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# Assessment of the LightSquared Ancillary Terrestrial Component Radio Frequency Interference Impact on GNSS L1 Band Airborne Receiver Operations

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# FOREWORD

This report was prepared by Special Committee 159 (RTCA SC-159) and approved by the RTCA Program Management Committee (PMC) on June 3, 2011.

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Executive Summary

This report documents a study conducted by RTCA Special Committee 159 in response to a request from the Federal Aviation Administration to address the issue of compatibility between the operation of a terrestrial wireless broadband network in the bands 1525-1559/1626.5-1660.5 MHz by LightSquared, pursuant to its FCC license, and GPS receivers onboard aircraft. The report addresses the issues analytically based on existing domestic and international standards and includes results of tests of four certified aircraft GPS receivers.

The study concludes that the current LightSquared terrestrial authorization would be incompatible with the current aviation use of GPS, however modifications could be made to allow the LightSquared system to co-exist with aviation use of GPS. The study's conclusions and recommendations are strictly based on an assumed set of operational parameters for the LightSquared system and identified source mitigations. These operational parameters would produce less Radio Frequency Interference (RFI) than if LightSquared were to operate at its fully-authorized limits.

In addition, the analysis is based upon the assumption that all equipment is minimally compliant with the interference rejection requirements in harmonized domestic and international standards. Additionally since GPS is an aviation safety service, the analysis includes a 6 dB safety margin as is standard practice. Results from the four receivers tested show that these receiver models are significantly more resilient to interference from the LightSquared terrestrial base stations than limits derived from the standards.

The impact of a LightSquared upper channel spectrum deployment is expected to be complete loss of GPS receiver function. Because of the size of the single-city station deployment, GPS-based operations below about 2000 feet will be unavailable over a large radius from the metro deployment center (assuming no other metro deployments are nearby). Given the situation in the high altitude U.S. East Coast scenario, GPS-based operations will likely be unavailable over a whole region at any normal aircraft altitude.

The results of this study indicate that terrestrial base station operation at the lower 5 MHz wide channel (1526.3 – 1531.3 MHz) is compatible with aviation GPS operations for all the representative scenarios (including both signal tracking and initial acquisition). The study indicates that for terrestrial base stations using only the lower 10 MHz channel at 1526-1536 MHz, there is a small positive margin for GPS tracking (but not necessarily initial acquisition) in the presence of mean aggregate terrestrial network interference. As noted above, these conclusions are based upon specific assumptions about LightSquared operation.

The main recommendations from this aviation GPS receiver operational assessment are:

1. From an aviation perspective, LightSquared upper channel operation should not be allowed.
2. Further study is recommended to more carefully determine a refined terrestrial base station power versus frequency limit considering:
    a. determination of the lowest path loss for the low altitude enroute scenario,
    b. confirmation of acceptable receiver susceptibility for GPS initial acquisition and signal tracking in the presence of the 10 MHz bandwidth terrestrial network interference,
    c. computation of the cumulative probability distribution function for the aggregate path loss.

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# 1 INTRODUCTION

## 1.1 Background

### 1.1.1 Brief History

LightSquared, whose planned signals are the subject of analyses in this report, is a privately held company. Its predecessor companies were SkyTerra Communications, Inc. (SkyTerra), Mobile Satellite Ventures (MSV), Motient Services Inc. and American Mobile Satellite Company (AMSC). The initial L-Band Mobile-Satellite Service (MSS) license, currently held by LightSquared, was issued by the Federal Communications Commission (FCC) to AMSC in 1989. In 2001, LightSquared (then MSV) filed the first application to deploy an integrated satellite-terrestrial system to provide broadband wireless communications, using L-band frequencies already authorized for LightSquared's MSS use in the band 1525-1559 MHz (space-to-Earth).

To address concerns regarding potential interference to GPS L1 signals, in 2002 LightSquared voluntarily agreed to meet certain restrictive emission limits in the band 1559-1610 MHz. In 2003, the FCC established, and then revised in 2005, rules for Ancillary Terrestrial Component (ATCt)[1] service in various MSS bands, including the L-band. The FCC defined "ancillary" based on a number of criteria, including the provision of "integrated service," for which it created a safe harbor if all customers used dual-mode handsets capable of communicating via both MSS and ATC. In 2004, the FCC granted LightSquared's application for ATCt authority. In its 2005 Second Order on Reconsideration, the FCC, among other things, granted an 8 dB increase in power over the power limits authorized in 2003 (See, 47 CFR 25.253 (d)(1)-(6)).

RTCA Special Committee-159 (SC-159) took note of some of the ATCt regulatory developments and unwanted out-of-band emissions (OOBE) limits but did not study fundamental emission overload effects in RTCA/DO-235B [1-1].

No ATCt deployment was made between 2003 and 2010.

### 1.1.2 Further Developments Since 2009

In March 2010, the FCC authorized the transfer of control of LightSquared to Harbinger Capital Partner Funds and imposed a condition that LightSquared expeditiously deploy a nationwide network, which would consist of approximately 36,000 base stations, covering hundreds of millions of people.

