Machine control	0.320	0.367	0.408	0.443	0.467	0.551	72%
Marine	1.650	2.351	2.978	3.254	2.766	3.254	97%
People-tracking	0.013	0.014	0.016	0.018	0.035	0.060	352%
Precision Ag.	0.480	0.497	0.499	0.490	0.467	0.499	4%
Railway	0.006	0.006	0.006	0.006	0.006	0.006	0%
Surveying/mapping	0.517	0.563	0.673	0.736	0.700	0.833	61%
Timing/Synchron.	0.287	0.317	0.346	0.439	0.558	0.558	94%
Noncommercial (consumer)	\$17.553	\$19.083	\$19.956	\$20.214	\$19.855	\$21.332	22%
Automobile	2.167	3.897	5.050	4.921	3.828	3.587	66%
Converged	15.077	14.815	14.461	14.677	15.409	16.939	12%
Recreational	0.309	0.371	0.445	0.616	0.618	0.807	161%
Military	\$3.240	\$4.255	\$5.282	\$6.447	\$6.125	\$7.989	147%
TOTAL	\$25.479	\$29.876	\$33.957	36.641	35.332	\$39.619	55%

Between 2005 and 2010, the number of GPS equipment units sold in North America rose by 75 percent from 69.8 million units to 122.4 million units in 2010. GPS equipment units sold in the commercial segment increased by 305 percent from 1.9 million units in 2005 to 7.7 million units in 2010. While revenues from the commercial segment accounted for 26 percent of total revenues in 2010, commercial units sold accounted for only 6.3 percent of total GPS

⁶ Bone, Dominique and Stuart Carlaw. 2009. "Global Navigation Satellite Positioning Solutions." ABI Research; and authors' estimates.

⁷ Bone, Dominique and Stuart Carlaw. 2009. "Global Navigation Satellite Positioning Solutions." ABI Research; and authors' estimates.

equipment units sold in 2010. In contrast, there were 109.9 million units sold in the noncommercial segment, a 68 percent increase from 65.2 million units sold in 2005. The military segment was the smallest destination for GPS equipment in 2010, with 4.7 million units sold (Table 1b).

Table 1b. GPS Equipment Units Sold by Segment, 2005-2010 (in millions)⁸

	2005	2006	2007	2008	2009	2010	Growth
Commercial	1.909	3.054	5.335	6.804	7.287	7.738	305%
Ground transport.	0.612	1.183	2.895	3.998	4.836	4.828	689%
Aviation	0.042	0.050	0.052	0.060	0.045	0.054	30%
Machine control	0.016	0.020	0.025	0.030	0.032	0.042	163%
Marine	1.100	1.650	2.200	2.530	2.151	2.530	130%
People-tracking	0.019	0.022	0.025	0.029	0.059	0.100	427%
Precision Agi.	0.024	0.028	0.031	0.034	0.032	0.038	58%
Railway	0.000	0.000	0.000	0.000	0.000	0.000	0%
Surveying/mapping	0.060	0.063	0.067	0.074	0.070	0.083	39%
Timing/Synchron.	0.036	0.037	0.038	0.049	0.062	0.062	73%
Noncommercial (consumer)	65.239	72.340	83.037	91.597	97.165	109.925	68%
Automobile	2.551	6.057	14.238	18.854	18.553	20.210	692%
Converged	60.942	64.213	66.342	69.604	75.422	85.761	41%
Recreational	1.747	2.070	2.457	3.140	3.190	3.955	126%
Military	2.674	3.045	3.528	4.030	3.828	4.688	75%
TOTAL	69.822	78.438	91.899	102.432	108.280	122.351	75%

Between 2005 and 2010, technology advances caused GPS equipment prices to decline—most notably in the commercial segment. On average, commercial GPS equipment prices declined by 46 percent from \$2,454 per unit in 2005 to \$1,331 per unit in 2010. Prices of GPS equipment for commercial automobiles declined by 56 percent from \$1,968 per unit in 2005 to \$873 per unit in 2010, followed by 34 percent price declines in the precision agriculture and machine control segments. However, prices of commercial GPS equipment rose in the aviation (20 percent), surveying/mapping (16 percent), and timing/synchronization segments (13 percent) (Table 1c).

Table 1c. Unit Price of GPS Equipment Sold by Segment, 2005-2010⁹

	2005	2006	2007	2008	2009	2010	Growth
Commercial	\$2,454	\$2,141	\$1,634	\$1,467	\$1,283	\$1,331	-46%
Ground transport.	1,968	1,813	1,201	1,059	845	873	-56%
Aviation	5,000	5,500	6,000	6,000	6,000	6,000	20%
Machine control	20,000	18,000	16,200	14,580	14,580	13,122	-34%
Marine	1,500	1,425	1,354	1,286	1,286	1,286	-14%
People-tracking	700	665	632	600	600	600	-14%
Precision Ag.	20,000	18,000	16,200	14,580	14,580	13,122	-34%
Railway	20,000	20,000	20,000	20,000	20,000	20,000	0%
Surveying/mapping	8,600	8,900	10,000	10,000	10,000	10,000	16%
Timing/Synchron.	8,000	8,500	9,000	9,000	9,000	9,000	13%
Noncommercial (consumer)	\$269	\$264	\$240	\$221	\$204	\$194	-28%
Automobile	850	643	355	261	206	177	-79%
Converged	247	231	218	211	204	198	-20%
Recreational	177	179	181	196	194	204	15%
Military	\$1,212	\$1,398	\$1,497	\$1,600	\$1,600	\$1,704	41%
TOTAL	\$365	\$381	\$369	\$358	\$326	\$324	-11%

⁸ Bone, Dominique and Stuart Carlaw. 2009. "Global Navigation Satellite Positioning Solutions." ABI Research; and authors' estimates.

