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

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

REPLY COMMENTS OF LIGHTSQUARED SUBSIDIARY LLC

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LightSquared Subsidiary LLC ("LightSquared") hereby replies to the comments filed in the above-captioned proceeding in response to the Public Notice released on June 30, 2011.[1]

I. INTRODUCTION

The Technical Working Group ("TWG") has been organized; it has conducted extensive tests; it has issued a final report; comments have been filed; and with the filing of reply comments the pleading cycle will come to a close. The time for rendering a decision has arrived.

The record strongly supports adoption of the solution proposed by LightSquared. In its Recommendation,[2] its comments, and these reply comments,

[1] *Comment Deadline Established Regarding the LightSquared Technical Working Group Report Public Notice*, Public Notice, DA 11-1133, IB Docket No. 11-109 (rel. Jun. 30, 2011) ("TWG Public Notice").

LightSquared has shown that its proposal to operate in only the lower 10 MHz will resolve overload issues for over 99 percent of GPS devices, and that LightSquared and GPS representatives, working together, can resolve the issue for the remainder of the devices.

It has become apparent, however, that the only way this solution can be realized is for the Commission to mandate it. The commercial GPS industry promised cooperation,[3] but it has not delivered. A comparison of the actions taken by LightSquared and those taken by the commercial GPS industry is instructive.

LightSquared has made major concessions. The company, having participated many years ago (along with the GPS industry) in a rulemaking to develop technical rules for ATC, and having agreed at the GPS industry's request to technical limits that were even more restrictive than those the Commission adopted, believed that the GPS industry was capable and willing to build receivers that could operate successfully in the vicinity of ATC facilities. Nevertheless, once the overload issue was raised, and notwithstanding the fact that the issue was raised in a proceeding that had nothing to do with the potential for overload, LightSquared committed to the TWG testing and has done the following:

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[2] Recommendation of LightSquared Subsidiary LLC, File No. SAT-MOD-20101118-00239 and IB Docket No. 11-109 (filed Jun. 30, 2011) ("Recommendation").

[3] *See* Comments of the U.S. GPS Industry Council, File No. SAT-MOD-20101118-00239 (Dec. 2, 2010) at 9-10 ("The Council believes that cooperative solutions continue to be available to mitigate harmful impact to existing services.").

- LightSquared volunteered to underwrite the expense of the testing, even though the commercial GPS industry should have performed these tests years ago if it had been serious about assessing the interference environment back when the Commission was developing rules for ATC.
- LightSquared agreed to forgo the higher power level for its terrestrial base stations it had applied for in 2009 and the Commission had authorized in 2010, without opposition from the GPS industry.
- LightSquared committed to a standstill during which it will initiate service using only the lower half of its L-band spectrum, thereby leaving a guard band of 23 MHz between LightSquared and GPS – a guardband that comprehensive testing shows will protect all mobile phones and personal navigation devices using any reasonable measure of harmful interference.
- To implement the standstill, LightSquared had to shift the timing of its access to portions of the frequency bands it shares with Inmarsat, which already has cost LightSquared over a hundred million dollars.
- Finally, to address the GPS industry's oft-repeated concerns about precision devices, LightSquared pledged to coordinate and share the cost of underwriting a workable solution for legacy precision measurement devices, coordinate its rollout, and put augmented precision devices on a more stable contractual basis than currently applies.

In response to these accommodations, the commercial GPS industry has offered nothing. The industry's pledges of cooperation months ago have since been replaced with choruses of "no."

- No to the limits in the ATC rules the industry helped the Commission develop.
- No to the more restrictive limits it negotiated with LightSquared.
- No to the representations the industry made to the Commission that these limits "ensure[] the continued utility of GPS receivers operating in the vicinity of … [LightSquared's] ATC stations."[4]
- No to the Department of Defense's GPS receiver standards.[5]
- No to the ITU's recommendations for GPS receiver performance.[6]
- No to acknowledging it has known for years of LightSquared's plans to deploy tens of thousands of ATC base stations, even when presented with a GPS industry filing from 2003 using precisely that description.
- No to LightSquared operating with licensed parameters that were approved without objection from the GPS industry.
- No to the possibility that ATC base stations and GPS receivers can co-exist side-by-side, despite the fact that "TV white spaces" devices operating at extremely low power can function on channels immediately adjacent to high power TV transmitters that cover entire metropolitan areas.
- No to considering the use of filters as a mitigation measure, even though some GPS devices that have filters passed the TWG tests with flying colors, and even though "[a]t least one GPS vendor thinks the problem in LightSquared's upper band can be solved" because "GPS filters have been improved over the past several years."[7]
- No to the notion that filters ever could be affordable; a major GPS manufacturer told LightSquared during TWG deliberations that paying five cents per filter is too much.
- No to coordinating usage of precision devices, without ever having spoken to LightSquared about how coordination might work.
- Even no to an offer of a 23 MHz guard band, after having told the Commission last September that what was needed primarily was a "modest" separation between ATC and GPS.

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[4] Letter from Raul R. Rodriguez, counsel to USGIC, to Marlene H. Dortch, Secretary, FCC, FCC File Nos. SAT-MOD-20031118-00333 *et al.* (March 24, 2004).
[5] *See* LightSquared's letter filed on August 11, 2011, in this proceeding.
[6] *Id.*
[7] Network World, "LightSquared vs. GPS raises big spectrum issues," available at http://www.networkworld.com/news/2011/072511-lightsquared-vs-gps-raises-big.html.

Instead, the GPS industry has repeated its story that, somehow, notwithstanding its own statements on the public record, it was surprised that LightSquared was going to deploy a widespread terrestrial network. Given the public record, a much more likely explanation it that the GPS industry believed that LightSquared's efforts to create a wireless broadband network would never succeed and took the calculated risk that GPS would always have free rein over LightSquared's spectrum. When, in 2010, the GPS industry realized LightSquared could and would deploy the ground network it had been authorized to deploy for years, the industry pursued a massive lobbying campaign designed to force LightSquared off its authorized spectrum.

Now it has come to this: In their comments, the commercial GPS parties have made clear that the only outcome they will accept voluntarily is one in which LightSquared gives up use of its band for any kind of terrestrial use – an argument that could have been made at any time between 2001 and 2005 when (1) the original rules were written, (2) LightSquared's predecessor received its ATC authorization, and (3) the rules were reconsidered. Indeed, the GPS industry could have made the same argument in 2009-2010 when LightSquared's predecessor sought and obtained an increase in its authorized power. In many cases, the Commission has to deal with parties that argue for a second bite at the apple. This may be one of the few times when it has actually had to deal with a party asking for a fifth bite at the apple.

The result the GPS industry wants is unwarranted in law, and would turn longstanding Commission policy regarding use of spectrum on its head. Indeed, if the

Commission were to grant the GPS industry's request, it would severely compromise any certainty licensees of spectrum may have, thereby substantially reducing the value of U.S. spectrum and the incentive of any new entrants to invest in U.S. telecommunications infrastructure. The GPS industry's position leaves the Commission with no choice but to mandate the practical solution that LightSquared has proposed to permit both wireless broadband and GPS to co-exist.

II. SUMMARY OF ARGUMENT

In these reply comments, LightSquared responds to the arguments made by parties in their initial filings. LightSquared addresses the following issues:

GPS Should Have Been Preparing for ATC Services Such as LightSquared's for Many Years. LightSquared demonstrates that the GPS industry has known for years how LightSquared would operate, yet continued to develop and market products that do not take LightSquared's operations into account. The GPS industry has asserted that before the Commission granted LightSquared a waiver of the integrated service requirement the company was precluded from deploying a nationwide network of ATC base stations. The waiver, however, was limited to application of the "integrated service" requirement, and did not change, in any way, the technical operation of LightSquared's network. Moreover, a wealth of evidence - including contemporaneous statements by GPS industry leaders, statements by the Commission and a senior NTIA official, findings by the Commission in the ATC rulemaking proceeding, statements by LightSquared in its SEC filings – shows that the rules for ATC long have permitted

deployment of tens of thousands of base stations and that the GPS industry was well aware of this fact.

The GPS Manufacturers Are Proposing to Turn Spectrum Management Principles Upside Down. The comments filed by GPS industry representatives overlook the fact that there are already restrictions in place on ATC operations, written into the FCC's rules and LightSquared's authorization following ample opportunity for comment by interested parties, that define the outer bounds of the interference protection to which GPS devices are entitled. GPS manufacturers must either design equipment that can function within this environment or request changes to the rules or to its coordination agreement with LightSquared. Having taken none of these steps, the GPS manufacturers have no legal basis for their overload-based objections. The industry does not get "squatters' rights" to LightSquared's spectrum because it chose to design receivers that may be vulnerable to overload.

The commercial GPS filings also fail to acknowledge that GPS receivers are Part 15 "unintentional radiators." As such, the receivers are required to accept interference, other than interference arising from prohibited out-of-band emissions that the GPS industry requested and has been granted.

The GPS industry's reliance on Section 25.255 of the Commission's rules is misplaced. That provision does not serve as a blank check to operators to deploy deficient technology. To the contrary, under the Commission's precedents commercial GPS manufacturers and service providers are responsible for designing and deploying

receivers that can reject signals transmitted on non-GPS frequencies. In any event, the rule by its terms applies solely to interference to services "authorized" by the Commission, and GPS receivers are not part of a service authorized by the Commission.

The GPS industry also has mischaracterized the terms of the agreement (which apparently has not gone into effect) between the United States and the European Union concerning the Galileo system. That agreement addresses only the issue of interference between the GPS system and the Galileo system. There is no stated intention to override FCC rules and policies for ATC that already were in effect when the agreement was reached.

LightSquared Operation on the Lower 10 MHz Channel Is Compatible With Over 99 Percent of Legacy GPS Devices. Following a rigorous process conducted by the TWG for testing a representative sample of GPS devices, the data shows that LightSquared's proposed lower 10 MHz channel operations would not have any meaningful impact on over 99 percent of legacy GPS receivers. The nearest edge of the proposed lower 10 MHz operation is 23 MHz removed from the GPS band and provides significant separation for almost all GPS receivers, except for certain wideband precision and network receivers that have been specifically designed to receive signals in the MSS L-band. The disagreements regarding the TWG test results are limited mostly to the category of personal navigation devices, and stem from some GPS manufacturers' use of an inappropriate interference threshold. While wideband precision and network receivers are more susceptible to LightSquared's proposed

operations, issues concerning these receivers can be resolved if the manufacturers of these receivers are willing to work with LightSquared — which they have so far been unwilling to do. Filter technology exists today and can be implemented in a reasonable timeframe if GPS manufacturers are willing to cooperate — LightSquared has already committed to develop at its own expense filters that can adequately protect precision receivers operating in the presence of LightSquared's planned lower 10 MHz operations.

Other Filings Confirm the Important Benefits LightSquared's Network Can Provide. There has been outpouring of public support for the development of LightSquared's network. Hundreds of community leaders, including elected officials representing public safety providers, small businesses, first responders, and a wide swath of industries have written to the FCC in support of LightSquared's plan to deploy a nationwide 4G-LTE network. Support for LightSquared's network has also come from telecommunications providers, providers of capital financing for telecommunications ventures, public interest organizations and others who have submitted more extensive comments urging the Commission to allow LightSquared to go forward with the deployment of it s network. These filings show how deployment of LightSquared's network will enhance competition in a highly concentrated wireless market; advance the objectives of the National Broadband Plan; and spur innovation, economic growth and job creation.

III. GPS SHOULD HAVE BEEN PREPARING FOR ATC SERVICES SUCH AS LIGHTSQUARED'S FOR MANY YEARS

The Commission first proposed ATC rules in 2001,[8] and it adopted ATC rules in 2003.[9] LightSquared has been authorized to provide ATC since 2004,[10] and the power levels and other material elements of LightSquared's ATC operations have been unchanged since 2005.[11]

Notwithstanding this history, GPS manufacturers and their representatives have claimed repeatedly that they could not have known earlier on that the company intended to deploy tens of thousands of ATC base stations.[12] The premise underlying these statements is that the GPS industry would have been content if LightSquared had chosen to operate consistent with the terms of the ATC authorization that LightSquared held before its modification application was granted in January 2011. That premise must be based on two assumptions: (1) the waiver the Commission granted when it acted on LightSquared's modification application enabled LightSquared for the first

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[8] *In the Matter of 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; Amendment of Section 2.106 of the Commission's Rules to Allocate Spectrum at 2 GHz for Use by the Mobile Satellite Service*, IB Docket No. 01-185, ET Docket No. 95-18, Notice of Proposed Rulemaking, 16 FCC Rcd 15532 (rel. Aug. 17, 2001).

[9] *In the Matter of 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; Review of the Spectrum Sharing Plan Among Non-Geostationary Satellite Orbit Mobile Satellite Service Systems in the 1.6/2.4 GHz Band*, IB Docket No. 01-185, IB Docket No. 02-364, Report and Order and Notice of Proposed Rulemaking, 18 FCC Rcd 1962 (rel. Feb. 10, 2003).

[10] *In the Matter of Mobile Satellite Ventures Subsidiary LLC; Application for Minor Modification of Space Station License for AMSC-1; Minor Amendment to Application for Authority to Launch and Operate a Next-Generation Replacement MSS Satellite; Application for Minor Modification of Blanket License for Authority to Operate Mobile Earth Terminals with MSAT-1*, File No. SAT-MOD-20031118-00333, File No. SAT-AMD-20031118-00332, File No. SES-MOD-20031118-01879, 19 FCC Rcd 22144 (rel. Nov. 8, 2004).

[11] *See* Recommendation at 13.

[12] *See, e.g.*, Comments of John Deere & Company ("Deere") at 7-9, Garmin International, Inc. ("Garmin") at 18-22, Trimble Navigation Limited ("Trimble") at 5-21, The Coalition to Save Our GPS ("Coalition") at 32-34, Verizon Wireless ("Verizon") at 15-17, and Rockwell Collins, Inc. at 4-7, IB Docket No. 11-109.

time to operate tens of thousands of base stations; and (2) absent a waiver, the Commission's ATC rules precluded LightSquared from operating tens of thousands of ATC base stations.

LightSquared demonstrates below that both assumptions are false. LightSquared's November 2010 modification application left unchanged the company's base station deployment plan, and LightSquared had full authority to operate tens of thousands of base stations before it filed the modification application. The U.S. GPS Industry Council ("USGIC") even told the Commission it anticipated there would be that many base stations.

The sad fact is that the GPS industry has known for years how LightSquared would operate, but continued to develop and market products that do not take LightSquared's operations into account. That is not the case for all GPS products, some of which performed well even in the TWG "upper 10" tests. But it is true that consumers of some GPS products, and LightSquared, are paying the price for the GPS industry's deliberate inaction. The very least the GPS industry can do at this late date is to take responsibility for its actions and work cooperatively with LightSquared.

A. LightSquared's 2010 Modification Application Had No Impact on the Potential for Overload

The January 2011 grant changed LightSquared's ATC authority in only one narrow respect: it waived the "integrated service" requirement, thereby permitting LightSquared to provide service to customers equipped with terrestrial-only handsets. Prior to the January 2011 grant, LightSquared was authorized to provide service to customers only if they were equipped with "dual mode" devices, *i.e.*, devices that can communicate with both LightSquared's terrestrial network and its satellite network.

The integrated service waiver did not change, in any way, the technical operation of LightSquared's network. From a technical perspective, LightSquared's pre-waiver base station operations and its post-waiver base station operations are indistinguishable.[13] The waiver did not affect the number of base stations LightSquared is authorized to operate, or where it is permitted to deploy them.[14] The waiver did not affect the power at which the base stations may be operated.[15] And whether end users

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[13] *See* RTCA, Inc., *Assessment of the LightSquared Ancillary Terrestrial Component Radio Frequency Interference Impact on GNSS L1 Band Airborne Receiver Operations*, dated Jun. 3, 2011, and filed in File No. SAT-MOD-20101118- 00239 under cover letter dated June 16, 2011, at Section 1.1.2 (stating that LightSquared's November 2010 modification application "*proposed no technical or operational changes to the ATCt network*" and that it was only after LightSquared filed the application that "*the GPS community first raised concerns to the FCC that high-powered LightSquared terrestrial transmitters adjacent to the 1559 MHz band edge would overload GPS signal reception.*") (emphasis added). RTCA is a Federal Advisory Committee that studies aviation issues.

[14] *See In the Matter of LightSquared Subsidiary LLC; Request for Modification of its Authority for an Ancillary Terrestrial Component*, File No. SAT-MOD-20101118-00239, 26 FCC Rcd 566 (rel. Jan. 26, 2011) ("*Jan. 2011 ATC Modification Order*"). The GPS industry's own actions further undercut its position. If GPS manufacturers were content with where things stood before the Commission granted LightSquared a waiver of the integrated service requirement, then why did the manufacturers' representative, USGIC, raise the overload issue in rulemaking comments that were filed in September 2010, two months before LightSquared filed its ATC modification application? *See* Comments of the U.S. GPS Industry Council, ET Docket No. 10-142, at 13-14 (filed Sept. 15, 2010).

[15] *See Jan. 2011 ATC Modification Order*.

are equipped with single-mode handsets or dual-mode handsets is irrelevant to the issue of whether GPS devices might experience overload in the vicinity of ATC base stations.

B. The ATC Rules Permit Deployment of Large Numbers of ATC Base Stations

The GPS industry has asserted that before the Commission granted LightSquared a waiver of the integrated service requirement the company was precluded from deploying a nationwide network of ATC base stations. The industry claims that under the ATC rules LightSquared was limited to operating a small number of base stations, well below the 40,000 base stations that currently are planned, and that the base stations were limited to areas in which satellite coverage is inadequate.[16]

The public record proves otherwise. A wealth of evidence - including contemporaneous statements by GPS representatives, statements by the Commission and a senior NTIA official, findings by the Commission in the ATC rulemaking proceeding, statements by LightSquared in its Securities and Exchange Commission ("SEC") filings, and the TWG test results relied on by GPS manufacturers and representatives – contradicts the GPS industry's claims. Their arguments should be seen for what they are – a transparent attempt to distract this Commission and the U.S.

[16] *See* Deere Comments at 7-9; Garmin Comments at 18-22; Trimble Comments at 5-21; Coalition to Save Our GPS Comments at 32-34. *See also* Verizon Comments at 15-17; Rockwell Collins Comments at 4-7.

government generally from the GPS industry's failure to do anything to prepare for LightSquared's authorized operations.[17]

1. Statements by GPS representatives

One need look no further than the statements of USGIC, the GPS manufacturers' representative, to see there is no truth to the GPS industry's assertions. In a filing asking that the Commission approve a coordination agreement in which LightSquared committed to out-of-band emissions ("OOBE") limits more stringent that what the Commission's rules require, USGIC recognized the likelihood that LightSquared would deploy ATC base stations in numbers along the lines it now proposes. USGIC stated that the limits it had agreed to with LightSquared in 2002 are necessary to protect GPS against "[t]he increased user density from potentially millions of MSS mobile terminals operating in ATC mode . . . [and] ***potentially tens of thousands of ATC wireless base stations***."[18]

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[17] Some GPS filers also claim they should have been able to assume there would be no issues between ATC base stations and GPS receivers because, in their view, whatever measures LightSquared took to protect its MSS receivers also should have protected GPS receivers. *See, e.g.,* USGIC Comments at 38. Any such assumption, if it were made, would have been unwarranted. Receivers have different performance characteristics. Some have filters. Some do not. Some filters are more effective. Others are less so. For this reason, in the TWG tests some GPS receivers experienced overload in the presence of base stations transmitting on "upper 10" frequencies and others did not. For similar reasons, the fact that LightSquared's MSS receivers could coexist with its base stations tells you nothing about how particular GPS receivers would perform.

[18] Reply Comments of USGIC, IB Docket No. 01-185, at 2 (Sep. 4, 2003) (emphasis added). *See also* the joint LightSquared-USGIC filing, dated July 17, 2002, in IB Docket No. 01-185, submitting their coordination agreement (stating that the OOBE limits agreed to are appropriate because MSS's "technical characteristics, operational interference scenarios, and expected density are published and understood" and LightSquared's "proposed terrestrial augmentations also are well known").

In a subsequent filing, USGIC represented to the Commission that the agreed-upon limits "ensure[] the continued utility of GPS receivers operating in the vicinity of … [LightSquared's] ATC stations."[19] In fact, USGIC stated that LightSquared was to be "commended for its proposal to use its spectrum in a responsible manner."[20] USGIC plainly perceived no issue at that time with having tens of thousands of ATC base stations using LightSquared's frequencies, and the GPS industry's filings are noticeably silent on these prior statements.[21]

2. Statements by the Commission and a senior NTIA official

The Commission has found that the prospect of widespread deployment of ATC equipment was well known. The Commission recently noted that "extensive terrestrial operations have been anticipated in the L-band for at least 8 years."[22]

NTIA's Office of Spectrum Management ("OSM"), which has jurisdiction over federal government spectrum, including the spectrum used by the GPS satellite system, has expressed similar sentiments. At a 2008 meeting of the National Space-Based, Positioning, Navigation, and Timing Advisory Board, the head of OSM recognized that

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[19] Letter from Raul R. Rodriguez, counsel to USGIC, to Marlene H. Dortch, Secretary, FCC, FCC File Nos. SAT-MOD-20031118-00333 *et al.* (March 24, 2004).
[20] *Id.*
[21] RTCA also appears to acknowledge that it was aware of the regulatory developments with respect to LightSquared's L-band ATC deployment plans and its planned transmission power levels, but that it did not study the receiver overload issue previously. *See* RTCA Report at Section 1.1.1 (discussing the history of the ATC proceeding, including the relevant power levels adopted in 2005 for LightSquared's base stations, and noting that while RTCA took note of some of the regulatory developments and OOBE emissions limits in an earlier study of interference relevant to the GNSS L1 frequency band, it "did not study fundamental emission overload effects" in the earlier study).
[22] *Fixed and Mobile Services in the Mobile Satellite Service Bands at 1525-1559 MHz and 1626.5-1660.5 MHz, 1610-1626.5 MHz and 2483.5-2500 MHz, and 2000-2020 MHz and 2180-2200 MHz,* ET Docket No. 10-142, ¶ 27 (rel. Apr. 6, 2011) (petitions for reconsideration pending).

ATC meant there would be ubiquitous, cellular-like deployment of ATC base stations: "MSS was no longer just a few handsets talking to satellites; rather, MSS was, potentially, a whole environment of cell phones connected into the system."[23] Attendees at that meeting included USGIC's chairman and a Trimble Navigation executive.[24]

3. Findings by the Commission in the ATC rulemaking proceeding

Several parties maintain in their comments that the GPS industry could not have anticipated widespread deployment of LightSquared's ATC base stations because, according to them, the ATC rules relegated ATC to a gap filler service in areas in which communication with LightSquared's satellite system was not possible.[25] They rely on the "gating criteria" in the ATC rules, which are intended to ensure that an ATC licensee continues to provide substantial satellite service. This argument, however, is inconsistent with explicit Commission statements in the ATC rulemaking proceeding.

Although the Commission has stated on occasion it believed ATC might be used to extend coverage to areas such as "urban canyons" in which satellite coverage is poor, it notably declined to adopt rules requiring that ATC be limited to such purposes. In 2005, the Commission rejected a proposed requirement that "any MSS/ATC handset first attempt to place a call through the satellite portion of the network and only

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[23] PNT Advisory Board Minutes, Presentation of Mr. Karl Nebbia, Associate Administrator NTIA, Office of Spectrum Management (March 2008), at 11.
[24] *See id.* at 29.
[25] *See* Garmin Comments at 21, Deere Comments at 7-8, Trimble Comments at 6-7.

transmit via ATC if the satellite signal is unavailable or unreliable."[26] The Commission disagreed with the suggestion by some parties "that such a requirement is the only way to ensure integrated service."[27] It found that "requiring satellite-first routing would defeat most of the benefits of authorizing ATC in the first instance,"[28] and it characterized the proposal for a satellite-first regime as "artificial and spectrally inefficient."[29] Accordingly, there is no requirement that LightSquared provide ATC only in areas in which communication with its satellite system is not possible.

It is also noteworthy that the ATC rules place no limit on terrestrial component deployment, including the number of base stations LightSquared is permitted to operate. The Commission eliminated all numerical limits for L-band ATC base stations in 2005[30] at the same time it rejected suggestions by some parties for limits on the percentage of traffic carried on the terrestrial component.[31] When GPS manufacturers designed their receivers, therefore, they had to know that LightSquared could deploy tens of thousands of base stations, as USGIC anticipated in its statements to the Commission.

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[26] *Flexibility for Delivery of Communications by Mobile Satellite Service Providers,* Memorandum Opinion and Order and Second Order on Reconsideration, 20 FCC Rcd 4616 (2005) ("2005 ATC Reconsideration Order"), ¶ 24.
[27] 2005 ATC Reconsideration Order, ¶ 24.
[28] 2005 ATC Reconsideration Order, ¶ 25, quoting *Flexibility for Delivery of Communications by Mobile Satellite Service Providers in the 2GHz Band, the L-Band, and the 1.6/2.4 GHz Band*, 01-185, Report and Order and Notice of Proposed Rulemaking, 18 FCC Rcd 1962 (2003) ("2003 ATC Order").
[29] 2005 ATC Reconsideration Order, ¶ 27.
[30] 2005 ATC Reconsideration Order, ¶ 50.
[31] *See* 2005 ATC Reconsideration Order, ¶ 20 ("We deny petitioners' requests to require that a specific percentage of an MSS/ATC operator's capacity be reserved exclusively for MSS.").

4. Statements by LightSquared in its SEC filings

LightSquared has made clear for many years its intention to construct and operate a ubiquitous ATC network that includes large numbers of ATC base stations. In its 2005 Annual Report filed with the SEC, for example, LightSquared (then known as SkyTerra) outlined its plans for "[b]uild out of an ATC-enhanced network [which] will require installation of a ground network in any given metropolitan area."[32] In its 2006 filing, LightSquared spoke of "pursu[ing] a top 50 market terrestrial footprint," and in its 2007 Annual Report[33] stated its intention "to provide ubiquitous wireless broadband services."[34] Similarly in 2009 and again in 2010, the company described the acceleration of its development of "an integrated satellite and terrestrial communications network to provide ubiquitous wireless broadband services." [35] These filings are additional proof that LightSquared's plans for a widespread terrestrial network have been known publicly for many years.

5. Test results relied on by GPS manufacturers and representatives

There is an additional flaw in the positions taken by GPS manufacturers and representatives relating to the ATC rules. Those parties state that their problem is with LightSquared's November 2010 modification application, thereby implying that their GPS products would have been able to co-exist with LightSquared's pre-modification

[32] SkyTerra Communications, Inc. (2005, March 31) Form 10-K.
[33] SkyTerra Communications, Inc. (2006, March 29) Form 10-K.
[34] SkyTerra Communications, Inc. (2007, March 16) Form 10-K.
[35] SkyTerra Communications, Inc. (2009, March 2) Form 10-K; SkyTerra Communications, Inc. (2010, February 25) Form 10-K.

network. They assert that the potential for overload was greater following grant of the modification application because, they claim, base station density was increased by the modification.[36] Not only is this claim untrue (as discussed above, the modification left untouched the technical characteristics of LightSquared's base station network), but it is inconsistent with those parties' characterization of the TWG test results.