In an order issued on the same day, the FCC separately approved LightSquared's 2009 ATCt modification application seeking additional flexibility for the technical operation of the ATCt network (including allowance for a base station to transmit at power levels up to 42 dBW effective isotropic radiated power (EIRP) per sector; see section 2.4 for specific technical details).

On November 18, 2010, LightSquared applied to the FCC for a license modification that would permit the use of terrestrial-only devices on its ATCt network. The application proposed no technical or operational changes to the ATCt network. In response, 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.

[1] This report uses ATCt as the abbreviation for Ancillary Terrestrial Component rather than the FCC designation, ATC, to avoid confusion with the standard aviation abbreviation (ATC) for air traffic control.

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### 1.1.3 January 2011 FCC Order and Authorization

On January 26, 2011, the FCC conditionally granted[1] a waiver of its rules, permitting LightSquared to use terrestrial-only devices on its ATCt network. Because of the concerns raised by the GPS community, the FCC conditioned the grant on LightSquared organizing and participating in a technical working group (TWG). The FCC tasked the TWG with analyzing a variety of types of GPS devices for their susceptibility to overload interference from LightSquared's terrestrial network of base stations, identifying near-term technical and operational measures that can be implemented to reduce the risk of overload interference to GPS devices, and providing recommendations on steps that can be taken going forward to permit broadband wireless services to be provided in the L-band MSS frequencies and coexist with GPS devices. The TWG consists of representatives from LightSquared, GPS manufacturers, and GPS users (federal and non-federal). LightSquared is required to provide periodic status reports on the progress made by the TWG and submit a final report by June 15, 2011, which addresses the tasks identified by the FCC.

### 1.1.4 FAA Request to RTCA

Since the extent and impact of the interference to aviation GPS receivers and to GPS-based aviation operations was unknown, the Federal Aviation Administration (FAA) asked RTCA to undertake studies of this source of potential radio frequency interference[2]. These studies "should include receiver vulnerability, as well as [operational] scenario studies including aggregate effects of LightSquared transmissions on GPS receivers used in aircraft." In order to provide timely input to the FAA, RTCA was requested to work in parallel with the FCC-mandated TWG and deliver a final report of its independent evaluation to the FAA by June 3, 2011. The RTCA Program Management Committee accepted this request March 17, 2011, as consistent with the existing Terms of Reference of RTCA SC-159 (Global Positioning System).

## 1.2 Terms of Reference

RTCA SC-159 develops minimum standards that form the basis of FAA approval of equipment using GPS as a primary means of civil aircraft navigation. One of its terms of reference (#6) is to address GPS receiver susceptibility to radio frequency interference (RFI). SC-159 Working Group 6 (WG-6), organized to perform and document detailed GPS RFI studies, has two specific terms that apply to the particular FAA request:

Develop quantitative assessments of the current and projected RF interference (RFI) environment;

Recommend measures to reduce RFI at the source where it is technically feasible and cost-effective to do so.

[1] LightSquared Subsidiary LLC, Request for Modification of its Authority for an Ancillary Terrestrial Component, Order and Authorization, DA 11-133 (Chief, International Bureau, 26 Jan., 2011)

[2] Letter to RTCA President, Margaret Jenny, from R. A. Frazier, Acting Group Manager, FAA Spectrum Engineering Services, RTCA Paper No. 047-11/PMC-881, 3 Mar. 2011

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## 1.3 Assessment Study Objectives

To address the FAA request, the assessment study objectives are to determine:

1. impact on GPS airborne receiver performance from fundamental emissions of a single LightSquared ATCt base station

and, through operational scenario analyses,

2. aggregate emissions impact from a distribution of LightSquared ATCt base and mobile stations on GPS airborne receivers and GPS receiver-based aviation operations.

The primary focus of the RFI effects analyses in this report is the LightSquared Phase 0 deployment (details in Section 2.4) and certain RFI effects of later planned and potential deployment phases are also considered.

## 1.4 Report Organization

Besides this introduction section, the report main body is organized into five more major sections with supporting material contained in five appendices. Section 2 describes the basic analysis framework and key model parameters of the RFI sources, GPS receiver, and the radio propagation path. Section 3 details five operational scenarios that each pull in various aspects of the RFI source, receiver, and propagation path to set up the analysis cases. Section 4 describes computations for each of the five operational scenarios and compares aggregate received RFI results against receiver susceptibility limits. Section 5, Possible RFI Mitigation Techniques, briefly describes some possible RFI source and GPS receiver measures to mitigate the estimated RFI effects. Section 6 contains the summary, conclusions, and recommendations.

Appendix A contains a GPS MOPS-based aviation receiver test procedure for wide bandwidth near-band RFI effects. Appendix B contains a detailed description of the aggregate RFI analysis method and the scenario analysis details. Appendix C contains detail of the GPS aviation receiver susceptibility to in- and near-band RFI (including an estimate of the RF front-end third-order intermodulation effect). Appendix D contains a summary of laboratory RFI measurement results on production GPS receivers. Appendix E contains a list of report acronyms, abbreviations, and definitions.

## 1.5 References

[1-1] SC-159, “Assessment of Radio Frequency Interference Relevant to the GNSS L1 Frequency Band,” RTCA Document No. RTCA/DO-235B, 13 Mar. 2008.

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