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April 15, 2011

ELECTRONIC FILING

Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: SAT-MOD-20101118-00239

Dear Ms. Dortch:

In its Order dated January 26, 2011 ("*LightSquared Order*"), the Federal Communications Commission ("Commission") required LightSquared Subsidiary LLC ("LightSquared") to submit reports on the 15th day of each month describing the progress of the Working Group ("WG") convened to study the GPS overload/desensitization issue discussed in the *LightSquared Order*, concluding in a Final Report due no later than June 15, 2011.[1]

A copy of the WG's second progress report ("April Progress Report"), hereby submitted to the Commission jointly by LightSquared and the United States Global Positioning System ("GPS") Industry Council ("USGIC") as Co-Chairs of the Working Group, is attached. As discussed in greater detail in the April Progress Report, the Technical Working Group is continuing the work

[1] *LightSquared Subsidiary LLC; Request for Modification of its Authority for an Ancillary Terrestrial Component*, SAT-MOD-20101118-00239, DA 11-133, ¶ 43 (rel. Jan. 26, 2011).

outlined by the initial report,[2] with various sub-teams of the Technical Working Group working to test various categories of GPS devices and receivers. Since the first progress report, the sub-teams have been meeting regularly and have been focused on identifying qualified laboratories for testing activities, developing test plans and identifying devices, receivers, and systems to be tested, making arrangement for testing, and/or commencing testing.

Please do not hesitate to contact me with any questions.

Respectfully,

Henry Goldberg
Counsel for LightSquared Subsidiary LLC

cc: Julius Knapp, FCC
Mindel De La Torre, FCC
Ruth Milkman, FCC
Ron Repasi, FCC
Karl Nebbia, NTIA
Tony Russo, NTIA
Eddie Davison, NTIA
IB-SATFO@fcc.gov

[2] Letter from Henry Goldberg, Counsel for LightSquared Subsidiary LLC, to Marlene H. Dortch, Secretary, Federal Communications Commission, File No. SAT-MOD-20101118-00239 (Feb. 25, 2011) (attaching initial report, including work plan).

Second GPS Working Group Progress Report
April 15, 2011

Introduction

On February 25, 2011, LightSquared and the United States Global Positioning System Industry Council (USGIC) submitted a Work Plan to the Commission outlining the intended actions and governance of the Working Group (WG), including the Technical Working Group (TWG) to study fully the potential for overload interference/desensitization to GPS receivers, systems, and networks. As directed in DA 11-133, LightSquared, along with the non-governmental members of the GPS Technical Working Group (TWG) hereby submit this second progress report which has been approved by the Co-Chairs of the WG to submit to the Commission[1].

Progress to date

The WG filed its first progress report to the Commission on March 15, 2011. In that filing, the WG reported that it was establishing sub-teams that would be comprised of members and advisors with expertise and/or interest of particular relevance to the specific device and receiver categories defined by the TWG.

Consistent with its policy of transparency and inclusiveness, as well as to provide additional expertise to each sub-team, the WG has welcomed several new Advisors that have been assigned to specific sub-teams. The current list of all WG members, including TWG Members and Advisors, can be found in Appendix A to this report. This list also details current sub-team participants.

Since the first progress report, the sub-teams have been meeting regularly and have been focused on identifying qualified laboratories for testing activities, developing test plans and identifying devices, receivers, and systems to be tested, making arrangement for testing, and/or commencing testing. The current draft test plans and the current list of devices and receiver models submitted for testing by companies are included in attachments to this second progress report; any updates to these will be included in the May 15 progress report. Each of the receiver category sub-teams will report on their progress to date in these areas. Test results will be published in the final report and the identity of each tested receiver will be randomly coded within each category.

The TWG has met weekly, including in person and/or via teleconference to monitor and review sub-team progress and to address matters of general applicability across sub-teams.

[1] This report was prepared with technical input from USG employees and contractors but does not necessarily represent their views.

Sub-Team specific updates

Aviation Sub-Team

Laboratory Engagement

The Aviation sub-team will rely primarily on testing, funded by the Federal Aviation Administration (FAA), that will be performed at Zeta Associates Incorporated, Fairfax, Virginia. The aviation sub-team is participating in the development of the plan for this testing, and the data will be made available to the TWG and considered in the TWG Final Report.

Additional testing is planned by the United States government at: (1) White Sands Missile Range (WSMR), New Mexico, and (2) Holloman Air Force Base (AFB), New Mexico. These tests will be used by the National PNT Engineering Forum (NPEF) LightSquared Working Group. Depending upon a review of the applicable test plans and availability of the data to the TWG, these test results will be considered for inclusion in the TWG Final Report by the aviation sub-team.

Status of Test Plan Development

Three different test plans will be used for the tests to be performed at the three locations listed above. Zeta Associates will be performing conducted emissions testing, using an RTCA Minimum Operational Performance Standard (MOPS)-based test procedure that is currently being written by RTCA Special Committee 159 (SC159) Working Group 6 (WG6). The current draft of this test plan is attached as Appendix C to this report.

Radiated emissions testing within an anechoic chamber was performed at WSMR, using a test plan developed by a team led by the Air Force GPS Directorate (GPSD). This test plan was approved on March 25, 2011, by the GPSD Chief Engineer, Col. Stephen Steiner. A later test plan will be used for “Live Sky” radiated-emissions testing at Holloman AFB.

High Level Description of Test Plan

Conducted emission testing – this testing will be performed at Zeta Associates following the standard test procedures required to certify ground and airborne aviation receivers. Emulated LightSquared signals are combined with simulated GPS/Wide Area Augmentation System (WAAS) signals and fed into the receiver input port for the devices under test. These emissions are created to faithfully represent the output of the antenna unit and cabling that is designed for each tested receiver, including the effects of antenna filtering, low noise amplification and all incurred losses. For airborne receivers, the testing follows the procedures defined in applicable RTCA MOPS (see discussion in the aviation appendix to the March 15 progress report). Tailoring is included only to add the emissions anticipated from LightSquared base stations in addition to the emissions called for within the MOPS test procedures to account for known interference sources. MOPS test procedures generally require demonstrating that the equipment under test meets all applicable performance requirements in the presence of the anticipated interference environment and with minimum anticipated desired signal levels. In terms of the LightSquared emission levels, the testing will extend beyond the MOPS pass/fail criteria up to the limitations of the test setup. Some deviations from the MOPS test procedure may be necessary for some equipment under test based upon the output data logging limitations. Any such deviations will be reviewed and approved by the aviation sub-team.

Radiated emissions testing (anechoic chamber) – testing of aviation receivers was performed by FAA personnel and contractors within a large anechoic chamber at WSMR, New Mexico. Simulated GPS signals were broadcast by one antenna within the facility, and emulated LightSquared base station signals were broadcast by another antenna. Aviation receivers were located within one area of the chamber, connected to appropriate antennas, and the outputs of the receivers logged as the LightSquared signal levels are varied. The FAA has not yet determined the extent to which test results for the non-military aviation receivers tested would be made available to the TWG.

Radiated emissions testing (Live Sky) – testing of aviation receivers will be performed by FAA personnel and contractors in the vicinity of a LightSquared base station that will be installed at Holloman AFB, New Mexico. The equipment under test will operate using live GPS signals and in the presence of the LightSquared base station emissions. Aviation receivers will be located on the ground and the outputs of the receivers logged as the LightSquared signal levels are varied. Testing is also planned during this particular test event with the set of available airborne receivers operating onboard a single test aircraft in flight around the tower. The FAA has not yet determined the extent to which test results for the non-military aviation receivers tested would be made available to the TWG.

Device Testing

The aviation receivers listed in Appendix B are representative of those in use today. Their selection was based, however, mainly upon device availability (e.g., those that were already owned by the FAA Technical Center). There are many other aviation receiver models from these and other manufacturers, including those certified for use in instrument conditions, which are not included within the above set.

Identification of Risks

The short timeframe of the working group activity poses a risk to the successful completion of the testing of aviation receivers.

Cellular Sub-Team

Laboratory Engagement

The Cellular sub-team is in the process of engaging the following laboratories for its device testing program:

- PC TEST, Columbia, MD

- CETECOM, Milpitas, CA
- InterTek, Lexington, KY
- ETS Lindgren, Cedar Park, TX

The above labs are CTIA authorized test labs and have extensive experience in testing various types of consumer devices utilized in the cellular industry.

Status of Test Plan Development

- Units entering the test process this week. Initial test bed set up has occurred and test equipment purchased to undertake tests at each location.
- Contribution of devices and supporting hardware, software, personnel from three of four major US operators.
- Also have support of GPS device, mobile device, test equipment vendors in this effort
- Test plan document is in final revision, with the current draft attached to this report as Appendix D.
- Procedural test plan draft is beginning this week

High Level Description of Test Plan

The testing will follow industry standards established by 3GPP and CTIA for GPS/AGPS, while applying LightSquared signals in a controlled fashion. Labs are able to test either in a conducted or radiated fashion depending on the construct of the specific device under test.

Testing will be performed in two major batteries. The first setup follows industry standards with a simple comparison test of C/N_0 and relevant performance parameters with and without the LightSquared signal applied. The second setup will test LightSquared signal interaction with GPS signal levels below what is used in cellular industry standard conformance testing and pass/fail criteria for mobile assisted GPS devices.

Device Testing

The Cellular sub-team currently expects to test approximately 50 different device models. Multiple devices within the same model may be tested if time permits. The devices selected represent both current and legacy devices and have been prioritized based on sales volumes. While it is expected that there will be some representation of data-only devices and femtocells, the testing will focus largely on handheld devices. A list of the devices currently designated for testing is included within Appendix B.

Identification of Risks

- Many devices to test – risk may be abating
- Test staging, test readiness logistics
- Managing tight schedule
- Information disclosure issues

General Location/Navigation Sub-Team

Laboratory Engagement

The General Location / Navigation Sub-Team investigated several potential test sites. The team has chosen Alcatel / Lucent as their initial facility for testing. Other test sites considered were Edwards Air Force Base's Benefield laboratory, University of Calgary, and the Navy's NAVAIR laboratory.

Status of Test Plan Development

The General Location/Navigation sub-team has completed the drafting of its test plan, a copy of which is attached as Appendix E.

High Level Description of Test Plan

All testing will be performed as radiated tests in an RF anechoic chamber. There will be two primary test cases: stationary and dynamic.

The key performance indicators (KPIs) for the stationary case are as follows:

- LightSquared signal levels resulting in 1, 3, 6, 10 and 20 decibels (dB) of degradation in C/N_0;
- LightSquared signal level at the Device Under Test (DUT) resulting in failure to acquire;
- Time to First Fix (TTFF) Cold Start at LightSquared signal levels corresponding to 1, 3, 6, 10 and 20 dB of C/N_0 degradation compared to TTFF Cold Start with no LightSquared signal;
- TTFF Warm Start at LightSquared signal levels corresponding to 1, 3, 6, 10 and 20 dB of C/N_0 degradation compared to TTFF Warm Start with no LightSquared signal; and
- If Wide Area Augmentation System (WAAS) equipped TTFF Cold Start Differential Fix Error with LightSquared signal levels corresponding to 1, 3, 6, 10 and 20 dB of C/N_0 degradation compared to TTFF Cold Start Differential Fix Error with no LightSquared signal.

The KPIs for the dynamic case are as follows:

- Position and Velocity errors for a GPS simulated moving DUT in the presence of LightSquared signal levels resulting in 1, 3, 6, 10 and 20 decibels (dB) of degradation in C/N_0

as determined in the stationary case with reference to position and velocity without a LightSquared signal;

- Position and Velocity errors for a DUT exposed to GPS signals played back from an urban canyon environment recording in the presence of LightSquared signal levels resulting in 1, 3, 6, 10 and 20 decibels (dB) of degradation in C/N_0 as determined in the stationary case with reference to position and velocity without a LightSquared signal;
- Time to First Fix (TTFF) Cold Start for a GPS simulated moving DUT in the presence of LightSquared signal levels corresponding to 1, 3, 6, 10 and 20 dB of C/N_0 degradation compared to TTFF Cold Start with no LightSquared signal; and
- TTFF Warm Start for a GPS simulated moving DUT in the presence of LightSquared signal levels corresponding to 1, 3, 6, 10 and 20 dB of C/N_0 degradation compared to TTFF Warm Start with no LightSquared signal.

The LightSquared downlink scenarios tested will be

- 1552.7 MHz Center Frequency at 5 MHz Bandwidth (BW) at a power spectral density equivalent to 24.77 dBW/MHz at the base station antenna (LightSquared's Phase 0).
- 1528.8 MHz Center Frequency at 5 MHz BW at a power spectral density equivalent to 24.77 dBW/MHz at the base station antenna.
- 1528.8 MHz Center Frequency at 5 MHz BW and 1552.7 MHz Center Frequency at 5 MHz BW at a power spectral density equivalent to 24.77 dBW/MHz at the base station antenna (LightSquared's Phase 1).
- 1528.8 MHz Center Frequency at 10 MHz BW and 1552.7 MHz Center Frequency at 10 MHz BW at a power spectral density equivalent to 21.77 dBW/MHz at the base station antenna (LightSquared's Phase 2).

The LightSquared uplink scenarios tested will be

- Low Channel Center Frequency at TBD Bandwidth (BW) at a total power of -7 dBW.
- Middle Channel Center Frequency at TBD Bandwidth (BW) at a total power of -7 dBW.
- High Channel Center Frequency at TBD Bandwidth (BW) at a total power of -7 dBW.

Device Testing

26 devices are expected to be tested, with the names and models listed in Appendix B. The devices selected were based upon nominations by manufacturers represented on the sub-team; these nominations were representative of the device category and considered the percentage of the installed user base.

Identification of Risks

- Time to contract test sites, schedule and commence testing;
- Time to execute tests for each device; and

- Total number of devices required to be representative.

The sub-team is exploring the possibility of setting up multiple devices for test simultaneously as a way to conduct its testing more efficiently.

High Precision Sub-Team
Networks Sub-Team
Timing Sub-Team

The High Precision, Networks and Timing sub-teams (HPN&T Sub-Teams) are collaborating extensively and are developing joint test plans and procedures. Their activities are being reported jointly, except where otherwise noted.

Laboratory Engagement

The HPN&T Sub Teams have finalized the lab selection process and have chosen the US Navy's NAVAIR facility due to its unique ability to test high precision and timing devices.

Status of Test Plan Development

Revision I of the Precision/Timing test plan is currently being circulated among sub-team members. A copy of current version of the HPN&T test plan is attached as Appendix F. The plan is about 80% complete pending discussions with specific lab personnel and considerations of their available equipment and capabilities. Team members visited the NAVAIR lab the week of April 11^{th} to work to finalize the testing plan

High Level Description of Test Plan

All the tests will be radiated within the NAVAIR RF chamber. There will be some reference receivers outside the chamber that will collect the "clean" GPS data conducted from an RF feed directly from the GPS simulator.

The NAVAIR chamber is a large facility measuring 40'x40'x100'. The sub-teams plan to install as many receivers into the chamber as possible. The goal is to test all receivers at one time, but it is not clear if that will be possible.

The Network testing will be analytical, based on results from testing of the High Precision and Timing receivers and on studies of the effects of degraded receiver operations on networks.

The testing plan will measure the impact of LightSquared signals on the following receiver performance attributes:

- Tracking

- Reacquisition
- Acquisition
- Tracking Sensitivity
- Acquisition Sensitivity

These receiver performance attributes will be measured in the presence of the LightSquared signal configurations (base station and handset) listed in the attached test plan.

The HPN&T sub-teams have begun working directly with NAVAIR on the fine tuning of the test plan and the development of a detailed schedule. The HPN&T sub-team will have full access to the NAVAIR chamber by April 28 for testing setup. Receiver testing could commence as soon as May 2, assuming test structures can be developed by that time

Device Testing

The HPN&T sub-teams have identified receivers for test which are listed in Appendix B.

Identification of Risks

- The logistics of staging the test are extensive and local support may be needed.
- The calibration of the emitted signal levels may take an extended period of time.
- The number of identified tests and receivers is large and may need to be evaluated during the test phase relative to the schedule. Being able to test large numbers of receivers simultaneously should help mitigate this risk

Space-Based Receivers Sub-Team

Laboratory Engagement

Lab testing has been conducted at the NASA Jet Propulsion Laboratory (JPL) in California. The space-based receivers identified in the TWG are used by NASA for space-based missions and high precision science applications. The TWG agreed that these would be tested at JPL by NASA, with participation by LightSquared personnel, and the results provided to the TWG. Extracts detailing the test setup and procedures in the preliminary test report are included as Appendix G.

High Level Description of Test Process

The testing performed at JPL was conducted testing only. NASA has informed the TWG that radiated testing of NASA space-based receivers will be accomplished separately from the TWG work as part of the National Space-based PNT Systems Engineering Forum (NPEF) test and analysis effort.

NASA performed interference measurements of the effects of a simulation of the LightSquared Phase 1A signal on four high precision receivers. All these receivers track at least the GPS CA code, and use semi-codeless tracking of P(Y)1 and P(Y)2. Two of these receivers are NASA science receivers which are used on board satellites, and two are typical of those used in NASA's high accuracy ground network, which is part of the International GNSS Service (IGS). The measurements were made at an RF lab at the Jet Propulsion Laboratory (JPL) on 22 March 2011. The tests were conducted by JPL and were observed by LightSquared.

Devices Tested

The devices tested are listed in Appendix B and are current or representative of GPS receivers currently in use by NASA or planned for use in the near future for space and science applications.

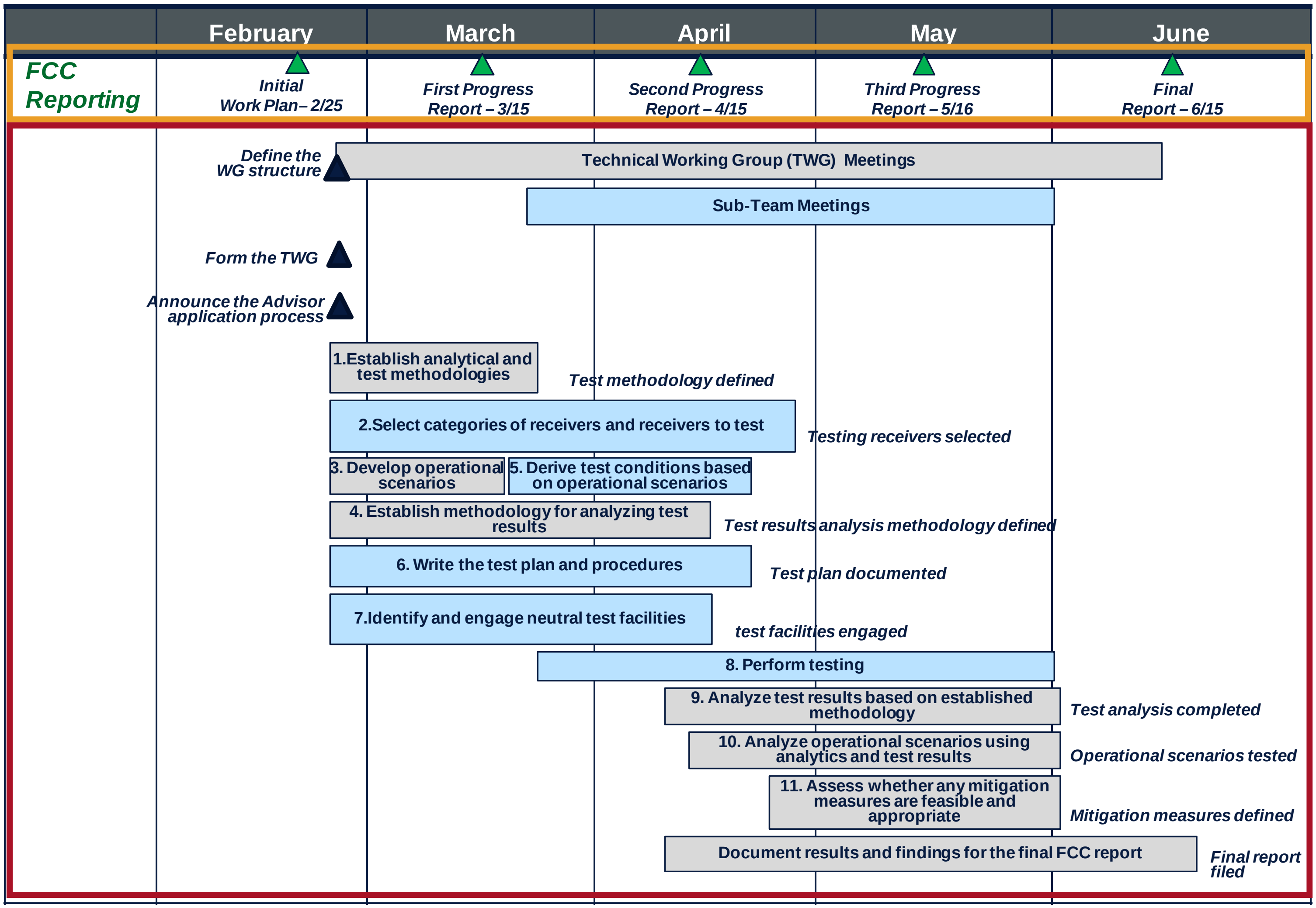
Additional Elements

As the sub-teams and the TWG analyze the results obtained through the testing outlined above, the TWG has agreed to assess two additional elements. First is the variation in filter performance across a range of temperatures that are typically encountered in device category use cases. This will be evaluated by examining the specification of filters that are used within specific device categories. Second, analyses will consider both LightSquared's expected transmit power of 62 dBm per channel and its maximum authorized transmit power of 72 dBm per channel.