The test results for land-based GPS devices are based on the potential for overload from a single ATC base station. The GPS manufacturers and representatives contend in their comments that the test results are indicative of the possibility of widespread overload. But if these parties' position is that widespread overload will be caused by a single ATC base station, then they cannot also take the position that their receivers would have been capable of co-existing with LightSquared's ATC network if ATC base station density had been lower. One cannot have lower density than a single base station. So by contending that the test results from a single base station are indicative of widespread overload, the GPS filers effectively are conceding that their products could not have co-existed with LightSquared's pre-modification base station network.

In sum, the technical elements of LightSquared's ATC network have been in place since 2005; the rules for ATC long have permitted deployment of tens of thousands of base stations, as GPS industry representatives previously acknowledged; and LightSquared's November 2010 modification application made no change to the

[36] *See* Trimble Comments at 20-21.

technical characteristics of LightSquared's base station network.[37] Given that the technical operations the GPS industry complains of today are the same as the technical operations it has known about for years, it is a fair question why the industry did not raise the overload issue sooner or make any effort to develop receivers that are more robust. Every one of the technical arguments made by the GPS industry today could have been made at anytime from 2001 through 2010. GPS interests actively participated in ATC rulemakings and licensing proceedings, but the interference concerns they expressed related to out-of-band emissions, not overload.[38] The GPS manufacturers ignored the potential for overload until the eleventh hour, and in an apparent effort to deflect attention from this shortcoming they improperly attempted to portray LightSquared's November 2010 modification application as having changed the overload environment.

It is time for the GPS industry to take responsibility for not expressing its overload issue concerns to the FCC, federal spectrum managers, and GPS policy makers while the ATC rules were being developed and the LightSquared authorizations and build-out requirements were put in place. The GPS industry also has to explain to

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[37] Also preceding the November 2010 modification application was LightSquared's filing of its business plan, which the Commission approved in the March 2010 order consenting to a transfer of control of LightSquared. *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, IB Docket No. 08-184, DA 10-535, ¶¶ 68-70 (rel. Mar. 26, 2010). No one from the GPS industry sought reconsideration of the March 2010 order.

[38] In a 2001 filing on merger and license modification applications filed by LightSquared's predecessors, Motient and TMI, Deere & Company expressed concern about the potential for GPS receiver overload. *See* Comments of Deere & Company, File Nos. SAT-ASG-20010302-00017 *et al.*, at 6 (May 7, 2001). Deere did not, however, pursue the issue in the ATC rulemaking proceeding or in LightSquared's ATC application proceeding despite multiple opportunities over the last 10 years.

federal spectrum managers and GPS policy makers why DoD's standards and the ITU's recommendations regarding filtering were ignored.[39]

Finally, the GPS manufacturers have to explain to their customers why they produced and sold products that they now claim to be at risk in the face of LightSquared's authorized terrestrial network transmissions. The GPS industry seems to have gambled that LightSquared would not be able to finance and construct its network. Now that LightSquared has proven the GPS naysayers wrong, they are doubling down by attempting to kill LightSquared's network through the political process.

IV. THE GPS MANUFACTURERS ARE PROPOSING TO TURN SPECTRUM MANAGEMENT PRINCIPLES UPSIDE DOWN

As demonstrated below, the interference claims of the commercial GPS industry turn the Commission's spectrum management principles upside down. The comments filed by representatives of that industry overlook the fact that there are already restrictions in place on ATC operations, written into the FCC's rules and LightSquared's authorization, that define the outer bounds of the interference protection to which GPS devices are entitled. Those rules and license restrictions do not give any grounds for inhibiting ATC base station transmissions to avoid possible overload of GPS receivers. The commercial GPS filings also fail to acknowledge that GPS receivers are Part 15 devices that are required to accept interference.

[39] *See* LightSquared's letter filed on August 11, 2011, in this proceeding.

The sole legal argument made in the filings relating to interference is based on Section 25.255 of the Commission's rules. That provision, however, has no bearing here for two separate reasons: It is inapplicable to GPS receiver overload and is inapplicable to unlicensed services such as GPS. Accordingly, there is no legal basis for inhibiting the operation of LightSquared's ATC base stations.

A. Inter-Band Sharing is Governed by FCC Rulemaking Determinations and Coordination Agreements, Not Squatters' Rights

The Commission has long-established procedures for developing technical rules addressing adjacent band issues. These procedures are well known to communications industry licensees and manufacturers.

Once the Commission has allocated a frequency band to a particular use, it issues a Notice of Proposed Rulemaking soliciting comment on service and technical rules for the band. In some cases, the allocation and technical determinations are made in the same rulemaking proceeding.

The technical rules specify the maximum power levels, out-of-band emissions limits, and other requirements that establish the interference environment in which licensees in adjacent bands must operate. The rulemaking in which technical rules are developed gives adjacent-band licensees an opportunity to raise interference concerns. Once the Commission has taken those concerns into account and adopted technical rules, it is the responsibility of adjacent-band licensees to employ equipment that can co-exist with transmissions satisfying the technical rules. Adjacent-band licensees that

wish to deviate from the framework the Commission adopts must either coordinate different technical parameters with their spectrum neighbors or seek changes to the rules.

The Commission developed technical rules for ATC networks in accordance with these principles. It issued a Notice of Proposed Rulemaking[40]; took comment on its proposals; added a footnote to the US Table of Allocations permitting ATC operations on MSS frequencies[41]; and adopted technical rules for ATC operations.[42]

GPS interests participated in these proceedings. In response to concerns raised about the potential for out-of-band emissions ("OOBE") from ATC stations to interfere with GPS reception, the Commission adopted attenuation requirements for ATC transmitters.[43] When the GPS manufacturers determined they needed tighter OOBE limits to protect GPS receivers, USGIC negotiated a coordination agreement with LightSquared for the tighter limits[44] that was subsequently made part of LightSquared's ATC authorization. At no time during the negotiations with LightSquared or the rulemaking or licensing proceedings, however, did the GPS manufacturers seek protections relating to the possibility of overload.

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[40] *Flexibility for Delivery of Communications by Mobile Satellite Service Providers in the 2GHz Band, the L-Band, and the 1.6/2.4 GHz Band*, Notice of Proposed Rulemaking, 16 FCC Rcd 15532 (2001).
[41] *See* 47 C.F.R. § 2.106, footnote US380.
[42] *See* 2003 ATC Order. Appendix A to the 2003 ATC Order, which is entitled "List of Commenting Parties," has 114 entries.
[43] 2003 ATC Order, ¶ 183.
[44] *See* Letter from Bruce D. Jacobs, Counsel for Mobile Satellite Ventures L.P., and Raul R. Rodriguez, Counsel for the U.S. GPS Industry Council to Marlene H. Dortch, Secretary, Federal Communications Commission, IB Docket (July 17, 2002).

Up to this point, everything unfolded in accordance with Commission requirements. Not until late 2010, after LightSquared had invested billions of dollars in developing an MSS-ATC network, did USGIC suggest for the first time that LightSquared's operations should be constrained because some GPS receivers are not capable of rejecting signals transmitted in the adjacent L-band.[45] Although USGIC stated at the time that it believed "cooperative solutions" could be found,[46] it has made a 180° turn in a very short time. In their comments in this proceeding, USGIC and GPS manufacturers assert that the only possible resolution to the overload issue is for LightSquared to relinquish terrestrial authority for all 20 MHz of its downlink spectrum. If such action were taken, it would orphan the 20 MHz of uplink spectrum with which LightSquared's downlink spectrum is paired, effectively removing 40 MHz from the pool of spectrum that is available for wireless broadband.

The commercial GPS industry's latest position has it backwards. The industry does not get "squatters' rights" to LightSquared's spectrum because it chose to design receivers that may be vulnerable to overload. Rather, under the principles described above, commercial GPS manufacturers must either: (1) design equipment that can function under the technical rules that the Commission adopted with the industry's input; (2) seek a rule change; or (3) attempt to convince LightSquared to agree to tighter restrictions than are provided for in the Commission's rules. Having taken none of

[45] *See* Comments of the U.S. GPS Industry Council, File No. SAT-MOD-20101118-00239 (Dec. 2, 2010).
[46] *Id.* at 9.

these steps, the GPS manufacturers have no legal basis for their overload-based objections.

B. Commercial GPS Receivers are Unlicensed Devices Governed By Part 15 of the Commission's Rules and Are Not Entitled to Claim Interference Protection

The GPS industry's position is particularly inappropriate given that commercial GPS devices operate on an unlicensed basis. Although the GPS satellite system is authorized by the federal government, commercial GPS receivers are subject to FCC jurisdiction and are unlicensed. Receivers in commercial services not licensed by the FCC are "unintentional radiators" that are subject to Part 15 of the Commission's rules.[47] Under Part 15, Section 15.5, operation of an unintentional radiator "is subject to the conditions that no harmful interference is caused and that interference must be accepted that may be caused by the operation of an authorized radio station."[48]

GPS manuals and publications reflect these limitations. The installation manual for Garmin's GNC 250, GNC 250XL, and GPS 150XL products, for example, states as follows:

> These devices comply with Part 15 of the FCC rules. Operation is subject to the following conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.[49]

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[47] *See* 47 C.F.R. § 15.101(b), which is entitled "[e]quipment authorization of unintentional radiators," and which states that "[r]eceivers operating above 960 MHz … are subject to § 15.5."
[48] 47 C.F.R. § 15.5.
[49] *See* http://www.motionaero.com/files/250XL_InstallationManual.pdf, p. 8.

Similarly, the following language appears in the owner's manual and reference guide for Garmin's GPS 72 personal navigator:

> These devices comply with Part 15 of the FCC rules. Operation is subject to the following conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.[50]

Notwithstanding their unlicensed status, the Commission has elected to give GPS receivers a degree of interference protection based on the concerns raised by GPS interests in the ATC rulemaking and in recognition of the importance of the GPS band.[51] In further recognition of GPS's importance, LightSquared entered into an agreement with USGIC under which it must observe limits that are tighter than those in the ATC rules.[52] It is for these reasons alone that LightSquared's ATC base stations are required to comply with limits on the out-of-band emissions they transmit in the GPS band.

The Commission did not, however, adopt any limits relating to the possibility of GPS receiver overload. There was no reason even to consider such limits; the GPS industry raised no overload concerns in the ATC rulemaking. In the case of overload, therefore, Part 15 principles apply, and GPS receivers, as unintentional radiators, must accept interference.

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[50] *See* http://ec1.images-amazon.com/media/i3d/01/A/man-migrate/MANUAL000012197.pdf, p. 3.
[51] *See* 2003 ATC Order, ¶ 183.
[52] *See* n. 44, above.

C. Section 25.255 Does Not Govern Overload Issues and Does Not Protect Unlicensed Devices

Several of the comments filed by the commercial GPS industry refer to Section 25.255 of the Commission's rules.[53] That provision, when applicable, requires that cases of harmful interference caused by ATC stations be resolved by the ATC licensee. Some filers claim, based on Section 25.255, that LightSquared is solely responsible for resolving overload issues.[54]

Section 25.255, however, does not serve as a blank check to operators to deploy inefficient technology. To the contrary, under the Commission's precedents commercial GPS manufacturers and service providers are responsible for designing and deploying receivers that can reject signals transmitted on non-GPS frequencies. In a discussion of ATC base stations and Inmarsat receiver overload in the ATC rulemaking proceeding, the Commission made clear that the Section 25.255 approach of "the ATC licensee is responsible" does not apply to overload issues:

> Generally, we do not regulate the susceptibility of receivers to interference from transmissions on nearby frequencies. Rather, we rely on the marketplace – manufacturers and service providers – to decide how much susceptibility to interference will be acceptable to consumers. In addition, we generally do not limit one party's ability to use the spectrum based on another party's choice regarding receiver susceptibility.[55]

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[53] 47 C.F.R. § 25.255.

[54] *See* USGIC Comments at 55-56; Trimble Comments at 24-25; Verizon Comments at 15-18; AT&T Comments at n. 24; Lockheed Martin Comments at 12 n. 23.

[55] *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 (2005) at ¶ 56. The Commission recently reaffirmed this principle. It found that "responsibility for protecting services rests not only on new entrants but also on incumbent users themselves, who must use receivers that reasonably discriminate against reception of signals outside their

Section 25.255 is inapplicable for a second reason. The rule by its terms applies solely to interference to services "authorized" by the Commission. [56] GPS receivers are not part of a service authorized by the Commission. Rather, as discussed above, they are unlicensed Part 15 devices that are required to accept interference.

Accordingly, the GPS industry's reliance on Section 25.255 is misplaced. That rule is inapplicable to overload issues and is inapplicable in the case of unlicensed devices such as GPS receivers.

D. New Services and Systems Must Operate Within the Already-Established Regulatory Framework

Some filers argue that certain wideband signals envisioned for the future, both on the GPS system and on other RNSS systems, present an issue that needs to be addressed.[57] They maintain that increased filtering would be required for these wideband signals to be received by commercial GPS devices, and they assert that the need for such filters would "penalize" advanced GPS applications and inhibit innovation.[58]

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allocated spectrum." *Fixed and Mobile Services in the Mobile Satellite Service Bands at 1525-1559 MHz and 1626.5-1660.5 MHz, 1610-1626.5 MHz and 2483.5-2500 MHz, and 2000-2020 MHz and 2180-2200 MHz,* ET Docket No. 10-142, ¶ 27 (rel. Apr. 6, 2011) (petitions for reconsideration pending).

[56] *See Spectrum and Service Rules for Ancillary Terrestrial Components in the 1.6/2.4 GHz Big LEO Bands, and Globalstar Licensee LLC, Authority to Implement an Ancillary Terrestrial Component*, 23 FCC Rcd 7210 (2008) at ¶ *32* (under Section 25.255, an "ATC operator must resolve any complaints of harmful interference to other *authorized services*") (emphasis added).

[57] *See* Deere Comments at 33-34; USGIC Comments at 16-18.

[58] *See* USGIC Comments at 16-18.

The answer to this argument is simple. There is a right approach and a wrong approach to attempting to find room for services, including wideband GPS services and services provided by non-US RNSS systems that have adjacent-band issues. The right approach is to develop equipment that can provide the services consistent with existing technical rules. Failing that, the proponents of the services need to seek rule changes or coordinate with adjacent-band licensees.

The wrong approach is to implement the services without taking any of the measures described above and to assume that the GPS industry has enough political power to shut down adjacent-band licensees to leave a clear path for GPS services. It is just such an approach that led to the current predicament. LightSquared could innovate more, too, if it were free to ignore the technical rules and coordinated limits for ATC that have been developed to protect GPS and other MSS operators in the L-band, such as Inmarsat. But the Commission never has and never would permit that, and it should not permit similar behavior from commercial GPS manufacturers, either.

As a related matter, some filers claim there is a "treaty" between the United States and the European Union under which the United States is required to protect the Galileo system under all circumstances.[59] These filers, however, mischaracterize the terms of this document, which in any event is an Executive Agreement, not a treaty, and does not appear to have entered into force.[60] The language in Article 11 of the

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[59] *See* Stansell Comments at 5; Deere Comments at 33.

[60] *See* USTR Report to Congress on U.S. Equipment Industry Access to the Galileo Program and Markets, available at http://www.ustr.gov/sites/default/files/Galileo%20Report%20Final.pdf, p. 3 ("The GPS-

agreement that is quoted,[61] when read in context, plainly is meant as a commitment to avoid having the GPS system interfere with the Galileo system, and vice versa.[62] There is no stated intention to override FCC rules and policies for ATC that already were in effect when the agreement was reached.

E. The Interference Threshold Proposed By the GPS Industry Is Not Appropriate For Analysis of Receiver Overload

In both the TWG process and in subsequent comments and other filings with the FCC, LightSquared and the GPS industry have disagreed as to how to define harmful interference in the context of GPS receiver overload. LightSquared believes that the compatibility of its proposed network with GPS receivers should be based on the performance of the receiver from the end-user's perspective — *i.e.*, on whether there are any material changes to user observable key performance indicators. This approach is entirely consistent with the FCC's definition of harmful interference (which in turn is based on the ITU's definition): "Interference which endangers the functioning of a radionavigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with [the ITU] Radio Regulations."[63]

Galileo Agreement … has not yet entered into force … . Once these States complete the process, the EC and the United States will exchange diplomatic notes to bring this executive agreement into force."). *See also* Treaties in Force, A List of Treaties and Other International Agreements of the United States in Force on January 1, 2011, available at www.state.gov/s/l/treaty/**treaties**/ (GPS-Galileo Agreement is not listed).

[61] *See* Stansell Comments at 5.

[62] The full text of the agreement, which is known as the "Agreement on the Promotion, Provision and Use of Galileo and GPS Satellite-Based Navigation Systems and Related Applications," is available at www.pnt.gov/public/docs/2004/gpsgalileoagreement.pdf.

[63] 47 C.F.R. § 2.1; *see also* No. 1.169 of the ITU Radio Regulations.

Note that in some cases, industry standards groups have established pass/fail criteria for testing the performance of GPS receivers that rely on standardized key performance indicators that are based on user perceptible performance attributes of the receivers. For example, 3GPP, which establishes global standards for commercial wireless networks, has established pass/fail criteria for handsets with GPS receivers based on keeping the position error below a certain level a certain percent of time in an experiment involving repeated trials.[64] This approach is consistent with LightSquared's suggested approach of evaluating harmful interference based on the performance of receivers from the end-user's perspective, and these pass/fail criteria established by 3GPP were evaluated as part of the cellular sub-group's testing and analysis.[65]

Some GPS industry commenters argue that a 1 dB degradation in the carrier-to-noise ratio of the received GPS signal is the appropriate threshold for measuring harmful interference to Personal Navigation devices.[66] They argue that the FCC has used a 1 dB threshold to evaluate interference in past proceedings,[67] but provide no information regarding how such a measure relates to the actual performance of GPS receivers. Indeed, in discussing the establishment of emission limits on ultrawideband devices, the Commission noted that such limits were "based on a level that could result in a 1 dB increase in the noise floor of a GPS receiver under very conservative

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[64] 3GPP TS 34.171: Terminal Conformance Specification, Assisted Global Positioning System (A-GPS), Frequency Division Duplex (FDD).
[65] *See* TWG Report Section 3.2.6.
[66] Deere Comments at 19; Trimble Comments at 47-49; Garmin Comments at 41-42; USGIC Comments at 22-24.
[67] *See* Trimble Comments at 49, n.134; Deere Comments at 19, n.61; USGIC Comments at 24, n.60.

conditions" but that, to the FCC's knowledge, "no correlation has ever been made between this slight rise in the noise floor and actual GPS harmful interference."[68]

Notably, none of the GPS industry commenters explains how their desired standard comports with the Commission's definition of harmful interference. The Commission's definition requires an actual effect: "Interference which endangers . . . seriously degrades, obstructs, or repeatedly interrupts." The Commission did not say "could" or "might" endanger, degrade, obstruct or repeatedly interrupt. The GPS industry commenters argue for a 1 dB threshold, but make no effort to explain how this threshold correlates to receiver performance. In fact, as shown by the data in this proceeding, an actual impact on Personal Navigation receivers, and thus the service, was not observed at much higher levels.

Moreover, the precedents cited involving prior use of a 1 dB degradation threshold in carrier-to-noise ratio to evaluate interference all involve rulemaking proceedings in which limits were being set for emissions in the "victim" receiver's assigned frequency band. In this case, LightSquared has already agreed to stringent out-of-band emission limits for its emissions into the 1559-1610 GPS frequency band based on an agreement reached with USGIC in 2002.[69] To use a 1dB C/N_0 degradation threshold to resolve concerns regarding GPS receiver overload, where GPS receivers fail to reject signals outside the frequencies allocated to GPS — frequencies in which LightSquared is authorized to operate — would turn the FCC's spectrum management

[68] *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, FCC 03-33, ¶ 14 (2003).
[69] *See* n. 44, above.

policy on its head. Here, the undesired signal or noise is not a signal being emitted into the frequencies allocated to GPS, it is an adjacent-band signal being transmitted by LightSquared in its own authorized frequencies.[70] In this context, when the undesired signal or noise is caused by the GPS receiver's inability to reject signals at least 23 MHz outside its assigned frequencies, and the undesired signal level at a given receiver depends on the specific receiver's ability to reject adjacent-band signals, it makes little sense to use such a conservative interference threshold.

V. LIGHTSQUARED OPERATION ON THE LOWER 10 MHZ CHANNEL PROTECTS OVER 99 PERCENT OF LEGACY GPS DEVICES FROM ANY MEANINGFUL INTERFERENCE

As LightSquared noted in its Recommendations, the TWG established and completed a rigorous process, driven by expert consensus, for the testing of a representative sample of GPS devices. As LightSquared further noted, the output of that process shows that all but a very small percentage of GPS receivers will never experience any appreciable impact from LightSquared base stations operating in its Lower 10 MHz, the band edge of which is 23 MHz from the edge of the RNSS band in which GPS operates.[71] This conclusion is based on the following assessment of the number and resilience of the different GPS receiver types:

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[70] As discussed further in the next section, another reason not to use C/N_0 as an interference threshold is that it cannot be verified by measurements on the raw C and N_0 values at the receiver input when the interfering signal is in an adjacent band; instead, all that the TWG sub-team was able to measure was the degradation in an equivalent C/N_0 parameter derived by the Personal Navigation devices themselves, an approach that may be unreliable as it is not subject to any conformance requirements. *See* Section V.A, pp. 48-49, *infra*.

[71] As discussed elsewhere, while the RNSS band extends from 1559-1610 MHz, DoD actually specifies a guardband of at least 4 MHz between the civilian receivers of the GPS L1 C/A code and the edge of the band in which LightSquared is licensed to operate. *See* Letter of Jeffrey J. Carlisle to Marlene H. Dortch, IB Docket No. 11-109 (August 11, 2011).

- Mobile phones (approximately 300 million mobile phones in use in the United States are GPS-enabled). All of the 41 devices tested passed industry-standard tests related to E911 compliance in the face of power levels no higher than what will be typical of roughly 99 percent of the LightSquared coverage area.

- Personal Navigation (approximately 100 million devices). All of the 29 devices met an interference threshold set to reasonable user-perceptible performance metrics in the face of power levels typical of roughly 99 percent of the LightSquared coverage area.

- Aviation (approximately 200,000 devices). The key report by RTCA showed that Lower 10 MHz operations would not impact the tracking capability of aviation receivers that are minimally compliant with FAA requirements, but all parties agreed that further study is required to resolve a few specific issues regarding the propagation analysis used in modeling interference and interpretation of differences between domestic and international requirements for in-flight acquisition.

- Timing (approximately 500,000 devices). Only one of the 13 devices tested experienced interference in the face of power levels typical of roughly 99 percent of the LightSquared coverage area.

- Precision and Network (200,000 to 1 million devices[72]). There was consensus that many of these legacy devices, particularly those designed to receive an L-band MSS augmentation signal, would experience interference in proximity to an ATC base station, regardless of whether LightSquared operates in only the Lower 10 MHz channel.

- Space-based. There was consensus that additional testing and filter implementation would be needed for space-based receivers not yet launched. The receivers currently in use have sufficient margin against overload.

The focus of these reply comments is on comments addressing LightSquared's proposal to operate only in the Lower 10 MHz channel rather than in both the Lower 10 MHz and Upper 10 MHz channels, inasmuch as LightSquared proposed a standstill with respect to its use of the Upper 10 MHz channel. Concerns with the possibility of LightSquared operations in the Upper 10 MHz, therefore, are not addressed here.

[72] Some parties disagree with LightSquared's characterization of the number of legacy Precision and Network devices in use (Comments of Trimble, pp. 54-55; USGIC, p. 23, n. 54), but no one has been able to present definitive numbers and, in any event, even the higher estimates do not change the fundamental point that these devices (as important as they obviously are to their users) do not represent even close to one percent of the universe of legacy receivers.

Though some of LightSquared's conclusions have been challenged, there generally is no disagreement that the TWG was inclusive and transparent, a representative sample of devices was tested for Lower 10 MHz operation using an appropriate methodology, and the results provided important insights.[73] More importantly, there also appears to be a broad consensus with respect to the characterization of the results for all but the Personal Navigation receivers.[74] As such, much of the discussion that follows is focused on the issues raised with respect to this category, including primarily the choice of interference threshold and the likelihood that a user would be in an area where the power from LightSquared base stations would exceed that threshold. These are issues which surfaced in the preparation of the sub-team report and have continued.[75]

A. Personal Navigation Devices

1. TWG Tests Show that 6 dB Degradation in C/N_0 is a Much More Reasonable Approximation of User-Perceptible Interference than 1 dB C/N_0

Unlike in the cases of Cellular or Aviation receivers, there is no industry or regulatory performance standard for personal navigation devices, let alone an agreed-upon interference threshold for overload from emissions outside the GPS band.[76]

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[73] *See, e.g.*, Comments of Trimble, p. 25 ("The TWG engaged in rigorous testing of all types of GPS receivers."). A few minor concerns raised regarding the TWG process are noted below.
[74] Trimble takes issue with the Cellular sub-team report but it did not participate in that sub-team. Comments of Trimble, pp. 30, 78. In any event, its comments on mobile phone tests and those of VZW and AT&T, which did participate in this sub-team, are discussed more fully below. *See* Section V.B, *infra*.
[75] TWG Report, Section 3.3.
[76] The Cellular sub-team used 3GPP and 3GPP2 pass/fail standards to test the impact of a LightSquared signal of mobile phones. These tests had been designed by the standards bodies so that passing them would allow the devices to meet the position accuracy requirements of E911. *See* TWG Final Report, Section 3.2.9.4. The Aviation sub-team, in conjunction with the RTCA committee, used RTCA DO-229D,

LightSquared therefore used the available data from the TWG tests to see if it could determine at what point a typical user would consider the performance of their personal navigation device to be impaired. The most compelling data came from dynamic tests that were developed by the General Location and Navigation sub-team itself, chaired by a Garmin representative. These tests recorded GPS signals in the field in a set of typical environments selected by the sub-team. The environments included Dense Urban, Suburban, Deep Wood, and Forest Path. The recordings were made by Alcatel Lucent under the supervision of sub-team members and included other, normal sources of degradation, such as non-LightSquared additive noise, multipath fading, and Doppler shift.[77] The recordings were rebroadcast in an anechoic chamber to conduct simulations of the impact on actual personal navigation receivers.[78] The LightSquared signal was added as a constant amplitude signal to the GPS signals recorded in the field and radiated into the GPS receiver from the direction of maximum antenna gain.[79]

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which is the Minimum Operations Performance Standard for aviation GPS receivers. It also considered Standards and Recommended Practices for GPS and in-flight acquisition adopted by the International Civil Aviation Organization.

Some comments argue that in fact there is a firm regulatory standard for harmful interference to all GPS receivers. *See* Trimble, pp. 48-49; Garmin, p. 42; USGIC, p. 24; Deere, p. 19. LightSquared disagrees with this assertion and its reasoning is set out in Section IV.E above.

[77] These sources of degradation are due to the existing RF and physical environment in which GPS devices operate. Most GPS devices have features to compensate for a temporary loss of signal so that the device can continue to operate as expected by the end user.

[78] As Garmin correctly notes, the laboratory tests were done using a combination of a lower 5 MHz channel and an upper 5 MHz channel, rather than a single lower 10 MHz channel. Comments of Garmin, pp. 38-39. For purposes of selecting an appropriate interference threshold, however, this difference should not be relevant and, in any case, it is likely that the use of only the Lower 10 MHz channel would have shown less impact than that of the two channels.