⁹ Bone, Dominique and Stuart Carlaw. 2009. "Global Navigation Satellite Positioning Solutions." ABI Research; and authors' estimates.

The above sales figures have several important implications: (1) Although fewer GPS units were sold in the commercial segment, the value of each unit and the prices per unit in the commercial sector are higher than those in the noncommercial (consumer) segment; (2) the commercial segment became more GPS-intensive over the period examined, and; (3) as with other innovations, technological advances and economies of scale have driven down the prices of GPS equipment.

Economic Benefits of Commercial GPS to the U.S. Economy

The revenues from GPS equipment sales and services represent only a small portion of the economic benefits of GPS to the U.S. economy. As Edward Morris of the U.S. Department of Commerce testified before Congress in 2006, “*Equipment sales represent only the tip of the economic iceberg. As with personal computers, the true value of GPS is not in the cost of the equipment, but in the productivity and growth it enables.*”¹⁰

Indeed, the economic benefits of GPS to the U.S. economy are substantial. GPS manufacturers create employment, provide earnings, add value, and generate tax revenues for governments. Importantly, GPS technology improves productivity and produces cost-savings for end-users. This section estimates the direct economic benefits of GPS to three industries—precision agriculture, engineering construction (heavy and civil engineering, and surveying/mapping), and commercial surface transportation.¹¹ These three industries account for approximately 58 percent of total commercial GPS equipment sales and 17 percent of combined commercial and noncommercial GPS equipment sales during the period 2005-10. In terms of quantity, these three industries account for approximately 60 percent of total commercial GPS equipment units sold but only 3.5 percent of combined commercial and noncommercial GPS equipment units sold during the period 2005-10. Again, there are fewer commercial GPS users than noncommercial users but the equipment they purchase is more expensive than the equipment purchased by noncommercial users.

Precision Agriculture. GPS technology is used extensively in agriculture for what is called precision or site-specific farming. GPS applications are used for farm planning, field mapping, soil sampling, tractor guidance, crop scouting, variable rate applications of seeds, fertilizers, and pesticides, and yield mapping. Before GPS, it was more difficult for farmers to match production techniques or crop yields with land variability. This limited their ability to develop the most effective strategies to increase yields. Today, GPS-guidance equipment enables more precise application of pesticides, herbicides, and fertilizers, and better control of the dispersion of those chemicals, which reduces expenses, increases yields, and creates a more environmentally-friendly farm. For example, ten years ago, a 4,000-acre farm might have required eight or nine tractors; today it needs just three or four machines and has the capacity to adopt 24 hour operations during critical planting and harvesting months. In surveys, studies, and other industry literature, GPS adoption rates (use of at least one GPS technology) in crop farming were found to range from 23 percent to 91 percent. Based on a measured consideration of those findings, we estimated an average adoption rate of 60 percent, which factors into our estimation of the current economic impact of GPS on crop farming.¹² Since firms are adopting GPS technology and equipment at an increasing rate, we provide an additional simulation to estimate the economic impact of GPS at the 100 percent adoption rate.

¹⁰ Morris, Edward. 2006. “Hearing on Space and U.S. National Power.” The statement of Edward Morris, Director Office of Space Commercialization National Oceanic and Atmospheric Administration, U.S. Department of Commerce, on June 21, 2006 before the Committee on Armed Services Subcommittee on Strategic Forces U.S. House of Representatives.

¹¹ “Commercial Surface Transportation” is not an official U.S. industry with associated official statistics. We are assigning this designation for the aggregate transportation-related functions of firms across industries in the economy because the beneficiaries of fleet management technology comprise firms in manufacturing, services, transportation, warehousing, and others.

¹² For example, Winstead, Amy T. and Shannon H. Norwood. 2010. “Adoption and Use of Precision Agriculture Technologies by Practitioners.” Auburn University Working Paper; The Allen Consulting Group. 2007. “The Economic Benefits of Making GPSnet Available to Victorian Agriculture.” Report to the Department of Sustainability and Environment, Government of Victoria, Australia; and, Diekmann, Florian and Marvin T. Batte. 2010. “2010 Ohio Farming Practices Survey: Adoption and Use of Precision Farming Technology in Ohio.” Ohio State University Department of Agricultural, Environmental, and Development Economics.

The measureable direct economic benefits of GPS to crop farming can be observed in greater output and reduced input costs.¹³ Industry studies, surveys, and testimonials from farmers about a variety of crops grown in different regions under different conditions find that the use of GPS equipment is associated with yield gains ranging from 3 percent to 50 percent. On the operation side, GPS technology provides crop farming with cost-savings on labor, capital (machine and equipment), and raw materials (seed, fertilizers, pesticides, other chemicals, fuels and oils, electricity). Estimates of input cost reductions range from 1 percent to 50 percent of total input costs. Based on a considered weighting of those findings, we estimate the average GPS-induced yield gain to be 10 percent and the average input savings to be 15 percent.¹⁴

According to data from the U.S. Department of Agriculture, the value of U.S. crop production averaged \$169.1 billion per year during the period 2007-2010. The industry spent an average of \$108.4 billion per year on affected inputs including seed, fertilizer and lime, fuels and oils, electricity, pesticides, repair and maintenance, and hired and contract labor expenses during the same period.¹⁵ With a GPS adoption rate of 60 percent, we estimate that the use of GPS technology accounted for \$10.1 billion of industry output per year (\$169 billion production x 0.60 adoption x 0.10 GPS yield gain) and reduced input costs by \$9.8 billion per year (\$108.4 billion input expense x 0.60 adoption x 0.15 GPS input cost-savings). The aggregate annual benefits of GPS to crop farming, thus, totaled \$19.9 billion per year, the equivalent of 11.8 percent of total annual production (Table 2).