Going-Forward Activities

The following updated timeline lays out the planned process and sequence of activities for the TWG up to and including the filing of the final report which is due to the FCC on June 15, 2011. The WG co-chairs will update the Commission on its progress in a subsequent progress report on May 16, 2011.

TWG Planned Process Timeline



List of Attachments

APPENDIX A
GPS WORKING GROUP ROSTER

NAME	AFFILIATION	ROLE	SUB-TEAMS: Aviation	Cellular	General Location /Nav	High Precision	Networks	Space-Based	Timing
Maqbool Aliani	LightSquared	Advisor	X	X	X				
Dominic Arcuri	RCC	TWG Member							
Steve Baruch	USGIC	Observer							
Chaminda Basnayke	OnStar	Advisor			X				
Steve Berger	LightSquared	Advisor		X					
Knute Berstis	NCO/PNT	TWG Member				X			
John Betz	MITRE/USAF	TWG Member							
Mike Biggs	FAA	TWG Member	X						
Ron Borsato	Sprirent	Advisor		X					
Pierre Bouniol	Thales	Advisor	X						
Joe Brabec	Topcon Positions Sys.	Advisor				X			
Cady Brooks	BI	Advisor			X				
Jim Buck	BI	Advisor			X				
Scott Burgett	Garmin	TWG Member			X				
Kevin Butler	Sprint Nextel	Advisor		X					
Bob Calaff	T-Mobile	Advisor		X					
Jeffrey Carlisle	LightSquared	WG Co-Chair							
Mark Cato	Airline Pilots Assoc.	Advisor	X						
Brett Christian	Sprint Nextel	Advisor		X					X
Ann Ciganer	Trimble	Info. Facilitator	X	X	X	X	X	X	X
Cormac Conroy	Qualcomm	Advisor		X					
Shawn Coppel	American Electric Power	Advisor					X		X
Charles Daniels	Overlook Systems Tech.	Advisor							
Wim De Wilde	Septentrio	Advisor				X			
Vinod Devan	LightSquared	Observer							
Santanu Dutta	LightSquared	TWG Member	X	X					
Rick Engelman	Sprint Nextel	TWG Member		X					X
Walter Feller	Hemisphere GPS	Advisor			X	X			
Pat Fenton	Novatel	TWG Member				X	X		Lead
John Foley	Garmin	TWG Member	X		X				
Collin Frank	Motorola Mobility	Advisor		X					
Hugo Fruehof	FEI-Zyfer	Advisor							X
Paul Galyean	Navcom	TWG Member				Lead	X		
Edward Gander	True Position	Advisor							X
Alex Gerdenitsch	Motorola Mobility	Advisor		X					
Henry Goldberg	LightSquared	Observer							
Capt. Anil Hariharan	USAF	TWG Member							
Martin Harriman	LightSquared	Info. Facilitator							
Scott Harris	Florida CORS Network	Advisor					X		

			SUB-TEAMS						
NAME	AFFILIATION	ROLE	Aviation	Cellular	General Location /Nav	High Precision	Networks	Space-Based	Timing
Chris Hegarty	MITRE/FAA	TWG Member	Lead						
Bronson Hokuf	Garmin	TWG Member			X				
Bruce Jacobs	LightSquared	Observer							
Jill Johnson	Leica Geosystems	Advisor				X			
Kevin Judge	Judge Software	Advisor		X	X				
Sai Kalyanaraman	Rockwell Collins	TWG Member	X					X	
Rich Keegan	Navcom	Advisor				X			
Jerry Knight	Navcom	TWG Member				X	X		
Galen Koepke	NIST	Advisor							X
Richard Kolacz	GSTS	Advisor							
Rob Kubik	Samsung	Advisor		X					
Eric Kunz	Furuno USA	Advisor			X				
Chris Kurby	LightSquared	Advisor		X					
John Lacey	Lockheed Martin	TWG Member							
Farokh Latif	APCO	TWG Member							
Rich Lee	LightSquared	TWG Member		Lead		X	X		
Alfred Leick	Univ. of Maine	Advisor				X			
Sanjay Mani	Symmetricom	Advisor							X
Keith Mathers	Sprint Nextel	Advisor							X
Amy Mehlman	LightSquared	Observer							
Charlie Meyer	Alcatel-Lucent	Advisor		X					X
Fred Moorefield	USAF	TWG Member							
Tim Murphy	Boeing	TWG Member	X						
Pierre Nemry	Septentrio	Advisor				X			
David Overdorf	AT&T	Advisor							X
Ajay Parikh	LightSquared	Advisor	X						X
Gary Pasicznyk	City and County of Denver	TWG Member							
Gil Passwaters	Furuno USA	Advisor			X				X
Bruce Peetz	Trimble	TWG Member			X	X	Lead		X
Brian Poindexter	Garmin	TWG Member			X				
Tom Powell	Aerospace/USAF	TWG Member			X			X	
Scott Prather	AT&T	Advisor		X					
Olav Queseth	Ericsson	Advisor							X
Brian Ramsay	NASA	TWG Member						Liaison	
William Range	New Mexico E-911	Advisor		X					
Pat Reddan	Zeta/FAA	TWG Member	X						
Daniel Reigh	Lockheed Martin	TWG Member							
Mark Rentz	Navcom	TWG Member				X	X		
Stuart Riley	Trimble	TWG Member				X	X		

			SUB-TEAMS						
NAME	**AFFILIATION**	**ROLE**	**Aviation**	**Cellular**	**General Location /Nav**	**High Precision**	**Networks**	**Space-Based**	**Timing**
Raul Rodriguez	USGIC	Observer							
Narothum Saxena	USCellular	Advisor		X					
Michael Shaw	Lockheed Martin	TWG Member (Alternate)							
David Shively	AT&T	TWG Member		X					X
Patryk Siemion	LightSquared	Observer							
Mike Simmons	Garmin	TWG Member			Lead				
Fraser Smith	Topcon Positions Sys.	Advisor				X			
Claudio Soddu	Inmarsat	Advisor				X			
Geoffrey Stearn	LightSquared	Info. Facilitator	X	X	X	X	X	X	X
Bill Stone	Verizon Wireless	TWG Member		X					
Mark Sturza	LightSquared	TWG Member	X						
Michael Swiek	USGIC	Info. Facilitator	X	X	X	X	X	X	X
Andreas Thiel	U-Blox	Advisor		X	X				
Charles Trimble	USGIC	WG Co-Chair							
Michael Tseytlin	LightSquared	Advisor		X	X	X	X	X	
Greg Turetzky	CSR	TWG Member		X	X				
A.J. Van Dierendonck	USGIC	TWG Member	X		X	X			
Rick Walton	Lockheed Martin	TWG Member	X						
David Weinreich	Globalstar	Advisor		X	X	X	X		
Marc Weiss	NIST	Advisor							X
Vince Wolfe	TomTom	Advisor			X				
Arthur Woo	Furuno/eRide	Advisor			X				
Michael Woodmansee	Ericsson	Advisor							X
Larry Young	NASA	TWG Member				X		X	

APPENDIX B

LIST OF DEVICES AND RECEIVERS PLANNED FOR TESTING (SUBJECT TO CHANGE)

Aviation

- Canadian Marconi GLSSU 5024
- Garmin 300XL
- Garmin GNS 430W
- Garmin GNS 480
- Rockwell Collins GLU-920 multimode receiver
- Rockwell Collins GLU-925 multimode receiver
- Rockwell Collins GNLU-930 multimode receiver
- Symmetricomm timing card (used for an FAA automation system)
- WAAS NovAtel G-II ground reference station
- Zyfer timing receiver (used for the WAAS ground network)

Cellular

- Apple iPhone 4 (GSM)
- Apple iPhone 4 (CDMA)
- HTC A6366
- HTC ADR6200
- HTC ADR63002
- HTC ADR63003
- HTC ADR6400L
- HTC Touch Pro 2
- LG Lotus Elite
- LG Rumor Touch
- LG VN250
- LG VS740
- LG VX5500
- LG VX5600
- LG VX8300
- LG VX8360
- LG VX8575
- LG VX9100
- LG VX9200
- Motorola A855
- Motorola DROID X
- Motorola VA76R
- Motorola W755
- Nokia 6650
- Nokia E71x
- RIM 8330C
- RIM 8530

- RIM 9630
- RIM 9650
- RIM 9800
- Samsung Moment
- Samsung SCH-U310
- Samsung SCH-U350
- Samsung SCH-U450
- Samsung SCH-U640
- Samsung SCH-U750
- Samsung SGHi617
- Samsung SGHi917
- Sierra Wireless 250 U USG 3G/4G
- Sony Ericsson W760a

General Location/Navigation

- Garmin Forerunner 110 (Fitness)
- Garmin Forerunner 305 (Fitness)
- Garmin ETREX-H (Outdoor)
- Garmin Dakota 20 (Outdoor)
- Garmin Oregon 550 (Outdoor)
- Garmin GTU 10 (Tracking)
- BI Inc. ExacuTrack® One (Tracking)
- Garmin GPS 17X (NMEA) (Marine)
- Garmin GPSMAP 441 (Marine)
- Hemisphere Vector MV101 (Marine)
- GM OnStar Model TBD (Automotive (in dash))
- Garmin GVN 54 (Automotive (in dash))
- TomTom XL335 (PND)
- TomTom ONE 3RD Edition (PND)
- TomTom GO 2505 (PND)
- Garmin nűvi 2X5W (PND)
- Garmin nűvi 13XX (PND)
- Garmin nűvi 3XX (PND)
- Garmin nűvi 37XX (PND)
- Garmin GPSMAP 496 (Portable Aviation (non-TSO))
- Garmin aera® 5xx (Portable Aviation (non-TSO))
- Honeywell Bendix/King AV8OR (Portable Aviation (non-TSO))
- Trimble iLM2730 (with Mobile Mark Option J antenna) (Fleet Management)
- Trimble TVG-850 (with Mobile Mark Option E glass-mount antenna) (Fleet Management)
- Trimble Placer Gold (Emergency Vehicles (post-OEM mounted in vehicle))
- Hemisphere Outback S3 (Low Precision Ground Agricultural Navigation)

High Precision and Networks

- Hemisphere R320 (with A52 antenna)
- Hemisphere A320 (with Integral antenna)
- Deere iTC (with Integral antenna)
- Deere SF-3000 (with Integral antenna)
- Deere SF-3050 (with Aero antenna)
- Trimble MS990
- Trimble MS992
- Trimble AgGPS 252
- Trimble AgGPS 262
- Trimble AgGPS 442
- Trimble AgGPS EZguide 500
- Trimble CFX 750
- Trimble FMX
- Trimble GeoExplorer 3000 series GeoXH
- Trimble GeoExplorer 3000 series GeoXT
- Trimble GeoExplorer 6000 series GeoXH
- Trimble GeoExplorer 6000 series GeoXT
- Trimble Juno SB
- Trimble NetR9 (with Zephyr 1 antenna)
- Trimble NetR9 (with Zephyr 2 antenna)
- Trimble R8 GNSS (with Integral antenna)
- Trimble 5800 (with Integral antenna)
- Trimble NetR5 (with Zephyr 1 antenna)
- Trimble NetR5 (with Zephyr 2 antenna)
- Leica SR530 (with AT502 antenna)
- Leica GX1200 Classic (with AX1202 antenna)
- Leica GX1230GG (with AX1202GG antenna)
- Leica GR10 (with AR10 antenna)
- Leica Uno (with GS05 antenna)
- Leica GS15 (with Intergral antenna)
- Topcon HiPer Ga
- Topcon HiPer II
- Topcon GR-3 (with Integral (5/8) antenna)
- Topcon GR-5 (with Integral (5/8) antenna)
- Topcon MC-R3 (with MC-A3/cabled (5/8) antenna)
- Topcon NET-G3A (with CR-G3/cabled (5/8) antenna)
- Topcon TruPath/AGI-3 (with Integral (special mount) antenna)
- NovAtel PROPAK-G2-Plus (with GPS-702/GPS-701 antenna)
- NovAtel FLEXG2-STAR (with GPS-701GGL/GPS-701 antenna)
- NovAtel FLEXPAK-G2-V1 (with GPS-701GGL/GPS-702 antenna)
- NovAtel FLEXPAK-G2-V2 (with GPS-702GGL/GPS-702 antenna)
- NovAtel PROPAK-V3 (with GPS-702GGL/GPS-702 antenna)
- NovAtel DL-V3
- NovAtel FLEXPAK6 (with GPS-702GGL/GPS-702 antenna)

- Septentri PolaRx3e (with PolaNt GG antenna)
- Septentrio AsteRx3 (with PolaNt G antenna)

Space-Based Receivers (Testing Complete)

- TriG (NASA Next-generation Space Receiver)
- IGOR (Space Receiver)

NASA/JPL also tested the following high precision receivers; the results of these tests have been shared with the HPT&N sub-team for its consideration:

- JAVAD Delta G3T (High Precision-IGS)
- Ashtech Z12 (High Precision-IGS)

Timing

- FEI-Zyfer UNISync GPS/PRS (with Yokowo, part number YOP-5145-YN01 antenna)
- TruePosition GPS timing receiver (with 34043A antenna)
- Symmetricom SSU 2000 (Motorola M12M) (with 32012937-012-0 (GPS L1 26 dB) antenna)
- Symmetricom Time Provider 1000/1100 (Furuno GT-8031) (with 090-58545-01 antenna)
- Symmetricom TimeSource 3500 (XR5 (Navstar/Symmetricom), Wall Mount config. (with 012-00013-01 (Wall Antenna) antenna)
- Trimble Resolution T
- Trimble Accutime Gold
- Trimble Resolution SMT
- Trimble MiniThunderbolt
- NovAtel OEMStar (with Antcom 2G0 antenna)
- NovAtel OEM4 (with GPS600 antenna)
- NovAtel OEMV3 (with GPS702GG antenna)

APPENDIX C
MOPS-Based Procedure for Minimum Recommended Testing of LightSquared RFI to GPS Aviation Receivers

The intent of the following test procedures is to evaluate the impact of Lightsquared's LTE (3GPP) signal transmissions on the GPS receiver's performance. The following test procedures focus on the application of CWI and broadband interferers at specific frequency ranges and varying power levels.

The simulation conditions used for the measurement accuracy tests in DO-229D (Section 2.5.8) are used as a baseline for the purposes of evaluating the GNSS receiver's performance in the presence of these transmissions. Based on available information, it is observed that Lightsquared's LTE (3GPP) transmission bandwidths will be 10 MHz wide (2 channels across 1526 – 1536 MHz and 1545.5 – 1555.2 MHz) during their final phase 2 deployment. The LTE downlink closest to the GPS band will be centered at 1550.5 MHz (1550.5 +/- 5 MHz). However, during the initial phase zero deployment, the LTE downlink is centered on 1552.7 and is 5 MHz wide (1550.2 to 1555.2 MHz).

For the purposes of the preliminary evaluation the total transmit power in the downlink band is assumed to be concentrated at a single frequency point (for e.g. at 1552.7 MHz). At the outset, the LightSquared signal is not expected to correlate with the GNSS signal. To validate this, the test will initially be performed with CWI. The next step would be to utilize a signal generator to replicate the Lightsquared Phase 0 transmissions and compare the receiver impact of these transmissions at varying power levels to that of the CWI. This will help towards potentially obtaining a correction factor between CWI and the LTE modulations. It will also help provide a reference point for the range accuracy SBAS message loss rate tests. To begin with, the power level of the Lightsquared transmission (for the baseline test conditions explained below) would be set at the same level as the CW Interference mask.

The reported Carrier to Noise ratio (CNR) from the GPS Receiver is used as a yardstick of receiver performance. In addition, the pseudorange measurement accuracy (which reflects a critical receiver performance metric) and SBAS Message failure rates (for applicable units) will be evaluated at specific 3GPP Interferer signal levels. However, for a given receiver architecture, the range measurement accuracy is typically tied to the CNR. The following depicts the test conditions used for comparison of relative impact of the CW versus the 3GPP LTE interferers.

1) Simulator and Interference Conditions

The simulation and interference conditions shall conform to the following requirements:

1) For all test scenarios, the broadband GNSS test noise and $N_{sky,antenna}$ (-172.5 dBm/Hz) shall be simulated. A broadband external interference noise ($I_{Ext,Test}$) has a spectral density equal to -173.5 dBm/Hz at the antenna port.
2) The CW power and frequencies are listed in Table 1. These CW frequencies are the mid band frequencies of the 5 and 10 MHz LTE 3GPP BTS bands that would be rolled out across Phases 0, 1A, 2.
3) The GNSS test noise depends on the number, power, and type of satellites simulated during the test. The power spectral density of the total GNSS Noise (I_{GNSS}) is -171.9 dBm/Hz (RTCA DO-235B, Appdx.F.2.3). This GNSS Noise was derived for GPS tracking but is used in the test for both GPS and SBAS

tracking to allow simultaneous testing of GPS and SBAS thereby reducing test time. However it is acceptable to run the SBAS testing separately using a total GNSS Noise (I_{GNSS}) of -172.8 dBm/Hz for collection of the SBAS message loss rate data. The effective noise power spectral density (I_{Test}) of the satellites present in the simulator scenario may be removed from the total GNSS Noise; to do so, the satellite equivalent power spectral density specified in Table 2 (I_{GH}, I_{GL}, I_{SH}, and I_{SL}) is removed for each satellite present. The number of maximum power GPS satellites is N_{GH}, the number of minimum power GPS satellites is NGL, the number of maximum power SBAS satellites is N_{SH}, and the number of minimum power SBAS satellites is N_{SL}. The GNSS test noise is determined by removing I_{Test} from I_{GNSS} as follows:

$$I_{GNSS,Test} = 10\log10[10^{-171.9//10} - 10^{I_{Test}/10}]$$

where:

$$I_{Test} = 10\log10[(N_{GL})10^{I_{GL}/10} + (N_{GH})10^{I_{GH}/10} + (N_{SL})10^{I_{SL}/10} + (N_{SH})10^{I_{SH}/10}]$$

Note: The indicated power levels (both signal and noise) are for the steady-state portion of the tests; power levels are set to the required values once steady state navigation has been achieved. Refer to Appendix M of DO-229D for an explanation of how I_{Test} is derived and examples of the computation of $I_{GNSS,Test}$ and how it may be applied. This appendix also provides guidance on how the test can be setup.

4) Simulated GPS and SBAS RF shall be at the minimum power level for the equipment. One GPS satellite shall be set to the maximum power level (including maximum transmit power and maximum combined satellite and aircraft antenna gain). At least two SBAS satellites shall be used.

TABLE 1: STEADY STATE ACCURACY TEST CWI VALUES*

Frequency (MHz)	Power (dBm)	I/S (dB)
1528.8	-22.2	111.8
1531	-28.1	105.9
1550.2	-79.6	54.4
1552.7	-86.4	47.6

* The CWI power is specified at the antenna port. The actual level used during testing is reduced by the minimum frequency selectivity of the active antenna adjusted for any filtering in the test set-up itself. When demonstrating compatibility with a minimum standard antenna, the frequency selectivity is specified in RTCA/DO-301. When using a specific antenna, its minimum frequency selectivity can be used when determined in accordance with RTCA/DO-301. A block diagram of an example test setup is shown Figure 1.

Note: Care should be taken when applying non-L1 CW frequencies so that the L1 CW and broadband specifications are not exceeded.

TABLE 2 SATELLITE EQUIVALENT POWER SPECTRAL DENSITY

Satellite Type	Maximum Power Satellite	Minimum Power Satellite
GPS	I_{GH} = -183.5 dBm/Hz	I_{GL} = -196.5 dBm/Hz
SBAS	I_{SH} = -179.8 dBm/Hz	I_{SL} = -198.3 dBm/Hz

Note: These values of equivalent power spectral density were computed using the same assumptions as were used to determine the total GNSS Noise in Appendix C of DO-229D.

2) Test Procedure (Delta CNR)

1) The test unit is connected to the RF signal and interference source.
2) The simulator scenario shall be engaged and the satellites RF shall be turned on.
3) The equipment under test shall be powered and initialized. It is assumed that the receiver has obtained a valid almanac for the simulator scenario to be tested prior to conducting these tests.
4) When the unit is navigating, the interference to be applied shall be applied to the equipment under test, and the power of the signal and interference shall be adjusted to the required level (at the appropriate freq. as seen in table 1)
5) At this base power level ensure that the unit meets the MOPS requirements per DO-229D. Record the CNR's of individual satellites (SBAS and GPS).
6) Increase the level of the CWI by 2 dB (this step size may be varied) and hold this level for 60 seconds.
7) Record the CNR's of the individual GPS SV's and the CWI level.
    1. If the CNR's on the SV's have not degraded go back to step (6).
    2. If the CNR is reduced by > 1dB, record the result for that RFI level and go back to the previous CWI level, ensure the unit attains the original CNR level and increase the CWI in smaller steps (in order to capture the CWI level that cause a 1dB degradation).
    3. Proceed to the next step.
8) Repeat steps 5-7 at the other CWI frequencies listed in Table 1.
9) Replace the CWI interference source with a signal generator that would replicate a 5 MHz bandwidth LTE (3GPP) signal transmission and repeat the test procedure (from step 1) for the 1528.8 and 1552.7 MHz frequencies.
10) Replace the CWI interference source with a signal generator that would replicate a 10 MHz bandwidth LTE (3GPP) signal transmission and repeat the test procedure (The starting point may be a I/S value somewhat less than in step 9, and using only center frequencies 1531.0 and 1550.2 MHz).