[79] This methodology will yield very conservative results, since it ignores the fact that, as is the case for the GPS signals, the LightSquared base station signal will also suffer blockage and multipath fading, with a mean value that will be several dBs lower than used in the test. Additionally, the LightSquared signal will likely enter the GPS receiver at a lower elevation angle than the GPS signals and hence see lower antenna gain.

Independent of the dynamic tests, static tests were performed in which constant power GPS signals from a GPS signal simulator and a constant power LightSquared signal were added together and radiated into the GPS receiver. The results show the LightSquared power levels at which the GPS receivers reported C/N_0 decreases at a range of values relative to the baseline of no LightSquared signal. Table 1 (identified in the TWG Report as Table 3.3.6) presents that data.

Table 1

	Phase 0b						
	TEST:	Static InterferenceSuceptibility, downlink 1531.0 (10 MHz BW)					
	Power at Device (dBm) vs C/N degradation						
	Device	1 dB	3 dB	6 dB	10 dB	20 dB	LOF
1	P14949	-33.0	-26.0	-21.0	-15.0	-8.0	-3.0
2	G15343	-32.0	-27.7	-24.3	-20.1	-9.4	-2.0
3	G14298	-29.5	-22.5	-17.5	-14.6	-8.6	-6.6
4	G18161	-23.6	-20.6	-18.2	-15.9	-9.3	-5.5
5	G15028	-23.5	-19.7	-14.5	-10.5	lof	-5.2
6	G16382	-22.0	-13.0	-9.0	-8.0	lof	-5.0
7	G12586	-19.7	-15.6	-12.7	-8.8	-3.5	*MPNE*
8	G17641	-13.7	-9.7	-8.7	-4.6	*MPNE*	
9	G12867	-13.3	-9.4	-6.5	-3.0	*MPNE*	
10	G10195	-9.6	-6.4	4.0	*MPNE*		
11	G12559	-9.5	-3.8	*MPNE*			
12	P15427	-8.0	-5.0	-3.0	*MPNE*		
13	G10968	-7.5	*MPNE*				
14	G18062	-7.3	*MPNE*				
15	G15448	-5.2	*MPNE*				
16	G13445	-5.1	*MPNE*				
17	G16534	-4.0	*MPNE*				
18	G17169	-3.5	*MPNE*				
19	G11207	-3.4	*MPNE*				
20	P17655	-2.0	*MPNE*				
21	G10607	*MPNE*					
22	G14188	*MPNE*					
23	G14666	*MPNE*					
24	G16449	*MPNE*					
25	G17783	*MPNE*					
26	G18696	*MPNE*					
27	P13275	*MPNE*					
28	P14730	*MPNE*					
29	P18892	*MPNE*					
		MPNE	Maximum Power reached with No Effect (> 0 dBm)				

In the dynamic tests, LightSquared signal power levels were used that corresponded to the 3, 6, and 10 dB decrement in the reported C/N_0 from the static tests. LightSquared mapped these results to the actual drive test routes, which it presented in a series of figures highlighting the variation in performance for three cases: (i) no LightSquared signal; (ii) a LightSquared signal causing a 3 dB decrease in C/N_0; and (iii) a LightSquared signal causing a 6 dB decrease in C/N_0. Copies of those maps are in Exhibit A of the attached Technical Appendix. The maps show no significant difference among the three cases. In the best case, the receivers performed very well

and in the worst case (Dense Urban), performance fluctuated significantly (presumably due to the low GPS signal availability), but was generally no worse in the 6 dB case, and sometimes actually appeared to be better owing presumably to the random nature of the position errors.

Trimble and USGIC criticized the LightSquared interpretation of the data for the Dense Urban environment, claiming that in some instances the performance at 6 dB was worse than the other two cases.[80] In fact, however, the data shows that, while this was sometimes the case, there are many other cases in which performance at 6 dB was actually better than the baseline. To remove subjectivity from this method of analysis, LightSquared performed a statistical analysis of the position errors relative to estimated true positions. The analysis was performed for the baseline case of no LightSquared signal, as well as the cases where a LightSquared signal corresponding to a 6 dB decrease in C/N_0 is added. The results are shown in Exhibit B. As demonstrated in that analysis, the tests show no meaningful variation in position accuracy statistics between the baseline and 6 dB cases. In the Dense Urban environment, the position accuracy was relatively poor for both cases, with a great deal of variability, and in the Suburban environment, it was routinely excellent for both cases.

[80] Comments of Trimble, p. 50, and USGIC, p. 25. Trimble and USGIC do not challenge LightSquared's characterization of the results for the other environments. Trimble also claims that the dynamic tests were too limited, but presents no indication of what further tests it would have performed and it does not deny that it was party to the development of the test methodology, which was developed by the sub-team to provide representative environments. Trimble also mistakenly claims that the use of 6 dB as an interference threshold ignores the potential for other sources of interference; in fact, the dynamic tests recorded all sources of noise in the chosen environments.

Garmin expresses concern that the use of a 6 dB C/N_0 difference as the interference threshold overlooks the impact on cold-start or Time to First Fix ("TTFF"), the ability of a personal navigation receiver that has not been used for an extended period of time to acquire sufficient information from a constellation of GPS satellites, particularly those that are enabled for use with the Wide Area Augmentation System ("WAAS"). Comments of Garmin, pp. 45-47. The statistical analysis of the dynamic tests, however, show clearly that in a Dense Urban environment there will be many cases where the GPS signal levels are degraded substantially (by more than 6 dB) regardless of any LightSquared signal. If it is assumed, as it was in the static tests, that the clear sky level of the GPS signal is -128 dBm, most GPS receivers would be expected to hold lock at -134 dBm. The fact that there were such large errors in the Dense Urban environment indicates that the mean signal level had probably dropped below -140 to -145 dBm. If cold start acquisition fails with a 6 dB decrease in C/N_0, this function will fail in most cases in urban areas today without the presence of LightSquared's signal. In those cases, regardless of the presence of a LightSquared signal, a user will need to move to a spot with better satellite visibility. This is also applicable to LightSquared's signal where the power on the ground varies greatly with shifts in distance, as shown by the Las Vegas field trial power scatter plots collected by both LightSquared and Trimble. *See* Figures 3.2.23 and 3.2.27, below (showing a wide variation in power on the ground within a few meters).

Moreover, any choice of an appropriate interference threshold also has to consider the likely power level of the LightSquared signal at the personal navigation receiver. In its Recommendations, LightSquared supported the use of -25 dBm (measured on the ground with a 0 dBi cross-polarized, reference antenna) as the appropriate power level for setting the interference threshold and demonstrated that it is reasonable to expect that LightSquared would not exceed this level on the ground within more than one percent of its coverage area. As Table 1 shows, however, even if the 1 dB preferred interference threshold of the GPS receiver manufacturers is used, all but two of the personal navigation devices were within that limit at -30 dBm. LightSquared estimates that, without making any modifications to its network, it will exceed that power level in no more than 1-2 percent of the area in which it provides service. *See* Tables 2 and 3, below.[81]

[81] For modeling the Washington, DC, the Korowajczuk model was used. For San Diego, Los Angeles, and San Francisco, the Planet General model was used because the tool using the Korowajczuk model does not have data for those markets.

The analysis was also performed using WI-LOS only, which ignores the actual morphology. This is tantamount to assuming that the propagation in the entire city would correspond to a lightly cluttered open environment where there was line-of-sight to the base station antenna everywhere). With this model, as shown in Table 2, the probability of exceeding -30 dBm was still only 1.2% in Washington DC, 1.2% in San Diego, 1.4% in LA and 0.8% in San Francisco.[82] It may be concluded from the above that the actual user experience may be conservatively predicted to be less than 1%.

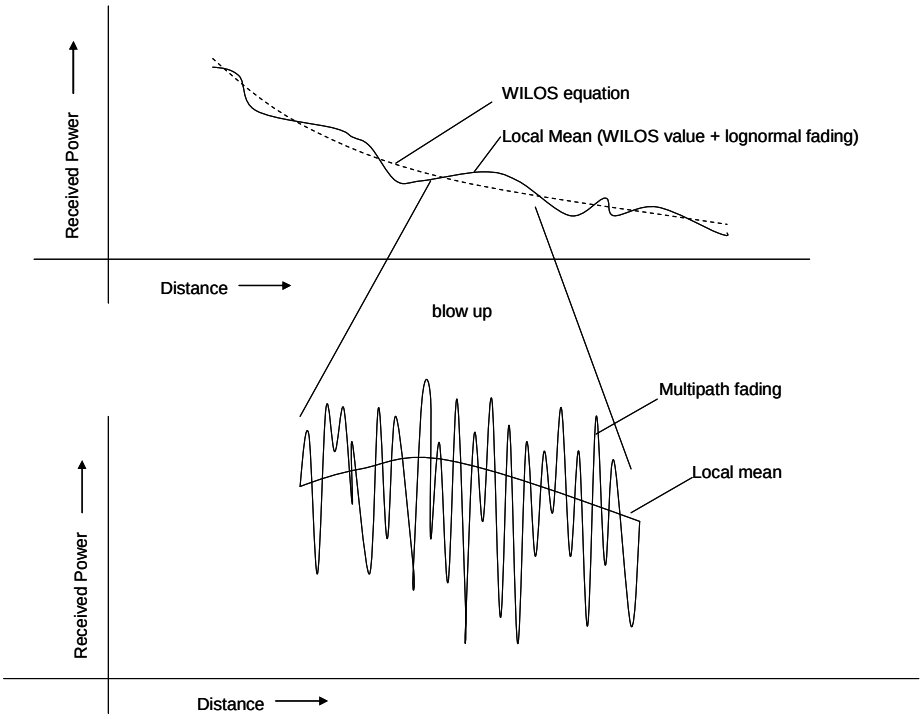
The GPS receiver manufacturers object to LightSquared's use of WI-LOS and Korowacjzuk models to estimate the propagation of the base station signals.[83] One of their claims is that it is inappropriate to use models designed for coverage to predict interference. In fact, though the models can be used to design network coverage, their predictions of power flux density at a particular location or set of locations is neutral as to whether the estimate of power is being used to predict coverage or interference.

That the models predict the mean value of the power at a given location, rather than the absolute maximum value, does not undermine their utility for purposes of predicting interference. Typically, a lognormal variation of around 7 dB is overlaid on the mean value predicted by the model as well as a Rayleigh distributed multipath component with typical variability of +10 to -30 dB. The lognormal variation is caused

[82] In LightSquared's initial WI-LOS analysis, there was an error in that a blend of free space and WI-LOS was used to model power from the base station out to 1 kilometer. In the corrected analysis, as provided in the WI-LOS model, free space is used only for the first 20 meters from the base station.
[83] *See* Comments of Trimble, pp. 29, 52-53; Garmin, p. 48; USGIC, pp. 44-45. LightSquared responded in general to these concerns in its Comments, pp. 8-9.

by local variations in the blockage and may be constant over a few meters, whereas the Rayleigh variation (fading) has extremely small spatial periods (of the order of a wavelength at L-band). A mobile GPS receiver does not consistently receive the power corresponding to a multipath peak, instead it will see a Rayleigh fading signal with a mean that is varying in a lognormal fashion. The average value of the local mean signal is what is predicted by the models. An example of a typical variation of power with distance is shown in Figure 1 below.

Figure 1. Typical variation of power with distance in terrestrial wireless propagation



Trimble and other members of the USGIC claim that protection should be offered against the absolute peaks of the power on the ground. This is unreasonable for the following reasons:

(1) A GPS receiver is typically able to deal with a Rayleigh fading adjacent-band interference with high peak values, due to the inherent averaging performed by its tracking loops and is affected more by its mean value than very short-lived peaks. This provides adequate protection against the local mean.

(2) GPS availability for receivers operating in cities is itself less than 100% (unlike aviation GPS receivers, which operate in open skies with close to 100% availability) and is a random variable in urban areas. Therefore the metric of overall, or macroscopic, impact must also be statistical rather than absolute. LightSquared has proposed as the appropriate metric the percentage of ATC coverage footprint where the local mean of the signal on the ground is above the threshold of harmful interference.

Contrary to what some parties claim,[84] there is little conflict between the Las Vegas field trial results and the use of the WI-LOS propagation models, when seen in the above context. The following examples from the TWG Report help to illustrate this:

(1) Figure 3.2.23 shows the power on the ground for three sectors of a suburban site of 17 m antenna height. For Sector 1, the peak excursions of the power is seen to lie between the Free Space and WI-LOS model, sometimes even exceeding the Free Space value, as is possible owing to constructive multipath. However, it is clear that the WI-LOS level is well above the median value. In the other sectors, the peak excursions of the power are even lower relative to the WI-LOS prediction. It is noteworthy that the valley of the predicted power profile, predicted by both Free Space and WI-LOS, is frequently exceeded in all sectors – this is most likely owing to multipath limiting the discrimination in the underbelly of the base station antenna.

(2) Figure 3.2.27 shows the results for a 72 m high antenna and dense urban morphology. The smearing of the predicted valley of the power profile is also evident here, as is the fact that most of the power values are below the WI-LOS prediction.

[84] Comments of Trimble, pp. 29, 52-53.

Figure 3.2.23

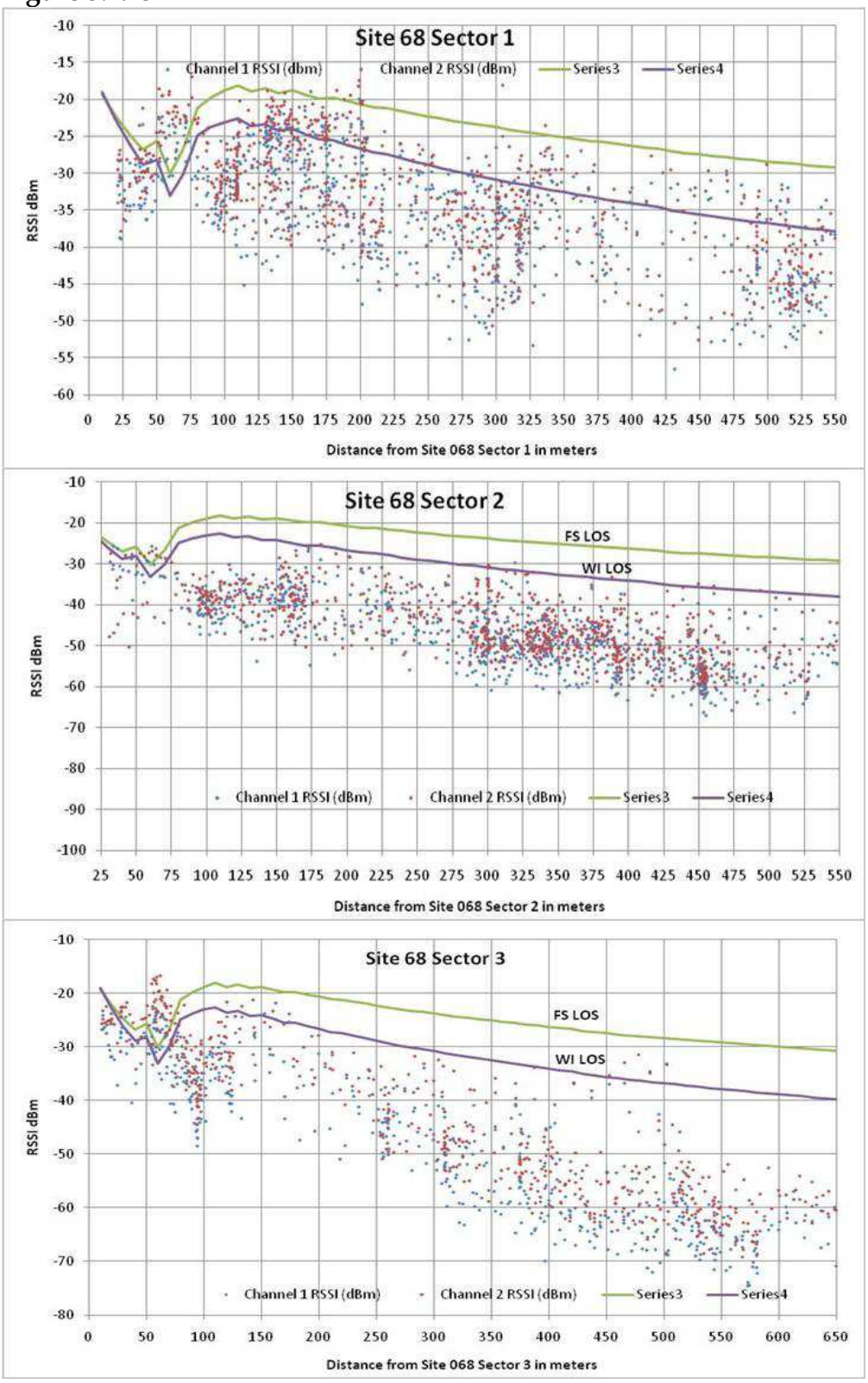
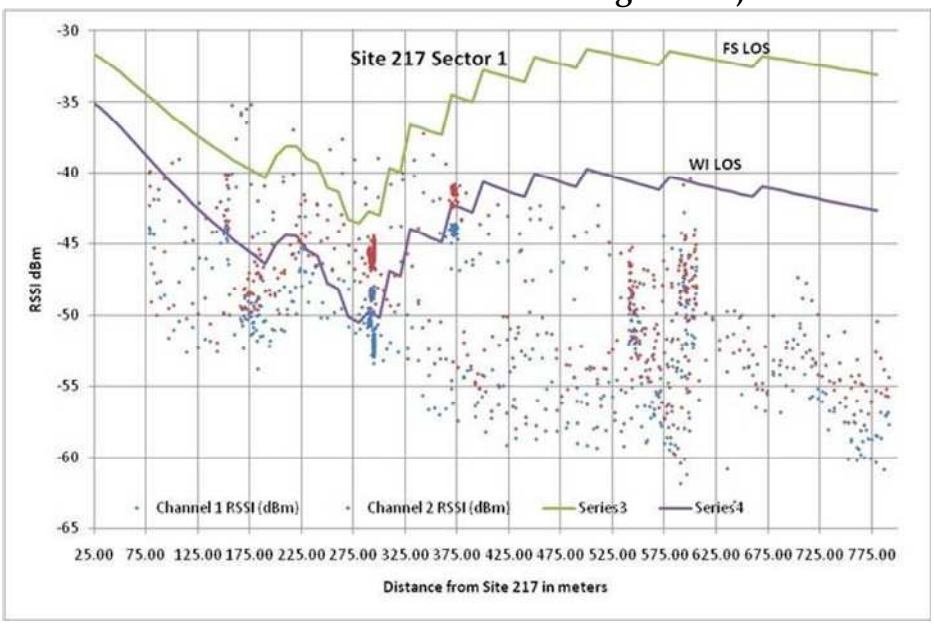

Site 68 Sector 1
Channel 1 RSSI (dbm)
Channel 2 RSSI (dBm)
Series3
Series4
RSSI dBm
Distance from Site 068 Sector 1 in meters
Site 68 Sector 2
FS LOS
WI LOS
Channel 1 RSSI (dBm)
Channel 2 RSSI (dBm)
Series3
Series4
RSSI dBm
Distance from Site 068 Sector 2 in meters
Site 68 Sector 3
FS LOS
WI LOS
Channel 1 RSSI (dBm)
Channel 2 RSSI (dBm)
Series3
Series4
RSSI dBm
Distance from Site 068 Sector 3 in meters

Figure 3.2.27. LightSquared Reported Field Data for Test Site 217 (Dense Urban, Tower Height 72 m)



An examination of the power profiles from the Las Vegas field data leads to the following conclusions:

(1) The power on the ground is primarily a function of the antenna height and secondarily the environmental clutter (morphology).

(2) For all antenna heights, the WI-LOS model is a good predictor of the upper percentiles of the distribution of power, i.e. the median value is usually less than the WI-LOS prediction, except in very open terrain over a highly reflective surface, such as site #53 in the Nevada desert.

LightSquared has performed network simulations using the WI-LOS propagation model of the macroscopic impact described above for cities with a full range of mean antenna heights. The results for a threshold level of -25 and -30 dBm are given below.

Table 2. Probability of power on the ground exceeding a threshold value in different cities using WI-LOS propagation model

	Washington DC	San Diego	Los Angeles	San Francisco
Mean Antenna Height (meters)	31	13	17	15
P (power > -25 dBm) (percent)	0.1	0.4	0.2	0.2
P (power > -30 dBm) (percent)	1.2	1.2	1.4	0.8

Table 3. Probability of power on the ground exceeding a threshold value in different cities using a morphology-based propagation model

	Washington DC	San Diego	Los Angeles	San Francisco
Mean Antenna Height (meters)	31	13	17	15
P (power > -25 dBm) (percent)	0.1	0.4	0.2	0.1
P (power > -30 dBm) (percent)	0.4	0.9	0.6	0.3

USGIC also mistakenly contends that LightSquared's models were not based on a uniform geographic sampling or a complete deployment of base stations;[85] in fact, they were.

Another flaw in the position of those that support the use of a 1 dB C/N_0 for Personal Navigation devices is their failure to acknowledge that the TWG tests were

[85] Comments of USGIC, p. 45, n.111.

able to report only a derived measure of C/N_0 and not an actual measure. The tests could not and did not measure the actual impact of a LightSquared signal on C/N_0, since the signal's power is not co-frequency with GPS and actual C/N_0 can be measured only over the signal's occupied bandwidth. (So, for instance, this measurement issue does not exist where compatibility is based on co-frequency interference.) As a result, the C/N_0 that is referred to in the TWG Report is only a *reported* C/N_0 that is derived by an algorithm in the receiver and reported only by the receiver. While such a reported metric theoretically could correlate accurately to key performance indicators such as position accuracy, there has been no validation of any such correlation. The use of this approach to measuring C/N_0 is widely understood to be at best an approximation, was acknowledged as such by several experts on the TWG and, is a major reason that the Cellular sub-team rejected the use of C/N_0 in favor of measuring Position Error. Moreover, measuring a 1 dB change in C/N_0 is difficult under the best of circumstance, since it is such a small change, but relying on the derived and reported measure for such a small change is even more perilous.

B. Mobile Phones

There were a few comments regarding the work of the TWG Cellular sub-team.[86] Trimble, which chose not to participate in the Cellular sub-team, claims that the tests show 6 of 41 devices failing at power levels at power levels between -25 dBm and -45 dBm and 4 devices failing at -15 dBm.[87] As discussed immediately below, however, the TWG Report shows clearly that all devices tested passed the 3GPP tests in the face of Lower 10 MHz operations producing a power flux density of -25 dBm for a 0 dBi antenna.

Table 3.2.4 from the TWG Report, containing the results of all laboratory tests for all mobile phones, is reproduced below. It shows that for the key test of Nominal Accuracy (test 2.4.2.4) all devices withstood a signal level of up to -30 dBm referred to the antenna connector. This test involves the use of 8 satellites at -130 dBm and is designed to be representative of outdoor conditions with relatively open skies, and was so characterized by the Cellular sub-team.[88] The sensitivity tests (2.4.2.1 – 2.4.2.3) involving lower GPS signal levels for all satellites are designed to be representative of

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[86] Verizon Wireless expresses several concerns with the Las Vegas field tests (pp. 9-14) but its comments ignore that the tests (which were designed with Verizon's full participation) were never intended to be as comprehensive as the laboratory tests and many of the TWG participants resisted using field tests, citing their lack of repeatability. VZW also is concerned that certain devices were not tested (p. 13) but it did not raise this concern when it was participating in the Cellular sub-team that selected the devices to test. In addition, the Precision, Network, and Timing sub-team tested several devices that are representative of some of the other device types that VZW indicates it would like to see tested.
USGIC claims that the Cellular sub-team report is flawed because LightSquared misrepresented the antenna downtilt required to meet 3GPP specifications. Comments of USGIC, pp. 10, 25, n. 62. USGIC misunderstands the 3GPP document it references. This was simply a study that used as an assumption a particular antenna downtilt. 3GPP does not mandate any particular downtilt and, in fact, the two degree downtilt that LightSquared specified for TWG testing is quite typical of industry practice.
[87] Comments of Trimble, p. 51.
[88] TWG Final report, Section 2.1.1.4.

either outdoor urban canyons or indoor conditions (for GPS signal levels less than -147 dBm).[89] For indoor usage scenarios, it is reasonable to reduce the assumed LightSquared power level relative to the outdoor level by 6-15 dB.[90] As building blockage will apply to both GPS signals and LightSquared base station signals, it is reasonable to reduce the assumed LightSquared signal power by the same amount as the GPS signal power relative to a conservative outdoor, street level power of -135 dBm.[91] This means, for instance, that a power level of -45 dBm for device CD48 for Test 2.4.2.3 would translate to a street level power of (-45+(-135-149) = -31 dBm) at the antenna port of the device.

[89] *Id*.
[90] TWG Final report, Section 3.2.9.6, p, 98.
[91] The open skies level for GPS signals is normally accepted at -130 dBm. We are using a baseline of -135 dBm assuming that there may already have been some blockage in the street level outdoor power.

Table 3.2.4 below summarizes the results of all Cellular sub-team tests for all devices for the Lower 10 MHz.

LTE Channel	LOW CHANNEL - 10 MHz																				
Test \ Device	CD-02	CD-03	CD-04	CD-05	CD-06	CD-07	CD-08	CD-09	CD-10	CD-11	CD-12	CD-15	CD-16A	CD-16B	CD-18	CD-20	CD-21	CD-22	CD-23	CD-24	CD-25
2.4.2.1	0	0	0	0	0	0	0	-15	-10	0	0	0	N/A	0	0	0	0	0	0	0	0
2.4.2.2	0	0	0	0	-5	0	0	-15	-15	0	-5	0	N/A	0	0	0	0	0	FB	0	0
2.4.2.3 (-135)	FB	0	0	0	0	0	0	-15	-10	0	0	0	N/A	0	0	0	0	0	0	0	0
2.4.2.3 (-149)	0	0	0	0	-5	0	0	-15	-10	0	0	0	N/A	0	0	0	0	0	0	0	0
2.4.2.3 (-152)	0	0	0	0	-5	0	0	-15	-10	-5	-5	0	N/A	0	0	0	0	0	-5	0	0
2.4.2.4	0	0	0	0	0	0	0	-15	-10	0	0	0	N/A	0	0	0	0	0	0	0	0
2.4.2.5	0	0	0	0	-5	0	0	-15	-10	0	0	0	N/A	0	0	0	-5	0	0	0	0

LTE Channel																					
Test \ Device	CD-26	CD-27	CD-28	CD-30	CD-31	CD-32	CD-33	CD-34	CD-35	CD-36	CD-37	CD-38	CD-39	CD-40	CD-41	CD-42A	CD-44	CD-45	CD-46	CD-47	CD-48
2.4.2.1	0	0	0	0	0	0	0	0	0	-30	-10	-20	-10	-45	-25	-10	-10	-10	-10	0	0
2.4.2.2	0	0	0	-5	0	0	0	0	0	-30	-20	-10	-10	-45	-10	-10	-15	-15	-10	0	0
2.4.2.3 (-135)	0	0	0	0	0	0	0	0	0	-30	-10	-10	-10	-35	-10	-10	-10	-10		0	0
2.4.2.3 (-149)	0	0	0	0	0	0	0	0	0	-30	-10	-45	-10	-45	-25	-10	-10	-15	-10	0	0
2.4.2.3 (-152)	0	0	0	0	0	0	0	0	0	-30	-25	FB	FB	FB	FB	-25	-15	FB	FB	0	0
2.4.2.4	0	0	0	0	0	0	0	0	0	-30	-10	-10	-10	-30	-10	-10	-10	-10	-10	0	0
2.4.2.5	0	0	0	0	0	0	0	0	0	-30	-10	FB	-10	-45	-20	-10	-10	-15		0	0

Table 3.2.4

From the above, it is evident that all tests and all devices showed compatibility at a power level of approximately -30 dBm at the antenna port when the power is referred to an equivalent, outdoor level.