As GPS technology continues to prove its value, the adoption rate will approach and possibly reach 100 percent, raising the potential benefits of current GPS technology to the industry to \$33.2 billion per year, the equivalent of 19.6 percent of the value of current annual U.S. crop production (Table 2).

Table 2. Annual Benefits of GPS to Crop Farming

	Annual Value (in \$ billions)	60% Adoption: Annual GPS Benefits (in \$ billions)	100% Adoption: Annual GPS Benefits (in \$ billions)
Crop production (2007-2010)	\$169.1	\$10.1	\$16.9
Affected input expenses (2007-2010)	\$108.4	\$ 9.8	\$16.3
Total		\$19.9	\$33.2
% of total annual production (\$169.1 billion)		11.8%	19.6%

Engineering Construction (Heavy & Civil and Surveying/Mapping). GPS equipment increases productivity in the construction industries by providing accurate machine guidance and measurement technology. The technology improves accuracy and increases efficiency in many related functions such as surveying, excavating, grading, sub-grading, transportation management, facility delivery, urban planning, and jobsite safety monitoring. Activities that once required a variety of tools and instruments such as measuring tapes, compasses, and levels, and weeks of intensive work by teams of specialists can now be done by one person with a GPS device in a matter of hours. With the GPS surveying instrument in his hand, the construction surveyor can take precise measurements without the requirement of line of sight. These devices work under any weather conditions, making the process of construction surveying fast, easy, and more precise. GPS technology in construction is also effectively used for material and equipment management, helping to improve efficiency, reduce costs, and increase profits. Based on industry surveys, GPS adoption rates are estimated to be about 40 percent in the heavy and civil engineering construction

¹³ This study does not estimate indirect economic benefits of using GPS in crop farming such as the environmental benefits of more efficient land and chemical use and reduced farm equipment emissions.

¹⁴ The Allen Consulting Group. 2007. "The Economic Benefits of Making GPSnet Available to Victorian Agriculture." Report to the Department of Sustainability and Environment, Government of Victoria, Australia; University of Illinois Extension. 2011. "Farm GPS Improves Profits and Quality of Life." News Release; Martin, Steven and James Hanks. 2005. "Estimating Total Costs and Possible Returns from Precision Farming Practices." *Crop Management*; Langcuster, James. 2010. "Experts: Precision Farming Does Save," Blog Post, Alabama Cooperative Extension System, November 23, 2010; and, Winstead, Amy. 2011. "Does Precision Ag Pay?" Blog Post, Alabama Cooperative Extension System, April 15, 2011.

¹⁵ ERS database, U.S. Department of Agriculture.

industry. Again, we provide an additional simulation to estimate the economic benefits of GPS at the 100 percent adoption rate, as use is likely to increase as the technology's value continues to be proven.

The benefits of GPS to the industry can be measured in terms of savings of labor, capital, and materials. Industry studies, surveys, and testimonials indicate that the potential reduction in labor usage (reduced man-hours of foremen, operators, surveyors, and workers on construction projects) attributable to GPS technology ranges from 57.4 percent to 62.3 percent, averaging 59.8 percent. The capital savings component includes the reduced use of machinery attributable to time savings, and is estimated as the savings in rental equipment expenditures and capital machinery purchases. Studies and surveys point to a capital savings rate in the range of 17.5 percent to 42.5 percent, averaging 30 percent. Lastly, studies estimate average fuel savings of 32.4 percent, ranging from 22.2 to 42.5 percent.¹⁶

In the latest 2007 survey data published by the U.S. Bureau of the Census, heavy and civil engineering construction reports \$32.0 billion in construction worker wages, \$10.6 billion on capital equipment purchases and rentals, and \$2 billion on fuels and lubricants for off-highway use.¹⁷ At an estimated 40 percent adoption rate, we find that GPS technology produces \$9.2 billion of cost savings for heavy and civil engineering construction, the equivalent of 3.8 percent of annual production. These savings include \$7.6 billion in construction labor wages (\$32 billion x 0.40 adoption x 0.598 GPS-labor-savings), \$1.3 billion in capital machinery and equipment (\$10.6 billion x 0.40 adoption x 0.30 GPS-capital-savings), and \$0.3 billion in affected inputs (\$2.0 billion x 0.40 adoption x 0.324 GPS-fuel savings). The potential benefits of GPS to the industry climb to \$23 billion per year, the equivalent of 9.4 percent of the annual value of the industry, when the adoption rate is 100 percent (Table 3).

Table 3. Annual Benefits of GPS to Engineering Construction (Heavy & Civil and Surveying/Mapping)

	Annual Value (in \$ billions)	40% Adoption: Annual GPS Benefits (in \$ billions)	100% Adoption: Annual GPS Benefits (in \$ billions)
Labor (2007)	\$32.0	\$7.6	\$19.1
Capital (2007)	\$10.6	\$1.3	\$ 3.2
Affected input expenses (2007)	\$ 2.0	\$0.3	\$ 0.7
Total		\$9.2	\$23.0
% of total annual production (\$245.7 billion)		3.8%	9.4%

Commercial Surface Transportation. Businesses across the economic spectrum—from mid-sized manufacturers to large service providers—own or lease vehicles used to carry out various functions of the companies' operations. Businesses in transportation, warehousing, manufacturing, express delivery, home delivery, and carpet cleaning services operate and attempt to manage vehicle fleets. Such management simply cannot be imagined without the use of GPS today. Vehicle tracking, one of the fastest-growing applications for GPS technology, helps increase mobile workforce productivity and safety and enables enterprises to reduce labor and fuel expenses.