Note 1: A comparison of the unit's CNR degradation across both types on interference sources is helpful to verify the assumptions in interference analyses. The value from steps 9 and 10 are also used in subsequent higher level receiver performance tests in

Section 3 and following sections. *Any receiver margin above the interference mask is considered as design margin.*

Note 2: As an option, the comparison test of Section 2 above may be performed for higher CNR degradation values.

3) Measurement Accuracy and SBAS Message Loss (as applicable) Tests

The purpose of this Accuracy Test is to evaluate the equipment's accuracy performance under specific interference levels that have been ascertained from the delta CNR test procedure (see above). It is not intended to verify the accuracy of the atmospheric corrections; these corrections need not be included in the test. Data may be collected concurrently during these tests to validate the SBAS Message Loss Rate requirements in Section 2.1.1.3.2 of DO-229D. In order to meet the MOPS requirements, the equipment must meet the accuracy requirements of Section 2.1.2.1, 2.1.3.1, and 2.1.4.1.3 of DO-229D.

Note: This evaluation method is based on the assumption that a least-squares position algorithm (per Section 2.1.4.1.4 of DO-229D) is implemented. If a different form of positioning is used, this evaluation method may not be appropriate.

The total duration of each test case test shall be based upon sampling intervals required to obtain samples that are statistically independent. Independent samples collected during the initial acquisition and before steady-state operation are used for the validation of σnoise overbounding. The samples collected prior to steady-state operation should not be used for the steady-state RMS accuracy evaluation and the steady-state evaluation of $\left(\sigma^2_{noise}[i]+\sigma^2_{divg}[i]\right)^{1/2}$. It would be advantageous to extend the duration of this test to support evaluation of SBAS Message Loss Rate.

The accuracy test and SBAS Message Loss Rate test (for applicable receivers) shall be performed under the following test conditions:

A. The baseline test condition (at the MOPS interferer levels) used in the delta_CNR test procedure for the 3GPP interferer (with $I_{Ext,Test}$ of -170.5 dBm/Hz vs. -173.5 dBm/Hz)

B. The equivalent LTE (3GPP) broadband RFI signal level at which the estimated CNR is lower by 1dB from the baseline used in Section 2. (option: higher level CNR degradation values may be used as desired)

This test is performed for following cases (with the listed order of priority)

a. 5 MHz 3GPP Interferer BW at 1552.7 MHz

b. 5 MHz 3GPP Interferer BW at 1528.8 MHz

c. 5 MHz 3GPP Interferer BW's at both 1552.7 and 1528.8 MHz

d. 10 MHz 3GPP Interferer BW at 1531 MHz

e. 10 MHz 3GPP Interferer BW at 1550.2 MHz

f. 10 MHz Interferer BW’s at both 1531 and 1550.2 MHz

4) Measurement Accuracy Test Procedure:

1) Perform steps 1 through 5 of the delta CNR test procedure. Sampling should begin for each satellite immediately after it is included in the navigation solution for the σnoise overbounding evaluation described in paragraph 4) below.
2) When steady-state accuracy is reached, data are recorded as follows:
3) Initially, 50 independent samples of pseudorange data are recorded at the required sampling interval (see note below).

Note: The sampling interval will be two times the integration interval used for carrier phase smoothing of pseudoranges. For example, if the integration interval used for carrier smoothing of the pseudoranges is 100 second, the sampling interval will be 200 seconds. If ten pseudoranges are collected per sampling interval (nine independent measurements), the duration of the initial data collection period will be 20 minutes.

4) The normalized RMS range error statistic, RMS_PR, is computed according to the following formula, using all collected samples (including those prior to steady-state operation):

$$RMS\_PR(M) \equiv \sqrt{\frac{\sum_{j=1}^{M}\left\{\sum_{i=1}^{N_j}\frac{Z_{ij}^2}{\left[\sigma_{norm,ij}^2 N_j\right]}\right\}}{M}}$$

where:

$$Z_{ij} \equiv PR_{ij} - R_{ij} - (c\Delta t)_j$$

$$(c\Delta t)_j \equiv \frac{1}{N_j}\sum_{i=1}^{N_j}\left(PR_{ij} - R_{ij}\right)$$

$$\sigma_{norm,ij}^2 = \frac{\left[\left(N_j - 1\right)^2 \sigma_{noise,ij}^2 + \sum_{\substack{k=1 \\ k\neq i}}^{N_j}\sigma_{noise,kj}^2\right]}{N_j^2}$$

where:

PR_{ij} = smoothed pseudo-range, channel i, time j

R_{ij} = true range, satellite i, time j (includes extrapolation)

N_j = number of satellites at time j

M = number of sampling intervals

$\sigma_{noise,ij}$ = satellite i, time j (refer to Appendix J.2.4 of the DO-229D MOPS)

Note 1: Interchannel biases on the simulator may impede the accuracy test specified herein. It may be necessary to determine this bias and inflate the test threshold based upon equipment calibration. If two receivers are used to remove this bias (via double-differencing), the test must account for potential interchannel biases in the receivers themselves and cannot simply remove all bias components.

Note 2: Since code-carrier divergence is not simulated in this test, the σ_{divg} *term is not used in this normalization. Validation of* σ_{divg} *should be accomplished by analysis.*

5) Verification of σnoise overbounding: The error statistic is compared to the 110% Pass Threshold of Table 2-25 based on the Number of Independent Samples (NIS), where NIS is given by:

$$NIS(M) \equiv \sum_{j=1}^{M} \left(N_j - 1\right)$$

If RMS_PR is below the pass threshold (Table 3), the result is a pass. If the RMS_PR is not below the pass threshold, additional data may be collected. In this case, the RMS_PR shall include the initial independent samples plus all additional data, and the formulas and pass criteria of this section (which apply for an arbitrary number of samples) shall be used.

Note: It is expected that the pass criteria will not be met with the initial data collection (only the initial acquisition and 50 steady-state operation independent samples due to the limited sample size. Development of the test criteria, and the associated pass probabilities are described in Appendix M of DO-229D.

6) Steady-state value of $\left(\sigma^2_{\text{noise}}[i] + \sigma^2_{\text{divg}}[i]\right)^{1/2}$: Using only those samples collected during steady-state, the average $\left(\sigma^2_{\text{noise}}[i] + \sigma^2_{\text{divg}}[i]\right)^{1/2}$ output values for each satellite are compared to the requirements of Appendix J.2.4 of DO-229D. The output values must be less than or equal to the required accuracy values for the designator of the equipment.

7) Verification of RMS accuracy: The steps defined in paragraph 3 and 4 are repeated using only those samples collected during steady-state operation and using the required RMS accuracy (sections 2.1.4.1.3.1 and 2.1.4.1.3.2) (minus any steady-state value of σ_{divg}) instead of the output $\sigma_{\text{noise},i,j}$ in the computation of $\sigma_{\text{norm},i,j}$. The pass criteria defined in paragraph 4 applies.

TABLE 3 PASS THRESHOLD TABLE

NIS	110% Pass Threshold	125% Pass Threshold
25-50	N/A	1.084
50-75	0.954	1.137
75-100	0.981	1.159
100-150	0.998	1.172
150-200	1.017	1.187
200-300	1.028	1.196

300-400	1.042	1.206
400-500	1.050	1.212
500-750	1.055	1.216
750-1000	1.063	1.222
1000-1250	1.068	1.226
1250-1500	1.072	1.229
1500-2000	1.074	1.231
> 2000	1.078	1.233

Note: The 110% pass threshold yields a 10% probability of passing equipment with a true accuracy of 110% of the required accuracy. The 125% pass threshold yields an 80% probability of failing equipment with a true accuracy of 125% of the required accuracy.

In essence, the measurement accuracy tests (and SBAS Message Loss rate tests – as applicable) are performed at interferer levels (CW/ Lightsquared) that are a function of the individual receiver's performance.

It is possible that a perceptible variation in the estimated one sigma PR noise is not observed at the 1dB delta_CNR point. As a result, it may be of value to evaluate the degradation of the receiver delta ranges/ phase measurements. However, these test points could result in a difference in the SBAS message loss rate (for an SBAS capable receiver over a statistically significant number of samples at each test point). The SBAS message loss rate shall be less than 1 message in 10^3 (Scn 2.1.1.3.2 of DO-229D).

EXAMPLE TEST SET-UP AND COMPENSATION OF SIGNALS, NOISE AND INTERFERENCE

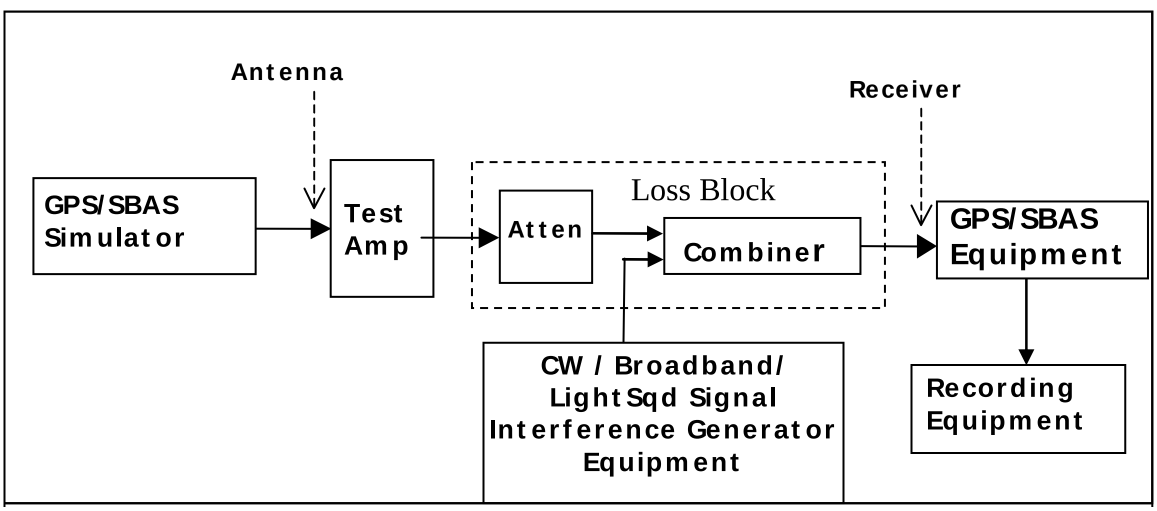


FIGURE 1 EXAMPLE TEST SET-UP

Laboratory Test Methodology

Evaluation of 3GPP Band 24 (MSS L-band) ATC impact to Cellphone GPS Receivers

Version 0.8 (Draft)

April 14, 2011

1. Introduction

This document describes the test methodology to be used by the Cellular Subgroup of the GPS Technical Working Group (TWG) for overload testing of cell phone-based GPS receivers in proximity to LightSquared's base stations and UE's using 3GPP Band 24[2] (henceforth referred to simply as Band 24).

The tests shall accommodate both conducted and radiated cases. Conducted testing is preferred where a suitably connectorized device is available. Radiated testing shall be performed when such a device is not available. For checking correlation of results obtained by the two methods, radiated testing may be performed for some devices which are also subjected to conducted testing.

The testing will be based on industry standards but a number of extensions will need to be made as (a) none of the current standards specify performance testing with adjacent band interference, (b) the standards do not stress the capabilities of modern receivers to their sensitivity limits, and (c) the standards do not correspond to all use cases of interest with respect to distribution of satellite power levels.

The following standards will be used as the bases of the tests described here. Both UE based and UE assisted AGPS devices will be tested.

- 3GPP 34.171: AGPS Minimum Performance for WCDMA/HSDPA devices (suitable for connectorized testing of 3GPP devices) [1]
- TIA-916: AGPS Minimum Performance for CDMA devices (suitable for connectorized testing of 3GPP2 devices) [2]
- CTIA v3.1: AGPS Radiated test plan for CDMA and WCDMA/HSDPA devices: suitable for radiated testing (in a chamber) of both 3GPP and 3GPP2 devices [3]

While most of the testing will emulate proximity to LightSquared base stations, some testing time will be dedicated to emulation of overload caused by proximate LightSquared UE's.

2. Lab Test Methodology

Devices will be exposed to Band 24 power from signals that are representative of LightSquared's planned ATC base stations and UE's. The planned levels and spectrum occupancies are shown in Figure 1; high level block diagrams of the test set up are show in Figure 2 and 3.

The exposure of GPS devices to high power ATC signals will be emulated through the use of conducted injection of adjacent band signals into the device under test (DUT), as well as radiated injection of the same in an anechoic chamber. Care will be taken to ensure that the out-of-band-emission (OOBE) power spectral density (PSD) of the emulated base station signals in the RNSS band (1559 – 1605 MHz), relative to the in-band power of the Band 24 signal, is consistent with LightSquared's base station

[2] Per ITU designation, this is also referred to as the MSS L-band and is at: 1525 – 1559 MHz for downlink transmissions and 1626.5 – 1660.5 MHz for uplink transimmions.

emission mask, which specifies a 125 dB reduction[3] between the in-band and out-of-band PSD in the RNSS band. Special LS provided transmit filters will be used that will ensure that, in conjunction of the PSD roll off of the LTE signal, the emulated base station signals have a PSD at the L1 frequency that is at least 16 dB below the system noise floor of the GPS receiver at the antenna connector, for all blocker power levels at which a measurement is performed. Instead of true LTE signals, bandpass filtered Gaussian noise, with an in-band PSD characteristic similar to that of 5 MHz wide LTE, may be substituted.

For testing with Band 24 UE signals, LTE signal generators producing out-of-band emissions according to 3GPP TS 36.101, Band 24, and transmitting at the corresponding uplink frequencies must be used. The special transmit filters may not be necessary with low OOBE signal generators like the R&S SMU200A, depending on the blocker level used. This subject is still under study. Appropriate bandpass filters suitable for uplink interference testing have been ordered by LightSquared and will be used if required.

Appendix I provides an example of test equipment that may be used in the lab setups.

2.1. Test Summary

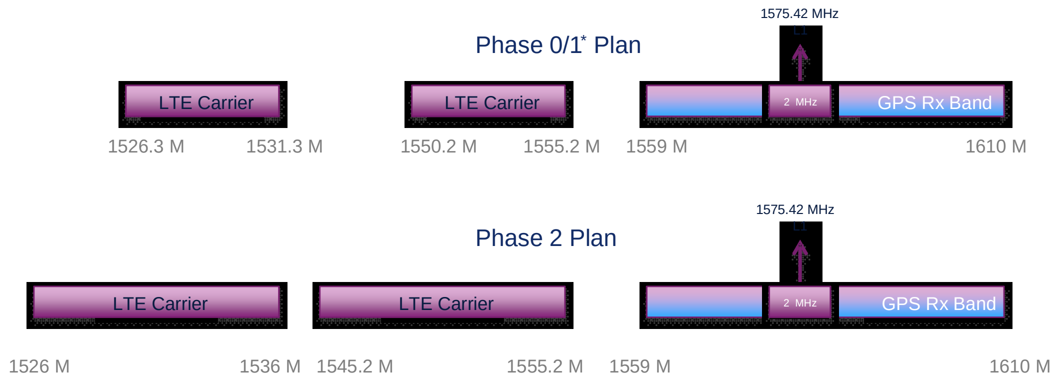
The performance of each device under test (DUT) will be tested in the presence of simulated Band 24 downlink and uplink signals and simulated GPS satellite signals from a signal generator. This GPS simulator has the ability to create a summation of received GPS signals from different satellites (space vehicles, or SV's).

2.2. Lab Test Variables

The GPS constellation on the GPS signal generator will be configured with 8 SVs. The GPS received signal power settings will be set as described in the individual test cases described below.

Tests will be performed for the spectrum occupancy corresponding to Phase 1 (two 5 MHz LTE carriers) as shown in Figure 1. Phase 1 is selected as it is likely to comprise the worst case in terms of overload potential – it creates 3rd order IM products at the L1 frequency and has the highest power density closest to the RNSS band. Testing will also be performed with the 5 MHz LTE carriers individually – this may show whether 3rd order IM products are a major contributor to any observed performance degradation.   At the discretion (basis TBD) of the TWG Cellular Subgroup, some devices may also be subjected to testing with Phase 2 signals.

[3] The 125 dB rejection is based on transmitting 32 dBW in a 5 MHz carrier (resulting a PSD of 25 dBW/MHz) and achieving a PSD of -100 dBW/MHz in the RNSS band (1559 – 1605 MHz).



*Only upper 5-MHz LTE carrier is used in Phase-0. Both 5-MHz carriers are used in Phase-1

Figure 1: LightSquared Downlink LTE Band 24 and GPS Band (EIRP per carrier: 32 dBW)

2.3. Lab Environment

The Figure 2 and 3 below show the lab test setup for conducted and radiated mode testing, respectively. It is noteworthy that these figures only show the 2x10 MHz Phase 2 deployment (as an example).

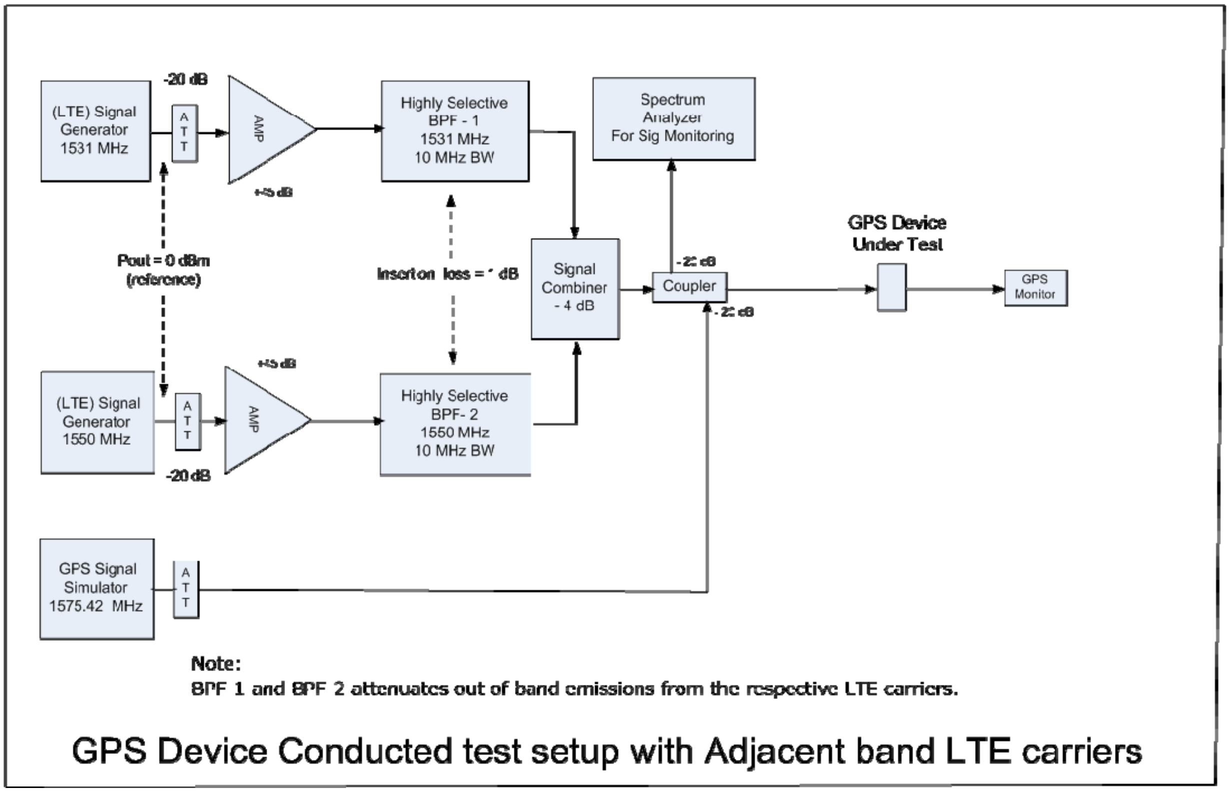


Figure 2: Lab Setup for GPS Device Conducted Test (Overload from BTS signal).