In addition, the Cellular sub-team, after reviewing the results of several cellular GPS antenna pattern measurements, concluded that a 5 dB coupling loss could be booked relative to a 0 dBi reference antenna.[92] Hence, the above -30 dBm power level, as received by the GPS receiver at the antenna port, is equivalent to -25 dBm when referring to propagation analyses and measurements, which state their results relative to a 0 dBi reference antenna.

AT&T suggests the test results indicate a possible problem with meeting E911 requirements through an erosion of the margin available to the receiver to meet the above requirements. Comments of AT&T, p. 7. The TWG Report, however, showed that there was no systematic impact on the position error caused by the LightSquared blocker signal at or near the passing threshold. This is shown in Figure 3.2.18 from the TWG Report.

[92] TWG Final Report, Section 3.2.9.6.

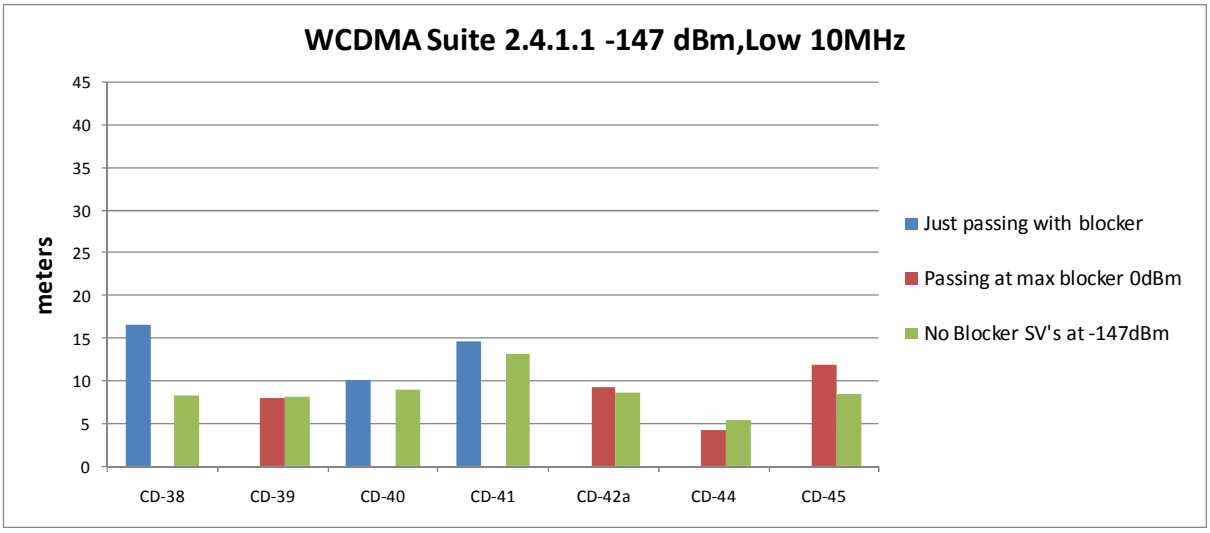

Figure 3.2.18

For some cases (e.g. CD-38) the position error was greater when the LightSquared signal was present and for others (e.g. CD-44) the position error was greater when the LightSquared signal was absent; for some, the position error was very similar with and without the LightSquared signal. The difference in the position error, with and without the LightSquared signal at the passing point, is more likely a consequence of the fact that the tests were stochastic in nature, where different runs of the test with exactly the same conditions would produce a spread of results. Moreover, even if there was some causal relationship between a small an increase in position error and the presence of the LightSquared signal, which LightSquared doubts, it is noteworthy that all the devices met the E911 requirements at the passing point with substantial margin.

C. Aviation Receivers

As noted above, there is a consensus that, before any definitive conclusion can be reached regarding the resilience of certified aviation receivers in connection with LightSquared operation in the Lower 10 MHz, there must be additional consideration given to certain assumptions used in the analysis undertaken by the RTCA committee and the Aviation sub-team. We remain optimistic that this analysis can be completed soon and will demonstrate positive margin between LightSquared operations in the Lower 10 MHz and all certified aviation receivers, regardless of whether FAA or ICAO standards are used.[93]

In its Recommendations, LightSquared pointed out that the aviation receivers that were tested all showed they reached a 1 dB degradation in C/N_0 at a level that was 25-30 dB higher than the FAA requirement for certification. Recommendation, p. 30. The point was made not to argue against the use of the emission mask in the FAA certification standard (despite the fact that the RTCA Report conceded that this standard was adopted after and without regard to the FCC's ATC proceeding), but simply to show the extent to which it is reasonable to assume that receiver manufacturers can, do, and will typically build their receivers with a very large margin relative to the specification. Two of the comments, however, take issue with LightSquared's characterization of the aviation receiver tests and contend that the tests

[93] Several parties cite the conclusions of a recent FAA internal document that was inadvertently disclosed to the public as evidence that the FAA has determined that LightSquared operation in the Lower 10 MHz is a threat to air safety. *See, e.g.*, Comments of AOPA/GAMA, p. 8. In fact, a closer reading of the document reveals that its analysis is based on the assumption that LightSquared would be operating in both its upper and lower channels.

showed failure to receive the WAAS communications signal at the point at which the GPS signal experienced degradation. [94] The tests they point to, however, cannot be used to support such a contention, because they were not designed to determine the point at which the WAAS-enabled GPS receivers would pass. Moreover, if such tests had been conducted, they likely would have shown ample margin for the WAAS signal as well since, as LightSquared understands, reception of a WAAS communications signal typically requires only 1-2 dB more margin than reception of a GPS signal. In any event, WAAS receivers are certified as meeting the same DO-229D that is the basis for the analysis for GPS protection.

AOPA/GAMA also express concern regarding the wide range of GPS receivers used by general aviation pilots. LightSquared's understanding is that all of the FAA-certified receivers must meet the emission mask of either RTCA DO-229D, which the RTCA committee and the Aviation sub-team studied, or RTCA DO-208, an older standard that requires aviation devices to be even more resilient. RTCA Report at C-8. Moreover, while non-FAA certificated Personal Navigation devices were outside the scope of the RTCA study, these devices were tested by other TWG sub-teams and those results are encouraging. None of the Personal Navigation devices experienced even a degradation of 1 dB C/N_0 at less than -33 dBm and the RTCA analysis concluded that, at the worst case altitude of 535 meters, the baseline LightSquared system would produce no more than -36.6 dBm. TWG Report, Table 3.1.9. Assuming the device is

[94] Comments of AOPA/GAMA p. 21; Garmin, pp. 37-38.

used inside the cockpit instead of mounted to the outside, there would be a further roughly 5 dB of margin against potential interference from LightSquared base stations, for a total margin of almost 9 dB before there would be even a 1 dB reduction of C/N_0.

Deere claims that aviation is moving to wideband receivers in order to meet still-developing FAA requirements for future Air Traffic Control operations. Comments of Deere, p. 30. As noted elsewhere, however, LightSquared operations on its Lower 10 MHz channel will not cause interference to or adversely affect the performance of even a wideband GPS receiver that is properly designed,[95] and certainly not to one that meets current FAA minimum performance requirements. Similarly, Rockwell Collins now suggests that the FAA should study potential impacts on future plans for NextGen ground surveillance and ADS-B applications. Comments of Rockwell Collins, p. 13. LightSquared appreciates that the NextGen plan will include new and developing receiver standards (including those not currently available for study) and is committed to working with the aviation community to develop standards for NextGen applications that are compatible with its use of its spectrum.[96]

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[95] *See* Section VI.A.2, *infra*.

[96] Perhaps the most puzzling comment regarding Aviation receivers is by Rockwell Collins, arguing without any specificity that the testing of Aviation receivers was inadequate. Comments of Rockwell, p. 8. This is particularly odd because it was a representative of Rockwell Collins who took the lead in designing the tests. Moreover, given the primary importance of the emission mask in the FAA minimum performance standard, the tests were understood to be for the limited purpose of identifying any unknown issues and, unlike some of the other sub-team tests, were not intended to determine the performance of a representative sample of receivers.
The summary chart that Garmin presents on p. 32 of its comments represents another mystery. Contrary to the text of Garmin's comments, the chart, which is accurate, actually supports the position that the RTCA and Aviation sub-team analysis show positive margin for the Lower 10 MHz case.

D. WAAS Reference Stations

Lockheed Martin filed comments expressing concern about the potential impact of LightSquared base station operations on its operation of WAAS ground-based facilities. LightSquared is highly optimistic that it can coordinate its operations with any nearby WAAS facilities, given both the demonstrated robustness of WAAS reference receivers, their fixed locations, and their small number (currently fewer than ten). The WAAS ground segment infrastructure uses GPS receivers ("G-II") whose susceptibility was measured in the RTCA/TWG testing program. The G-II receivers are among the most robust of those tested, showing no C/N_0 degradation at the maximum adjacent power level the test system could generate, i.e. -10 dBm. LightSquared is working with Lockheed Martin to demonstrate compatibility between the Ground Uplink Station sites that it manages and LightSquared's base station locations. It has been shown that compatibility exists naturally for the omnidirectional GPS antenna by virtue of the natural standoff distances from the nearest LightSquared base stations. Work is in progress to show the same for the high gain, directional, L-band downlink antenna used for communication with the WAAS space segment. Similar analyses will be performed for the WAAS Reference Stations. As these are all fixed stations, LightSquared sees no difference between these coordination obligations and those it already has with respect to AMT and SARSAT.

E. Maritime Receivers

Trimble for the first time raises the issue of maritime GPS receivers and refers to tests it apparently conducted at White Sand Missile Range, the results of which it did not share with LightSquared or the TWG. Comments of Trimble, pp. 35-37. Without more information about the tests it is difficult to offer much substantive comment, but it does not appear that Trimble has considered a variety of factors, including: (i) LightSquared obligations pursuant to its coordination agreement with Inmarsat to operate at reduced power near navigable waterways; (ii) Inmarsat's commitment to add filters to its maritime receivers; and (iii) a reasonable propagation model for predicting path loss between a LightSquared base station and a maritime vessel. Trimble's attempt to raise issues using data it has never shared with anyone and which have already been the subject of extensive work should be viewed as nothing more than a makeweight argument. Certainly, it is yet another demonstration of how the GPS industry has no intent of working out any interference issues cooperatively, but instead prefers to posit worse case scenarios based on incomplete analysis for the sole purpose of scaring the Commission and key constituencies.

F. Aeronautical Mobile Telemetry operations

A few comments express concern that LightSquared's proposal to operate only on the Lower 10 MHz will be detrimental to coordination with Aeronautical Mobile Telemetry ("AMT") operations at 1430-1525 MHz.[97] LightSquared, however, is already under an obligation to coordinate with AMT operations in the adjacent band and, as AFTRCC acknowledges, has made substantial progress in completing that coordination. That coordination was always premised, from LightSquared's perspective, on the inclusion of the Lower 10 MHz channel in all LightSquared base stations, so there is no reason to expect that coordination will be any more difficult if the Commission adopts the LightSquared proposal.

VI. OTHER INTERFERENCE CONCERNS CAN BE RESOLVED

A. Precision and Network Receiver Overload Issues are Resolvable

1. Overload and Interference Issues Can Be Resolved With Cooperation From GPS Manufacturers

Several manufacturers of GPS precision and other wideband receivers criticize the proposals related to high precision and other wideband GPS receivers that were part of LightSquared's Recommendation. As an initial matter, because some manufacturers appear to have misunderstood LightSquared's proposal,[98] it is worth summarizing what LightSquared proposed.

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[97] Comments of Aerospace and Flight Test Radio Coordinating Council ("AFTRCC"); Lockheed Martin, pp. 9-10; and NPEF July 6 Report, p. 9-2.

[98] *See, e.g.*, Deere Comments at 30 (suggesting that LightSquared proposed that the FCC act as a frequency coordinator to coordinate LightSquared's base stations with high precision receivers).

First, LightSquared acknowledged that legacy GPS precision and other wideband receivers present challenges because they are designed to "listen in" to the L-band frequencies in order to improve their accuracy and to receive augmentation signals via commercial agreements with MSS providers. LightSquared noted that given its rollout plans focusing on urban areas initially, most precision agriculture and other wideband receivers used in rural areas would be unaffected for several years.

With respect to future precision receivers, LightSquared proposed that it will (1) work with Inmarsat to ensure that precision GPS receivers receive MSS augmentation signals in a "safe" portion of the L-band, isolated from LightSquared's planned terrestrial operations; (2) commit contractually to keep precision GPS receivers at the same MSS augmentation signal frequency for a sustained period; (3) work at its own expense with filter manufacturers and GPS device manufacturers to develop filters that can adequately ensure protection for new precision receivers operating in the presence of planned LightSquared operations in the lower 10 MHz of the MSS L-band; and (4) work with precision GPS receiver manufacturers to incorporate dual-mode receivers into their devices, which could provide an ATC communications link/augmentation signal with a much higher data rate and potentially even greater accuracy. With respect to legacy precision GPS receivers, LightSquared committed to maintaining an automated database that includes information regarding LightSquared base station locations, and proposed a coordination obligation on both LightSquared and precision GPS users.

While Deere and Trimble argue that LightSquared's coordination proposal is vague, the reality is that LightSquared cannot protect precision receivers on its own. LightSquared needs the help of these very manufacturers in order to understand how their receivers function and the scenarios in which they operate. Despite numerous efforts by LightSquared to reach out to and work with precision GPS manufacturers to address concerns, work to develop robust filters, etc., these manufacturers have by and large chosen to ignore cooperative efforts. They have chosen instead to lead the Save Our GPS Coalition's vitriolic lobbying and PR campaign, with the explicit goal of forcing LightSquared to vacate spectrum it has been authorized to use for ground operations for almost a decade and on which it has spent billions of dollars to develop. LightSquared has already spent vast sums of money to shift its planned rollout to the lower 10 MHz frequencies and has pledged a standstill for half of its authorized downlink frequencies. And yet, precision manufacturers have refused to discuss steps that can be taken — including filter development that LightSquared has pledged to pay for — to mitigate the impact on precision receivers.

Finally, it should not be forgotten that most precision GPS receivers are susceptible to LightSquared's planned lower 10 MHz terrestrial operations because they are designed to receive an MSS augmentation signal for which they have a contractual arrangement with an L-band MSS operator (either LightSquared or Inmarsat). Ultimately, then, this issue is one of a commercial arrangement between the MSS operator that provides an augmentation signal and precision GPS manufacturers. The

Commission should continue its policy of deferring to commercial agreements; as the Commission has previously stated: "It would not serve the public interest for the Commission to assume the role of an arbiter of disputes between a satellite operator and its customers …."[99] This is very much the role that Trimble and Deere want the Commission to take. For its part, LightSquared has pledged to cooperate with precision GPS manufacturers to mitigate the impact of its planned terrestrial operations, and hopes that the manufacturers will follow suit.[100]

2. Filter Technology Exists Today and Can Be Implemented in a Reasonable Timeframe

Several GPS receiver manufacturers argue that better filtering is not possible for GPS receivers and that filters needed to reject LightSquared signals operating in the adjacent MSS L-band do not exist today.[101] Often, this argument is made in such a way as to obscure the fact that filters do, in fact, exist today for cellular and timing devices,

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[99] *SkyTerra Subsidiary LLC, Application for Modification Authority for an Ancillary Terrestrial Component*, Order and Authorization, File No. SAT-MOD-20090429-00047, DA 10-534, at 11, ¶ 30 (rel. Mar. 26, 2010). In granting LightSquared's predecessor SkyTerra's license modification request, the International Bureau rejected objections by two Inmarsat customers, Amtech and Skywave, who argued that increased ATC power would result in "overload interference" to their receivers. The Commission rightly deferred to a negotiated agreement between SkyTerra and Inmarsat, and noted that the appropriate recourse for satellite customers was to raise their concerns in contract negotiations. *Id.* at 4-12. The same principle applies to those providers of augmented GPS service that are satellite customers in the MSS L band.

[100] *See Jan. 2011 ATC Modification Order* at 21, ¶ 42 ("Because the GPS interference concerns stem from LightSquared's transmissions in its authorized spectrum rather than transmissions in the GPS band, the Commission . . . expects the GPS industry to work expeditiously and in good faith with LightSquared to ameliorate the interference concerns."); *see also* Stephen Lawson, *LightSquared vs. GPS Raises Big Spectrum Issues*, Network World, July 25, 2011, *available at* http://www.networkworld.com/news/2011/072511-lightsquared-vs-gps-raises-big.html (quoting Dale Hatfield, former Chief of the FCC Office of Engineering and Technology, as saying that disputes like the one between LightSquared and the GPS industry "can be and have been resolved in the past by engineers working together") (hereinafter, Lawson, *Spectrum Issues*).

[101] Garmin Comments at 50-56; Trimble Comments at 37-39; USGIC Comments at 13-19; Save Our GPS Coalition Comments at 25.

and that many devices tested showed high levels of resilience because of the design of their front ends and filtering. Focusing on precision receivers, this argument obscures the reality that precise, ready-to-be-implemented filters for GPS receivers do not exist today because receiver manufacturers never bothered to invest in implementing such filters. As a technical matter, technology exists today that could be used to provide adequate rejection,[102] but filters meeting the specific requirements for particular receivers have not been developed because, absent demand from GPS receiver manufacturers, no market exists today for such filters.

In general, manufacturers develop filter solutions by following a methodology that includes: developing a filter mask with required design goals such as passband and stopband corner frequencies, the maximum amplitude ripple and group delay variation tolerable in the passband based on the receiver performance objectives, the maximum insertion loss and minimum stopband attenuation, etc.; selecting an appropriate filter structure; selecting a specific filter technology (cavity resonator, solid dielectric resonator, SAW, FBAR, etc.) based on insertion loss, environmental requirements, and form factor requirements; simulating the filter performance to determine conformance with the desired objectives; and creating sample filters and testing them in a laboratory environment. Several of these steps may be performed by a filter vendor, in consultation with the manufacturer as needed.

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[102] One GPS vendor was recently quoted as being optimistic about the availability of filters that will allow GPS services to operate in the presence of LTE signals. *See* Lawson, *Spectrum Issues*, *supra* note 100 (quoting Kanwar Chadha, founder of SiRF and Chief Marketing Officer of CSR).

By way of example, when LightSquared agreed to stringent OOBE limits on its terrestrial L-band operations to protect GPS, the filters needed to implement the agreed to limits did not exist. LightSquared, working in concert with its chipset vendor, Qualcomm, developed the filter mask as describe above, considering both the OOBE obligations of the ATC Order and the need to avoid any impact to its on-board GPS modules. Thereafter, an RFI was conducted with the major filter vendors, one vendor was selected, and samples were created. In short, LightSquared invested the time and money to develop the needed filters so that LightSquared's device manufacturers would have the necessary parts to supply devices for LightSquared's network today.

In contrast, none of the GPS manufacturers who were members of the TWG performed any of the above-discussed steps as part of the TWG work, although they were far better positioned than LightSquared to assess and develop filter solutions. This is because GPS manufacturers, not LightSquared, own the receiver performance objectives and the filter vendor relationships. Rather, GPS manufacturers have accused LightSquared of not demonstrating the feasibility of filtering. Despite not having all the information necessary to determine the required filter specs, LightSquared brought to the TWG three filter vendors that develop filters for use in a variety of GPS receiver categories. Unfortunately, the response of the GPS manufacturers was lukewarm at best, and hostile at worst,[103] and none of the manufacturers took advantage of the TWG

[103] For example, in opposing the use of filters as a mitigation option, one large manufacturer of GPS devices balked at including filters that would cost as little as *five cents* per device, saying that even a cost of five cents per device would impose an unacceptable cost on GPS manufacturers that sold millions of devices.

process and meetings with filter vendors to seek quotes or proposals or otherwise develop filters based on actual receiver performance objectives.

With respect to high precision receivers specifically,[104] manufacturers have argued that, even if the augmentation signal were moved to the top of the MSS L-band, obviating the need for a wide-open front end listening across the entire MSS L-band, it would still be infeasible to develop a filter to protect just the GPS receiver given the demanding requirements of a carrier phase-based high precision receiver. In spite of repeated requests, however, precision GPS receiver manufacturers have largely refused to share the receiver performance objectives with LightSquared. Nevertheless, based on a reasonable set of assumptions as to the desired filter performance objectives, and given the large separation between the GPS band and LightSquared's planned terrestrial operations on the lower 10 MHz, it is certainly technically feasible to design filters. Preliminary filter vendor interactions suggest that the desired performance objectives are realizable, and LightSquared does not envision any insurmountable technical challenges to developing the needed filters for future high precision receivers. The only real barrier is the willingness of some GPS manufacturers, to do so. As stated above, LightSquared stands ready to work with precision GPS manufacturers to develop the required filters.

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[104] Note that part of the problem with overload of precision receivers is that they use an open front end to receive both the GPS signal and the MSS augmentation signal. The design of filters for precision receivers can be simplified by separating the GPS signal band from the MSS band used for augmentation. The GPS filter can be made narrower than a single filter used to intercept both GPS and MSS, making the GPS filter easier to build. The receiver would also need a second filter for the MSS augmentation signal, which can be narrower and also easier to build to than a single wide GPS + MSS filter.

B. Interference from user devices

A few comments raise the prospect of interference to GPS receivers from user devices operating on the LightSquared terrestrial network.[105] In each case, the concern seems to be with the emissions of those user devices, operating at 1627.5-1637.5 MHz, into the RNSS band below 1610 MHz. As the Commission is well aware, these emissions (out-of-band from LightSquared's perspective and in-band from the GPS perspective) are governed by long-standing requirements that LightSquared's predecessor voluntarily agreed to in 2002 after discussions with the USGIC.[106] For GPS interests to now call into question the specific limits that they agreed to nearly ten years ago perhaps should not be surprising given their recent behavior, but it is still shocking. Moreover, if in fact GPS receivers are as vulnerable as claimed, it calls into question how the receiver manufacturers expect their users to be protected from the myriad of other wireless devices that are not required to meet the rigorous emission limits by which LightSquared is proscribed. For instance, cellular and PCS devices are permitted much higher OOBE into the GPS band. The following represents LightSquared's

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[105] Comments of Thomas Stansell, p. 4; Garmin, pp. 49-50; and Trimble, p. 32 and Exhibit 1.0. Trimble claims that its high precision receivers require a separation distance of 1400 meters from a single operational LightSquared user device.

[106] *See* Letter from Bruce D. Jacobs, Counsel for Mobile Satellite Ventures L.P., and Raul R. Rodriguez, Counsel for the U.S. GPS Industry Council to Marlene H. Dortch, Secretary, Federal Communications Commission, IB Docket (July 17, 2002). In connection with the negotiated limits on OOBE into the GPS band from ATC base stations and user devices, LightSquared's predecessor and USGIC also submitted an analysis of OOBE limits showing a permissible GPS noise floor rise of 1.3 dB for a single ATC handset operating 4.5 meters from the GPS receiver. *See* Peter Karabinis and A.J. Van Dierendonck, Interference Analysis of Out-of-Band Emissions (OOBE) Limits to GPS from Ancillary Terrestrial Mobile Satellite Services in the L-Band, (IB Docket No. 01-185), August 8, 2002.

current understanding of the obligations of presently deployed cellular and PCS bands for OOBE into the RNSS band:

- Cellular bands in general: 43 + 10logP (-13 dBm/MHz) (FCC Rules, Section 24.238)
- 746–763 MHz, 775–793 MHz, and 805–806 MHz bands: -40 dBm/MHz (FCC Rules, Section 27.53(f))
- 3GPP requirements for UE – UE interference (3GPP TS 36.101, Table 6.6.3.2-1): -50 dBm/MHz. This does not apply specifically to the RNSS band but as Band 24 (L-band) is protected, it is likely that the protection may extend to the RNSS band.

In comparison, LightSquared's requirement is to emit less than -60 dBm/MHz during its first five years of operation and less than -65 dBm/MHz after five years of operations. Thus, other wireless devices are much more likely to cause OOBE interference to GPS than LightSquared devices. In fact, such interference cases have in fact been reported in a NASA paper.[107] The NASA paper cites a particular PCS handset, compliant with FCC rules, that was found to emit -55 dBm/10 kHz, or -35 dBm/MHz at the GPS L1 frequency.

[107] Evaluation of a Mobile Phone for Aircraft GPS Interference, *Truong X. Nguyen, Langley Research Center, Hampton, Virginia*, NASA Report NASA/TM-2004-213001.

C. Interference to LightSquared's own satellite service

Several of the comments seem to be based on the perception that the operation of LightSquared base stations will be detrimental to its satellite service.[108] This perception is misplaced. In fact, LightSquared satellite service will continue to be robust. The mobility management protocol in the dual-mode devices, paired with a single, common core network serving both satellite and terrestrial services, makes sure that after 2014 (when legacy service is discontinued) all satellite users operating on the next generation network will switch to the terrestrial network where available anywhere the user does not receive a good-quality satellite signal. This benefits users because the terrestrial network will typically deliver better performance, particularly in areas where satellite service is likely to be obstructed.

VII. OTHER FILINGS CONFIRM THE IMPORTANT BENEFITS LIGHTSQUARED'S NETWORK CAN PROVIDE

There has been outpouring of public support for the development of LightSquared's network. Hundreds of community leaders, including elected officials representing public safety providers, small businesses, first responders, and a wide swath of industries have written to the FCC in support of LightSquared's plan to deploy a nationwide 4G-LTE network. Support for LightSquared's network has also come

[108] Comments of Trimble, p. 11; USGIC, p. 42. These same parties also misunderstand the extent that LightSquared's satellite and terrestrial network and service remain integrated even with the offering of terrestrial-only service. Comments of Trimble, p. 12; USGIC, pp. 32, n. 77, and 42. The fact is that LightSquared will continue to provide both services through a single, common and integrated network core. LightSquared has spent over $50 million in researching, patenting and developing mobility management methods that will allow seamless interoperability between satellite and terrestrial modes. These methods are written into the open 3GPP2 standard (xHRPD) which governs LightSquared's next generation satellite air interface.

from telecommunications providers, providers of capital financing for telecommunications ventures, public interest organizations and others who have submitted more extensive comments urging the Commission to allow LightSquared to go forward with the deployment of it s network. We summarize below, first the comments of the hundreds of community leaders who have written to the Commission in support of the rapid deployment of LightSquared's network and, second, the more formal comments of other telecommunications industry organizations and business interests.

A. Community Leaders Writing in Support of LightSquared's Network Deployment

1. Those Commenting. More than 70 elected officials across the country, including mayors, state senators and representatives, county commissioners, city councilpersons and sheriffs have filed supportive comments concerning LightSquared's deployment plans. Dozens of current and former public safety providers, including first responders, emergency medicine practitioners, firefighters, and chiefs of police have weighed in with comments to the FCC. More than 100 community leaders representing a wide swath of industries and interests, including education, minorities, small businesses, healthcare services, tourism and public policy consultants, have advocated on behalf of LightSquared.

2. Summary of Benefits of LightSquared's Network Identified by Community Leaders

The Community leaders writing to the Commission identify a wide range of benefits of LightSquared's network, including:

i. Closing the digital divide;

ii. Generating economic opportunities through its infrastructure build out and its wholesale business model;

iii. Providing needed improvements in public safety communications technology, especially in rural areas; and

iv. Increasing competition in the wireless industry in a fashion that will lead to better quality of service, more coverage and greater affordability.