Studies, surveys, and other industry research indicate that between 50 and 86 percent of all firms that manage vehicle fleets have adopted GPS equipment for that purpose. We estimate the current GPS adoption rates in the U.S. to be 67.9 percent. Estimates from industry studies indicate GPS technology provides average savings of labor, fuel,

¹⁶ Caterpillar. 2006. "Road Construction Production Study." MALAGA Demonstration and Learning Center; Adalsteinsson, Dadi. 2008. "GPS Machine Guidance in Construction Equipment." Working Paper; Trimble Navigation. 2005. "Soil Challenges and Complex Grading Test Machine Control." Testimonial, *Trimble Productivity*, Fall 2005; Trimble Navigation. 2006. "Mid-size Contractor Makes Bold Move Pay." Testimonial, *Trimble Productivity*, Spring 2006; Aliant Engineering Inc. 2007. "Best Practices: Machine Control Evaluation." Report Prepared for Minnesota Department of Transportation; Vonderohe, Alan. 2007. "Implementation of GPS Controlled Highway Construction Equipment." Final Report, University of Wisconsin (Madison), Construction Materials and Support Center; and, Clear Seas Research. 2009. "Survey and Mapping Industry Equipment Study 2009." CleaReport.

¹⁷ U.S. Census Bureau; Heavy and civil engineering construction industry (NAIC 237) consists of highway, street, and bridge construction, oil and gas pipeline construction, power and communication line construction, and land subdivision, and others related construction.

and capital equipment (primarily vehicle maintenance and repair) of 11.3 percent, 13.2 percent, and 13.2 percent, respectively. Other reported benefits that are not factored into our calculations include a 25 percent increase in work orders (on account of faster completion rates), 45 percent fewer accidents, and 40 percent fewer issuances of speeding violations.¹⁸

Similar to the previous two industries evaluated, we estimate the economic benefits of GPS fleet management applications on businesses across the economy by calculating the labor, capital and fuel savings. The U.S. Census Bureau reports an annual average of 85.1 billion commercial miles traveled in the United States during the period of 2005 through 2009. The Bureau of Labor Statistics estimates the annual earnings of commercial drivers were \$83 billion in 2009/2010. And to estimate capital and fuel expenditures, we used the IRS standard vehicle mileage tax deduction of \$0.51 per mile (devoting \$.255 per mile each to fuel and capital). Based on the commercial mileage figure, we estimate commercial fuel and capital expenditures to have been \$21.7 billion each. Added to the labor expenditures of \$83.0 billion, the recent total annual transportation-related expenditures of U.S. businesses was approximately \$126.4 billion.¹⁹

With estimated fleet management equipment adoption rates of 67.9 percent, estimated fuel and capital savings of 13.2 percent, and estimated labor savings of 11.3 percent, the total annual benefits of GPS equipment are estimated to be \$10.3 billion, which is 8.1 percent of annual U.S. expenditures on commercial surface transportation activities. The break-down of benefits are \$6.4 billion in labor savings (\$83 billion x 0.679 adoption x 0.113 GPS labor savings), \$1.9 billion in capital savings (\$21.7 billion x 0.679 adoption x 0.132 GPS capital-savings), and another \$1.9 billion in fuel savings (\$21.7 billion x 0.679 adoption x 0.132 GPS fuel-savings). Again, the benefits of GPS to the industry potentially reach \$15.1 billion per year, the equivalent of 12 percent of annual U.S. commercial surface transportation expenditures, when adoption rates reach 100 percent (Table 4).

Table 4. Annual Benefits of GPS to Commercial Surface Transportation

	Annual Value (in \$ billions)	67.9% Adoption: Annual GPS Benefits (in \$ billions)	100% Adoption: Annual GPS Benefits (in \$ billions)
Labor (2009-10)	\$83.0	\$6.4	\$9.4
Capital (2005-09)	\$21.7	\$1.9	\$2.9
Raw Materials (2005-09)	\$21.7	\$1.9	\$2.9
Total	\$126.4	\$10.3	\$15.1
% of total annual related costs (\$126.4 billion)		8.1%	12.0%

All Commercial GPS Users in the U.S. Economy. Under current GPS adoption rates, the aggregated benefits of GPS technology in the three industries examined here (precision agriculture, engineering construction (heavy & civil and surveying/mapping), and commercial surface transportation) total \$39.4 billion per year, resulting from the investment of \$4.8 billion in annual purchases of commercial GPS equipment during the period 2005-2010. The potential GPS benefits are as high as \$71.3 billion per year when the GPS adoption rates reach 100 percent (Table 5).

The \$4.8 billion in annual purchases of the three examined industries accounted for 58.2 percent of total commercial GPS equipment sales during the period 2005-2010. Sales of commercial GPS equipment for other industries averaged approximately \$3.5 billion per year. We use the weighted average benefits ratio of the three examined industries to project the benefits of GPS technology on all other U.S. commercial GPS users. We estimate those benefits to be in the range of \$28.2 billion to \$51.1 billion per year, depending on the rate of GPS adoption. Accordingly, the direct economic benefits on \$8.3 billion in commercial GPS equipment sales are estimated to be

¹⁸ Aberdeen Group. 2007. "The Impact of Location on Field Service," Industry Study, December 2007; Fletcher, Lauren. 2010. "Commercial Fleets See Cost Savings from Telematics," *Automotive Fleet*, February 2010; and, O'Hara, Kristy J. 2011. "Mark Leuenberger Takes Cox Enterprises to New Green Levels," *Smart Business*, June 1, 2011.