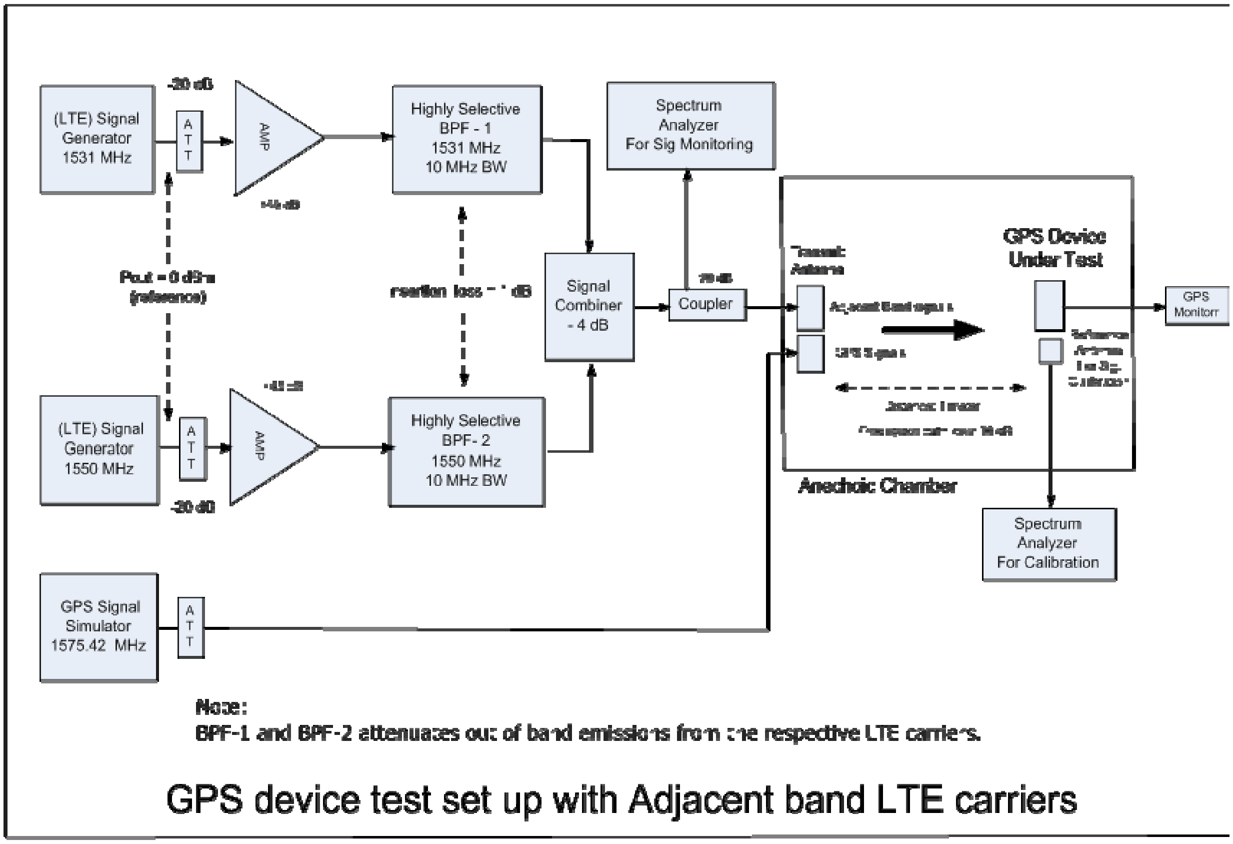


Figure 3: Lab Setup for GPS Device Radiated Test (Overload from BTS signal).

2.4. Test Execution

The tests described below will be performed. All tests are foundationally based on the standards specified in Section 1.

The following key performance indicators (KPI's), as defined in the relevant standards, will be logged:

a. 2D position error[4]
b. Response Time

C/N_0, as reported by the GPS, receiver will also be logged if it is available on the accessible interfaces of the receiver. Furthermore, the GPS SV power level will also need to be logged in order to perform the tests as per the standards.

In addition to determining the threshold values of Band 24 power levels where "failure", as defined in the standards, is encountered, all tests will be extended to higher levels of Band 24 power until any one of the following conditions is met:

[4] It is recognized that, in the case of UE based position reporting (contrasted with UE assisted position reporting), special software (non-native to the UE) may be required to read position measurements logged by the UE.

- lock cannot be maintained simultaneously on at least 3 satellites (i.e. the 4th satellite encounters consistent loss of lock, as observed continuously over a period of time to be finalized by the test team)
- the device fails to provide a GPS-based position report
- the Band 24 Signal power at the DUT antenna connector exceeds -20 dBm.

The KPI's described above will be recorded as functions of Band 24 power levels from zero power until any one of the conditions described above is met. There is no pass/fail criterion in this test – simply logging of KPI's at different blocker power levels. In this document, this is referred to as *full range testing*.

When testing at blocker levels beyond the point where a defined pass/fail criterion has been met, the number of trials at each blocker level will be set at a fixed number (75) and the 67% and 95% values of the KPI will be recorded.[5]

It is recommended that, procedurally, the testing for pass/fail criteria be conducted from an assumed catastrophic blocker level (e.g. --20dBm) and then reduced to no blocker. This is to ensure that test system starts with the minimum number of trials and then increments up to the maximum. Notwithstanding the above, the testing team may propose alternate methods of optimizing the test execution.

It is noteworthy that all tests described below must be performed separately for Band 24 signals corresponding to base station and UE.

It shall be ensured that tests performed with and without Band 24 signals, for a given test environment, use exactly the same satellite constellations.

As multiple labs will be used, some devices will be used as common objects and subjected to the same tests at different labs to check calibration across test sites.

2.4.1 Connectorized Device 3GPP tests

The following tests, based on 3GPP 34.171 [1] will be performed. It is noteworthy that the test values in the following sections are subject to the test tolerances in Table F.2.1 of TS 34.171 [1].

2.4.1.1 AGPS Sensitivity test with Coarse Time Assistance *as per standard*

This test will exactly follow [1, Section 5.2.1], except for the addition of Band 24 signals. A permitted exception is that the number of trials used may change from [1] to speed test time, while giving up some confidence. The sensitivity without interference will be tested using the trial methodology of [1][6]

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[5] Alternative percentile values of the CDF and the number of trials may be proposed by the testing team and used if approved by the TWG Cellular Subgroup.

[6] Number of trials still under development in [1]

It is noteworthy that the SV levels for this test are set as follows [1, Section 5.2.1.2].

GPS signal for one satellite: -142 dBm
GPS signals for remaining (7) satellites: -147 dBm

To determine the relative impact of the jammer, the above test will be performed with the Band 24 blocker signal applied to the DUT at levels including zero and the maximum value where the success criterion as defined in [1, Table 5.2.1.4] is met (the result is a pass).

Additionally, full range testing will be performed as defined in Section 2.4, ignoring the pass/fail criteria.

2.4.1.2 AGPS Sensitivity test with Coarse Time Assistance at *minimum, uniform SV power levels*

This test will exactly follow [1, Section 5.2.1], except for the addition of Band 24 signals and the use of lower SV power levels. The test will determine, for a given DUT, the lowest set of SV power levels at which the test will pass as per [1, Table 5.2.1.4], while maintaining the same number of SV's and relative SV power levels as in [1, Section 5.2.1]. This makes the test essentially similar to the CTIA OTA Sensitivity test of [3, Section 6.12.2.1].

To determine the relative impact of the jammer, the above test will be performed with the Band 24 blocker signal applied to the DUT at levels including zero and the maximum value where the success criterion as defined in [1, Table 5.2.1.4] is met (the result is a pass). However, notwithstanding the above, the application of the blocker signal may be omitted in this test if the levels necessary to induce failure are found to be very low (below -70 dBm). In that case, this becomes a test purely of the DUT sensitivity without the blocker.

2.4.1.3 AGPS Sensitivity Test with Coarse Time Assistance at *discrete, uniform SV power levels*

The test of ([1], Section 5.2.1) will be performed at the following discrete levels for the 7 lower powered SV's instead of the -147 dBm in the standard: -135, -149, -152 dBm. The 8^{th} SV is 5 dB above the other 7 SV's for each case. The testing is identical to that described in Section 2.4.1.1 in all other respects.

2.4.1.4 AGPS Nominal Accuracy test *as per standard*

This test will exactly follow [1, Section 5.3], except for the addition of Band 24 signals.

It is noteworthy that the SV levels for this test as set as follows [1, Section 5.3.5].

GPS signals for all (8) satellites: -130 dBm

To determine the relative impact of the jammer, the above test will be performed with the Band 24 blocker signal applied to the DUT at levels including zero and the maximum value where the success criterion as defined in [1, Table 5.3.4] is met (the result is a pass). Note the number of trials used presently follows [1] but is under sturdy.

Additionally, full range testing will be performed as defined in Section 2.4, ignoring the pass/fail criteria.

2.4.1.5 AGPS Nominal Accuracy test with *different SV power levels*

This test will exactly follow [1, Section 5.3], except for the addition of Band 24 signals and the use of the following SV power levels: -125, -128, -131, -134, -137, -140, -143, -146 dBm.

To determine the relative impact of the jammer, the above test will be performed with the Band 24 blocker signal applied to the DUT at levels including zero and the maximum value where the success criterion as defined in [1, Table 5.3.4] is met (the result is a pass). Note the number of trials used presently follows [1] but is under sturdy.

Additionally, full range testing will be performed as defined in Section 2.4, ignoring the pass/fail criteria.

2.4.2 Connectorized Device 3GPP2 tests

The following tests, based on TIA-916 [2] will be performed on 3GPP2 compliant devices. All general requirements mentioned in Section 2.4 also apply here.

2.4.2.1 GPS Sensitivity Test *as per standard*

The test will exactly follow ([2], Section 2.1.1.3) except for the addition of Band 24 signals.

Per standard, the mobile device will return a **Provide Location Response** message if the mobile station is capable of location computation; or it shall return one or more **Provide Pseudorange Measurement** messages if it is not capable of location computation.

The measurement method will be as described in [2, Section 2.1.1.3.2]. In summary, the GPS SV signal levels will -147 dBm with C/No of 27 dB-Hz with 4 SVs visible.

The pass/fail criterion is as per the minimum standard set forth in [2, Table 2.1.1.3.3-1]. In summary the mobile device will provide the Pseudorange Measurements and Location Responses within the limit values defined in applicable table.

To determine the relative impact of the jammer, the above test will be performed with the Band 24 blocker signal applied to the DUT at levels including zero and the maximum value where the success criterion as defined in [2, Table 2.1.1.3.3-1] is met (the result is a pass).

Additionally, full range testing will be performed as defined in Section 2.4, ignoring the pass/fail criteria.

2.4.2.2 GPS Sensitivity Test at *minimum, uniform SV power levels*

The test will exactly follow [2, Section 2,1.1.3] except for the addition of Band 24 signals and the use of alternative satellite signal levels.

Per standard, the mobile device will return a **Provide Location Response** message if the mobile station is capable of location computation; or it shall return one or more **Provide Pseudorange Measurement** messages if it is not capable of location computation.

The measurement method will be as described in [2, Section 2.1.1.3.2]. Instead of the SV levels used in the standard test case, this test will *determine* the minimum GPS SV signal level, with 4 SV's visible, where the pass/fail criterion defined in [2, Table 2.1.1.3.3-1] is passed.

To determine the relative impact of the jammer, the above test will be performed with the Band 24 blocker signal applied to the DUT at levels including zero and the maximum value where the success criterion as defined in [2, Table 2.1.1.3.3] is met (the result is a pass). However, notwithstanding the above, the application of the blocker signal may be omitted in this test if the levels necessary to induce failure are found to be very low (below -70 dBm). In that case, this becomes a test purely of the DUT sensitivity without the blocker.

2.4.2.3 GPS Sensitivity Test at *discrete, uniform SV power levels*

The test of ([2], Section 2.1.1.3) will be performed at the following discrete SV levels: -135, -149, -152 dBm instead of the -147 dBm in the standard. The testing is identical to that described in Section 2.4.2.1 in all other respects.

2.4.2.4 GPS Accuracy *as per standard*

The test will exactly follow [2, Section 2.1.1.1] except for the addition of Band 24 signals.

Per standard, the mobile device will return a **Provide Location Response** message
if the mobile station is capable of location computation; or it shall return one or more
Provide Pseudorange Measurement messages if it is not capable of location computation.

The measurement method will be as described in [2, Section 2.1.1.1.2]. In summary the GPS SV signal levels will be -130 dBm with C/No of 44 dB-Hz with 8 SV's visible.

The pass/fail criterion is defined per the minimum standard set forth in [2, Table 2.1.1.1.3-1]. In summary the mobile device will provide the Pseudorange Measurements and Location Responses within the limit values defined in the applicable table.

To determine the relative impact of the jammer, the above test will be performed with the Band 24 blocker signal applied to the DUT at levels including zero and the maximum value where the success criterion as defined in [2, Table 2.1.1.3.3-1] is met (the result is a pass).

Additionally, full range testing will be performed as defined in Section 2.4, ignoring the pass/fail criteria.

2.4.2.5 GPS Accuracy Test with *non-uniform SV power levels*

The test will be performed as exactly defined in Section 2.4.2.4 with the following exception: the following SV power levels will be used: -125, -128, -131, -134, -137, -140, -143, -146 dBm.

To determine the relative impact of the jammer, the above test will be performed with the Band 24 blocker signal applied to the DUT at levels including zero and the maximum value where the success criterion as defined in [2, Table 2.1.1.1.3-1] is met (the result is a pass).

Additionally, full range testing will be performed as defined in Section 2.4, ignoring the pass/fail criteria.

2.4.3 Radiated Tests

The radiated tests are only performed for certain 3GPP devices which are not available with wired connectors attached to the DUT's antenna port. All 3GPP2 devices and some 3GPP devices are expected to be available with wired connectors and will be tested in the conducted mode.

The objective is to run the 3GPP TS34.171 based tests [1] described in Section 2.4.1 but leveraging the CTIA OTA tests in [3] to the maximum extent. In particular, the following approaches will be taken.

2.4.3.1 Sensitivity Test *(minimum, uniform SV power levels)*

The *minimum SV level* sensitivity tests described in Section 2.4.1.2 and 2.4.2.2 are essentially identical to the Sensitivity test defined in [3, Section 6.12.2.1] without the blocker. This test will be run both with and without the blocker to determine the relative impact of the blocker. As in Section 2.4.1.2 and 2.4.2.2, it is anticipated that the maximum blocker level required to induce failure at the SV's corresponding to the sensitivity point may be very low (less than -70 dBm), in which case the injection of the blocker signal may be omitted.

It is noteworthy that, as per the standard [3, Section 6.12.2.1], this test is performed with the SV (and blocker signals if present) injected from the direction of greatest antenna pattern sensitivity of the DUT.

2.4.3.2 Other tests of 3GPP TS34.171

Tests described in Sections 2.4.1.1 and 2.4.1.3 to 2.4.1.5 fall in this category. All of these tests can be performed as *virtual connected mode tests* by calibrating the antenna gain of the DUT towards the angle-of-arrival (AoA) of the signal radiated by the Measurement Antenna (MA). This is done as a normal part of setting up the CTIA OTA tests. The tests will be performed by radiating the SV signals from the Angle-of-Arrival (AoA) corresponding to greatest sensitivity for the DUT[7].

Knowledge of the DUT antenna gain towards the AoA of the radiated SV signals (all SV signals are summed and radiated from a single direction) allows the SV power levels at the DUT's antenna connector to be predicted. The blocker signal is linearly added to the SV signals before they are injected into the chamber. Therefore its level at the antenna connector is also predictable.

The above method of signal injection means that the SV signals and the blocker signal enter the DUT with the same antenna gain. This would *actually* be the case if the DUT antenna had isotropic receive gain. As this is unlikely to be the case in reality, and as the AoA's of the SV's and the blocker are indeterminate and therefore associated with unknown gains, in the interpretation of results, an adjustment will be made of the blocker level corresponding to the difference between the pattern gain

[7] It is noteworthy that the insertion of the composite signal (SV + blocker) from the AoA of greatest sensitivity is simply a testing convenience that preserves the dynamic range of the SV and blocker signal generators. There is no implied claim that this is actually the direction from which the signals will enter the DUT. In reality, the AoA's of each SV and the blocker will be different and be associated with unknown gains. The difference in the *average gains* faced by the SV's and the blocker is accounted from by an adjustment factor described below.

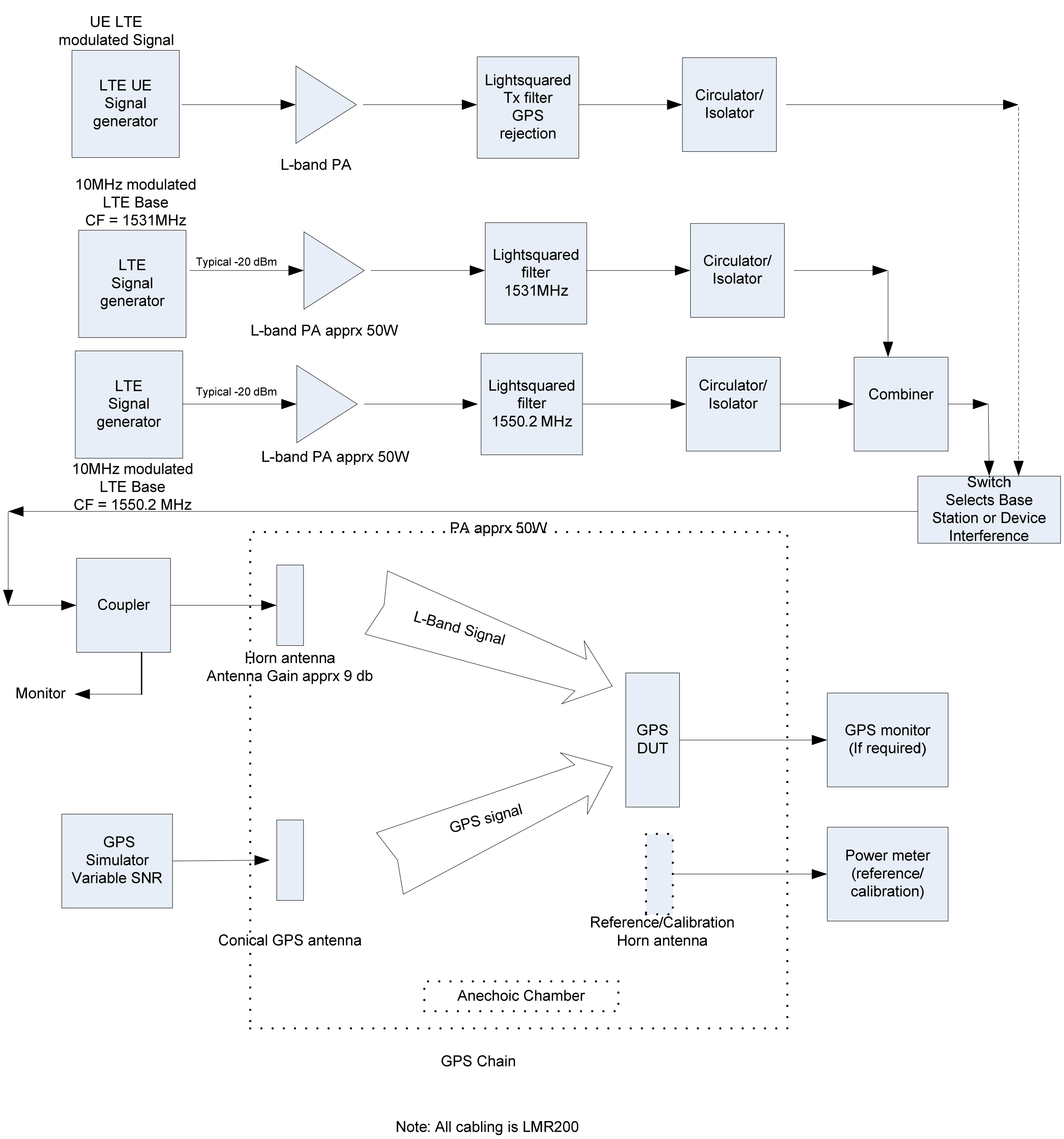
averaged over the upper hemisphere (corresponding to AoA's associated with the SV's) relative to the pattern gain averaged in elevation over +/- 30^0 and over all azimuths.

The above requires the pattern gains to be known over the relevant AoA domains. It is understood that the procedures for setting up the tests of [3] provide this information.

Appendix I

This section shows an example block diagram for a radiated test setup and is followed by a suggested equipment list.

Equipment Block Diagram. Radiated Test for Anechoic Chamber



Example Equipment List

Band-24 Chain

Number required	Equipment	Manufacturer	Model
2	Vector Signal Generator (used to generate LTE signals for Base Station)	Agilent	E4438C w/ Options: 005 – Hard Drive 602 – Dig Bus Baseband 1E5 – High Stability Time Base 503 – 250 kHz to 3 GHz
1	LTE Signal Generator (used to generate LTE signals for UE)	**Agilent**	E4438C
2	Amplifier	Comtech	ARD8829 50 or ARD88285 50
2	Band Pass Filter	Lightsquared	1531MHz and 1550.2MHz
2	RF Isolator	MECA	CN 1.500
2	Power Combiner	MECA	H2N - 1.500V
1	Directional Coupler	Mini Circuits	ZGDC20-33HP
Multiple	Cable	Microwave Systems	LMR200
2	Transmission Antenna and Reference/Calibration antenna	AH Systems	SAS-751 Horn 9.5dBi gain
1	Power meter reference and calibration	Agilent	E4419B

GPS Chain

Number required	Equipment	Manufacturer	Model
1	GPS Simulator	Spirent	Spirent GSS6700, GSS6560, or GSS5060
1	Transmission Antenna	ETS-Lindgren	3201 Conical Antenna (RHCP)
Multiple	Cable	Microwave Systems	LMR200
N/A*	Power meter reference and calibration	Agilent	E4419B
N/A*	Reference/Calibration antenna	AH Systems	SAS-751 Horn 9.5dBi gain

* - The same equipment can be used for both the L-band chain and the GPS chain as they are for calibration.

Recommended configuration of LTE Signal from Base Station

If using the Agilent E4438C ESG vector signal generator, the latter needs to be loaded with the Agilent N7624B Signal Studio with the 3GPP LTE FDD option package.