3. <u>Sample Passages</u>. Comments from these community leaders include the following:

> *"I believe that accessible, affordable high-speed broadband is essential for Arkansas to remain economically competitive in the coming years. LightSquared will help ensure that rural America has adequate broadband capacity, through private-sector, job-creating investment."*
> ***-Sharon Priest, Executive Director of the Downtown Little Rock Project, former Little Rock Mayor and Secretary of State of Arkansas.***

> *"I have the honor of serving Arkansas's 54th District, and I want to be sure that we have the best equipment for our safety officials and first responders in order to keep our citizens safe. With my experience in the emergency services industry, I know the need for top quality wireless service to communicate with each other and with those individuals in need. LightSquared's new network would ensure that our community has this extremely important wireless access…It is apparent that LightSquared is committed to the nation's public safety community. It continues to have Push-to-Talk and other critical communications features that our safety officials have come to depend on."*
> ***-Hudson Hallum, Arkansas State Representative, District 54***

> *"As a Professor of History at Cabrillo College in Santa Cruz, I write in support of LightSquared's efforts to launch a nationwide 4G-LTe broadband wireless network. This*

network represents a rare opportunity to increase the amount of spectrum assigned to broadband wireless, a crucial goal of our National Broadband Plan."
-Enrique Mea Buelna, PhD, History Professor, Cabrillo College (CA)

"Rural businesses are fast falling behind in today's rapidly changing global economy. Coachella business owners must gain more access to dependable telecommunications technology, and we need the Federal Communications Commission to fight on our behalf. LightSquared's model will specifically help rural business owners in Coachella because it will allow more competitors to enter the broadband market, making broadband not only more accessible for business owners, but also more affordable. This new network will allow for greater innovation, and will ultimately help shrink the "digital divide."
-Eduardo Garcia, Mayor of the City of Coachella, California

"As GPS has become an essential and useful part of the fabric of the lives of many Americans. I believe that LightSquared, too, has the same incredible potential. For example, I support LightSquared's plans to bring high-speed wireless capacity to rural communities that I represent in the 40th Senate District in the California State Legislature. I believe that increasing the availability of high-speed mobile capacity to these areas and other underserved regions is positive and may allow more Americans to take advantage of cutting-edge telecommunications technology."
-Juan Vargas, California State Senator, 40th District

"As the CEO for one of the most established mediation firms in the country – and a volunteer firefighter for the small mountain community of Jamestown – I want to encourage the FCC's support for a wireless company, LightSquared...Especially in the mountainous regions, it is critically important for the fire crew to keep in touch with each other. I know this technology could help fire departments keep in better contact with their fire crew…It is essential to Colorado's economic competitiveness that we continue to build out our mobile broadband infrastructure. LightSquared would bring more broadband communications to Colorado, and thus would also create jobs and economic development."
-Jonathan Bartsch, CEO, CDR Associates (CO)

"When Hurricane Katrina wreaked havoc on the Gulf Coast, I know that FEMA and state officials in Louisiana relied on LightSquared's satellite communication technology to coordinate rescue and rebuilding efforts when ground-based telecom networks were inoperable…A state-of-the-art wireless broadband system like LightSquared's could be of enormous help the next time an unforeseen crisis hits Kansas or other parts of the nation including Tuscaloosa, Alabama or Joplin, Missouri."
-Anthony Hensley, Kansas Senate Democratic Leader, 19th District

"A company called LightSquared has agreed to help in expanding broadband wireless capacity by investing in a new 4G-LTe network. Unfortunately, the GPS industry has put a road block in LightSquared's path. GPS is very important, but the GPS industry must also understand the importance of expanding broadband wireless capacity across the nation."
-Dave Pearson, City Council, Peoria, Arizona

"LightSquared's proposed 4G-LTE network represents the best chance in the short term for a significant expansion of the nation's wireless broadband spectrum. This network would be privately funded initiative using spectrum long assigned to LightSquared and its predecessors…LightSquared is well known to the public safety community (and especially here in Kentucky because of their work with the state on an almost-gratis basis during emergencies before) as an experienced service provider to federal, state and local fire, police, rescue and disaster-relief departments, specializing in on-call mobile satellite communications services, personnel and equipment…Given the critical need for first responders to have access to reliable, high-bandwidth communications technology, I hope you will support the FCC's efforts to resolve these issues so that LightSquared can move forward with its plans to upgrade the nation's wireless broadband capability and allow public safety providers to employ this important technology."
-Berl Perdue, Clark County Sheriff (KY)

"We have proudly provided quality construction services throughout the world for over 100 years…as a wholesale provider, LightSquared will allow smaller wireless providers to offer world-class service and also enable many new competitors to enter the wireless market. LightSquared's proposal to launch operations only in the lower band of its licensed spectrum takes care of 99.95% of GPS receivers. Given the United States' urgent need for expanded wireless broadband capacity, it seems that the next step is for the GPS industry to make the necessary adjustments to its receivers to fix the remaining 1%...When it comes to this issue, I don't think there is a middle ground. I urge the FCC to take the necessary steps to allow LightSquared to go forward and provide this network to the marketplace. As a company who operates throughout the state and much of the time in rural Kentucky, we would benefit from what LightSquared has to offer."
-James Codell, IV, President/CEO, Codell Construction Management (KY)

"Large portions of rural Minnesota lack reliable broadband internet coverage. Consequently, the benefits of telemedicine are not available to all and rural residents must incur additional expense and travel time to receive care. We need reliable and affordable wireless broadband throughout Minnesota, and we urge the Federal Communications Commission to move quickly to support proposals to apply innovative technology solutions, including wireless broadband, to enhance the delivery of health care in rural America."

-Mark Schoenbaum, Director, Office of Rural Health and Primary Care, Minnesota Department of Health

"I am writing to ask the Commission's help to improve the access of low-income, minority and other un-served and underserved communities to essential telecommunications services, including wireless high-speed Internet and cell phones…I encourage the Commission to support LightSquared's proposal, which will make technology more accessible and more affordable for low-income citizens like those I represent."
-Bobby Joe Champion, Minnesota State Representative

"I encourage you (FCC) to make recommendations on how we move forward with both LightSquared and GPS. No one wants interference between the two technologies, including me and the men and women on my police force, but I am confident there is a win-win solution that can allow both to peacefully co-exist and we can finally bridge the "digital divide" that exists."
-Bob Muenz, Chief of Police, Oak Grove, Missouri

"As the former Sheriff of Monmouth County I dealt extensively with communications issues over my twelve year career. I believe that incidents like September 11th and Katrina make it imperative that we provide LightSquared with the ability to bring new and innovative communications systems to the marketplace. Their network of satellite and ground-based wireless coverage would have helped provide uninterrupted service during both of those catastrophes. Their proposed network is essential to providing a reliable communication infrastructure to the law enforcement and first responder community. I participated on the National Sheriff's Association's post-Katrina debriefing. Throughout our deliberations, it was painfully clear that systems such as those developed by LightSquared would have been enormously beneficial. Accordingly, I would respectfully suggest that the FCC allow LightSquared to move forward with their plans."
-Joseph W. Oxley, former Sheriff of Monmouth County (NJ)

"Authorizing LightSquared to deploy a nationwide 4G-LTE network, under its newly proposed plan, is a step in the right direction towards bridging the digital divide. By offering smaller carriers, as well as device makers and content providers, significantly less expensive wholesale access to a nationwide 4G-LTE network, LightSquared will enable companies like Cricket and Portland-based Consumer Cellular to offer a very affordable world-class wireless broadband service to their niche, often underserved consumers. Given the considerable benefits to consumers, especially to those who most need it in rural and underserved communities, I would urge the FCC to move forward in ensuring the availability of both LightSquared's 4G-LTE service and GPS services. The recommendations recently proposed by LightSquared certainly seem to accomplish just that in both the short and long-terms.

Ultimately, all Americans should have the opportunity to succeed in life and this opportunity begins in the creation of sustainable communities where a variety of people have a place to call home and an income sufficient to meet their basic needs. LightSquared's service and business plan will facilitate this opportunity and we urge the FCC to allow LightSquared to proceed with its terrestrial deployment as soon as safely possible."
-John Miller, Executive Director, Oregon Opportunity Network

"I believe that any new technologies such as those developed over many years by LightSquared are beneficial to both first responders and taxpayers. Not only would this technology improve the tools available to first responders in emergency situations where traditional communications break down, but it will create the availability of alternatives for local governments when seeking communications solutions, which will decrease costs to the taxpayers. We need solutions that work well during significant emergencies that many times take place during power outages. That is why I firmly believe that the introduction of new technologies, such as LightSquared's proposed network, are essential to providing reliable communications infrastructure to law enforcement and first responders."
-Gerald M. Turning, Sr., Administrator, Borough of Tinton Falls, former Chief of Police (NJ)

"LightSquared's proposed 4G-LTE network could address many of the challenges to maximizing the available healthcare technology and improving communication between EMS personnel in the field, medical command and receiving hospitals. The need for this technology is particularly great in rural states like West Virginia where the existing networks are underdeveloped and ambulance squads are relied upon to connect people with needed medical care."
-Chris Hall, Executive Director, West Virginia EMS Coalition

"Rural counties in Kentucky have suffered for decades because they have been cut off and isolated from modern technology. By offering 4G-LTE access via wholesale, LightSquared is essentially democratizing wireless broadband in the United States, a move that will help rural areas. LightSquared's proposal would help put rural America on the same playing field as everyone else by providing the same high-speed 4G service to rural residents as urban residents enjoy."
-Kenny Rice, Board Member and Volunteer, Clay City Volunteer Fire Department (KY)

"Too many rural Minnesotans live in communities or on farms with no reliable wireless communications. There appears to be a solution to the challenge of bringing wireless to rural communities. By making it possible for dozens of new competitors to bring high-

speed wireless Internet to all Americans on wireless devices, LightSquared will drive down consumer costs, help bridge the digital divide and enable businesses and individuals to remain in now-underserved areas rather than having to relocate to urban settings with reliable broadband availability. Reliable telecommunications, including broadband Internet, is a key building block for economic growth and we urge the Commission to not delay its consideration of LightSquared's application.
-Doug Magnus and Gary Kubly, Chair and Lead Minority Member of Minnesota Senate Committee on Agriculture and Rural Economies

B. Telecommunications Industry Organizations and Businesses Submitting Comments in Support of LightSquared's Network Deployment

The support of community leaders for LightSquared's network deployment is echoed by the many telecommunications organizations and telecommunications business interests that have filed comments in support of LightSquared. The benefits of LightSquared's network deployment identified by these parties are summarized below:

1. Increased Wireless Competition in a Highly Concentrated Market

The Computer & Communications Industry Association ("CCIA") is one of several commenting parties to emphasize that "LightSquared's plan to become a wholesaler of wireless voice and broadband capacity and services would significantly advance the Commission's goal to promote competition in the wireless market."[109] The Public Interest Organizations note that LightSquared's wholesale network would help

[109] CCIA Comments, IB Docket No. 11-109, at 3 (July 29, 2011) ("CCIA Comments"). *See also* Comments of Leap Wireless International, Inc. and Cricket Communications, Inc. (collectively, "Leap"), IB Docket No. 11-109, at 3-4 (July 30, 2011) ("Leap Comments"); Comments of News America Foundation, Free Press, Public Knowledge, and Media Access Project (collectively, "Public Interest Organizations"), IB Docket No. 11-109, at 13-14 (Aug. 1, 2011) ("Public Interest Organizations Comments"); Comments of SI Wireless, IB Docket No. 11-109, at 2 (July 22, 2011) (""SI Wireless Comments").

address "[m]any of the barriers to competition faced by smaller and regional carriers – including data roaming on a near-nationwide basis at reasonable rates and terms…."[110] SI Wireless also points to these competitive barriers and urges the Commission to allow LightSquared to move forward with its network so as to enable small regional carriers, like SI Wireless, "to compete more effectively in a wireless market in which users increasingly demand access to nationwide services."[111]

2. Furthering the National Broadband Plan; Extending Broadband To Those Without Access

Many commenting parties point out the benefits of LightSquared's network in furthering the National Broadband Plan, and point to the value of the network in expanding broadband access to communities currently without broadband access. The Public Interest Organizations in their Comments state "the public interest benefits associated with the LightSquared business plan and buildout…are central to the Commission's overall broadband policy goals."[112] Also focusing on the broader implications of LightSquared's network for national broadband goals, CCIA states: "LightSquared's wholesale business model will allow broadband providers to offer services to unserved areas without incurring the high-costs of building out their own infrastructure. Not only will LightSquared's network allow service providers to reach unserved areas, it will do so without consuming USF subsidies– a winning proposition

[110] Public Interest Organizations Comments at 12-13.
[111] SI Wireless Comments at 2.
[112] Public Interest Organization Comments at 11.

for both customers and taxpayers."[113] In its Comments, Sprint Nextel, also points to the increasing demand for wireless spectrum as set forth in the National Broadband Plan.[114] Finally, SI Wireless points to the benefits that LightSquared's network will provide to it in serving its rural market.[115]

With regard to service to rural and other underserved areas, LightSquared hereby reiterates its commitment to bring broadband service to such areas. USGIC attempts to cast doubt on that commitment by referring out of context to the initial coverage estimates in LightSquared's Recommendation[116] and ignoring the immediately preceding sentence of the Recommendation which states that LightSquared's "deployment plans necessarily focus initially on population centers and only gradually begin to cover less densely populated areas." [117] In any event, the population centers to be covered in the initial plan (which would cover 270 million Americans) do include many rural population centers. In fact, LightSquared is in discussions with multiple companies involving rural service, and already has entered into reciprocal roaming agreements with two of them and an MOU with another of them, to implement its rural service plans.

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[113] CCIA Comments at 7.
[114] Comments of Sprint Nextel, IB Docket No. 11-109, at 4, 10 (Aug. 1, 2011) ("Sprint Nextel Comments").
[115] SI Wireless Comments at 1.
[116] *See* USGIC Comments at 48 (Aug. 1, 2011).
[117] Recommendation of LightSquared Subsidiary LLC, File No. SAT-MOD-20101118-00239 and IB Docket No. 11-109, at 32 (Jun. 30, 2011) ("Recommendation").

3. LightSquared's Network will Spur Innovation, Economic Growth and Job Creation

Multiple technology and large capital firms have banded together to submit Comments emphasizing this country's urgent need for LightSquared's network:

> "The importance of building the world's first ever nationwide end-to-end full IP wireless network and taking the global lead in LTE deployment cannot be overstated. Once complete, the LightSquared network will sharply increase the nation's broadband capacity, enhancing wireless competition and providing additional choice in the wireless industry. In addition, LightSquared is poised to deliver unique capabilities to support public safety and has made an aggressive commitment to bring broadband to rural communities. Moreover, its unique, collaborative open-platform design combined with its 100% wholesale business model promises to spawn innovation by supporting new entrants and leading edge applications."[118]

Similarly, CCIA urges that "[t]he deployment of LightSquared's network will lead economic growth and jobs and provide a much needed boost to the sputtering American economy."[119] CCIA concludes its discussion of the benefits of LightSquared's network, as does LightSquared herein in its summary of other supporting comments, with the words of Chairman Genachowski, "the opportunity presented by LightSquared, which if successfully realized, would result in billions of dollars of new private investment and the creation of tens of thousands of jobs."[120]

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[118] Letter from dem, Mesirow Financial, Mission Ventures, Highland Capital Partners, Wasatch Cross Creek Capital, CENX, Vonage, CFN Services, telemetria, AnyDATA, Soundtracker, ALIANZA, Ortiva Wireless, UMBER, vidtel, SIMPLEXITY, FCC File No. SAT-MOD-20101118-00239, at 1 (Aug 1, 2011).

[119] CCIA Comments at 11.

[120] *Id, quoting* Letter from Julius Genachowski, Chairman, FCC, to Charles E. Grassley, U.S. Senator at 3 (May 31, 2011), *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-307461A1.pdf.

VIII. THE OBJECTIONS TO THE STUDY DERIVING THE ECONOMIC BENEFITS OF LIGHTSQUARED'S NETWORK AND THE SUBSIDY TO THE COMMERCIAL GPS INDUSTRY MISS THE MARK

In its comments, the Save Our GPS Coalition takes issue with a study by Dr. Coleman Bazelon of the Brattle Group on which LightSquared relied to derive estimates of the economic benefit that LightSquared's network will deliver to U.S. consumers and the implicit subsidy to the commercial GPS industry.[121] As explained in greater detail in the attached response by Dr. Bazelon,[122] the Coalition's comments and the analysis by NDP consulting that it commissioned display a lack of understanding of the Bazelon study and the sources it relied on.

In the attached Response, Dr. Bazelon explains in detail how he derived the $12 billion estimate of the economic value of LightSquared's L-band spectrum based on a current value of $1 per MHz-pop.[123] Dr. Bazelon also explains how he derived the estimate of $120 billion in consumer surplus that will be derived from LightSquared's network, based on a multiplier derived from several empirical studies on the estimated consumer surplus from a spectrum allocation.[124] Dr. Bazelon further explains that commercial GPS industry does indeed receive a subsidy by any reasonable definition of that term.[125] Finally, Dr. Bazelon explains that while estimates of filter costs and other

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[121] Save Our GPS Coalition Comments at 45-48, App. B (discussing and attaching analysis of the Bazelon study by NDP Consulting).
[122] Dr. Coleman Bazelon, *Response to NDP Consulting Group Concerns Regarding Bazelon 2011*, attached as Exhibit C ("*Bazelon Response*").
[123] *Bazelon Response* at 2-5.
[124] *Bazelon Response* at 5-6.
[125] *Bazelon Response* at 6-9.

costs associated with ensuring that all GPS receivers are compatible with LightSquared's terrestrial network may vary, by any measure such costs are a small fraction of the total economic benefits to be derived from LightSquared's planned network.[126]

Finally, it should be noted that the Coalition's arguments related to the benefits of the GPS industry are beside the point. LightSquared is not arguing that the GPS industry does not provide valuable services or even that the policy decisions made to subsidize the commercial GPS industry were incorrect. After all, LightSquared is not arguing that commercial GPS users should vacate their spectrum. Indeed, it is because of the importance of GPS that LightSquared has spent hundreds of millions of dollars to move its planned ground network to the lower 10 MHz frequencies furthest away from GPS and has committed to a standstill with respect to the upper 10 MHz of frequencies — half of its total downlink frequency authorization — in which it has been authorized to operate terrestrial base stations since 2003.

LightSquared raised the subsidy to the commercial GPS industry in the context of the steadfast refusal of the large GPS receiver manufacturers to take any steps to ensure that their receivers reject signals operating outside the frequencies allocated to GPS and to address concerns related to the performance of GPS receivers that is entirely of their own making. Despite the large subsidy to commercial GPS manufacturers, they

[126] *Bazelon Response* at 9-11.

refuse to cooperate with LightSquared to ensure that consumers can enjoy the significant benefits of both GPS and LightSquared's LTE network. Instead, these manufacturers have chosen to engage in a vitriolic lobbying and PR campaign to have LightSquared vacate its spectrum — a move which would effectively colonize the valuable 1525-1559 MHz L-band for use by commercial GPS manufacturers, adding immeasurably to their already large subsidy.

CONCLUSION

For the reasons stated herein and in LightSquared's comments and Recommendation, the Commission should adopt the solution that LightSquared has proposed, which will permit wireless broadband and GPS to co-exist.

Respectfully submitted,

/s/ Jeffrey J. Carlisle
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and Public Policy
LightSquared Subsidiary LLC
10802 Parkridge Boulevard
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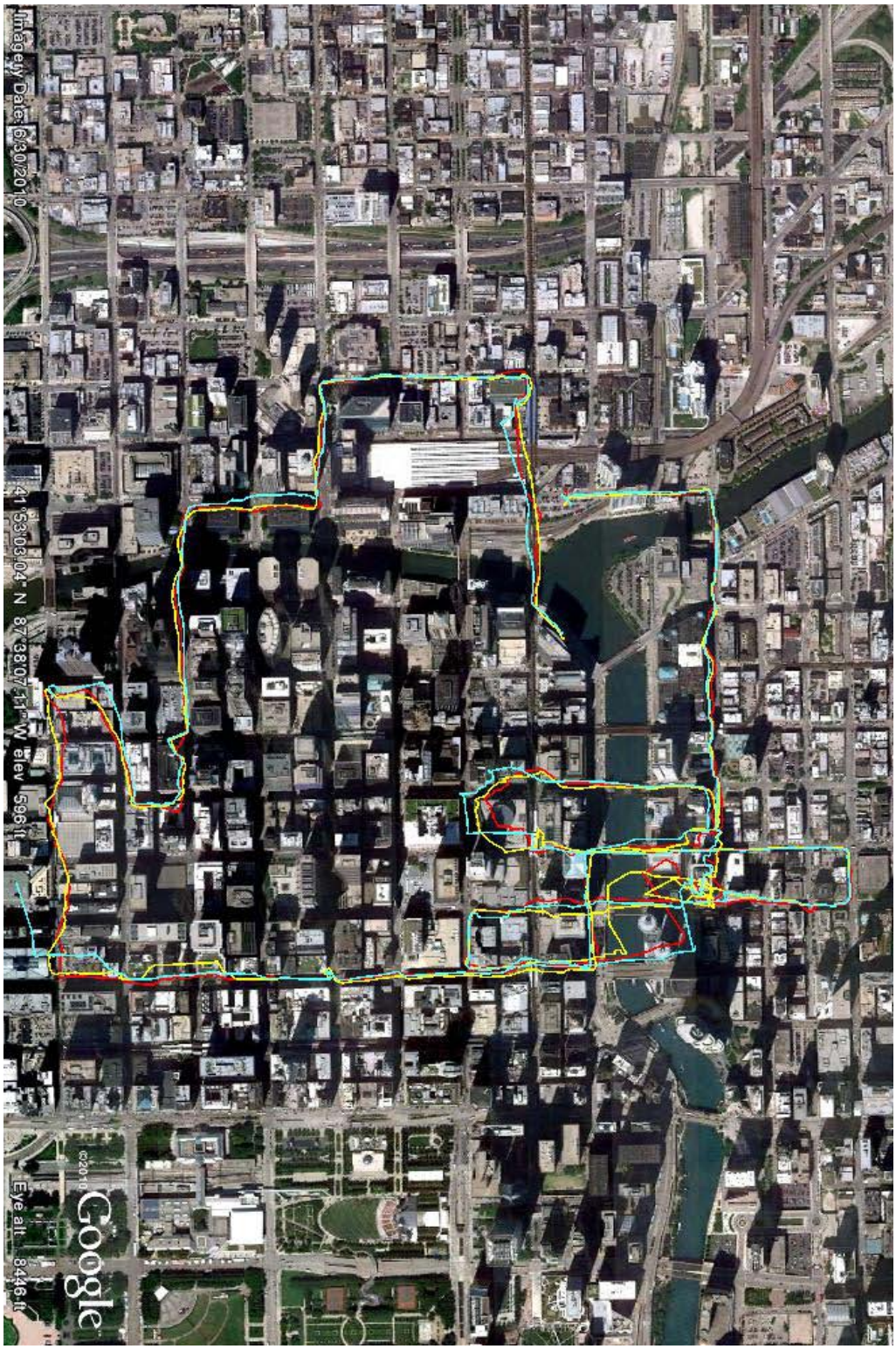
(703) 390-2001

August 15, 2011

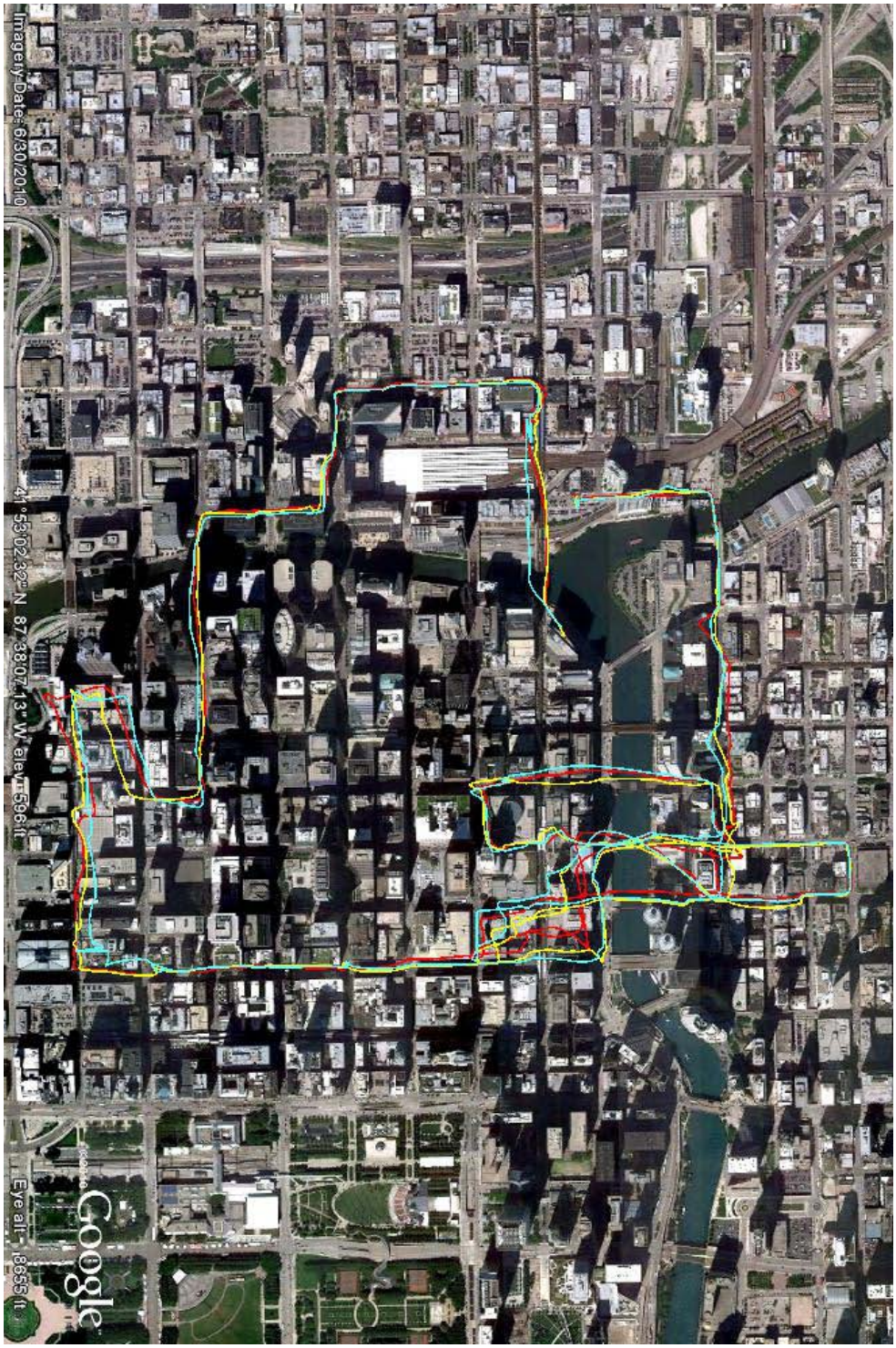
Maps for Devices Tested in Urban Simulation