¹⁹ U.S. Census Bureau; U.S. Bureau of Transportation Statistics; U.S. Bureau of Labor Statistics; and Internal Revenue Service.

between \$67.6 billion and \$122.4 billion per year—the equivalent of 0.5 percent to 0.9 percent of the U.S. economy. (Table 5).

Table 5. Annual Benefits to All Commercial GPS Users in the U.S. Economy

	Annual GPS Equipment Spending (in \$ billions)	Estimated Annual Benefits (in \$ billions)
Precision agriculture (crop farming)	\$0.5	\$19.9 - \$33.2
Engineering Construction (heavy & civil and surveying/mapping)	\$1.1	\$9.2 - \$23.0
Transportation (commercial surface transportation)	\$3.2	\$10.3 - \$15.1
Sub-total (3 industries examined)	\$4.8	\$39.4 - \$71.3
Other commercial GPS users	\$3.5	\$28.2 - \$51.1
Total commercial GPS users in the U.S. economy	\$8.3	\$67.6 - \$122.4

Our estimates of the benefits of GPS technology to the economy capture only the direct economic benefits to commercial GPS end-users generated by increased productivity and input cost-savings. Our figures underestimate the full economic benefits for several reasons. First, we have not analyzed the direct and indirect economic impact of GPS manufacturers on job creation and wage generation. Second, GPS equipment produces other social benefits, including emissions reduction (environmental benefit) and reduction in injuries and fatalities (health and safety benefit). Lastly, our estimates do not incorporate commercial benefits such as certain time-value benefits that flow from faster job completion rates, reduced food and other commodity prices, and a higher tax base from which to fund government expenditures.

In addition, our analysis considers the relatively small volume but high economic impact GPS user segment. We therefore underestimate benefits to noncommercial and military GPS users. For example, GPS technology provides value for community safety by improving response time and location accuracy for emergency responders and public safety officials. Indeed, response time is estimated to be improved by twenty percent with the use of GPS-enabled equipment installed in emergency response vehicles. In a recent survey, one local government estimated that a quarter of his staff would be required to spend two hours per day correcting coordinate and other location errors if GPS use is disrupted. On a larger scale, GPS technology can reduce the response time in the aftermath of natural disasters, which translates directly into saved lives.

LightSquared Operations and Disruptions to GPS

LightSquared is a mobile satellite service (MSS) provider with two space vessels that cover North America. The service plans to operate in the 1.5-1.6GHz zone, part of the L-Band. Although the company traces its roots back to 1988, when it was known as American Mobile Satellite Corporation and later as Mobile Satellite Ventures and Skyterra, it has only recently sprung to the forefront of public attention.

The FCC's decision to grant LightSquared permission to build a stand-alone network of 40,000 ground mobile stations has created serious concerns within the broader GPS industry and user community. LightSquared is not in competition for business with the GPS industry, but its plans have potential to wreak serious economic damage on both GPS users and equipment producers. The reason for alarm is that LightSquared's proposed LTE network will operate in spectrum space immediately adjacent to the spectrum used by the Global Positioning System, which might lead to unintentional jamming when LightSquared's terrestrial receivers overpower the much weaker GPS signals. LightSquared claims that it will be able to deploy the network in a manner that would be harmonious with GPS.

However, the FCC and a number of other governmental agencies concluded that LightSquared should not commence commercial operations until after conducting a thorough study of the potential interference to GPS.²⁰

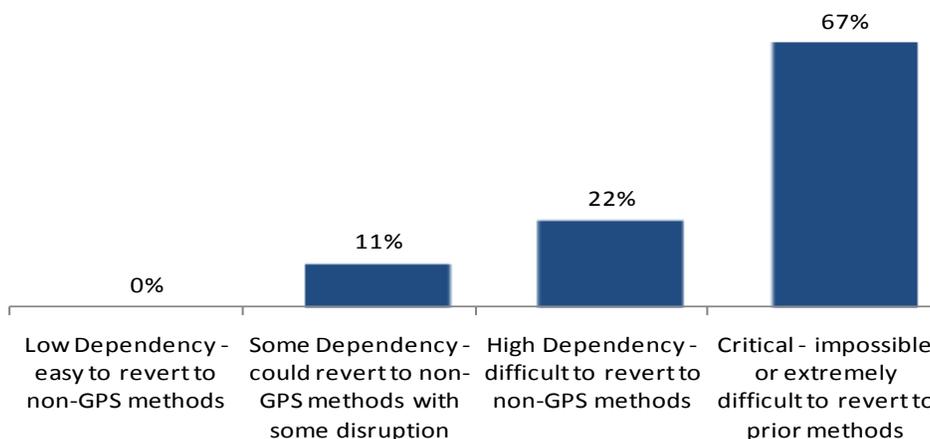
Initial testing of GPS receivers carried out by the National Position, Navigation and Timing Engineering Forum (NPEF -- a multi-agency governmental technical forum) confirms aircraft navigation systems will experience significant jamming from thousands of broadband-wireless transmitters planned to be deployed across the United States.²¹ Based on the simulations conducted by NPEF, after the new network is launched, GPS is likely to be unavailable for aviation purposes over the whole U.S. East Coast.

According to a report by the Radio Technical Commission for Aeronautics, the effect of LightSquared's deployment is expected to be a complete loss of the GPS receiver function. The Departments of Homeland Security and Transportation also have expressed reservations about the plan.²² Although the precise outcome of such a major and unprecedented disruption to GPS is hard to predict, it will have serious economic repercussions for the U.S. economy.