Name	Setting	Comment
Center frequencies	For 2 x 5 MHz Downlink channels LTE Carriers centered @ 1552.7 MHz and @ 1528.8 MHz, BW:5 MHz For 2 x 10 MHz Downlink channels LTE Carriers centered @ 1531 MHz and @ 1550.2 MHz , BW:10 MHz	According to test
Release	3GPP R8	
Duplexing	FDD	
Modulation	OFDM/OFDMA	
Frame Duration	10 ms	
Sub frame Duration	1.0 ms	
Subcarrier Modulation	QPSK	For PCH , PDCCH, PDSCH
Subcarrier Size	15 KHz	
Channel Bandwidth	5/10 MHz	According to test
PRB Bandwidth	0.180 MHz	
Sampling Rate	7.68 MHz / 15.36 MHz	According to channel size 7.68 MHz for 5MHz channel and 15.36 MHz for 10 MHz channel
FFT Size	512/1024	According to channel size 512 for 5MHz channel and 1024 for 10 MHz channel
Dummy Data	PN9	

Recommended configuration of LTE Signal from UE

The Rohde and Schwarz CMU200A Vector Signal Generator, configured with worst case scenario for GPS interference - device operating at the lowermost single RB of lower LTE channel with full power

Name	Setting	Comment
Center frequencies	LTE Carriers centered @ 1632.5 MHz	According to test
Release	3GPP R8	
Duplexing	FDD	
Modulation	OFDM/OFDMA	
Allocation	1 Leftmost RB Frequency 1628-1628.180	
RB Bandwith	180 kHz	
UE power	23 dBm	
Subcarrier Modulation	QPSK	
Dummy Data	PN9	

A-GPS Systems Required for Test Plan Execution

Spirent A-GPS Test systems will be used to conduct the 3GPP2 TIA-916, 3GPP 34.171, and CTIA OTA testing. In addition, specific scripts will be provided by Spirent to automate the Interferer setup and power level sweeps in conjunction with A-GPS performance testing and metric analysis. The following Spirent solutions are required for this test plan:

2.4.1 Connectorized Device 3GPP tests:

- Spirent 8100-A500 UMTS Location Test System (ULTS)
- Test Pack: TM-LBS-3GPP-TS34.171

2.4.2 Connectorized Device 3GPP2 tests

- Spirent C2K-ATS Position Location Test System (PLTS)
- Test Pack: PLTS-MP-SET (PLTS C.S0036 SOFTWARE BUNDLE)

2.4.3 Radiated Tests (UMTS Devices)

- Spirent 8100-A500 or 8100-A750 UMTS Location Test System (ULTS)
- Test Pack: TM-LBS-OTA

2.4.3 Radiated Tests (CDMA Devices)

- Spirent C2K-ATS Position Location Test System (PLTS)
- Test Pack: PLTS-OTA-01

References

[1] 3GPP TS 34.171
[2] TIA-916
[3] CTIA v3.1

Detailed Test Plan

General Location / Navigation Sub-Team

Draft Version 1.3

April 8, 2011

Introduction

The following detailed test plan describes the equipment, setup and methods for measuring the susceptibility of various GPS receivers to interference from LightSquared LTE transmitters operating in the Mobile Satellite Service (MSS) L-band. Any modifications to or deviations from this test plan must be approved by the members of the General Location / Navigation Sub-Team.

Test Equipment and Setup

Overview:

The general parameters for test are to provide an interfering set of signals at the LightSquared downlink and uplink frequencies in the presence of a controlled set of GPS signals. Figure 1 illustrates the basic test setup for testing interference from the LightSquared downlink.

All tests contained in this document shall be performed as radiated tests in a FCC-approved RF anechoic or semi-anechoic chamber. (A GigaHertz Transverse Electromagnetic (GTEM) cell may be substituted for select tests with the approval of the sub-group.) The test lab shall calibrate the chamber with the understanding that all power references in this document are specified as radiated power (EIRP) incident on the DUT. It is not anticipated that the power level from the LightSquared downlink source at the receiver will be high enough to require additional isolation from the other sources. Also, if the test lab chooses to use RF switches (as indicated in the block diagram) to reduce test time, high quality mechanical RF switches rated for at least 18GHz shall be used.

In order to maintain consistency and ensure uniform product set-up between DUTs and manufacturers, all tests shall be run in accordance with ANSI C63.4. The FCC specifies ANSI C63.4 for all radiated tests.

Specific manufacturers and models of test equipment are mentioned throughout this document. These are provided for reference. The test lab may make equivalent equipment substitutions with approval from the General Navigation Sub-group.

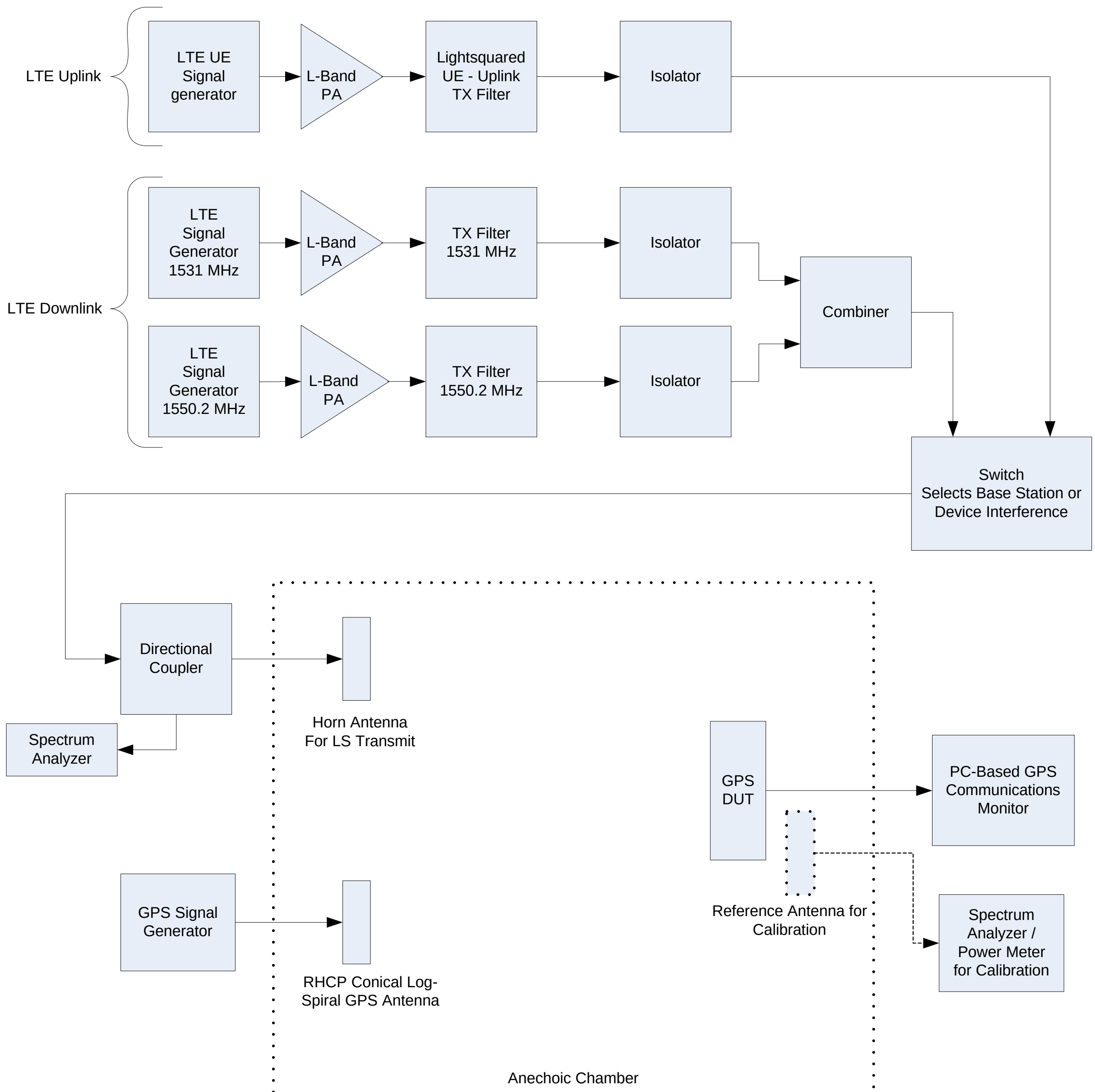


Figure 3 – Simplified Test Equipment Block Diagram: Radiated Immunity Tests

LightSquared Downlink Source:

Recommended Test Equipment

The test equipment recommended for simulating this source is listed in Table 1. Equivalent equipment may be substituted with the permission of the sub-group members (except where noted).

Equipment	Manufacturer	Model	QTY
Vector Signal Generator	Agilent	E4438C	2
Signal Studio for 3GPP LTE FDD	Agilent	N7624B	2
Amplifier	Comtech	ARD8829 50 or ARD88285 50	2
Band Pass Filter	RF Morecomm	RMC1531B10M01	1
	RF Morecomm	RMC1550B10M01	1
RF Isolator	MECA	CN 1.500	2
Power Combiner	MECA	H2N - 1.500V	1
Directional Coupler	Mini Circuits	ZGDC20-33HP	1
TX Antenna	AH Systems	SAS-751 Horn 9.5dBi gain	1

Table 1: Test Equipment – LS Downlink

Test Equipment Setup

Two vector signal generators capable of producing LTE modulation shall be used to simulate the LightSquared downlink transmitters at 1531 MHz and 1550 MHz. The signal bandwidth shall either bet 5 MHz or 10 MHz depending on whether Phase 0, 1, or 2 signals are being tested. Table 2 provides the LTE signal setup parameters. The signals shall be amplified and filtered using the LightSquared provided transmit filters. The signals shall then be combined and fed to the Transmit Antenna. Both vertically and horizontally polarized signals shall be radiated on the DUT. The Horn antenna shall be polarized vertically for the first set of tests and then the tests shall be repeated with the horn horizontally polarized.

Parameter	Setting	Comment
Center Frequency	1552.7 MHz	Phase 0
	1528.8 MHz & 1552.7 MHz	Phase 1
	1531 MHz and @ 1550.2 MHz	Phase 2
Release	3GPP R8	
Duplexing	FDD	
Modulation	OFDM/OFDMA	
Frame Duration	10 ms	
Sub frame Duration	1.0 ms	
Subcarrier Modulation	QPSK	For PCH , PDCCH, PDSCH
Subcarrier Size	15 KHz	
Channel Bandwidth	5 MHz	Phase 0 / 1
	10 MHz	Phase 2
PRB Bandwidth	0.180 MHz	
Sampling Rate	7.68 MHz	Phase 0 / 1
	15.36 MHz	Phase 2
FFT Size	512	Phase 0 / 1
	1024	Phase 2
Dummy Data	PN9	

Table 2: LTE Downlink Signal Setup Parameters

Calibration

The power of the sources shall be measured at the directional coupler as well as at the reference antenna in order to establish the losses due to the equipment setup. The net loss shall be documented in the test report. The reference antenna shall then be removed from the anechoic chamber and the DUT shall be substituted in its place. The reference antenna may be substituted with a field measuring probe and test chamber may be calibrated according to EN 61000-4-3.

LightSquared Uplink Source:

Recommended Test Equipment

The test equipment recommended for simulating this source is listed in Table 3. Equivalent equipment may be substituted with the permission of the sub-group members (except where noted).

Equipment	Manufacturer	Model	QTY
Vector Signal Generator	TBD Waiting on LightSquared		1
			1
Amplifier	Comtech	ARD8829 50 or ARD88285 50	1
Band Pass Filter	TBD	TBD	1
RF Isolator	MECA	CN 1.500	2
Power Combiner	MECA	H2N - 1.500V	1
Directional Coupler	Mini Circuits	ZGDC20-33HP	1
TX Antenna, Horn	AH Systems	SAS-751	1

Table 3: Test Equipment – LS Uplink

Test Equipment Setup

A vector signal generator capable of producing LTE modulation shall be used to simulate the LightSquared uplink transmitter. The low, middle, and high channel shall be simulated. Table 4 provides the LTE signal setup parameters. The signal shall be amplified and filtered using a LightSquared provided transmit filter. The signal shall then be fed to the Transmit Antenna. Both vertically and horizontally polarized signals shall be radiated on the DUT. The Horn antenna shall be polarized vertically for the first set of tests and then the tests shall be repeated with the horn horizontally polarized.

Parameter	Setting	Comment
Center Frequency	TBD (waiting on update from LightSquared)	
Release		
Duplexing		
Modulation		
Frame Duration		
Sub frame Duration		
Subcarrier Modulation		
Subcarrier Size		
Channel Bandwidth		
PRB Bandwidth		
Sampling Rate		
FFT Size		
Dummy Data		

Table 4: LTE Downlink Signal Setup Parameters

Calibration

The source power shall be measured at the directional coupler as well as at the reference antenna in order to establish the losses due to the equipment setup. The net loss shall be documented in the test report. The reference antenna shall then be removed from the chamber and the DUT shall be substituted in its place. The reference antenna may be substituted with a field measuring probe and test chamber may be calibrated according to EN 61000-4-3.

GPS Simulator Source:

Recommended Test Equipment

The test equipment recommended for simulating this source is listed in Table 5. Equivalent equipment may be substituted with the permission of the sub-group members (except where noted).

Equipment	Manufacturer	Model	QTY
Satellite Simulator	Spirent	GSS 6700*	1
Record Playback System	Spirent	GSS 6400*	1
Active GPS Patch Antenna for Live Test Recording	TBD	TBD*	1
GPS Transmit Antenna, RHCP Conical Log-Spiral	ETS-Lindgren	3102	1
GPS Communications Monitor	Provided by DUT Manufacturer	N/A	1

** Substitutes are not allowed for this equipment.*

Table 5: Test Equipment – GPS Signals

Static Use Case Simulator Setup: *A Spirent GSS 6700 (or equivalent) shall be used to simulate the following satellite signals under static conditions.*

Exactly 5 GPS satellites transmitting C/A code only
Highest elevation satellite at maximum power (-119.5 dBm) (per GPS SPS, including maximum satellite antenna gain- DO-229D 2.1.1.10)
Lowest elevation satellite at minimum power (-128.5 dBm) (per GPS SPS, including minimum satellite antenna gain - DO-229D 2.1.1.10)
The other three (3) satellites shall be 3 dB higher than the satellite at minimum power (-125.5 dBm)
HDOP range from 1.4 to 2.1

Dynamic Use Case Simulator Setup: *A Spirent GSS 6700 (or equivalent) shall be used to simulate the following satellite signals under dynamic conditions.*

Exactly 6 GPS satellites transmitting C/A code only
HDOP range from 1.4 to 2.1
Reference signal power for all satellites: -127 dBm
Trajectory Description: A rectangular trajectory with rounded corners similar to the trajectory described in section 5.6.4.1 of 3GPP TS 34.172 v10.0.0. This scenario is a rectangle 940m by 1440m with various linear acceleration and deceleration profiles and an angular acceleration of 2.4 m/s^2 in the turns.

Dynamic Use Case Record Playback System Setup: *Representative signals for each of the following scenarios shall be recorded using a Spirent GSS 6400 Record Playback System to ensure that the same scenario can be replayed consistently for all tests. A* *calibrated RHCP patch antenna shall be used to collect the data and shall be oriented in a manner consistent the use case being recorded, as specified below.*

PND Use Case 1: Suburban

The DUT is mounted on the dash of a vehicle which is moving in a suburban, tree lined environment. The DUT will experience frequent changes of direction, obscuration of signals by the roof of the car, and mild dynamics. This use case shall be recorded with a predetermined route specified by the sub-group.

PND Use Case 2: Urban Canyon

The DUT is mounted on the dash of a vehicle which is moving in an urban canyon environment. The DUT will experience frequent changes of direction, obscuration of signals by the roof of the car, and mild dynamics. This use case shall be recorded in downtown Chicago with a predetermined route specified by the sub-group.

Outdoor Use Case: Deep Forest

The DUT is held in the hand of a moving user while walking in a deep forest environment when leaves are on the trees. The DUT will experience some dynamics associated with walking. This use case shall be recorded with a predetermined route specified by the sub-group.

Fitness Use Case: Arm Swing Environment

The DUT is mounted on the arm of a user who is swinging his/her arms in a manner consistent with distance running. The DUT will experience frequent heading changes and the signal will be obscured by the body at times. Stressful dynamics are associated with the arm swing. This use case shall be recorded with a predetermined route specified by the sub-group.

Calibration

The source power shall be measured at the output of the GPS satellite simulator as well as at the reference antenna in order to establish the losses due to the equipment setup. Due to the low signal power in the GPS band, a Network Analyzer should be substituted into the test setup and used for calibration. The net loss shall be documented in the test report. The Network Analyzer shall be removed from the setup. Likewise, the reference antenna shall then be removed from the anechoic chamber and the DUT shall be substituted in its place. The reference antenna may be substituted with a field measuring probe and test chamber may be calibrated according to EN 61000-4-3.

Test Plan Summary

The number of tests and configurations required for each DUT is quite large due to many variables and constraints that require investigation. The test matrices in Tables 6 and 7 provide a concise summary of these tests. Details relating to specific tests can be found in Sections IV and V. The members of the General Navigation sub-group may choose to omit some test cases for certain devices, but only with unanimous consent from all members. A complete list of devices to be tested can be found in Appendix A.

		LightSquared Interference - Downlink			
		Phase 0 --> 5 MHz BW		Phase 1 --> 5 MHz	Phase 2 --> 10 MHz
	Test Item	1552.7 MHz	1528.8 MHz	1552.7 MHz * 1528.8 MHz	1552.7 MHz * 1528.8 MHz
Static Test Cases	Interference Susceptibility Test	X	X	X	X
	Interference Susceptibility Test (Acquisition Sensitivity)	X	X	X	X
	TTFF - Cold Start	X	X	X	X
	TTFF - Warm Start	X	X	X	X
	WAAS Demodulation Test - Cold Start to Differential Fix	X	X	X	X
Dynamic Test Cases	Simulated Position and Velocity Tests	X	X	X	X
	Naviation Position and Velocity Tests	X	X	X	X
	TTFF - Cold Start	X	X	X	X
	TTFF - Warm Start	X	X	X	X

Table 6: Test Matrix – Downlink Tests

		LightSquared Interference - Uplink		
		1626.5 - 1660.6 MHz		
	Test Item	Low Channel	Mid Channel	High Channel
Static Test Cases	Interference Susceptibility Test	X	X	X
	Interference Susceptibility Test (Acquisition Sensitivity)	X	X	X
	TTFF - Cold Start	X	X	X
	TTFF - Warm Start	X	X	X
	WAAS Demodulation Test - Cold Start to Differential Fix	X	X	X
Dynamic Test Cases	Simulated Position and Velocity Tests	X	X	X
	Naviation Position and Velocity Tests	X	X	X
	TTFF - Cold Start	X	X	X
	TTFF - Warm Start	X	X	X

Table 7: Test Matrix – Uplink Tests

Stationary Tests

Interference Susceptibility Test

Test Setup: *The device under test (DUT) shall be exposed to test signals per Section II.D.2. Use a communications monitor (provided by manufacturer) to record the baseline C/N_0 reported by the GPS receiver.*

Measurement Parameters: *Measure and record interfering simulated LightSquared transmitter power levels that result in 1dB, 3dB, 6dB, 10dB, and 20dB degradations in reported C/N_0, as well as a complete loss of fix.*

Key Performance Indicator (KPI): *C/N_0 Degradation from Baseline (dB-Hz)*

Interference Susceptibility Test (Acquisition Sensitivity)

Test Setup: *The device under test (DUT) shall be exposed to test signals per Section II.D.2. Use a communications monitor (provided by manufacturer) to delete ephemeris (including predicted ephemeris) and restart the acquisition engine. Then iterate the GPS signal level to find the baseline Acquisition sensitivity (minimum level at which the receiver can acquire a GPS signal) reported by the GPS receiver.*

Measurement Parameters: *Measure and record the acquisition sensitivities that result from the LightSquared transmitter power levels measured in Section 0, above. (Note, ephemeris must be deleted and the acquisition engine restarted prior to each iteration/trial).*

Key Performance Indicator (KPI): *Acquisition Sensitivity (dBm)*

TTFF (Time to First Fix) - Cold Start

Test Setup: *The device under test (DUT) shall be exposed to test signals per Section II.D.2. Use a communications monitor (provided by manufacturer) to delete ephemeris (including predicted ephemeris), time, position, and almanac. Then restart the acquisition engine to simulate a* ***Cold Start*** *condition. The command to cold start the device shall be issued 10 s after the playback is started. Measure the TTFF over several iterations on the DUT (with no interference present) and record that level as the baseline TTFF.*

Measurement Parameters: *Start by measuring and recording the LightSquared transmitter power level that results in the inability of the DUT to obtain a fix within 3 minutes. Decrease the LightSquared transmitter power level in 3dB increments and record TTFF until no further change is observed. Also record C/N_0 for each satellite after the DUT has acquired a fix.*

Key Performance Indicator (KPI): *TTFF (s)*

TTFF - Warm Start

Test Setup: *The device under test (DUT) shall be exposed to test signals per Section II.D.2. Use a communications monitor (provided by manufacturer) to delete ephemeris (including predicted ephemeris) and restart the acquisition engine to simulate a*

Warm start *condition. The command to warm start the device shall be issued 10 s after the playback is started. Measure the TTFF over several iterations on the DUT (with no interference present) and record that level as the baseline TTFF.*