Colors:
Blue – Base Line
Yellow – 3dB
Red – 6dB

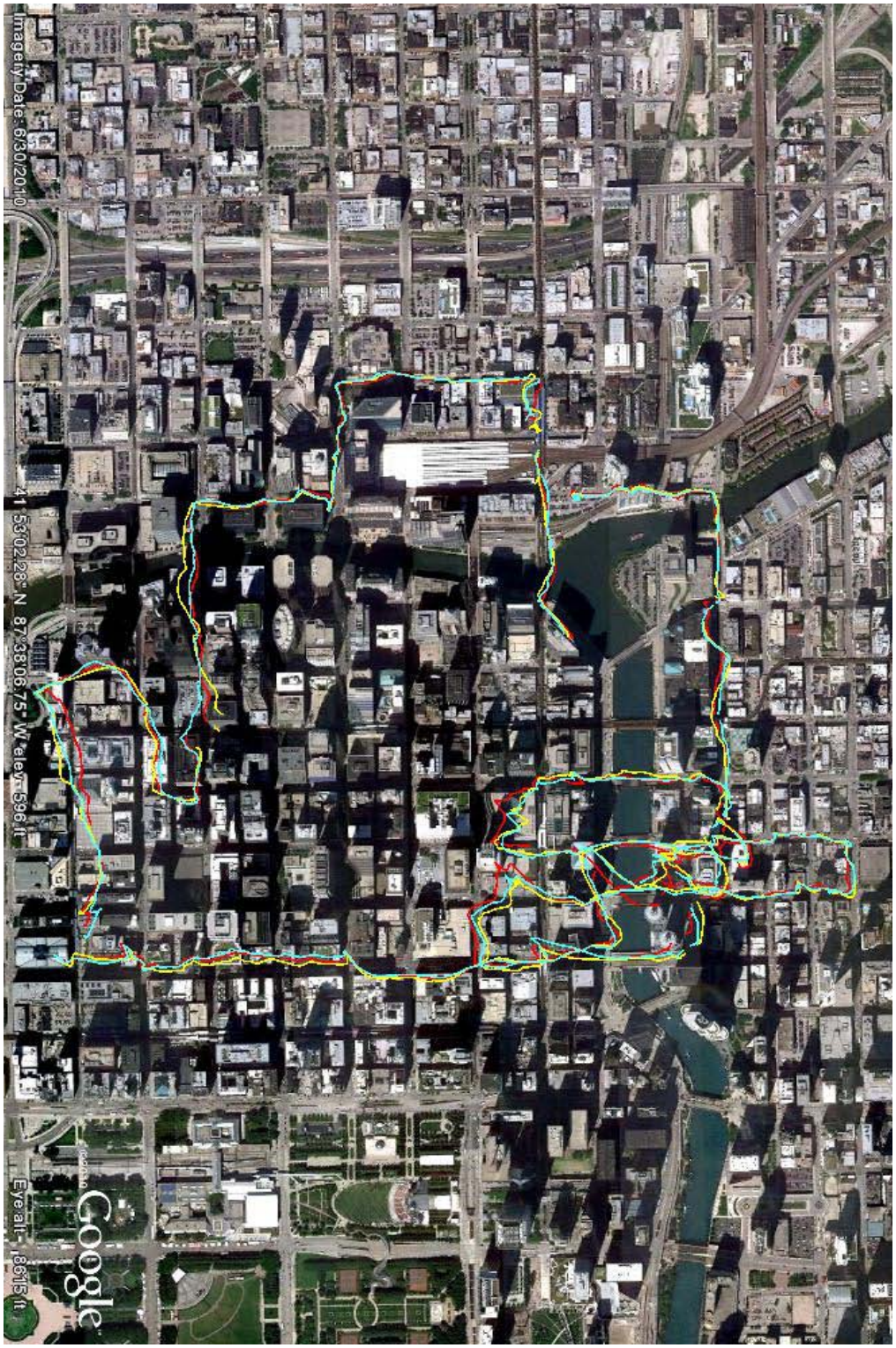
Device G10968



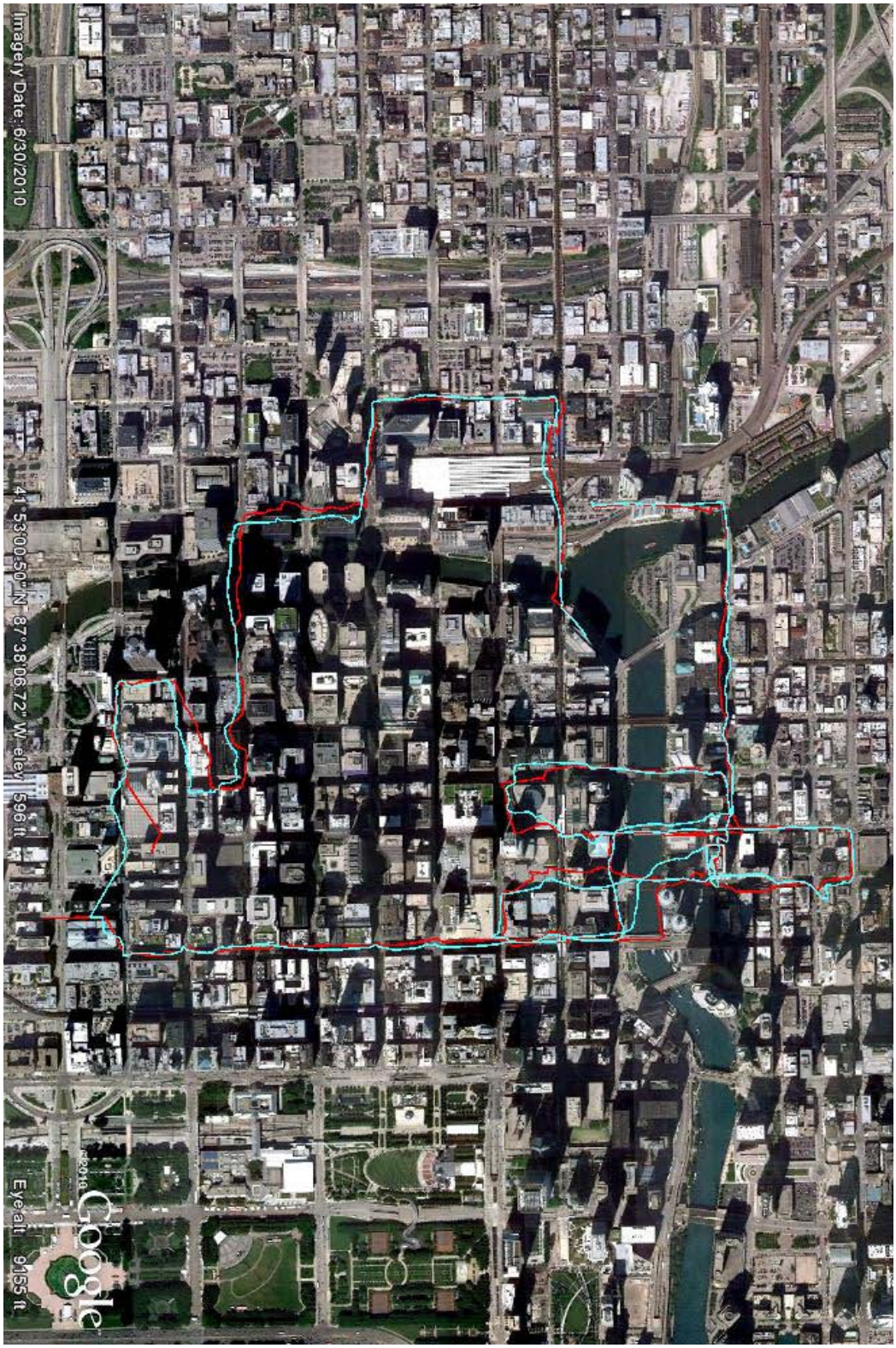
Device G12586



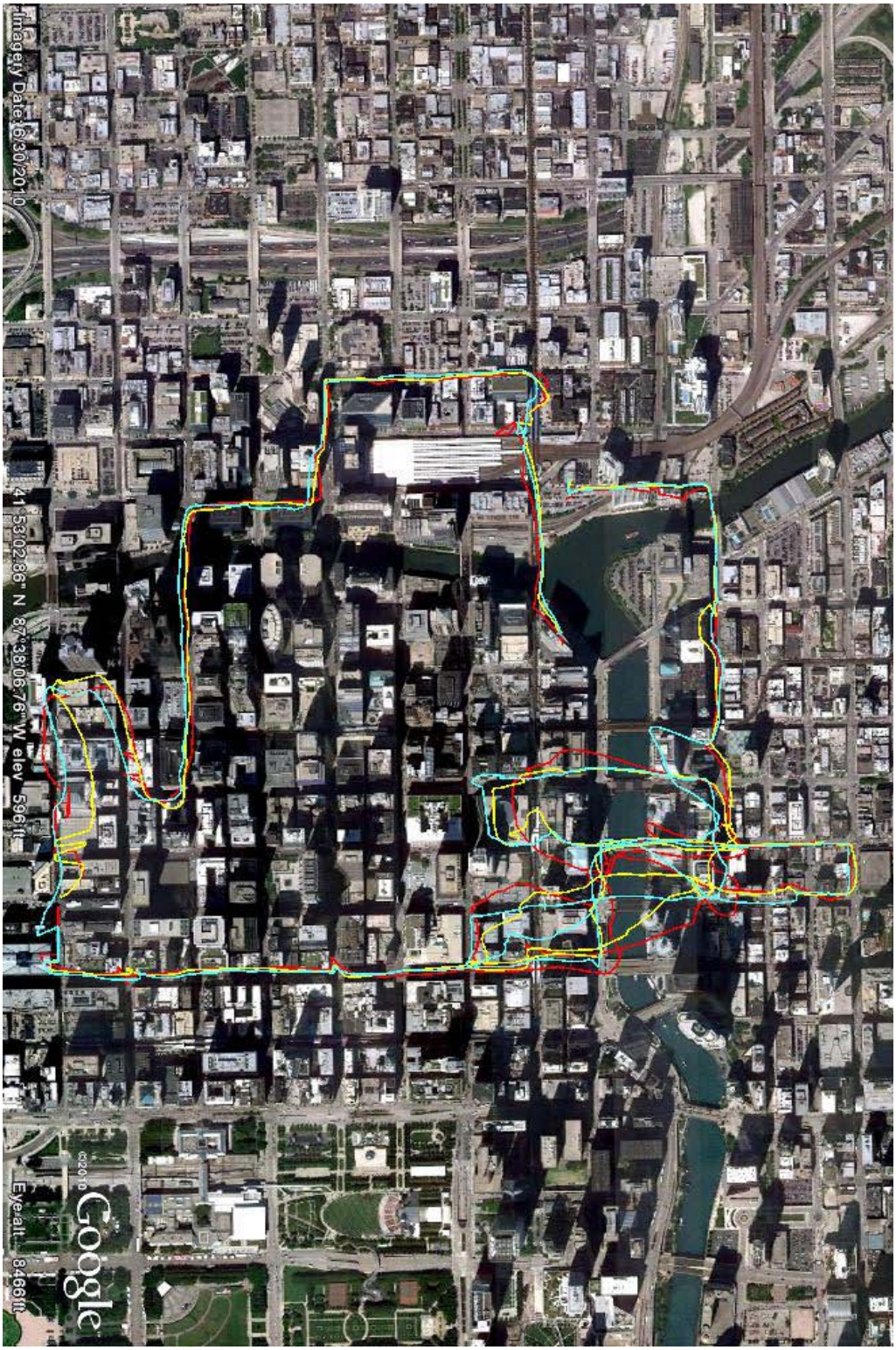
Device G12867



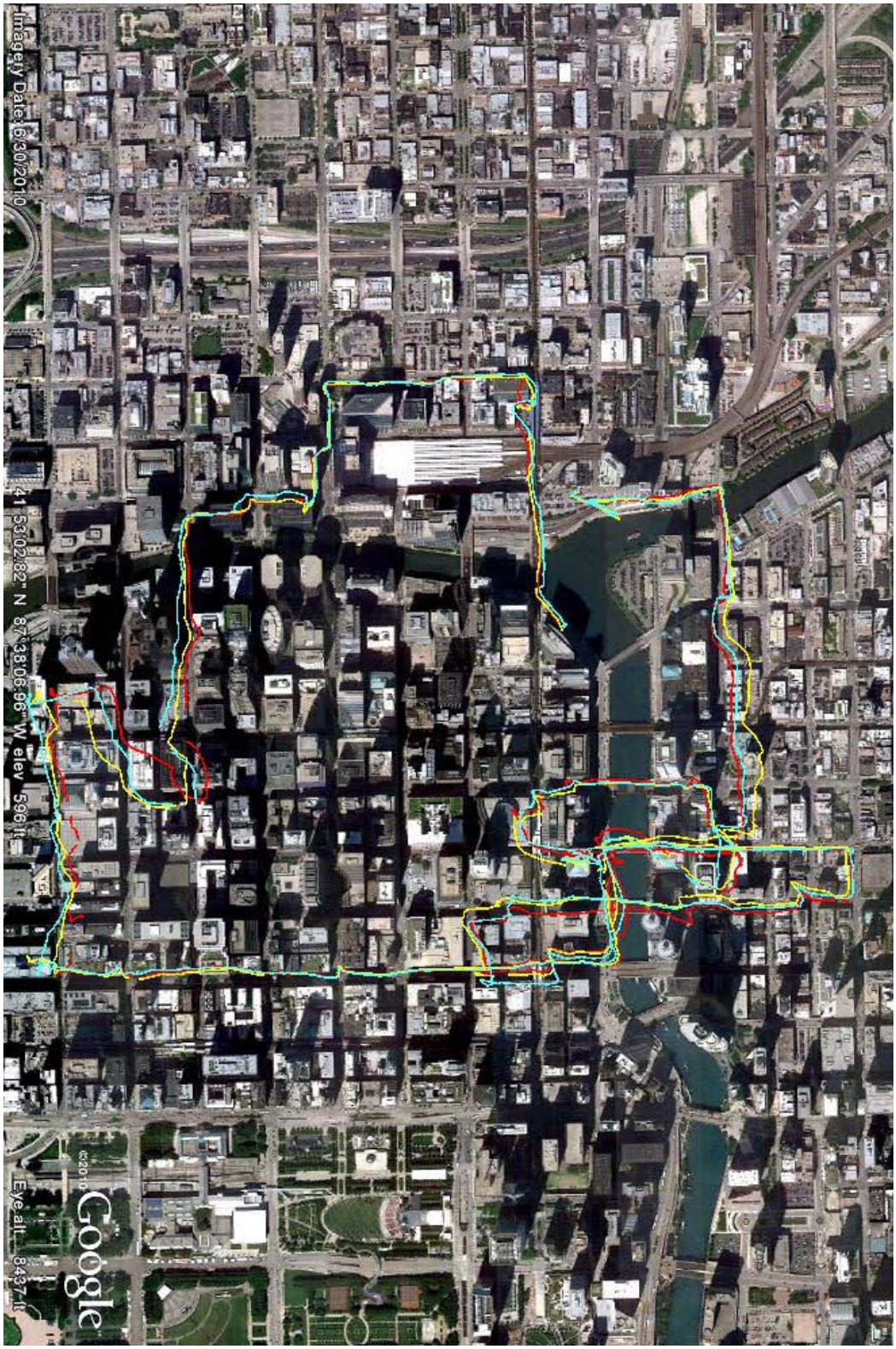
Device G15448 (BL and 6 dB Only)



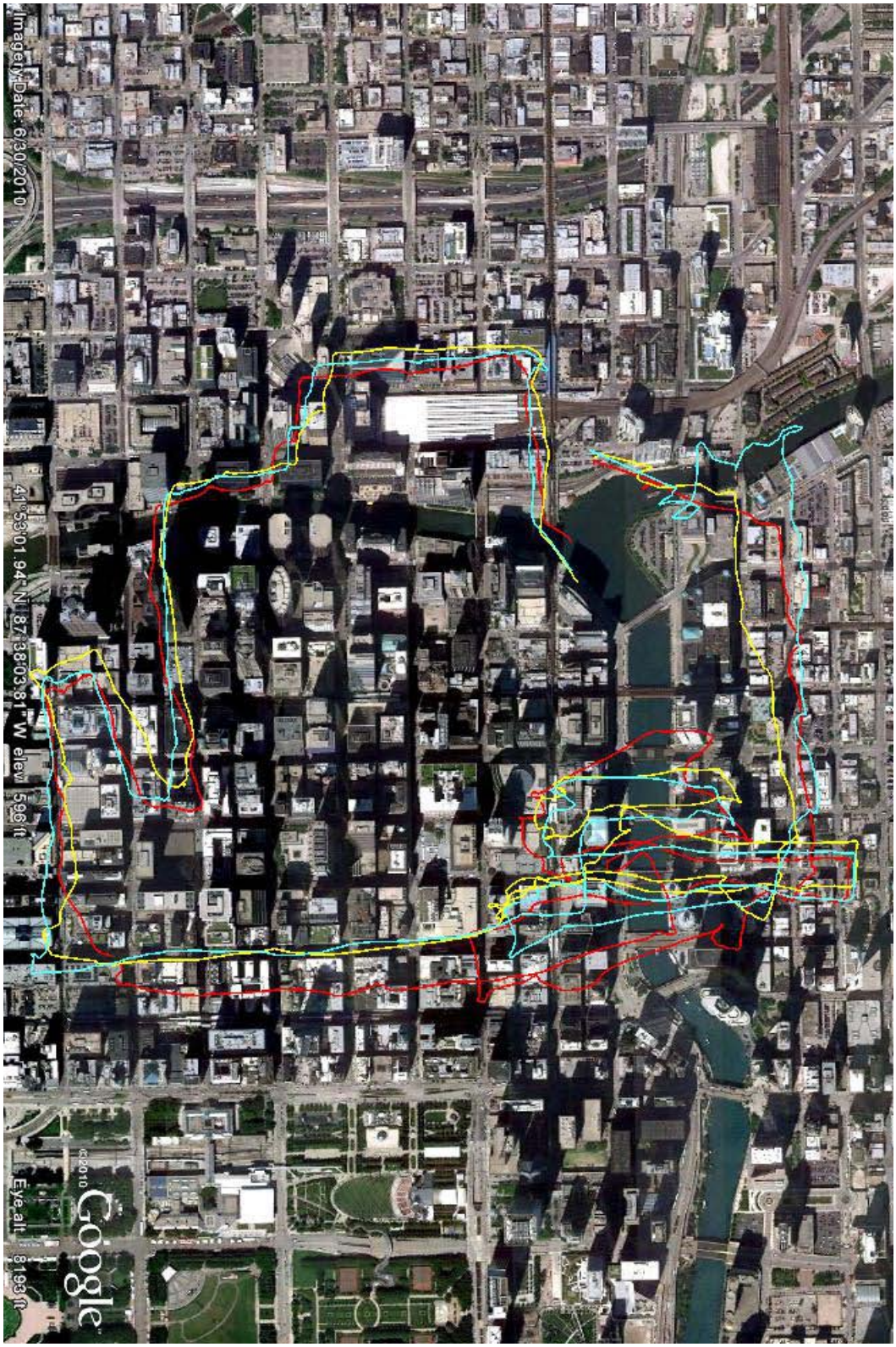
Device G17641



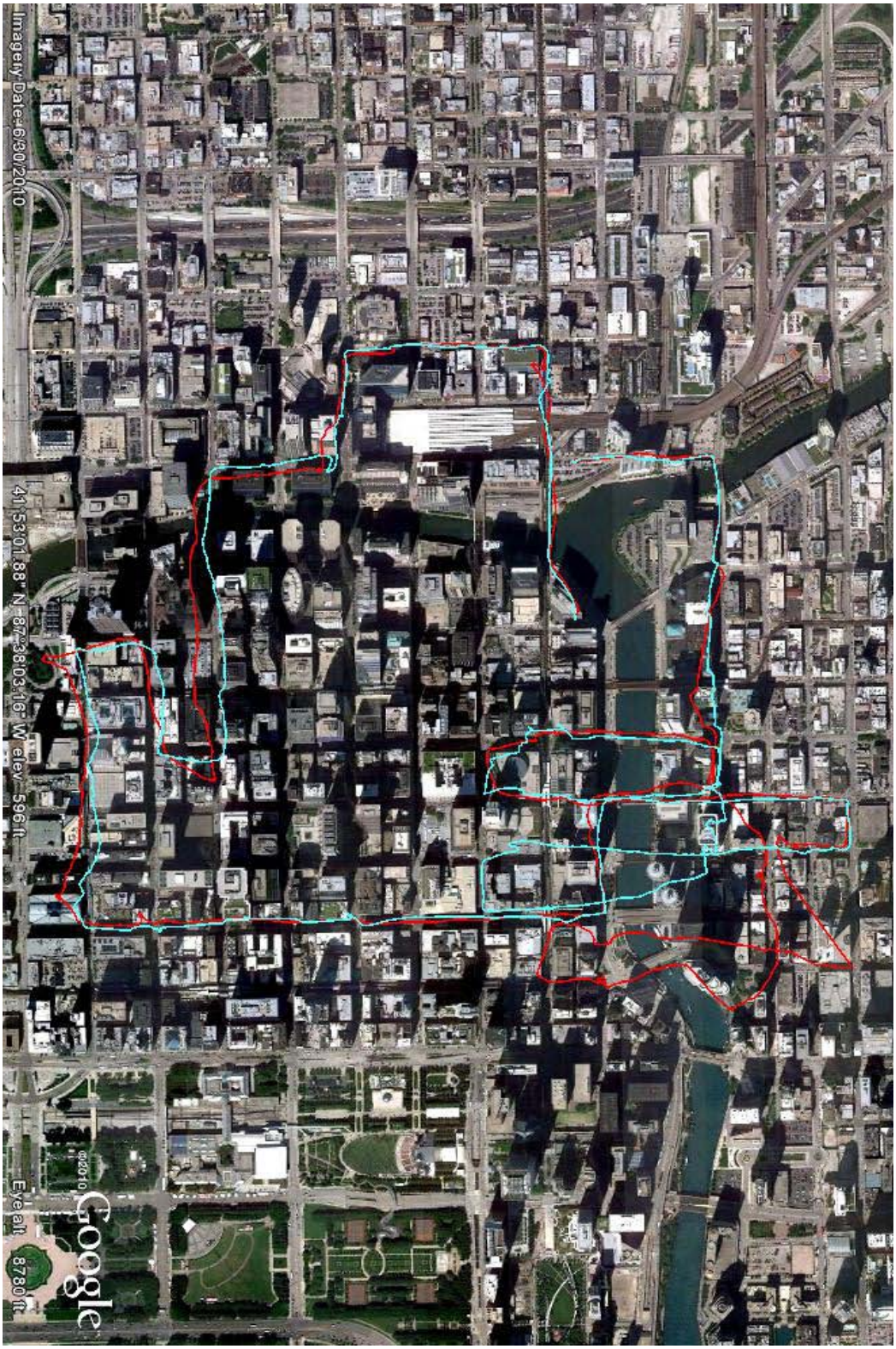
Device G17783



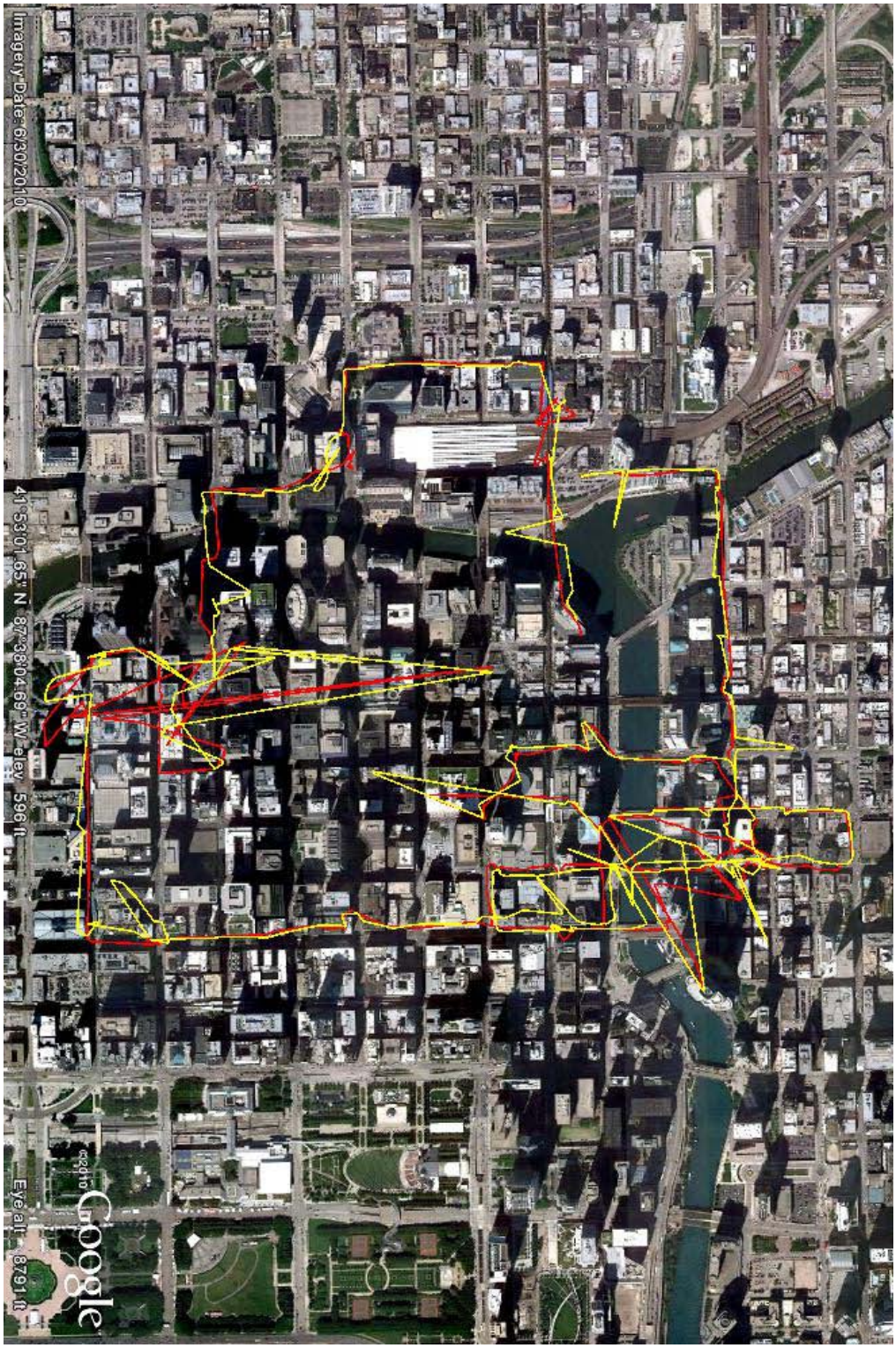
Device G18171



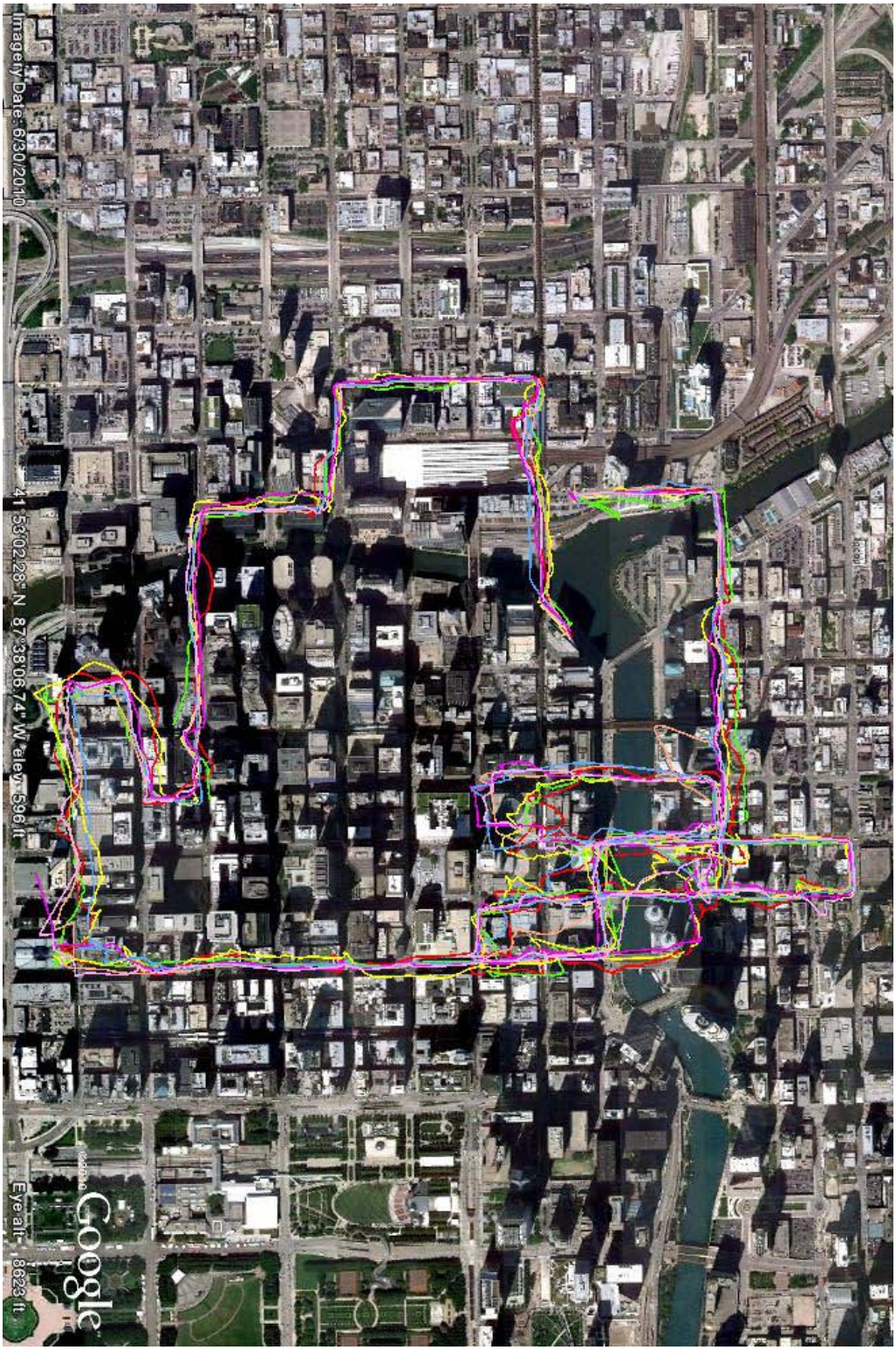
Device P14730 (BL and 6 dB Only)