As described above, the daily operations of thousands of businesses in a variety of industries and economic industries rely on GPS. Signal interference could affect the functionality of GPS equipment used by U.S. federal agencies, state and local governments, first responders, airlines, industry, civil engineering, construction and surveying, agriculture, and everyday consumers in their cars and on hand-held devices—causing severe financial losses and having adverse national security implications.

Indeed, GPS has become essential to U.S. businesses. A recent industry survey sent out to 149 users in the agricultural, construction, and surveying/mapping industries inquired about their operational dependency on GPS technology. Nearly 67 percent of respondents said that it is *impossible or extremely difficult* to revert to prior methods; 22 percent said that their daily operations are *highly dependent on GPS and it is difficult* to revert to non-GPS methods; and only 11 percent of respondents said that their operations have *only some dependency and could revert* to pre-GPS methods with some disruption (Figure 3).

Figure 3. Operational Dependency on GPS in Commercial GPS Users²³



²⁰ Space-based Positioning, Navigation and Timing Executive Committee.

²¹ Warwick, Graham. 2011. "LightSquared Tests Confirm GPS Jamming." Aviation Week.

²² Halsey, Ashley. 2011. "LightSquared wireless Internet plan concerns officials pushing GPS for aviation". The Washington Post.

²³ An only survey conducted by Trimble Navigation Ltd. in May 2011.

LightSquared's Adverse Economic Impact on GPS Users and GPS Manufacturers

LightSquared broadband operations will inflict costs on both GPS users and GPS manufacturers. The total economic cost of signal degradation includes explicit and implicit costs to firms and workers in the GPS equipment manufacturing industries,²⁴ firms and workers in the GPS equipment end-user industries, and firms and consumers of the products and services produced by the GPS equipment end-user industries. For commercial GPS users, the disruption caused by LightSquared operations will inflict real costs. The observed benefits and impressive productivity gains attributable to GPS technology in recent years would disappear. Additionally, there would be a loss of value—equal to the depreciated stock—of already-purchased commercial equipment that is no longer functional.

For GPS manufacturers, the cost of the disruption caused by LightSquared would include R&D spending costs devoted to attempting to mitigate the interference from LightSquared's operations, the opportunity costs of committing resources to such mitigation efforts (instead of improving or developing new products), and the value of foregone commercial sales, which would shrink if the GPS signal is impaired. At present there is substantial doubt about the availability and effectiveness of any available technical means of mitigation that could be developed in the future by GPS manufacturers. Nonetheless, as discussed fully below, GPS manufacturers will have no choice but to invest in R&D to attempt to reduce interference to the greatest extent feasible short of making GPS products unprofitable by doing so.

Even though LightSquared is not yet operational, the expectation of signal problems has already created mitigation costs in the form of research and development (R&D), public relations, lobbying, customer relations, outreach, and legal, testing and evaluation analyses. Those are sunk costs regardless of the magnitude of signal degradation, if and when LightSquared goes live. If mitigation is possible, there are likely to be manufacturing, replacement, and retrofitting costs, depending on the nature of available mitigation options. During the period in which GPS product performance is significantly degraded, manufacturers will also suffer the cost of foregone sales, as the U.S. market for GPS equipment shrinks.

Though it is widely assumed that the implementation of LightSquared's operations will cause GPS signal degradation (and loss of functionality of GPS equipment), the likely scope and magnitude of signal degradation is unknown as of the date of completion of this study. Accordingly, so as to provide maximum utility once the scope of the problem is better understood, the model developed herein could be scalable for estimations of different signal degradation.²⁵

Using the model described below, we estimate the economic cost of signal degradation on an annual, retrospective basis. In other words, our estimates should be considered the annual economic cost of signal degradation in the absence of a high level of mitigation. Implementation of interference mitigation carries a cost, but it is a one-time cost, not an annual cost. Likewise, failure to implement achieve a high level of mitigation would carry a much larger one-time cost (up to the U.S.-attributed portion of the value of the GPS equipment manufacturing industry). The cost of implementing interference mitigation and the cost of not achieving mitigation are tallied separately from the annual cost figures developed below. The aggregate cost (of any estimate of signal degradation) should be interpreted as the annual economic cost of the "LightSquared Problem."

The main cost components in our methodology are:

²⁴ We include the costs of developing and implementing interference mitigation techniques, if they exist, in this broad category of costs, although that is not to imply that GPS manufacturers and GPS users should ultimately be responsible for covering those costs.

²⁵ The estimated economic costs are based on 100 percent signal degradation. However, degradation may affect some GPS products and not others, or some geographic locations and not others. Thus, 50 percent of our estimated costs equates roughly the cost of a 50 percent signal degradation. By assuming a linear relationship, we are effectively treating equally the economic impacts of all categories of GPS equipment. Although the true relationship between the degree of signal degradation and the cost to the U.S. economy may not be linear, our estimated costs could be used as a base for discounting the degree of disruption. We believe this is a reasonable approach to estimating the impact across the full range of possible signal degradations.

1. *Commercial GPS Users – Loss of productivity and efficiency.* As shown earlier, the annual economic benefits of GPS to commercial users range from \$67.6 billion to \$122.4 billion. GPS disruption would erase those benefits. To estimate the cost of the LightSquared Problem, we use the lower bound in the range of costs estimates. Thus, we estimate \$67.6 billion to be the cost of lost of productivity and efficiency for commercial GPS users.