Measurement Parameters: *Start by measuring and recording the LightSquared transmitter power level that results in the inability of the DUT to obtain a fix within 3 minutes. Decrease the LightSquared transmitter power level in 3dB increments and record TTFF until no further change is observed. Also record C/N0 for each satellite after the DUT has fixed.*

Key Performance Indicator (KPI): *TTFF (s)*

WAAS Demodulation Test

Test Setup: *The device under test (DUT) shall be exposed to test signals per Section II.D.2 with the addition of a WAAS PRN and Signal in Space. Use a communications monitor (provided by manufacturer) to delete ephemeris (including predicted ephemeris), time, position, and almanac. Then restart the acquisition engine to simulate a* ***Cold start*** *condition. The command to cold start the device shall be issued 10 s after the playback is started. Measure the TTFF of a Differential Fix over several iterations on the DUT (with no interference present) and record that level as the baseline TTFF.*

Measurement Parameters*: Start by measuring and recording the LightSquared transmitter power level that results in the inability of the DUT to obtain a fix within 5 minutes. Decrease the LightSquared transmitter power level in 3dB increments and record the following for each measurement until no further change is observed.*

TTFF – Differential (Time to First Differential Fix)
WAAS Satellite Bit Error Rate Degradation
(some receivers may not support this test)
Loss of Frame Synchronization - increase in age of differential correction
(some receivers may not support this test)

Key Performance Indicator (KPI): *TTFF - Differential*

<u>Dynamic Tests</u>

Simulated Position and Velocity Tests

Test Setup*: The device under test (DUT) shall be exposed to simulated GPS signals per Section II.D.3. Use a communications monitor (provided by manufacturer) to measure and record the parameters detailed in the Measurement Parameters Section at 1 Hz intervals. Record baseline measurements without interference from the LightSquared transmitter.*

Measurement Parameters: *Collect the following data (at 1Hz intervals) for each DUT in the presence of the LightSquared transmitter at the power levels measured in Section IV.A. Then record the deltas from the baseline measurements.*

Reported position including latitude, longitude, and altitude
Reported velocity
Reported Time
Reported C/N_0 for each satellite

Key Performance Indicators (KPIs): *Position, Velocity, and Time (PVT) Error with respect to the truth as reported by the GPS satellite simulator, C/N_0 degradation.*

Navigation Position and Velocity Tests

Test Setup*: The device under test (DUT) shall be exposed to pre-recorded test signals per Section II.D.4. The recorded scenario shall be played back per the appropriate test case. Use a communications monitor (provided by manufacturer) to measure and record the parameters detailed in the Measurement Parameters Section at 1 Hz intervals. Record baseline measurements without interference from the LightSquared transmitter.*

Measurement *t* ***Parameters:*** *Collect the following data (at 1Hz intervals) for each DUT in the presence of the LightSquared transmitter at the power levels measured in Section IV.A. Then record the deltas from the baseline measurements.*

Reported position including latitude, longitude, and altitude
Reported velocity
Reported Time
Reported C/N_0 for each satellite

Key Performance Indicators (KPIs): *Position, Velocity, and Time (PVT) Error with respect to the baseline, C/N_0 degradation*

TTFF – Cold Start

Test Setup: *The device under test (DUT) shall be exposed to pre-recorded GPS signals per Section II.D.4. The recorded scenario shall be played back per the appropriate test case. Use a communications monitor (provided by manufacturer) to delete ephemeris (including predicted ephemeris), time, position, and almanac. Then restart the acquisition engine to simulate a* ***Cold Start*** *condition. The command to cold start the device shall be issued 10 s after the playback is started. Measure the TTFF over several iterations on the DUT (with no interference present) and record that level as the baseline TTFF.*

Measurement Parameters: *Start by measuring and recording the interferer power level that results in the inability of the receiver to obtain a fix. Decrease the LightSquared transmitter power level in 3dB increments and record TTFF until no further change is observed. Also record C/N_0 for each satellite after the DUT has fixed.*

Key Performance Indicator (KPI): *TTFF (s)*

TTFF – Warm Start

Test Setup*: The device under test (DUT) shall be exposed to pre-recorded GPS signals per Section II.D.4. The recorded scenario shall be played back per the appropriate test case. Use a communications monitor (provided by manufacturer) to delete* *ephemeris and restart the acquisition engine to simulate a* ***Warm Start*** *condition. The command to warm start the device shall be issued 10 s after the playback is started. Measure the TTFF over several iterations on the DUT (with no interference present) and record that level as the baseline TTFF.*

Measurement Parameters*: Start by measuring and recording the interferer power level that results in the inability of the receiver to obtain a fix. Decrease the LightSquared transmitter power level in 3dB increments and record TTFF until no further change is observed. Also record* C/N_0 *for each satellite after the DUT has fixed.*

Key Performance Indicator (KPI): *TTFF (s)*

Appendix A to General Location/Navigation Draft Test Plan

Device Category	Manufacturer	Model	Interface Capability	Manufacturer Support for Communications Monitor	Logging Capability Built into Unit
Fitness	Garmin	Forerunner 110	Y	Y	Y
		Forerunner 305	Y	Y	Y
		EDGE 500	Y	Y	Y
		EDGE 800	Y	Y	Y
Outdoor	Garmin	ETREX-H	Y	Y	Y
		Dakota 20	Y	Y	Y
		Oregon 550	Y	Y	Y
		GPSMAP 62	Y	Y	Y
		Astro 220	Y	Y	Y
		Rino 530HCx	Y	Y	Y
Tracking	Garmin	GTU 10	Y	Y	N
		DC40	Y	Y	Y
	Secure Alert	TBD			
	BI ExacuTrack® One	TBD			
Marine	Garmin	GPS 17X (NMEA)	Y	Y	Y
		GPSMAP 441	Y	Y	Y
		GPSMAP 740	Y	Y	Y
		GPSMAP 541	Y	Y	Y
		GPSMAP 546	Y	Y	Y
	Hemisphere	Vector MV101	Y	Y	N
Automotive (in dash)	GM	OnStar Model TBD			
	Garmin	GVN 54	Y	Y	Y
PND	TomTom	XL335			
		ONE 3RD Edition			
		GO 2505			
		VIA 1400/1405 or VIA 1500/1505			
		XXL 530/530S or XXL 540/540S			
		GO 720, GO 920			
		GO 730, GO 930			
	Garmin	nűvi 2X5W	Y	Y	Y
		nűvi 13XX	Y	Y	Y
		nűvi 3XX	Y	Y	Y
		nűvi 37XX	Y	Y	Y
		Zumo 550	Y	Y	Y
		StreetPilot c330	Y	Y	Y
		zumo 220	Y	Y	Y
		nuvi 760	Y	Y	Y
Portable Aviation (non-TSO)	Garmin	GPSMAP 496	Y	Y	Y
		aera® 5xx	Y	Y	Y
		GPSMAP 696	Y	Y	Y
	Honeywell Bendix/King	AV8OR			
First Responder Location	Motorola	TBD			
	TBD	TBD			
Fleet Management	Trimble	iLM2730 (with Mobile Mark Option J antenna)	Y	Y	N
		TVG-850 (with Mobile Mark Option E glass-mount antenna)	Y	Y	N
		MTS521 (with CAT Shark Fin antenna)	Y	Y	N
		DCM300G (with Taoglas Combo antenna)	Y	Y	N
Emergency Vehicles (post-OEM mounted in vehicle)	Trimble	Placer Gold	Y	Y	N
	Motorola	TBD			
Low Precision Ground Agricultural Navigation	TBD	TBD			
	Hemisphere	Outback S3	Y	Y	N

** Please note that items listed in gray are devices that the sub-group believes should be tested, but are probably not feasible due to the extremely short time frame imposed on us. **

APPENDIX F

PRECISION AND TIMING RECEIVER LIGHTSQUARED L-BAND LTE RFI TEST PLAN

REVISION HISTORY

REV	Date	Editor	DESCRIPTION
B	3/22/2011	P. Fenton	Initial Draft
C	3/25/2011	P. Fenton	Incorporating initial feedback
D	4/4/2011	P. Galyean	Incorporating result of first Sub-Team meeting
E	4/6/11	P. Galyean	Incorporating results of second Sub-Team meeting
F	4/7/11	P. Fenton	Incorporating homework
G	4/7/11	P. Fenton	Incorporating results of second Timing Team meeting
H	4/7/11	P. Galyean	Incorporating homework
I	4/8/11	P. Galyean	Revisions per Sub-Team meetings

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Purpose

This document outlines the test setup and test procedure to evaluate Timing and High Precision GNSS receiver performance when the LightSquared L-band LTE signals are present.

Basic Assumptions

The following assumptions control certain aspects of this Test Plan.

1) All testing must be completed by 5/31/2011.
2) Testing must be controlled and executed by a laboratory independent of LightSquared and of USGIC and its members.
3) All testing must be transparent, i.e., the testing can be observed by the concerned parties.
4) The test data must be recorded and available to all appropriate parties, in accordance with overall TWG agreements. The test results must be made publicly available.
5) We expect the processing of the raw data into performance data to be done by the manufacturers, with LightSquared as observers.
6) Anechoic chamber testing must be done, and open air testing will be done if possible.
7) The selection of receivers to be tested must represent the installed base as well as current production receivers, and must represent critical applications.
8) It will be necessary to test multiple receivers at one time.
9) Testing over temperature is not required, and can be at ambient temperature.
10) It is necessary to characterize and record the effects on receiver performance as observed by users of the receivers as well as the internal metrics of the receivers.
11) Testing of LightSquared handsets (or functionally similar replicas) is to be done, but the emphasis will be on testing interference from LightSquared base stations.
12) Testing of receivers must range broadly over the population, and not be restricted to "obvious" receivers.
13) Glonass will not be radiated in the chamber tests.
14) We don't plan to deal with process variations for a given receiver type. One inside the chamber and one outside is judged to be adequate.
15) Testing of a handset in the chamber at the same time as the base station testing will be done by using three generators.

Test Scenarios

High Precision Receivers – Anechoic Chamber

High precision receivers have multiple modes, depending on the particular receiver, which must be tested. These include:

1) Autonomous (stand alone)
2) RTK
3) Augmentation (WAAS, OmniSTAR, StarFire)

For RTK testing, there are four sub-cases to consider:

1) The Rover and Base both experience interference.
2) The Rover experiences interference and the Base does not.
3) The Base experiences interference and the Rover does not.
4) The Rover and Base both do not experience interference (this is for comparison to the interference cases).

Timing Receivers – Anechoic Chamber

Timing receivers have multiple modes, depending on the particular receiver, which must be tested. These include:

1) Autonomous (stand alone)
2) WAAS augmentation

High Precision Receivers – Field

TBD

Timing Receivers – Field

TBD

Anechoic Chamber Testing

Test Structure Requirements

To permit testing that meets the requirements of Section 0, the test structure must have the following characteristics:

1) An anechoic chamber of sufficient size to permit the testing of multiple receivers simultaneously must be available. To avoid geometric effects that could result from having transmitting and receiving antennas too close, at least 5 meters are needed between them.

2) The signals generated by the LightSquared generators must replicate the signals that will be used in field operations.

3) Calibration of the transmitters and anechoic chamber must be done to ensure the transmitted signals are well characterized and understood. There must be sufficient high quality instrumentation to ensure that the measurements taken are valid.

4) For each unit under test (UUT), a similar unit must be operated in parallel outside the anechoic chamber to characterize the differences in performance between units subject to LightSquared signals and those not subject to it. For certain RTK test cases, this will involve two units in the chamber and two outside.

5) It must be possible to vary the LightSquared signal power, to generate both the 5 MHz and 10 MHz LightSquared signals, and to operate two generators simultaneously.

6) It must be possible to generate GPS satellite signals with varying number of satellites and signal powers, and both L1 and L2 signals must be generated.

7) It must be possible to generate augmentation signals for those receivers which use them.

8) There must be sufficient isolation and attenuation to ensure that signals from inside the chamber do not feed back or affect the measuring instruments or receivers outside the chamber.

9) The frequency stability of the GNSS Signal Generator must be of higher quality than the oscillators in the Timing UUT.

Figure 4 below illustrates the test setup.

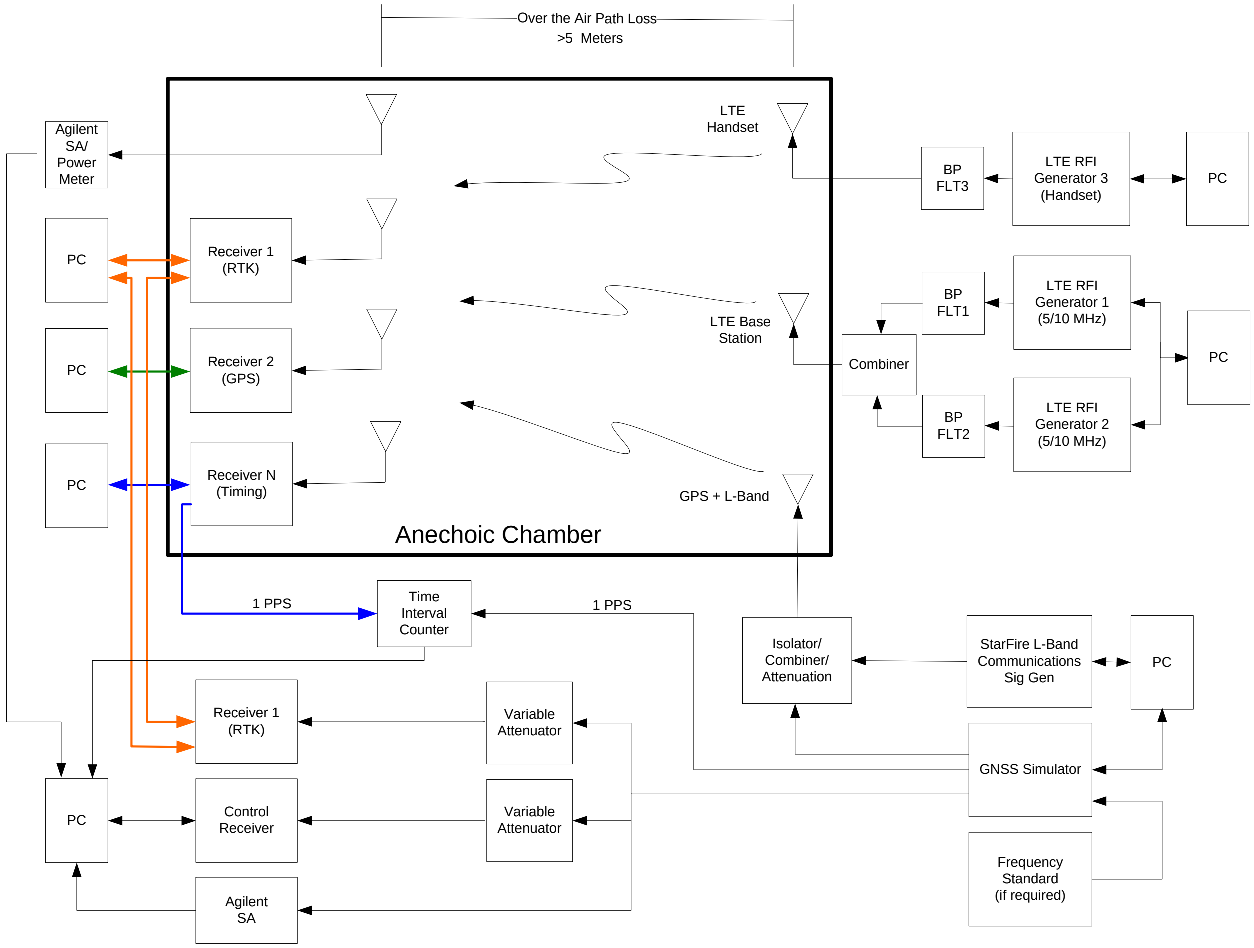


Figure 4 Test Setup

Batch Testing

Receivers will be tested in batches. The batches are defined in Appendix A.

LightSquared LTE Signals

The LightSquared LTE base station signals will be in the 1525 MHz – 1559 MHz band. The LightSquared handset signals will be in the 1626.5 MHz – 1660.5 MHz band. LightSquared will implement their system in three phases:

- Phase 0: One 5 MHz channel: 1550.2 MHz - 1555.2 MHz, 62 dBm EIRP per 5 MHz channel ($F5_{High}$)
- Phase 1A: Two 5 MHz channels: 1526.3 MHz - 1531.3 MHz ($F5_{Low}$) and 1550.2 MHz - 1555.2 MHz, 62 dBm EIRP per 5 MHz channel

- Phase 2: Two 10 MHz channels: 1526 MHz -1536 MHz ($F10_{Low}$) and 1545.2 MHz - 1555.2 MHz ($F10_{High}$), 62 dBm EIRP per 10 MHz channel

LightSquared plans in all three phases to operate base stations at least 4 MHz away from the GPS band at 1559 MHz.

For some tests, a simulated handset will be used. The frequency for the handset (HS) will be 1627.5 – 1637.5 MHz.

The following LTE base station carrier frequency configurations will be used for the interference testing:

- $F5_{Low}$
- $F5_{High}$
- $F5_{High}$ + $F5_{Low}$
- $F5_{High}$ + $F5_{Low}$ + HS
- $F10_{Low}$ + HS
- $F10_{High}$ + HS
- $F10_{High}$ + $F10_{Low}$ + HS

These frequencies are chosen to have the potential to create 3^{rd} order intermod products that may fall within the GPS L1 band.

Setup and Calibration of LightSquared LTE Signals

- Since the actual base station antenna cannot be used, a measured, calibrated field strength will be generated using a vertical, linear polarized horn antenna with a known gain. This antenna will be directed with the peak gain pointed at the region where the UUTs will be tested.
- The LTE signal will be pointed directly at the boresight of the UUTs.
- The distance in meters between the face of the horn antenna and the UUTs will be measured and recorded.
- Mount both the LTE horn and the GPS simulator transmit antenna in place with no UUT equipments in place.
- Turn the LTE transmitter on with the attenuator at a known setting and measure the field strength at the locations where the UUTs will be placed.
- Vary the attenuator through at least three settings across the range of LightSquared power and record the field strength to calibrate the attenuator(s), or calibrate the attenuator(s) using a network analyzer.

The equivalent outdoor separation which will have a similar effect can be determined (and bounded) using a propagation model:

- Free space model: $(1/R^2)$
- $R_{outdoors}=R_{chamber}*sqrt(Gain_{LTE\ outdoor\ antenna}/Gain_{Tx\ Horn\ used\ in\ test})$
- Urban environments: $(1/R^{3.5})$

The LTE signal will be pointed directly at the boresight of the UUT, while a typical use case will be at a lower elevation. This will likely produce some rolloff and will reduce the equivalent outdoor separation.

Setup and Calibration of GNSS Signals

- The GNSS signal generator shall be locked to a high quality external frequency Cesium or Rubidium reference.
- The simulator used to generate the GNSS signals will have internal noise that permits the C/N_0 ratios to be set independent of the actual output power. This can be maintained even when using external amplifiers, provided the additional amplifier's noise power is well below the simulator output power.
- The GPS radiating antenna must be right hand circularly polarized and be pointed at the boresight (top or zenith) of the UUTs.
- The UUT antenna gain characteristics should be entered into the simulator, or an approximation, to correct for elevation variations of the constellation.
- Set the peak C/N_0 to 47 dB.
- Using a representative UUT and antenna and with the LTE on, record the C/N_0 of the peak satellite and reduce the gain of the GNSS signal until the UUT reports a decrease in C/N_0 of 3 dB. Now the noise in the environment and the simulator are equal and any additional noise will be detected.
- This level and setting must be recorded and used throughout the testing.

Setup and Calibration of the Timing Equipment

- Each Timing UUT shall have an associated Time Interval Counter (TIC).
- The primary 1PPS control signal shall be provided by the GNSS Signal Generator.
- If required by the TIC, a stable frequency source can be provided by the GNSS frequency reference.
- Measure and record the steady-state time interval before the LTE signals are applied.
- Use the clean steady-state measurement above as the "truth" value during the subsequent LTE emissions tests.

Data Recording

To the extent possible, the following GPS, WAAS, and augmentation internal performance parameters will be recorded at a minimum rate of 1 second for each receiver undergoing test, inside or outside the chamber:

- Pseudorange
- Carrier Phase
- Doppler
- C/N_0
- Optional Parameters (UUT specific)
  - Carrier tracking variance
  - Pseudorange tracking variance
  - Lock Times
  - Lock Breaks
  - Signal Quality
  - WAAS Bit Error Rate
  - L band augmentation communications
    - Packet Error Rate
    - E_b/N_0

To the extent possible, the following GPS, WAAS, Timing, and augmentation external performance parameters will be recorded at a minimum rate of 1 second for each receiver undergoing test, inside or outside the chamber:

- Position accuracy
  - GPS stand alone
  - GPS + Augmentation
  - GPS + WAAS
  - GPS + RTK
- Pseudorange accuracy
- Carrier phase accuracy
- Range Rate (Doppler) accuracy
- Mean Time between Cycle Slips
- Mean Time between Lock breaks

- Reacquisition time statistics (Hot Start)
- Acquisition time statistics (Warm and Cold Starts)
- RTK ambiguity resolution statistics
- 1PPS error as measured by the TIC (for timing receivers)
- Receiver Status including Holdover Mode flag (for timing receivers)

Interference Tests

For each batch of receivers, five types of tests will be conducted:

- Tracking
- Reacquisition
- Acquisition
- Tracking Sensitivity
- Acquisition Sensitivity

These are defined in the sections below.