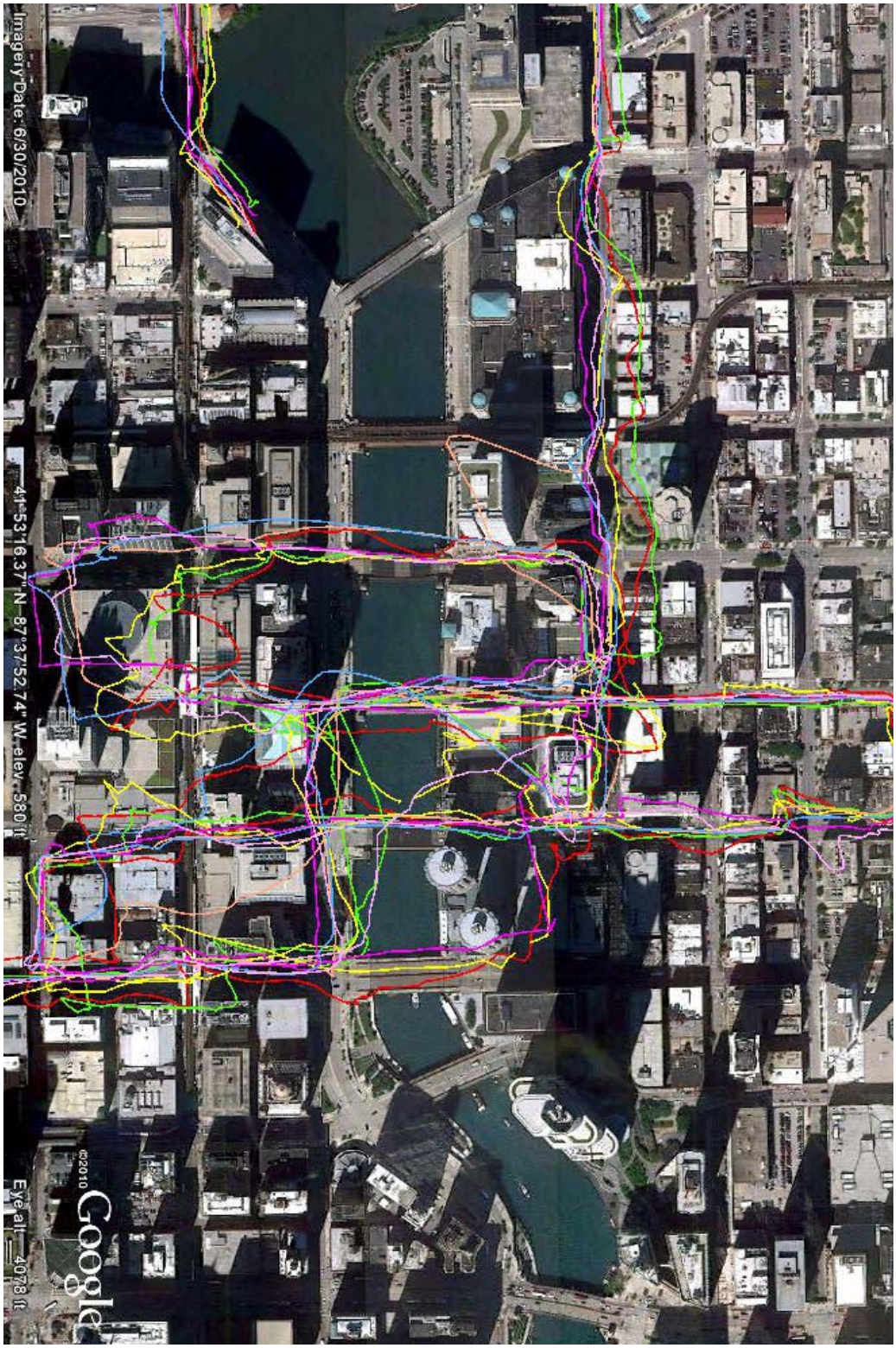
Device P17655 (3dB and 6dB Only)



All Devices Base Line



All Devices Base Line (Zoom)

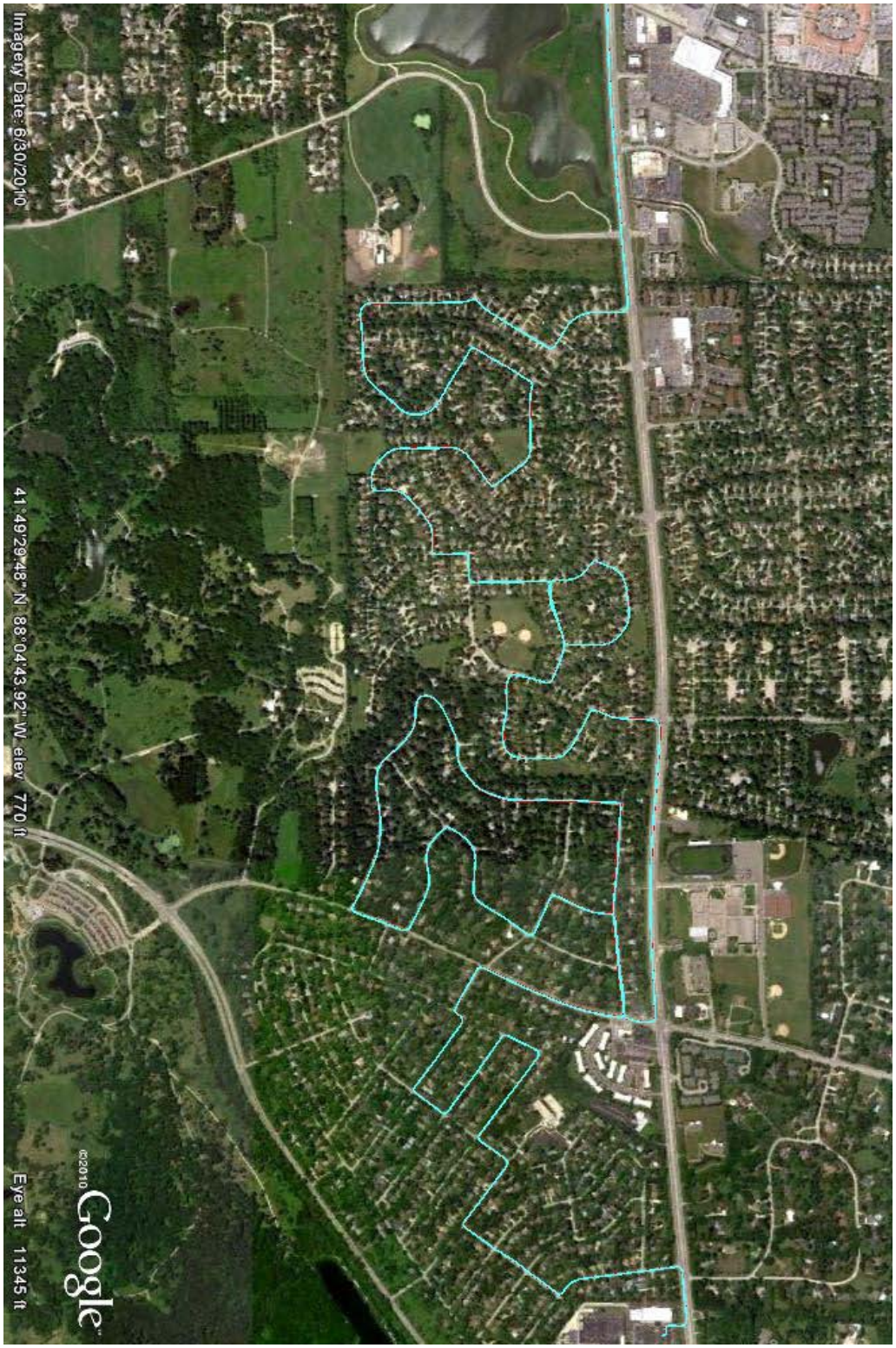


Maps for Devices Tested in Suburban Simulation

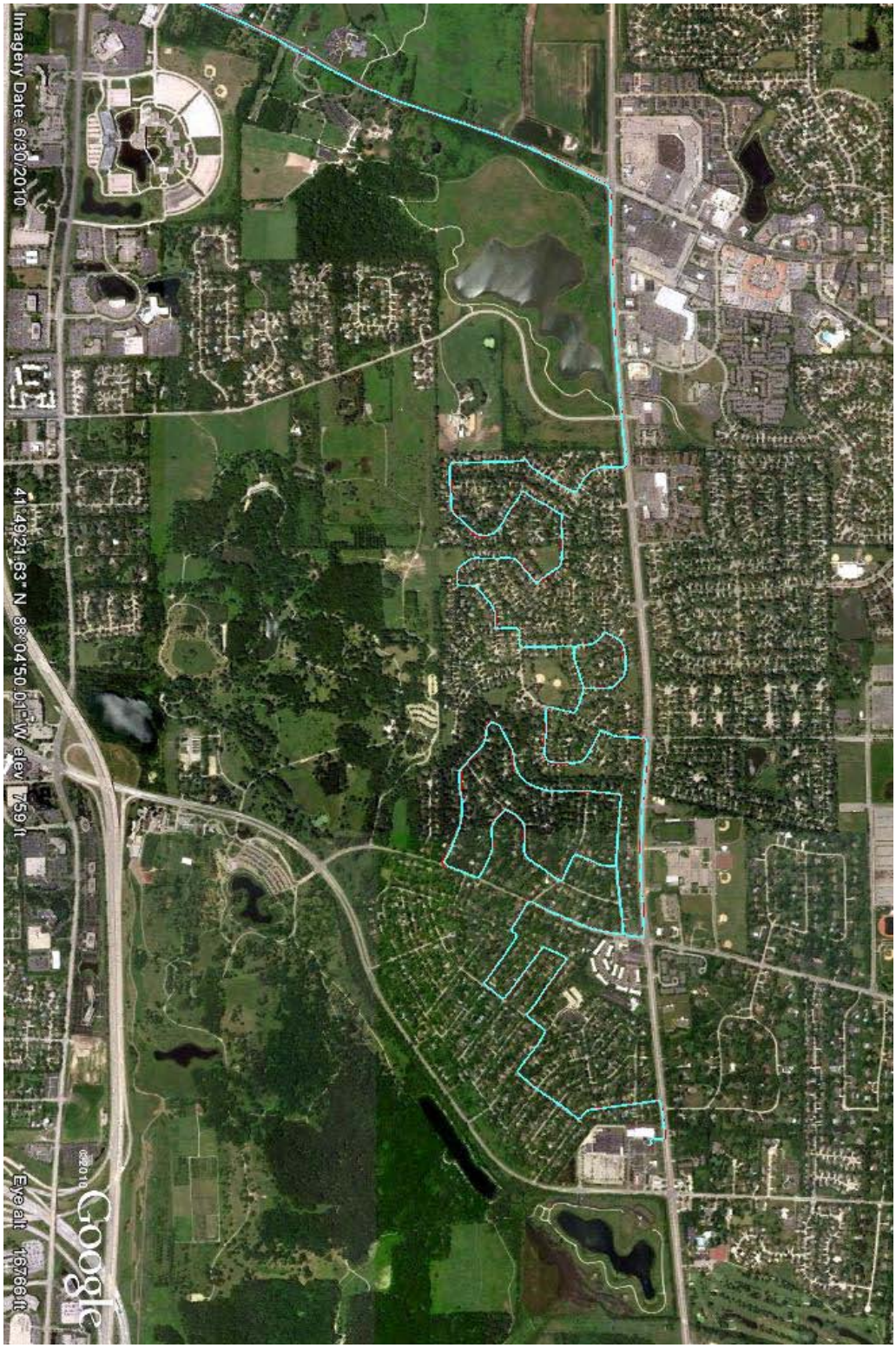
Colors:
Blue – Base Line
Red – 6dB

Note: in order to improve clarity, only the baseline and 6 dB lines are shown on the following maps. Even with the elimination of the 3 dB measurement line, in many areas it is difficult to see the 6 dB line as it is nearly identical to the blue line which represents the baseline measurements.

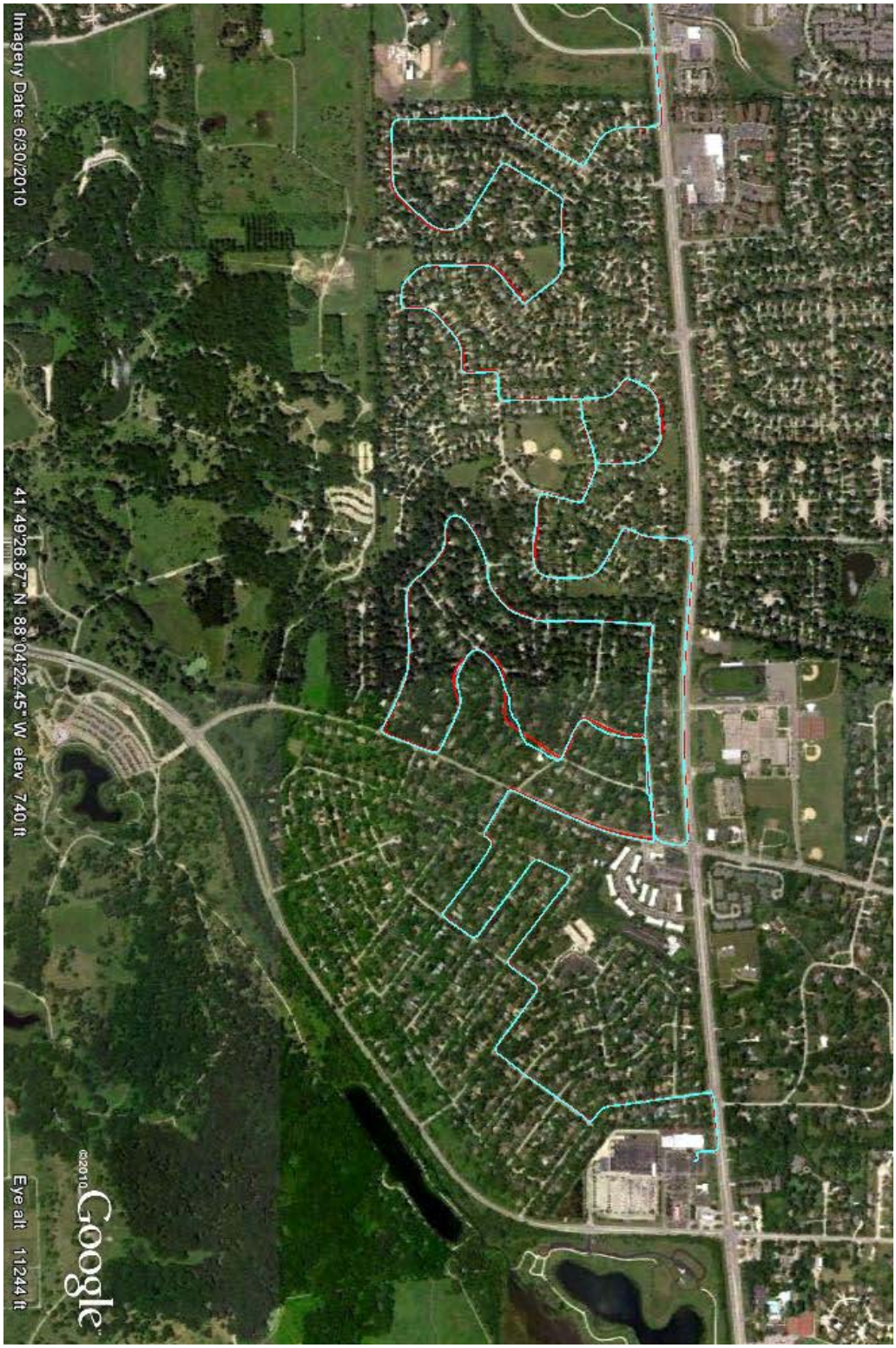
G14298


Imagery Date: 6/30/2010
41°49'29.48" N 88°04'43.92" W elev 770 ft
©2010 Google
Eye alt 11345 ft

G18171


Imagery Date: 6/30/2010
41°49'21.63" N 88°04'50.01" W elev 759 ft
Eye alt 16766 ft
Google

P14730


Imagery Date: 6/30/2010
41°49'26.87" N 88°04'22.45" W elev 740 ft
Eye alt 11244 ft
©2010 Google

P18892

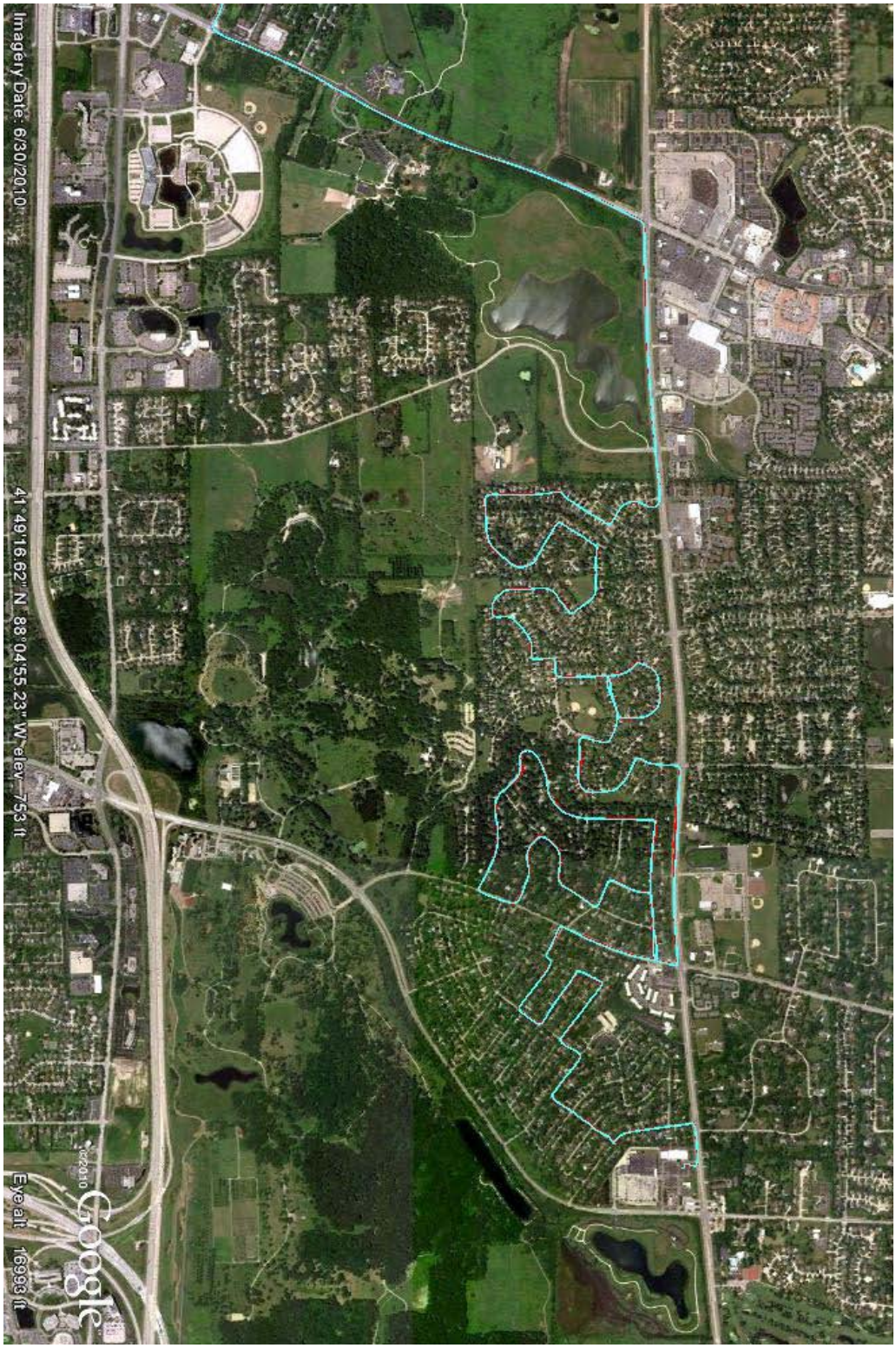

Imagery Date: 6/30/2010
41°49'16.62" N 88°04'55.23" W elev 753 ft
Eye alt 16993 ft
Google

EXHIBIT B

Statistical Analysis of Dynamic Tests of Personal Navigation Devices

The following statistical analysis is based on data collected in the Dense Urban and Suburban dynamic tests of Personal Navigation devices, performed by the TWG General Location and Navigation sub-team. The methodology for the tests involved driving a test route selected and mapped by the Working Group representatives using a calibrated Spirent GPS recorder to record a the actual GPS signals with present ambient noise along an approximately 40 minutes longroute. The recorded GPS signal was replayed at the laboratory tests, first without any LightSquared signal to establish a baseline for each device, and then with different levels of exposure to LightSquared signal as per previous measurements with static tests, including 3 dB and 6 dB degradation in C/No The GPS devices reported the measured latitude and longitude positions as well as some other statistics at one-second intervals as re-playing of the GPS recoded data progressed; this data was captured and reported to the Working Group. A total of 13 devices were tested for the Dense Urban and 9 devices for the Suburban environment.

The statistical analysis compares the reported latitude and longitude data for each of the Baseline, 3 dB, and 6 dB cases for each device tested and calculated (a) the mean error in GPS position from the estimated locations on the true route, (b) the standard deviation from that mean, and (c) the GPS availability, calculated as the percent of time the device had a valid GPS fix.

The analysis showed no significant difference between the performance of the devices in either the Baseline, 3 dB, or 6 dB cases, in either the Dense Urban or Suburban devices. In the Dense Urban environment, the devices showed roughly the same relatively

poor performance in terms of the number and degree of position error. In the Suburban environment, both were typically excellent – again, in all three cases: Baseline, 3 dB, and 6 dB.

For example, for device G12586, in the Dense Urban environment, the mean error for the baseline level was 25.9 meters, showing that without any exposure to LightSquared's signal, on average the device recorded its location as being 25.9 meters off its true route . When that device was exposed to 6 dB interference from the LightSquared signal, that average amount of error increased to only 28 meters. Several of the devices even showed a lower mean error in distance with exposure to 6 dB interference than for the baseline figure. *See, e.g.,* Devices G10968, G15448, and P17655. The variation in the number of outage events was also low – in the Baseline case there were 94 such events and in the 6 dB case there were 97 outage events.

The average of all devices in the Dense Urban environment for the Baseline showed a mean error of 45.9 meters and a standard deviation of 56.3 meters. With 6dB, the average mean error was 49.8 meters and standard deviation 54.5 meters. Availability was about the same 95.9% and 94.2%, respectively.

In the suburban environment, test results revealed much lower rates of error in the location-accuracy of the GPS devices in both Baseline case (3.7 meters, on average) and 6 dB case (3.8 meters, on average). Availability actually increased from 99.7% in the Baseline case to 99.8% in the 6dB case. In all cases, the standard deviation was below 9, in most cases well below.