2. *Commercial GPS Users -- Investment losses in GPS equipment.* Commercial GPS users purchase GPS equipment to make themselves more efficient or their operations more productive. The value of existing stock of already-deployed GPS equipment will decrease proportionally with the degree with GPS disruption caused by LightSquared. At 100 percent signal degradation, no equipment will be functional. The economic loss would be the total loss of the entire stock of GPS equipment. The annual sales of commercial GPS equipment ranged from \$6.5 billion to \$10.3 billion during the period 2006-2010. We estimate the book value of the current stock of commercial GPS equipment by applying a 5-year straight line average annual depreciation of 20 percent of original purchased value. As a result, we estimate the investment losses in GPS equipment for commercial users to be \$19.6 billion.

In sum, the economic losses to commercial GPS users will be \$87.2 billion, if GPS is fully disrupted (Table 6).

3. *GPS Manufacturers -- Foregone sales of GPS equipment.* GPS equipment sales will suffer if their functionality is impaired by a degraded GPS signal. Few people are willing to purchase products that are known to suffer from performance issues, whatever the cause. Under a scenario of 100 percent signal degradation, no GPS products would be functional and the GPS degradation caused by LightSquared potentially puts \$8.3 billion of annual commercial GPS equipment sales at risk.

4. *GPS Manufacturers -- R&D to develop mitigation measures.* GPS manufacturers and related parties have spent resources to test and evaluate means of mitigating interference from LightSquared. As of this writing, engineers, scientists, and industry experts have not yet identified effective mitigation measures and there is substantial uncertainty whether interference can be significantly reduced. Estimating the cost of mitigating a problem under such circumstances presents certain obvious complications.

Based on annual financial reports of major GPS manufacturers, annual research and development (R&D) expenditures averaged 9 percent of annual sales between 2008 and 2010. As a percentage of the \$39.6 billion total GPS equipment sales in 2010, that amounts to approximately \$3.6 billion. Since the LightSquared Problem presents a unique challenge, the industry might need to spend the entire \$3.6 billion annual R&D budget or even more to ways of mitigating the problem. From a cost-benefit-analysis perspective, the industry would be willing to spend as much as the expected economic losses (i.e., the industry value) to try to fix the problem.

For the purpose of referencing the experiences in somewhat analogous situations, we considered the reactions of business to the Y2K problem, as well as the expenditures of Sony to address a disruptive privacy breach with respect to its Playstation product. In the late 1990s, U.S. businesses were concerned about the potential impact of the so-called Y2K bug. Although different from the LightSquared problem in several ways, Y2K was similar in that some kind of costly technical disruptions were expected and the magnitude of the problem could not be predicted with certainty.

Between 1995 and 2001, U.S. businesses spent an estimated \$130 billion on R&D to find solutions and insulate their operations from disruptions expected to be caused by the Y2K problem. The amount spent comes to about 13 percent of annual U.S. business spending on R&D (and about 0.23 percent of U.S GDP) in those years.²⁶ In response to the recent data privacy breach concerning Sony "Playstations," Sony spent \$170 million (that is more than 21 percent of the value of Playstation sales) just to respond to one hacking incident.²⁷ That is equivalent to GPS equipment manufacturers spending \$8.3 billion to attempt to mitigate the LightSquared problem. To be conservative, we used the lower number of Y2K experience as a benchmark. We estimated that approximately 13 percent of

²⁶ Kliesen, Kevin L. 2003. "Was Y2K Behind the Business Investment Boom and Bust?" *Review*, Federal Reserve Bank of St. Louis.

²⁷ Forbes.com.

aggregate R&D spending of GPS equipment manufacturers will be required to attempt to mitigate LightSquared Problem. In that case, the annual industry cost amounts to an estimated \$460 million (13 percent of R&D expenditure of GPS manufacturers).

5. *Opportunity costs of R&D spending to mitigate interference.* Every R&D dollar devoted to fixing the problem is a dollar of foregone investment toward creating new and improved products. The opportunity cost of that foregone investment can be calculated as the expected rate of return that would have been generated from that investment had it been made. There is a vast empirical academic literature on the topic of returns to research and development expenditures. A survey of the literature yields estimated returns in the United States to be in the range of 7 percent to 76 percent, with the mode clustered in the 20-30 percent range.²⁸ For our purposes, we assume conservatively that the expenditures devoted to mitigation measure would have produced a 20 percent return had those dollars been invested in new or improved products. The opportunity costs of R&D spending to interference mitigation are estimated at nearly \$100 million for \$460 million R&D spent.

On top of the \$87.2 billion cost to GPS users, the economic costs to GPS manufacturers are estimated to be over \$8.8 billion per year until a high level of mitigation can be achieved. The estimate includes nearly \$8.3 billion average annual sales of GPS equipment during 2005-10, and nearly \$0.6 billion in R&D expenses related to LightSquared Problem. The largest component for manufacturers is expected to be the foregone GPS equipment sales, which will depend on the degree of GPS signal degradation caused by the LightSquared Problem. Although smaller than other cost components, GPS manufacturers face a fixed cost of R&D and its opportunity costs until a high level of mitigation can be achieved.

If the LightSquared operations will disrupt GPS 50 percent, the economic costs are estimated to be \$48.3 billion per year, \$43.6 billion to commercial GPS users and \$4.7 billion to GPS manufacturers. Regardless if the disruption is fully or partial, GPS manufacturers will spend the same amount of R&D and consequently the opportunity cost of R&D spending. All cost components to commercial GPS users and GPS manufacturers' foregone GPS equipment sales are assumed to be half of the fully degradation scenario.