Tracking Test Procedure

This test case will start after all receivers are tracking all GPS satellites for at least 1 minute.

For each of the base station configurations specified in section 0, the following procedure should be performed with the GPS simulator set up as described in section 0.

1) Record the performance parameters for each UUT as defined in section 0, including C/N_0.
2) Set each LTE simulator employed for the selected configuration to an output power of -85 dBm/m^2. This sets the received signal to approximately -180 dBm/Hz power density for a 10 MHz LTE signal.
3) Pass 1:
   a) Record the performance parameters for each UUT as defined in section 0 and the LTE simulator power for 60 seconds.
   b) Gradually increase each LTE carrier in 5 dB steps
   c) Repeat steps a) and b) until all of the UUTs indicate a loss of lock condition on all GPS satellites being generated by the GPS simulator or the output power of the LTE simulators have reached +10dBm/m^2, whichever comes first.
4) Using the data collected in 3):

a) Determine the minimum LTE simulator power that caused a 3dB degradation in C/N_0 on any UUT.

b) Determine the maximum LTE simulator power where at least one UUT was still tracking at least one GPS signal.

5) Pass 2:

   a) Set the output power of the LTE simulators to the level recorded in 4a) – 20 dB (*a smaller back-off may be acceptable if all UUTs can operate without degradation at that level*).

   b) Record the performance parameters and LTE simulator power for 60 seconds.

   c) Increase the power of the LTE simulator output by 1 dB.

   d) Repeat steps 5b) through 5c) until the LTE simulator power is set to the level of 4b) + 10 dB, or the output power of the LTE simulators has reached +10 dBm/m^2.

6) From the data collected in 5) determine the minimum LTE simulator power that caused at least one UUT to lose lock on at least one GPS signal.

<u>Reacquisition Test Procedure</u>

This test case will start after all receivers are tracking all GPS satellites for at least 1 minute.

For each of the base station configurations specified in section 0, the following procedure should be performed with the GPS simulator set up as described in section 0. The data required from 0 should be that collected during the test using the same base station configuration.

1) With LTE power off, collect 15 minutes of tracking performance parameters.

2) From the associated test from 0, record the data collected during steps 4a) and 6.

3) Calculate the following power level for each of the LTE power test cases (section 0):

   a) power(k) = (1 - .25k)*power(4a) + .25k*power(6), k= 0…4.

4) For each of the LTE power test cases:

   a) Set the LTE simulators to a power output of power(k)

   b) Record tracking parameters for 30 seconds

   c) Reduce the GPS signal power to zero (0) for at least 10 seconds, or until all UUTs indicate a loss of lock, whichever is greater.

   d) Resume GPS signal level to nominal value indicated in section 0.

   e) Repeat 4b) through 4d) for 100 iterations.

Acquisition Test Procedure

This test case will be done once from a warm start condition and then again from a cold start condition.

For each of the base station configurations specified in section 0, the following procedure should be performed with the GPS simulator set up as described in section 0. The data required from 0 should be that collected during the test using the same base station configuration.

For each LTE power level calculated in 0 step 3):

1) Power on all UUTs
2) Record performance data for 5 minutes or for 60 seconds after all UUTs have indicated GPS time synchronization, whichever is less.
3) Power down all UUTs
4) Repeat 1) through 3) for 10 iterations.

Sensitivity Tracking Test Procedure

This test case will start after all receivers are tracking all GPS satellites for at least 1 minute.

For each of the base station configurations specified in section 0, the following procedure should be performed with the GPS simulator set up as described in section 0. The data required from 0 should be that collected during the test using the same base station configuration.

1) With LTE simulator power off and GPS at nominal signal levels specified in section 0, collect 15 minutes of tracking performance parameters.
2) For each LTE power level, power(k) k = 0…4, calculated in 0 step 3):
    a) Set the power level of the LTE simulators to power(k) – 10 dB.
    b) Continuously record performance data during 2).
    c) Reduce GPS simulator power at a rate of 1 dB/min for 30 minutes, or until all UUTs indicate loss of lock on all satellite signals being generated by the GPS simulator.
3) Repeat 2).

Sensitivity Acquisition Test Procedure

This test case will start after all receivers are tracking all GPS satellites for at least 1 minute.

For each of the base station configurations specified in section 0, the following procedure should be performed with the GPS simulator set up as described in section 0. The data required from 0 should be that collected during the test using the same base station configuration.

1) With LTE simulator power off and GPS at nominal signal levels specified in section 4.5, collect 15 minutes of tracking performance parameters
2) For each LTE power level, power(k) k = 0…4, calculated in 0 step 3):
    a) Set the power level of the LTE simulators to power(k) – 10 dB.
    b) Continuously record performance data during 2).
    c) Reduce GPS simulator power 1 dB/min, at the minute mark, for 30 minutes, or until all UUTs indicate loss of lock on all satellite signals being generated by the GPS simulator.
    d) During the test, each minute at the 20 second mark, drop the signal level on all GPS satellites being generated by the GPS simulator to zero to force the UUTs to initiate a re-acquisition cycle.
3) Repeat 2).

Expected Processing Results

It is expected that each manufacturer will need to use its proprietary software to process the recorded data. The data needs then to be presented in a uniform structure that is amenable to evaluation and aggregation.

TBD.

References

TBD

Appendix A

Receivers and Test Batches

Test Batch 1

This test batch is an autonomous test in which the receivers are operated in a standalone mode subject to interference, so there will be one receivers of each type in the chamber and one outside the chamber.

The receivers in this test batch are:

A Timing Receivers

B

C

Etc.

Test Batch 2

This test batch will be a RTK test in which only the base station receiver is subject to interference, so there will be only one receiver of each type in the chamber and one outside the chamber.

The receivers in this test batch are:

A

B

C

Etc.

Test Batch 3

This test batch will be a RTK test in which only the rover receiver is subject to interference, so there will be only one receiver of each type in the chamber and one outside the chamber.

The receivers in this test batch are:

A

B

C

Etc.

Test Batch 4

This test batch is a RTK test in which both the receivers are subject to interference, so there will be two receivers of each type in the chamber and two outside the chamber.

The receivers in this test batch are:

A

B

C

Etc.

Test Batch 5

This test batch is autonomous with WAAS augmentation test in which the receivers are operated in a Standalone mode subject to interference, so there will be one receivers of each type in the chamber and one outside the chamber.

The receivers in this test batch are:

A WAAS capable Timing Receivers

B

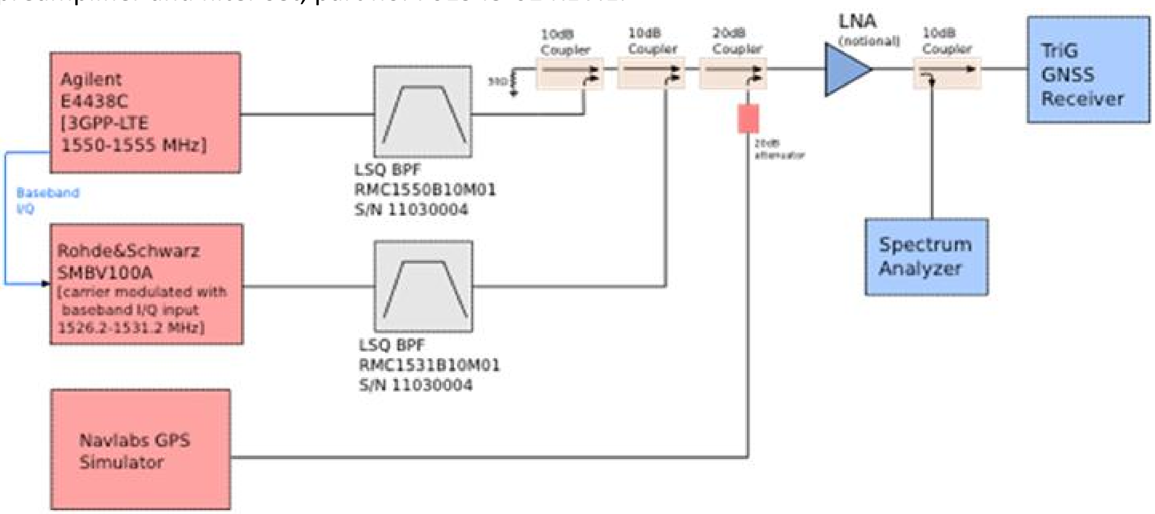
C

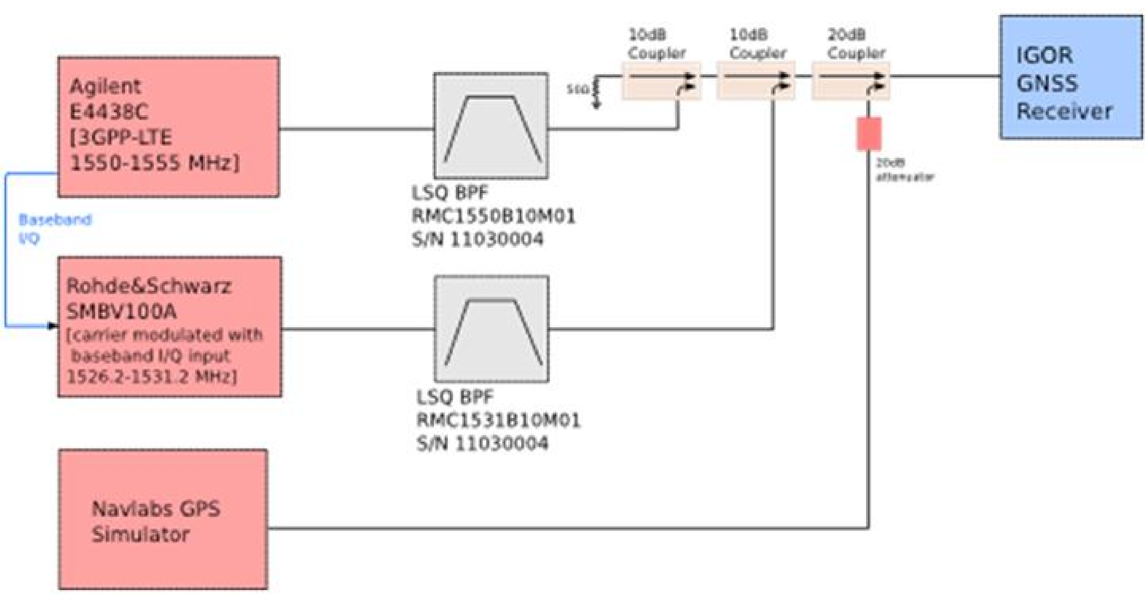
Etc.

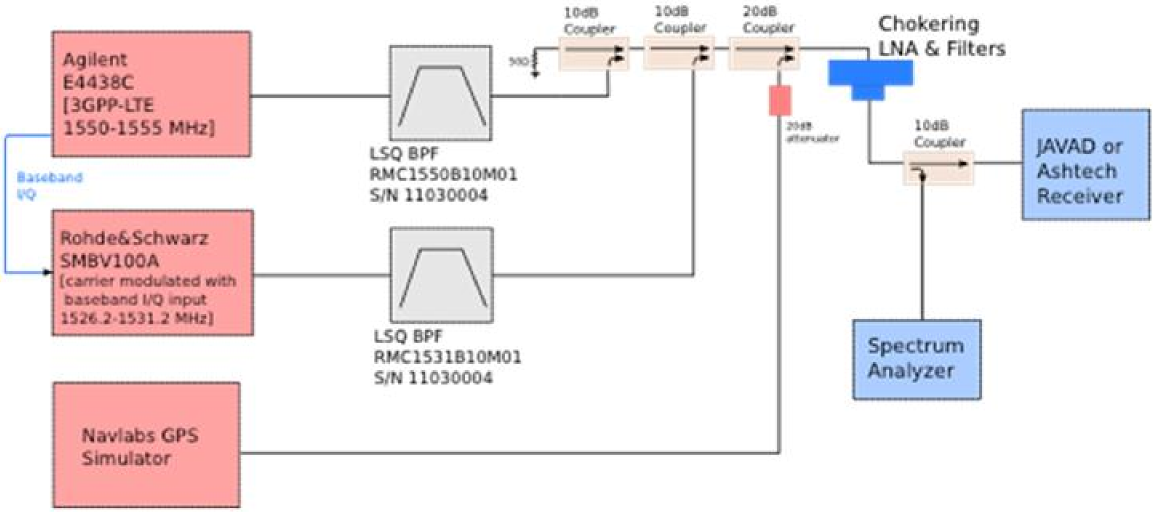
EXTRACTS FROM NASA/JPL PRELIMINARY TEST REPORT DETAILING TEST SETUP AND PROCEDURES

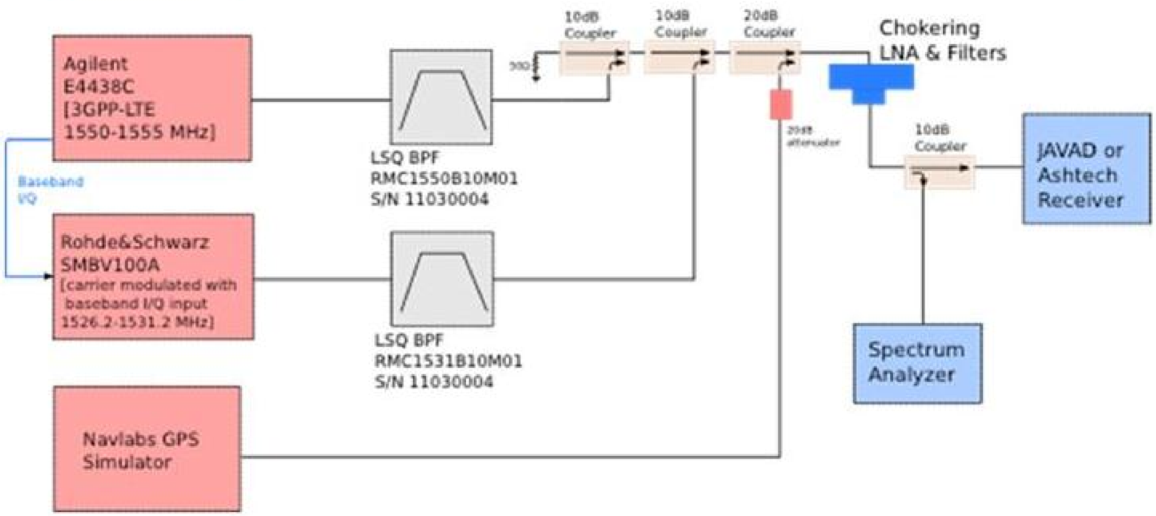
Block Diagram of Test Setups

The test setups for the TriG, IGOR, JAVAD Delta G3T, and Ashtech Z12 receivers are shown below. The signal to the Javad and Ashtech was amplified using a standard Ashtech choke ring preamplifier and filter set, part no. 701945-02 REV:E.









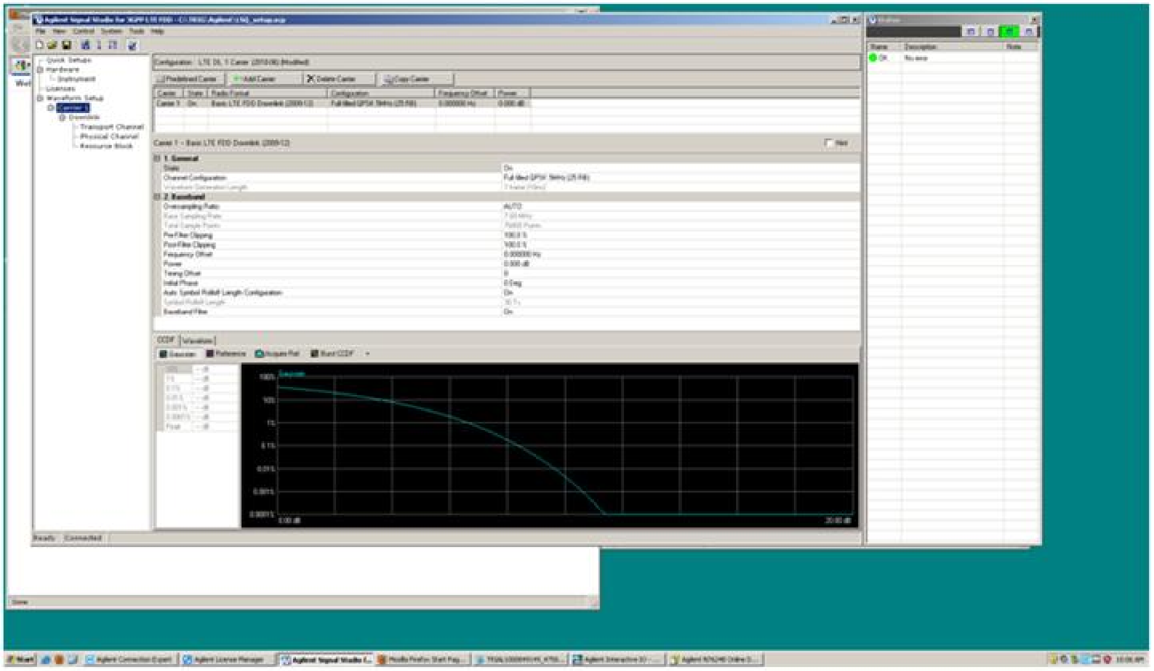
Antenna Output Simulator

LightSquared Signal Generation and Band-Pass Filters.

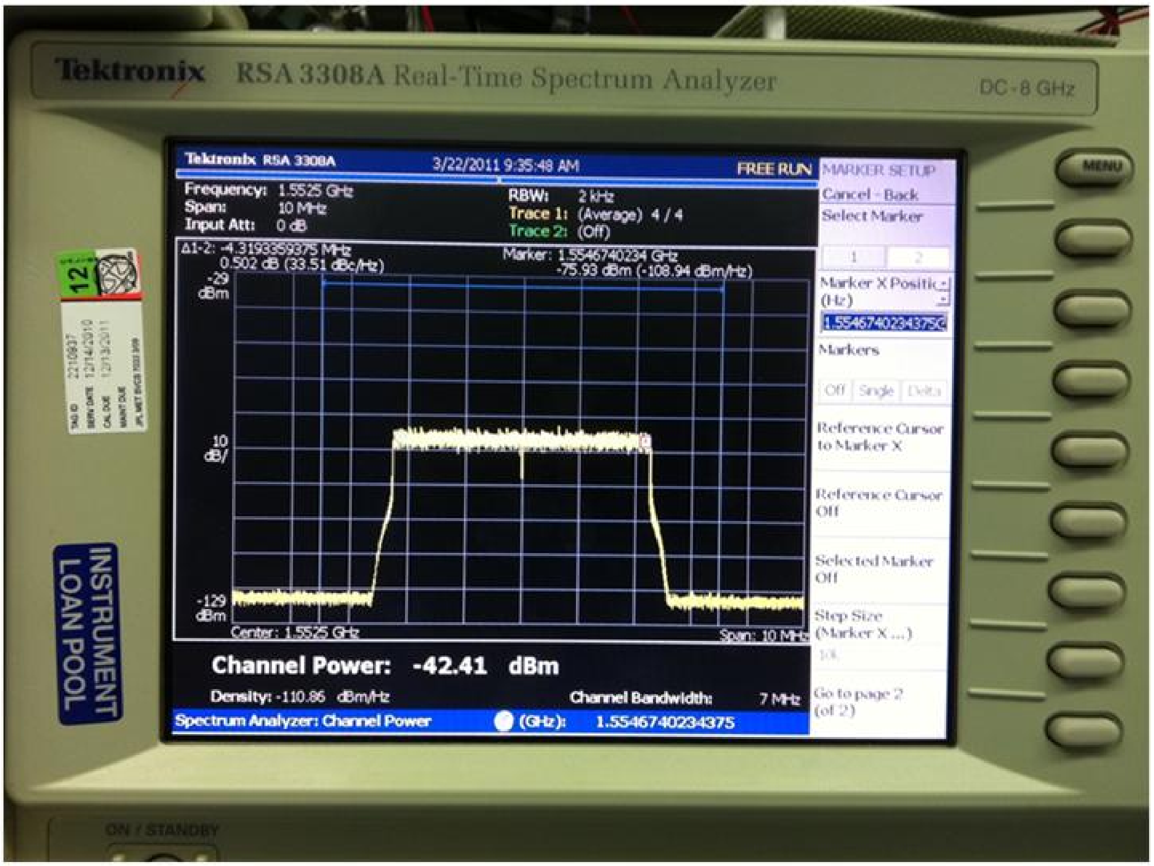
We are generating a Phase 1A LightSquared downstream signal configuration:

CHANNEL 1:

Agilent Signal Studio for 3GPP LTE FDD is used to generate a **Full filled QPSK 5MHz (25RB) Basic LTE FDD Downlink (v. 2009-12)**