Device	Estimated GPS Fix Position Error (m)								
	Baseline			3 dB Interference			6 dB Interference		
	Mean	Std Dev.	Availability	Mean	Std Dev.	Availability	Mean	Std Dev.	Availability
G10195	33	33.8	100.0%	33.4	28.9	100.0%	N/A	N/A	N/A
G10968	22.5	23.3	98.1%	23.3	25.4	100.0%	21.6	23	100.0%
G12586	25.9	42.8	100.0%	28.8	38.4	100.0%	28	35.8	100.0%
G12867	33.1	29	96.6%	33.5	31	96.4%	33	31.6	96.1%
G15028	30	36.4	87.9%	33	23.7	95.4%	37.3	29.5	91.0%
G15448	25.8	28.4	100.0%	N/A	N/A	N/A	23.3	25.3	99.5%
G16534	89.9	61.8	99.7%	87.6	61.5	99.9%	93.4	65.7	99.8%
G17641	27.9	36.7	100.0%	29.5	24	99.9%	36	32.8	99.5%
G17783	34.6	33.3	96.0%	37.5	37.4	95.3%	34.8	38	97.1%
G18161	106.4	61.5	100.0%	98	63.3	100.0%	121	64.8	99.6%
P14730	22.4	17.9	100.0%	N/A	N/A	N/A	50.9	64.2	99.9%
P15427	84.8	52.1	93.0%	86.4	52.7	90.3%	84.7	53.1	83.3%
P17655	64.3	116.5	74.8%	39.3	45.5	68.4%	31.3	39.9	64.0%
Aggregate of ALL DEVICES	**45.9**	**56.3**	**95.9%**	**48.3**	**49.4**	**95.1%**	**49.8**	**54.5**	**94.2%**

Table B-1. Statistical Summary of GPS Position Errors vs. Interference Level in Dense Urban Environment

Device	Baseline				3 dB Interference				6 dB Interference			
	Num. Outage Events	Mean Outage Duration (sec.)	Max. Outage Duration (sec.)	Total Outage Seconds	Num. Outage Events	Mean Outage Duration (sec.)	Max. Outage Duration (sec.)	Total Outage Seconds	Num. Outage Events	Mean Outage Duration (sec.)	Max. Outage Duration (sec.)	Total Outage Seconds
G 10195	0	0.00	0	0	0	0.00	0	0	N/A	N/A	N/A	N/A
G 10968	1	34.00	34	34	0	0.00	0	0	0	0.00	0	0
G 12586	0	0.00	0	0	0	0.00	0	0	0	0.00	0	0
G 12867	13	4.77	18	62	18	3.61	19	65	23	3.09	17	71
G 15028	42	5.21	35	219	27	3.11	30	84	35	4.66	35	163
G 15448	0	0.00	0	0	N/A	N/A	N/A	N/A	1	9.00	9	9
G 16534	6	1.00	1	6	2	1.00	1	2	4	1.00	1	4
G 17641	0	0.00	0	0	1	1.00	1	1	1	9.00	9	9
G 17783	32	2.28	7	73	47	1.83	6	86	18	2.89	15	52
G 18161	0	0.00	0	0	0	0.00	0	0	1	7.00	7	7
P14730	0	0.00	0	0	N/A	N/A	N/A	N/A	1	1.00	1	1
P15427	30	4.23	18	127	34	5.18	22	176	56	5.39	33	302
P17655	94	4.85	39	456	99	5.78	38	572	97	6.72	40	652
AVG. of ALL DEVICES	**16.8**	**4.3**	**11.7**	**75.2**	**20.7**	**2.0**	**10.6**	**89.6**	**19.8**	**4.1**	**13.9**	**105.8**

Table B-2. Summary of GPS Tracking Outages Due To Loss of Valid Fix in Dense Urban Environment

Device	Estimated GPS Fix Position Error (m)								
	Baseline			3 dB Interference			6 dB Interference		
	Mean	Std Dev.	Availability	Mean	Std Dev.	Availability	Mean	Std Dev.	Availability
G10968	**1.7**	**1.3**	**100.0%**	**1.8**	**1.1**	**100.0%**	**2.2**	**1.4**	**100.0%**
G12586	1.3	0.7	100.0%	1.4	0.8	100.0%	1.9	1	100.0%
G12867	3.3	2.2	100.0%	3.1	2	100.0%	3.3	2.2	100.0%
G13445	9.7	4.5	100.0%	7.1	3.4	100.0%	6.6	3.9	100.0%
G15448	1.5	0.8	100.0%	1.8	1.1	100.0%	2.1	1.2	100.0%
G17641	1.4	0.7	100.0%	1.5	0.8	100.0%	1.7	0.9	100.0%
G17783	8.1	5.8	97.6%	8	4.9	98.6%	8.9	5.6	98.2%
P14730	2.9	3.5	100.0%	2.4	1.6	100.0%	3	1.9	100.0%
P18892	3.8	3.6	99.9%	N/A	N/A	N/A	4.6	3.9	100.0%
AGGREGATE	**3.7**		**99.7%**	**3.4**		**99.8%**	**3.8**		**99.8%**

Table B-3. Statistical Summary of GPS Position Errors vs. Interference Level in Suburban Environment

EXHIBIT C

Response to NDP Consulting Group Concerns Regarding Bazelon 2011[1]

August 15, 2011

I. INTRODUCTION

NDP[2] criticized my paper,[3] which estimated the subsidy enjoyed by the GPS industry as a result of using the government's GPS satellite system for free. They accused me of cherry picking spectrum values; using speculative estimates of consumer surplus; falsely calling the benefits enjoyed by the GPS industry a subsidy; and cherry picking estimates of the cost of better filtering technology. In addition, the language of their response was also somewhat overwrought,[4] suggesting catastrophes such as planes crashing. NDP's response raises doubts about their understanding of my original paper, and the issues between LightSquared and the GPS industry. To clarify these issues raised by NDP, I elaborate in further detail the following points from my paper.

To summarize,

- My estimate of the economic value of LightSquared's L-band allocation is based on a current spectrum value of about $1 per MHz-pop, applied to their 40 MHz of spectrum to be deployed for their Ancillary Terrestrial Component (ATC). This valuation is well supported, including a previous paper of mine that I cited in the current report and NDP misunderstood.

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1 The views expressed herein are strictly those of the author and do not necessarily state or reflect the views of The Brattle Group, Inc. or its clients.

2 NDP Consulting Group, "Analysis of the Bazelon Study," Comments of the Coalition to Save Our GPS, FCC IB Docket No. 11-109, File No. SAT-MOD-20101118 (August 1, 2011), p. 3. (Herein "NDP Response (2011)").

3 Coleman Bazelon, "GPS Interference: Implicit Subsidy to the GPS Industry and Cost to LightSquared of Accommodation," The Brattle Group (June 22, 2011). Available at: http://www.brattle.com/_documents/UploadLibrary/Upload957.pdf (last visited August 13, 2011).

4 NDP makes two misleading statements that "reports based on those tests and evaluations confirm that LightSquared's operations will disrupt GPS signals, imposing real economic costs to GPS end users, and the broader economy" and that "the economic costs of GPS signal disruption for airplanes are much more significant, and include the costs of a crash or other accident or mishap." These statements refer to reports based on LightSquared's original operations proposal. Following the completion of testing and analysis conducted by the working group (TWG) required by the FCC, LightSquared revised its proposal, and now plans to first begin operations in the lower 10 MHz.

- A ratio of consumer surplus to spectrum value of 10-to-1 is both a well-established empirical regularity and conservative—the multiple could easily be higher.
- Definitions of a subsidy—including the one cited by NDP—clearly include valued services provided without compensation. Allowing use of satellite based geo-location signals free of charge clearly fits this definition of a subsidy.
- In order to evaluate whether or not it is economically sensible—that is cost effective—to upgrade GPS equipment to coexist with LightSquared's terrestrial deployment, I provide estimates of the costs of fixing the problems with current GPS equipment. Comparing these cost with the benefits of doing so suggests that upgrading GPS equipment to allow for LightSquared's terrestrial build-out is cost effective. Even the author of the estimate preferred by NDP notes that the actual costs associated with upgrading the filters on GPS devices is much smaller than his total estimate.

NDP's criticisms of my paper in no way undermine its central conclusions. The GPS industry enjoys, free of charge, the benefits of a satellite network that would cost the industry $18 billion to replicate. Additionally, the LightSquared terrestrial LTE network will provide significant economic benefits that would be lost if the GPS industry is successful in getting LightSquared's ATC authorization revoked.

II. POINTS OF CLARIFICATION

A. LIGHTSQUARED'S L-BAND SPECTRUM IS WORTH $12 BILLION

NDP raised concern that the rationale for valuing LightSquared's 40 MHz of L-Band spectrum intended for 4G Long Term Evolution (LTE) terrestrial wireless broadband at $12 billion was not sufficient. They suggested I cherry picked, without explanation, the highest number possible from previous work of mine. To remedy this concern, I provide a detailed explanation below. I derived this estimate by applying the average price for

wireless broadband spectrum ($1.03 per MHz-pop[5]) to the 40 MHz of spectrum that LightSquared intends for terrestrial deployment nationwide,[6] assuming the nationwide population is around 285 million.[7] Details of this calculation are expressed in Table 1.

Based on the price of AWS-1 wireless broadband spectrum in June 2011, the average nationwide price of unencumbered spectrum available for wireless broadband services was around $1.03 per MHz-pop. The AWS-1 average nationwide price reflects a baseline price for unencumbered terrestrial wireless broadband spectrum. The FCC's AWS-1 Auction 66 in September 2006 is generally accepted as a competitive auction.[8] As a result, it likely realized the true value of unencumbered nationwide wireless broadband spectrum licenses. In September 2006, the average nationwide spectrum price from Auction 66 was $0.54 per MHz-pop. To adjust this price to reflect the change in spectrum value since, I apply the change in SpecEx Spectrum Index value since September 2006. According to the SpecEx Spectrum Index, between September 18, 2006 and June 22, 2011 (the date of my original report) the spectrum value increased by 91%. If wireless broadband spectrum was worth $0.54 per MHz-pop in September 2006, a 91% increase implies the value was $1.03 per MHz-pop on June 22, 2011. See Table 1 for details.

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5 The unit price of spectrum is typically expressed in terms of value in dollars per MHz-pops, where MHz-pops is the product of the total MHz of a band and population covered by the region of a license.

6 See "Order and Authorization in the Matter of LighSquared Subsidiary LLC Request for Modification of its Authority for an Ancillary Terrestrial Component," FCC, Docket DA 11-133 (January 26, 2011), p. 2.

7 During the Auction 66, FCC applied a population estimate of 285 million based on Census 2000 data. See Auction 66 results at http://wireless.fcc.gov/auctions/. Using a population estimate from 2000 is conservative, but ensures that the spectrum prices over time are comparable.

8 Jeremy Bulow, Jonathan Levine and Paul Milgram, "Winning Play in Spectrum Auctions," NBER Working Paper No. 14765 (March 2009).

Table 1
Implied LightSquared's L-Band Wireless Broadband Spectrum Value

			AWS-1 Auction Value 9/18/2006 *[1]*	LightSquared L-Band ATC Market Value* 6/22/2011 *[2]*
Spectrum Value				
SpecEx	[A]		156	298
SpecEx Percentage Change	[B]	%		91%
Base Population	[C]	Pops	285,620,445	285,620,445
Spectrum Band Size	[D]	MHz	90	40
Auction Value of AWS-1 Spectrum	[E]	$	$13,879,110,200	
Average Price of Wireless Broadband Spectrum	[F]	$/MHz-Pop	$0.54	$1.03
Projected Value of L-Band Spectrum for Wireless Broadband	[G]	$		**$11,783,404,101**
Consumer Surplus Multiplier				
Multiplier Assuming 5% Discount Rate	[H]			10
Multiplier Assuming 10% Discount Rate	[I]			20
Consumer Surplus of L-Band Wireless Spectrum				
Estimated Minimum	[J]	$		$117,834,041,014
Estimated Maximum	[K]	$		$235,668,082,028

Source and Notes:
* Value of LightSquared's L-Band spectrum licenses for ATC is based on LightSquared having a pre-existing MSS network in operation. Without an existing satellite system, the value of the L-Band for terrestrial wireless broadband would likely be much lower due to the substantial costs related to meeting FCC gating criteria for ATC authority.
[A]: Spec Ex Spectrum Index values downloaded from http://spectrumbridge.com/specex/index.aspx (accessed 8/10/2011).
[B]: ([A][2]-[A][1])/[A][1].
[C]: FCC population estimates based on Census 2000 data aggregated by basic trading area (BTA).
[D][1], [E]: Auction 66 results downloaded from FCC Auctions at http://wireless.fcc.gov/auctions.
[D][2]: Based on FCC Order and Authorization for LightSquared, January 26, 2011.
[F][1]: [E][1]/([C][1]*[D][1]).
[F][[2]: [F][1]*(1+[B][2]).
[H] & [I]: Brattle Group Analysis. See section II.B for description
[J]: 10 * [G][2].
[K]: 20 * [G][2].

Since LightSquared plans to devote 40 MHz of spectrum to its nationwide 4G LTE network, the total value implied from a price of $1.03 per MHz-pop for nationwide spectrum is nearly $12 billion. See Table 1. This $12 billion reflects the present value of expected cash flows LightSquared is likely to receive from providing wireless broadband service on this spectrum.[9] Since LightSquared has already met the FCC's gating criteria

[9] For a detailed explanation of the relationship between spectrum value and the net present value of expected cash flows from services deployed on the spectrum see Coleman Bazelon, "The Economic Basis of Spectrum Value: Pairing AWS-3 with the 1755 MHz Band is More Valuable than Pairing it with Frequencies from the 1690 MHz Band," The Brattle Group (April 11, 2011). Available at: http://www.brattle.com/_documents/UploadLibrary/Upload938.pdf (last visited August 12, 2011).

for ATC authority,[10] for LightSquared's intents and purposes, the L-band is already unencumbered. This suggests the economic value of this spectrum is similar AWS-1. As a result, applying a price similar to that of AWS-1 is appropriate in for this case.[11]

B. LIGHTSQUARED LTE NETWORK CREATES $120 BILLION IN CONSUMER SURPLUS

NDP criticized the use of 10-to-1 multiple to translate spectrum value to consumer surplus or the benefits to consumers of spectrum above what they pay for wireless services. The 10-to-1 multiple is based on an empirical regularity. Several empirical studies have estimated consumer surplus and found that the annual consumer surplus from a spectrum allocation is roughly equal to total value of the spectrum (also equal to producer surplus) that led to those consumer benefits.[12] Table 2 summarizes these results.

Assuming annual consumer surplus is equal to the value of spectrum, the ratio of total consumer surplus to spectrum value is simply the present value of the stream of consumer surplus divided by the spectrum value. The present value of consumer surplus from a spectrum allocation depends critically on the discount rate used. Some would argue for a social discount rate of 5%.[13] A more conservative discount rate would be 10%, a bit above the average cost of capital in the wireless industry.[14] These discount rates imply a

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[10] For further explanation of the ATC authority gating criteria see the FCC webpage on ATC, available at http://transition.fcc.gov/ib/sd/ssr/atc.html (last visited August 13, 2011).

[11] It could be argued that, even though the L-Band is essentially unencumbered to LightSquared, the total value of this spectrum is slightly lower than that for AWS-1. This might be true, for example, if there was not an ecosystem for equipment (a problem LightSquared seems to have already overcome.) Nevertheless, if a 10% discount to the AWS-1 price was appropriate, then the spectrum would be worth nearly $11 billion.

[12] Some studies find that annual consumer surplus is equal to annual service revenues. See Jeffrey Church, "Spectrum Policy as Competition Policy: A Good Choice for Canada?," Working Paper (February 28, 2011), fn 18. This is expected and consistent with a 10-to-1 multiplier, because spectrum value is often roughly equal to annual service revenues. The lease payment for use of spectrum is often 10% of service revenues. This 10% of service revenues discounted at 10% implies that the discounted cash flow from leasing spectrum (equivalent to its value) would equal one year of service revenues.

[13] See T. W. Hazlett and R. E. Munoz, "A Welfare Analysis of Spectrum Allocation Policies," Joint Center: AEI-Brookings Joint Center for Regulatory Studies (August 2004), p. 18.

[14] Cost of Capital for various telecommunications sectors, including Telecom. Equipment, Telecom. Services, Telecom. Utility and Wireless Networking are all between 6% and 9%. See "Cost of

ratio of consumer surplus to spectrum value of between 10-to-1 and 20-to-1. If the spectrum is worth $12 billion, then the annual consumer surplus would also be about $12 billion. Consequently, the present value of $12 billion in annual consumer surplus would be $240 billion using a 5% discount rate and $120 billion using a 10% discount rate. See Table 1.

Table 2
Empirical Results on Ratio of Consumer Surplus to Spectrum Value

		Annual Consumer Surplus *$ Billion*	Total Spectrum Value *$ Billion*	Surplus to Value Ratio
[1]	Hazlett & Munoz (2004)	24.0	27.0	0.9
[2]	Hazlett & Munoz (2009)	8.8	9.1	1.0
[3]	Rosston (2003)	30.0-50.0	30.0	1.0-1.7

Sources:

[1] T. W. Hazlett and R. E. Munoz, "A Welfare Analysis of Spectrum Allocation Policies," Joint Center: AEI-Brookings Joint Center for Regulatory Studies (August 2004).

[2] T. W. Hazlett and R. E. Munoz, "A welfare analysis of spectrum allocation policies," RAND Journal of Economics Vol. 40 No. 3 (2009): 424-454.

[3] G. L. Rosston, "The long and winding road: the FCC paves the path wih good intentions," Telecommunications Policy 27 (2003): 501-515.

C. COMMERCIAL GPS INDUSTRY DOES RECEIVE A SUBSIDY

Despite NDP's protests, by both international and domestic definitions, the GPS Industry does enjoy a substantial subsidy by the free use of the U.S. Federal GPS Satellite network. Even by NDP's own admission, this zero-priced use of the GPS network confers substantial economic support and benefits on the GPS industry. NDP's economic justifications for not considering the benefits to the GPS industry a subsidy are inconsequential and inaccurate.

Capital by Sector" webpage at http://pages.stern.nyu.edu/~adamodar/ (last visited August 10, 2011).

Even according to the World Trade Organization's (WTO) definition cited by NDP, the GPS Satellite network represents a subsidy to the GPS Industry. According to the WTO's definition, government subsidies include "goods or services other than general infrastructure" provided without proper payment, or "any form of income or price support" that confers a benefit to the recipient.[15] The free use of the GPS system by the commercial GPS industry represents a service offered free of charge—and therefore undervalue—to a select group of firms. As discussed in my report, if the commercial GPS industry were to build an equivalent system for their use, it would cost around $18 billion. Because this benefit can only be utilized by firms capable of developing GPS receivers, the GPS Satellite network hardly constitutes "general infrastructure." By effectively reducing the cost of operations exclusively for commercial GPS service providers, this benefit represents a form of "price support" to this industry alone.

For the current purposes of discussing U.S. domestic policy, however, the definition provided by the U.S. Government Accountability Office (GAO) is likely more applicable. Presumably for the WTO, a definition that addresses subsidies in the context of international trade is most important; and likewise for a domestic service, a domestic definition would be appropriate. The U.S. commercial GPS industry is primarily using the GPS satellite network to provide services domestically.[16] According to the GAO, a subsidy includes:

> A payment or benefit made by the federal government where the benefit exceeds the cost to the beneficiary. Subsidies are designed to support the conduct of an economic enterprise or activity, such as ship operations. They may also refer to (1) provisions in the tax laws for certain tax

[15] See World Trade Organization, "Agreement on Subsides and Countervailing Measures," Part I: General Provisions, Article 1 Definition of a Subsidy, p. 229. Available at: http://www.wto.org/english/docs_e/legal_e/24-scm.pdf (last visited August 12, 2011).

[16] In fact, my estimation of the cost of a commercial GPS satellite system restricts services to the U.S., which reduces the costs of such a system. A system capable of offering services worldwide would likely require additional satellites and be more costly.

> expenditures and (2) the provision of loans, goods, and services to the public at prices lower than market value.[17]

The benefit conferred on the commercial GPS Industry by the free use of the GPS certainly fits the GAO's definition of a subsidy. The benefit to the GPS industry—approximately $18 billion in avoided cost—exceeds the cost to using the system for free. As NDP suggests, these benefits support the economic enterprise of the commercial GPS industry, likely inducing increased entry into this industry. These characteristics all fit the definition of a subsidy provided above.

Further, NDP's economic arguments for suggesting the GPS Industry is not subsidized are both largely irrelevant and inaccurate. That the original purpose of the GPS system was to support U.S. military operations during the Cold War is irrelevant to whether the commercial GPS industry is benefiting today. As NDP points out, subsidies are often used to "align behavior of firms with a particular policy objective."[18] In fact, in 1996 the Clinton administration implemented a new GPS policy to encourage the use of the GPS satellite system for military, commercial and scientific purposes.[19] Currently GPS satellite policy and Federal spending intentionally extends beyond military purposes. There are specific budget line items allocated to civil use of GPS.[20] Recent generations of GPS satellites were intentionally designed to better accommodate the needs of commercial uses.[21] Current civil use of GPS is not simply a positive externality of the

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17 See Government Accountability Office, "A Glossary of Terms Used in the Federal Budget Process," GAO-05-734SP (September 2005), p. 96. Available at: http://www.gao.gov/new.items/d05734sp.pdf (last visited August 12, 2011).

18 See NDP Response (2011), p. 3.

19 According to the 1996 White House Fact Sheet on GPS policy, the policy represented "a strategic vision for the future management and use of GPS, addressing a broad range of military, civil, commercial, and scientific interests, both national and international." See "U.S. Global Positioning Policy," White House Fact Sheet (March 29, 1996). Available at: http://www.marshall.org/pdf/materials/873.pdf (last visited August 12, 2011).

20 For instance, in addition to the benefits the GPS industry receives from GPS general funding and satellites developed with commercial uses in mind, the 2012 Presidential budget request includes $50.3 million for "the addition of new, civil-unique capabilities to the GPS program." See http://www.gps.gov/policy/funding/2012/ (last visited August 12, 2011).

21 For more information about civilian signals and modifications for commercial users, see "Second Civil Signal: L2C," webpage at GPS.gov. Available at:

U.S. military system—it is an addition to the original GPS system that is specifically budgeted for. One explicit goal of the 1996 U.S. GPS Policy was to "[e]ncourage private sector investment in and use of U.S. GPS technologies and services."[22] As many subsidies are intended to do, the free use of GPS is designed to encourage commercial use of GPS system.

NDP suggests that if the GPS industry was receiving subsidies, then the industry should be earning higher profits. As an initial matter, NDP does not demonstrate that the industry is not already receiving 'higher rents.' But more fundamentally, NDP's supposition that an industry that is receiving subsidies would necessarily be earning higher economic rents is simply bad economics. It is true that receiving a subsidy would make investing in an industry more attractive—in fact, the point of the subsidy—but unless there was some barrier to entry in the industry, there is no reason to believe that the additional subsidy induced profits would not be competed away through entry into the industry. In fact, the current GPS industry is, by its own admission[23], filled with many new firms finding additional ways to commercially deploy GPS based services. This is exactly the result to be expected in an industry receiving subsidies.

D. ESTIMATED COST OF FIX FOR GPS HANDSETS

NDP suggests that the report did not include sufficient justification for applying Dan Hays's estimated cost of replacing and retrofitting GPS receivers, as opposed to Tim Farrar's inflated projection of the potential total cost to the GPS industry. The purpose of

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http://www.gps.gov/systems/gps/modernization/civilsignals/#L2C (last visited June 20, 2011). See, also, "Next-Generation GPS for Enhanced Business Productivity: Because Time is Money, and Location is Everything!" Seminar Schedule on the Office of Space Commercialization Website http://www.space.commerce.gov/library/workshops/2006-01-25/ (last visited June 21, 2011).

22 See Kim, Jason Y, "Commercial Uses of GPS," Office of Space Commercialization, U.S. Department of Commerce (September 13, 2004). Available at: http://www.pnt.gov/public/1997-2004/2004-09-brazil/ (last visited June 20, 2011).

23 See, for instance, the variety of commercial applications touted on the Coalition to Save Our GPS website at http://www.saveourgps.org/what-is-GPS-good-for.aspx. See, also, the numerous commercial applications listed at http://www.gps.gov/applications/. Further, according to NDP, "free access to the GPS infrastructure has encouraged more firms to participate in the market." See NDP Response (2011), p. 4.

my report was to provide a basic annualized estimate of the cost of replacing GPS receivers in order to illustrate that this cost was relatively small compared to the loss to LightSquared. In this case, Hays's estimate of the cost to replace commercial receivers was more applicable. Even according to Farrar's blog, the cost of "actually fixing the problem" is much smaller than his vague projection. Farrar's estimates include many costs that either the commercial GPS industry is unlikely to incur in equipping their receivers with better filters, and costs that the GPS industry is likely to incur over the next decade regardless of LightSquared.

Even by his own admission Farrar's estimate of the cost to commercial GPS industry to solving their interference problems with GPS is inflated. Farrar claims that the cost to the GPS industry could exceed $1 billion per year over the next decade. However, Farrar bases his estimate on a statement by Inmarsat suggesting that it will spend up to $250 million—paid for by LightSquared—for modifications of its existing network to support its partnership with LightSquared.[24] Based on Inmarsat statements it is not clear how much of this cost is due to retrofitting similar to what the GPS industry would have to do. Even Farrar concedes that the cost of "actually fixing the problem" is much smaller than this contracted value, with the cost of filters being less than 1% of this cost.

A more rigorous approach is needed to estimating the cost of upgrading the existing and future stock of GPS devices to ensure that they are effectively protected when LightSquared begins using its L-Band spectrum. To this end, GPS devices fall into two categories: (1) devices likely to be replaced by newer devices with upgraded filters, and (2) more permanent devices that will have to be retrofitted with new filters. Devices that are likely to be replaced in the next several years will have to be manufactured with improved filters. With respect to the added cost per device of improved filters, Hays

[24] See Peter B. de Selding, "LightSquared Boosts Payment to Inmarsat by $40 Million," Space News (May 10, 2011). Available at: http://www.spacenews.com/satellite_telecom/lightsquared-boosts-payment-inmarsat-million.html (last visited August 12, 2011).

estimates that the cost per device for an improved filter is $0.30 per device.[25] For the 128 million personal navigation devices (PNDs) to be manufactured by 2014, this is clearly the most applicable estimate. Even if there are 32 million new PND devices each year, this implies a little less than $10 million in added cost per year.

While certainly the installation cost of retrofitting more permanent devices will be higher, the actual replacement costs are likely dependent on the location of the device. Two factors, however, seem clear: First, the number of devices is substantially lower. For instance, according to Congressional testimony by Garmin International Inc. Vice President, Philip Straub, only around 190,000 aircraft are currently equipped with GPS.[26] Second, these costs will be lower than Tim Farrar's estimates.

III. CONCLUSION

NDP's criticisms of my paper suggest they did not understand the central issues discussed, nor the supporting documents cited therein. Many of their concerns were either not based on sound economic understanding or simply irrelevant. In order to clarify these issues, I elaborated in further detail on four critical issues raised from my original paper. First, the value of LightSquared's L-Band spectrum deployed for a LTE terrestrial network is worth approximately $12 billion. This estimate is based on the average price of nationwide radio spectrum for wireless broadband services. Second, the consumer surplus from LightSquared's planned LTE network is at least 10 times greater than the original spectrum value—suggesting a consumer surplus of at least $120 billion. This is a well accepted empirical regularity of the economics of spectrum value that was woefully misunderstood by NDP. Third, the benefits bestowed on the GPS industry from

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[25] Charles Arthur, "US wireless network could drown out GPS, experts warn," Guardian (April 6, 2011). Available at: http://www.guardian.co.uk/technology/2011/apr/06/us-wireless-network-lightsquared-gps (last visited June 19, 2011).

[26] See "Written Testimony of Philip Straub, Vice President, Aviation Engineering Garmin International, Inc.," Before the Transportation and Infrastructure Subcommittees on Aviation and Coast Guard and Maritime Transportation United States House of Representatives (June 23, 2011). Available at: http://www.saveourgps.org/pdf/Testimony_of_Philip_Straub.pdf (last visited August 13, 2011).

the free use of the Federal GPS satellite system is, under the most widely accepted definitions (including their own), a subsidy. NDP's arguments to the contrary are largely irrelevant or the result of faulty economic understanding. Fourth, and finally, my estimates of the costs of upgrading the stock of GPS devices to ensure that they adequately filter interference are based on the most reliable data available. Tim Farrar's estimates suggested by NDP are inflated with a number of costs that are irrelevant to the LightSquared interference issues. These costs to the GPS industry of improving the quality of filters in GPS devices are substantially smaller than the potential loss to LightSquared and consumer surplus.