Thus, the LightSquared Problem is estimated to cost the U.S. economy \$96 billion per year if the LightSquared operations disrupt GPS fully and \$48.3 billion per year if the disruption is 50 percent (Table 6).

Table 6. Estimated Annual Economic Costs of GPS Signal Disruption

	100 percent Degradation (in \$ billions)	50 percent Degradation (in \$ billions)
<u>Commercial GPS Users</u>	<u>\$87.2</u>	<u>\$43.6</u>
Foregone increased in productivity and cost-savings	\$67.6	\$33.8
Precision agriculture (crop farming)	\$19.9	\$10.0
Engineering Construction (heavy & civil and surveying/mapping)	\$ 9.2	\$ 4.6
Transportation (commercial surface transportation)	\$10.3	\$ 5.1
Other commercial GPS users	\$28.2	\$14.1
Investment losses in GPS equipment	\$19.6	\$ 9.8
<u>GPS Manufacturers</u>	<u>\$ 8.8</u>	<u>\$ 4.7</u>
Foregone GPS equipment sales	\$ 8.3	\$ 4.1
R&D spending	\$ 0.5	\$ 0.5
Opportunity costs of R&D spending	\$ 0.1	\$ 0.1
Total	\$96.0	\$48.3

²⁸ Hall, Bronwyn H., Mairesse, Jacques, Mohnen, Pierre, 2009, "Measuring the Returns to R&D," National Bureau of Economic Research Working Paper 15622.

Conclusion

The advent of the Global Positioning System and its subsequent commercialization has delivered enormous benefits to the U.S. economy. Production tasks that were once time-intensive, labor-intensive, capital-intensive, and material resource-intensive have been streamlined and simplified on account of the innovative adaptation of GPS technology to business functions across the economic spectrum. Productivity gains, input cost reductions, time savings, and environmental, health, and safety benefits are among the various fruits of GPS commercialization. We estimate that the value to the U.S. economy of the productivity gains and input cost reductions alone amounts to between \$68 billion and \$122 billion per year, or 0.5 to 0.9 percent of annual U.S. gross domestic product.

But those benefits and more are at risk due to the operational plans of LightSquared—the “LightSquared Problem.” LightSquared’s operations are expected to adversely affect the quality of GPS signal transmission and reception, which could impair or render useless all forms of commercial GPS equipment. The largest cost would be the lost benefits described above, estimated conservatively at \$68 billion per year. But there would be other costs, including investment in nonfunctioning GPS equipment (\$20 billion per year), the value of lost or foregone GPS equipment sales (\$8.3 billion per year), and the costs associated with research and development devoted to solving the problem (\$0.6 billion per year). In total, the economic cost of the LightSquared Problem could reach \$96 billion per year, the equivalent of 0.7 percent of the U.S. economy. The economic costs are expected to be \$48.3 billion per year under the scenario of 50 percent GPS disruption caused by LightSquared.

The stakes are indeed very high. Policymakers and authorities would need to decide whether it is worth risking those enormous and growing benefits to enable the far lower amount of investment in broadband made by LightSquared to attempt to create the value that already exists from use of GPS. In fact, the U.S. government has already invested some \$35 billion taxpayer money in the GPS constellation alone and continues to invest at a rate approaching \$1 billion per year in the GPS constellation.

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About the Author

Nam D. Pham is Managing Partner of NDP Consulting Group. Prior to founding NDP Consulting Group in 2000, Dr. Pham was Vice President at Scudder Kemper Investments in Boston, where he was responsible for research, asset allocations, and currency hedging for Scudder's global and international bond funds. Before that he was Chief Economist of the Asia Region for Standard & Poor's DRI in Boston; an economist at the World Bank in Washington D.C.; and a consultant to both the Department of Commerce and the Federal Trade Commission in Washington D.C.. Dr. Pham is also adjunct professor at the George Washington University, where he teaches graduate courses in monetary economics, international trade and finance, macroeconomics, and microeconomics. Dr. Pham holds a Ph.D. in economics from the George Washington University, with concentrations in international trade and finance, economic development and applied microeconomics; an M.A. from Georgetown University; and a B.A. from the University of Maryland.

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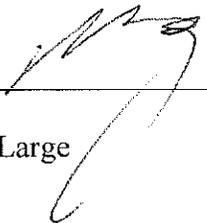
EXHIBIT B

Declaration of Peter Large
Vice President, Trimble Navigation Limited

DECLARATION OF PETER LARGE

1. My name is Peter Large. I provide this declaration in support of the Comments submitted by Trimble Navigation Limited ("Trimble") in response to the Technical Working Group report submitted to the Federal Communications Commission, evaluating the interference that will be caused by the proposed operations of LightSquared Subsidiary, LLC ("LightSquared") to Global Positioning System ("GPS") receivers.
2. I am a Vice President of Trimble Navigation.
3. I have over 20 years experience with high precision GPS technology including 15 years with Trimble in a range of technical and commercial roles with detailed knowledge of Trimble GPS technologies, products, customer applications and markets.
4. I hold a Bachelor Science degree, with honors, in Surveying and Mapping Sciences University of Newcastle upon Tyne and a Master of Science in Management from Stanford University. I am an Associate Fellow of the Royal Institute of Navigation.
5. I have generally reviewed the attached Comments of Trimble and believe them to be accurate to the best of my knowledge, information and belief.
6. I have particularly reviewed those elements of the attached Comments, including Section II.C., which contain analyses of tests designed to assess the harmful interference that LightSquared operations will cause to GPS receivers and find those analyses to be accurate and complete.
7. I declare under penalty of perjury that the foregoing is true and correct.

August 1, 2011



Peter Large