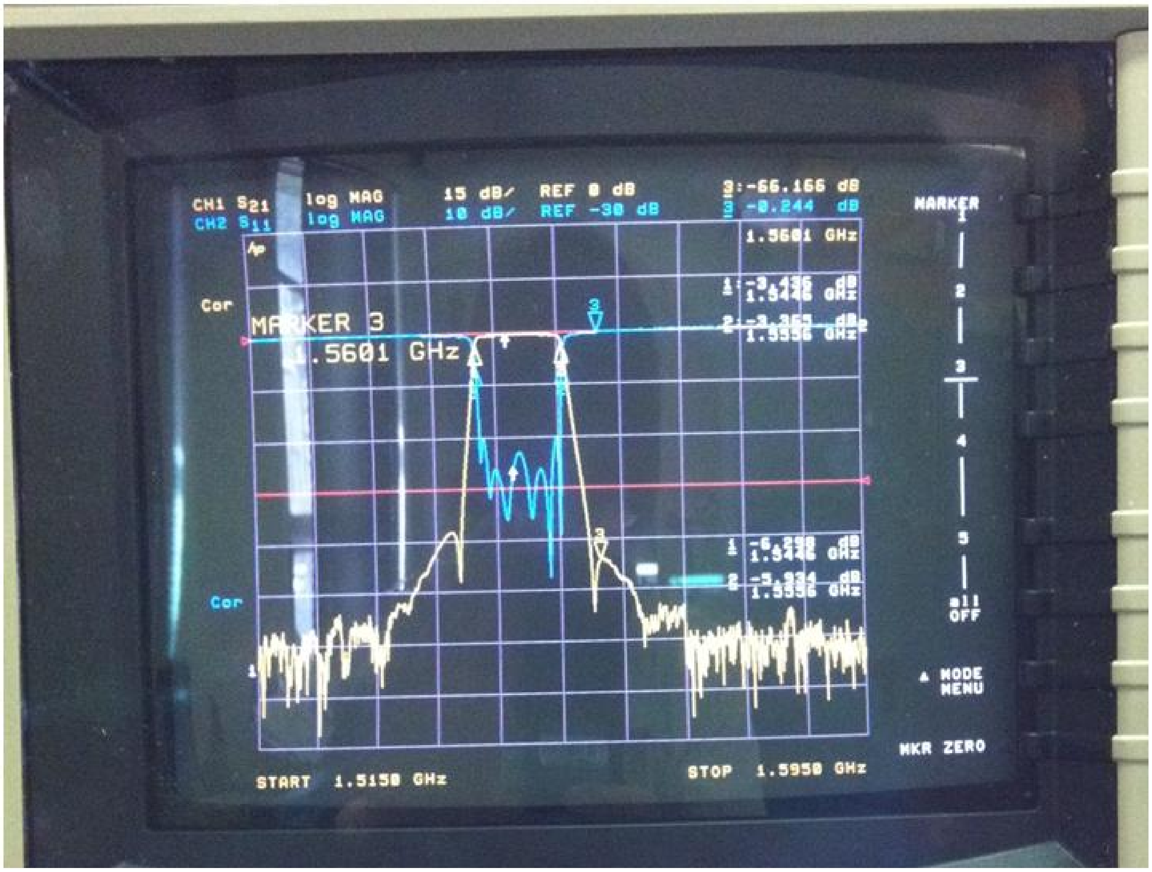
This LTE Base-Band signal is then loaded onto an **Agilent E4438C** Vector Signal Generator which modulates it onto a **1552.5 MHz carrier.**



The E4438C is configured to simultaneously output this same LTE Base-Band waveform onto its **External I/Q Outputs.**

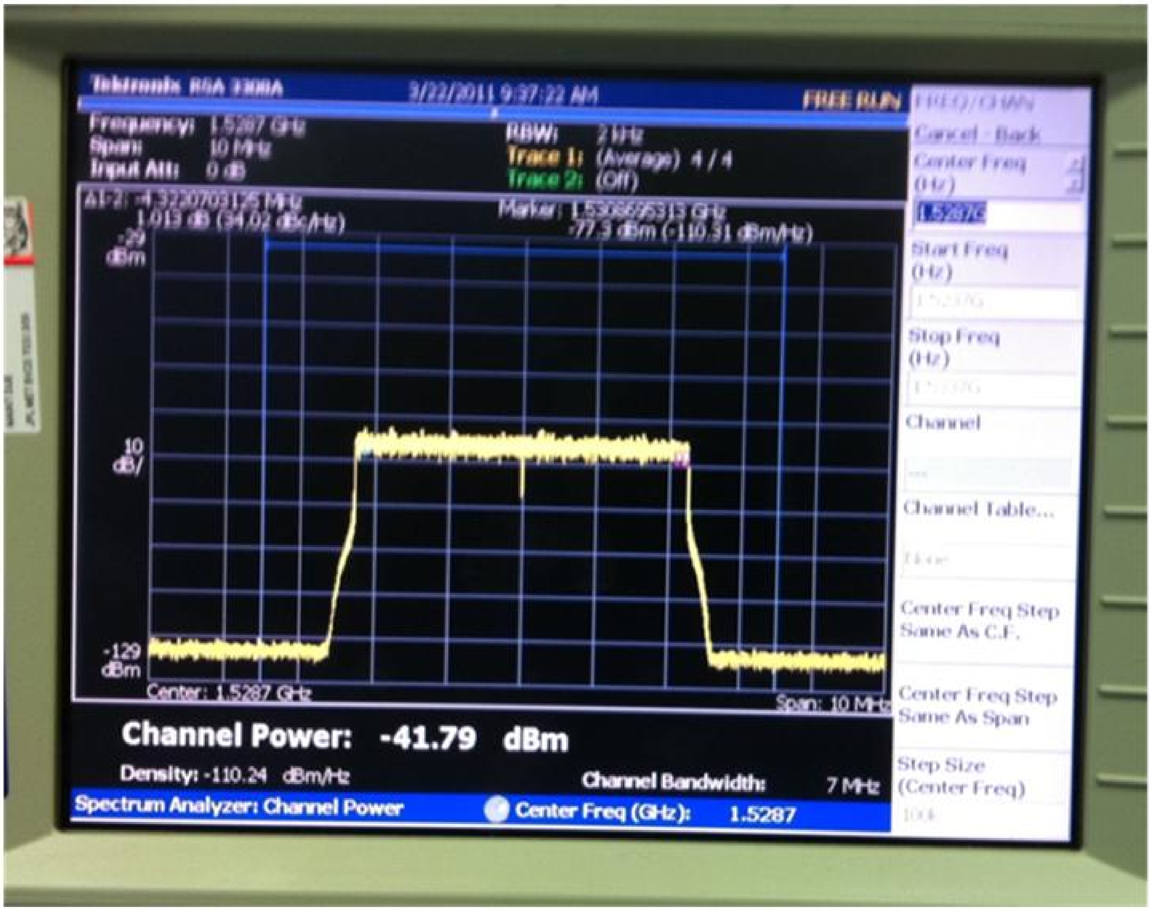
The E4438C RF output is connected to a Band-Pass Filter supplied by LightSquared:

Model: **RMC1550B10M01**
S/N: **11030004**
S21 -3dB pts: **1446.1 MHz -- 1555.61 MHz**
Attenuation: **At least 66dB above 1560 MHz**



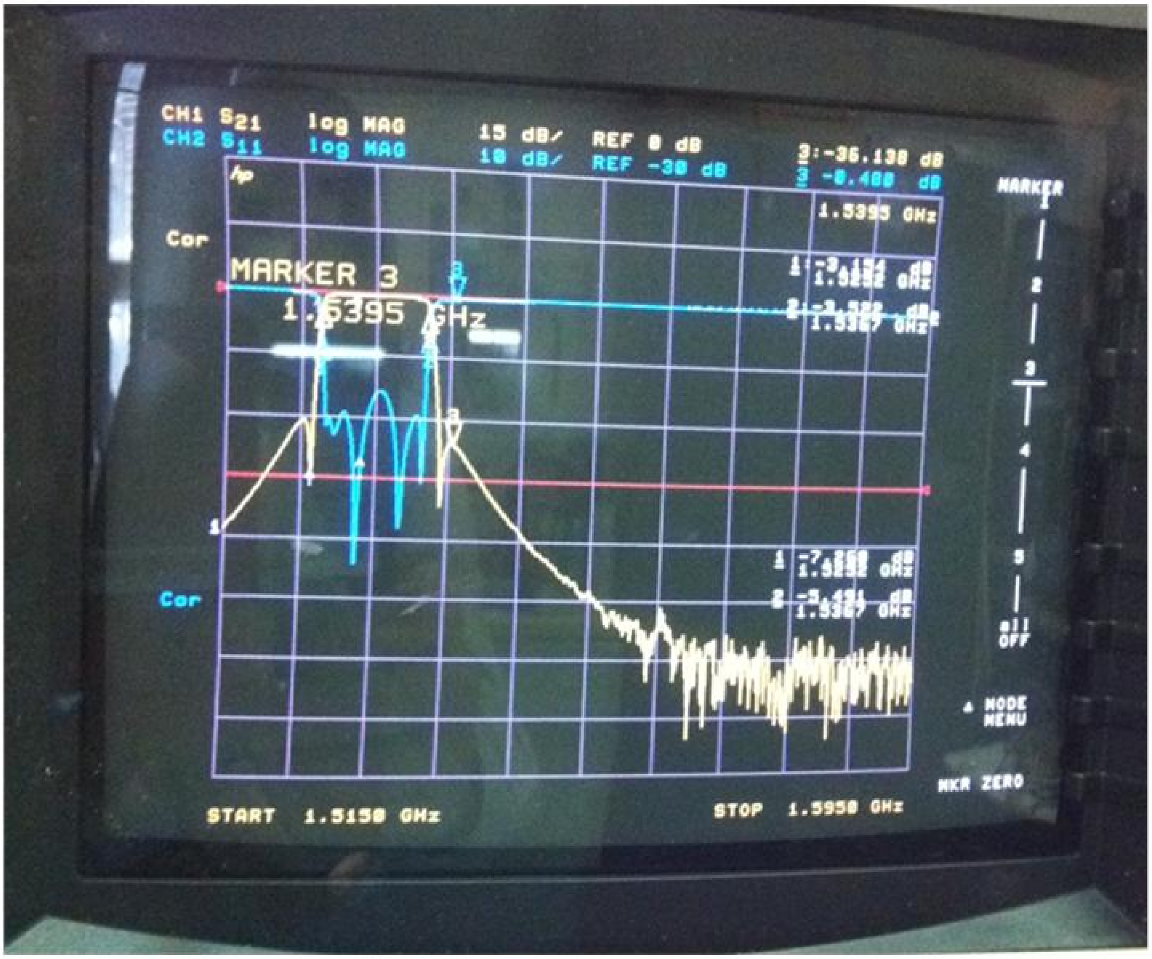
CHANNEL 2:

The External I/Q Outputs of the E4438C are connected to the **I/Q modulator** inputs of a **RHODE&SCHWARZ SMBV100A** Vector Signal Generator set to a **1528.7 MHz carrier**.



The SMBV100A RF output is connected to a Band-Pass Filter supplied by LightSquared:

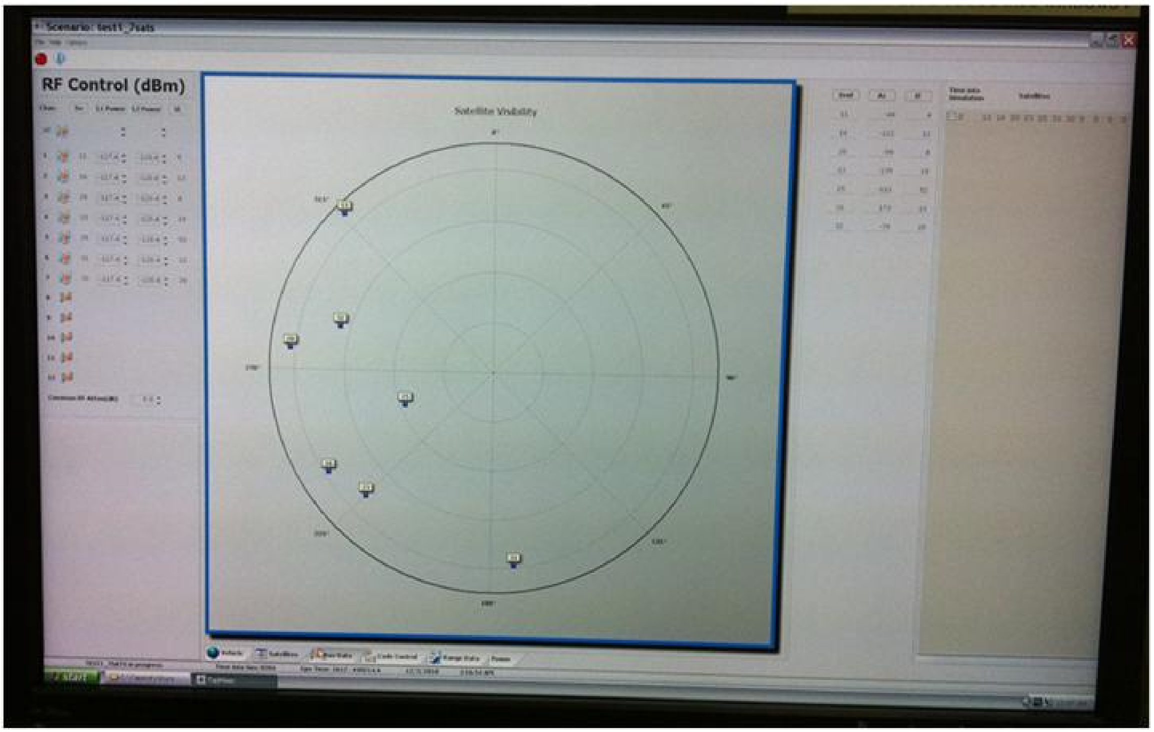
Model: **RMC1531B10M01**
S/N: **11030004**
S21 -3dB pts: **1525.2 MHz – 1536.7 MHz**
Attenuation: **At least 36dB at 1539.5 MHz**

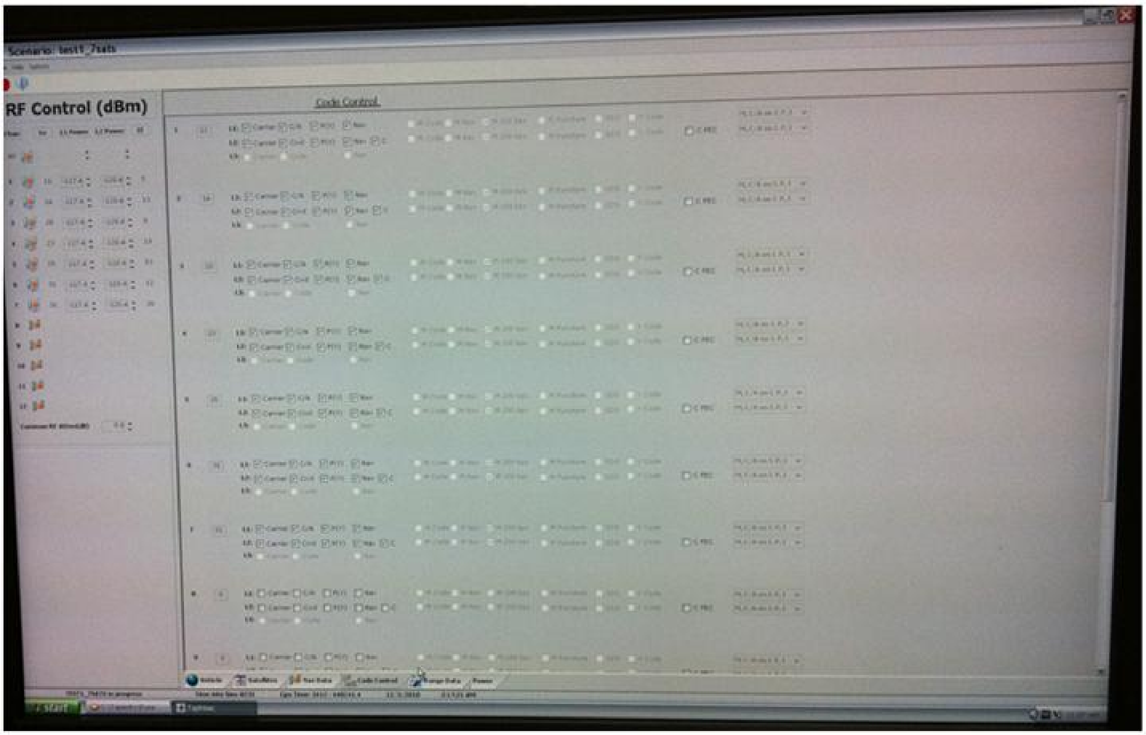


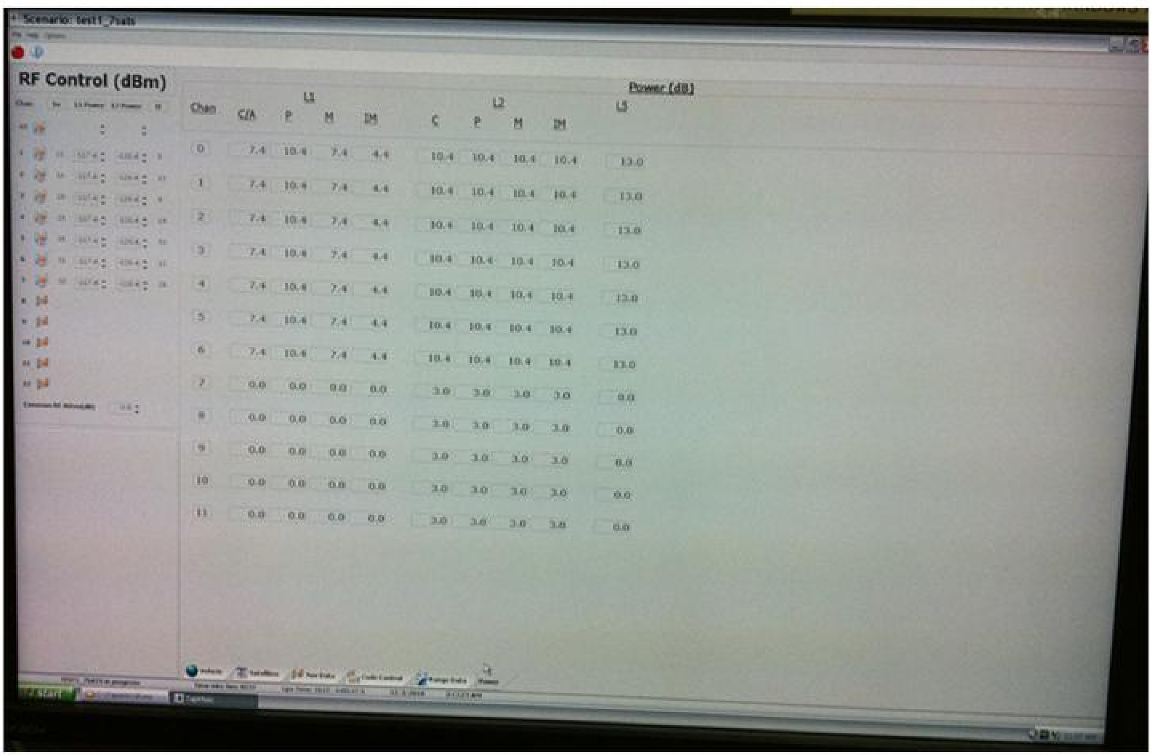
GPS Signal Generation

We are using a **NAVLABS** GPS Simulator configured as:

- 7 satellites
- **Constant Power** throughout the scenario (ie: no Antenna Gain Pattern effects, Atmospheric Attenuation, etc) in order to make the interference effects more apparent
- L1 C/A power set 3dB above P1 and P2 powers


Scenario: test1_7sats
RF Control (dBm)
Satellite Visibility





Combining Signals into an Antenna Simulator: Measured Resulting Signal Power, Noise Spectrum and Power, and Distortion-Free Dynamic Range

We would like our ”Antenna Output Simulator” be as close as possible to reproducing real signals picked up by an antenna:
An important goal for our strategy for combining the three Signal Sources was to produce a **constant low power density broadband noise floor,** representative of normal operation. Of particular importance is maintaining **a constant noise power in the GPS L1 pass-band, independent of varying interfering LightSquared signal powers.**

Our strategy for combining the three Signal Sources was chosen for the following reasons:

1. The “Antenna Output Simulator”” mainline is terminated with a **50 Ohm broadband shunt**.
    - This presents a broadband 50 Ohm source impedance to the GPS receiver LNA.
    - This shunt acts as a noise generator producing a constant noise density of approx -174 dBm/Hz or equivalent to 300K (room temperature) across a wide frequency range.

2. The two LightSquared Signals are coupled onto the ”Antenna Output Simulator” mainline using **-10dB Directional Couplers**
    - This isolates the GPS receiver LNA from the uneven output impedance of the LightSquared band-pass filters.
    - Only a 10^{th} of the broadband noise from the VSG’s and band-pass filters is coupled into the Antenna Simulator Mainline, or approx 30K.

3. The signal from the GPS Simulator is first attenuated by a **-20dB pad** and then coupled onto the ”Antenna Output Simulator” mainline using a **-20dB Directional Coupler**
    - With this attenuation, the simulator power sets a realistic C/No of approx 48 dB-Hz. Note: Because of its lower noise floor, the TriG receiver used a simulator signal power setting 2 dB below the other three receivers.
    - Only a 100^{th} of the broadband noise from the -20dB pad is coupled into the Antenna Simulator Mainline, or approx 3K.
    - The -20dB pad effectively isolates the Antenna Simulator mainline from the broadband noise generated by the GPS simulator which may be shaped and higher than 300K.

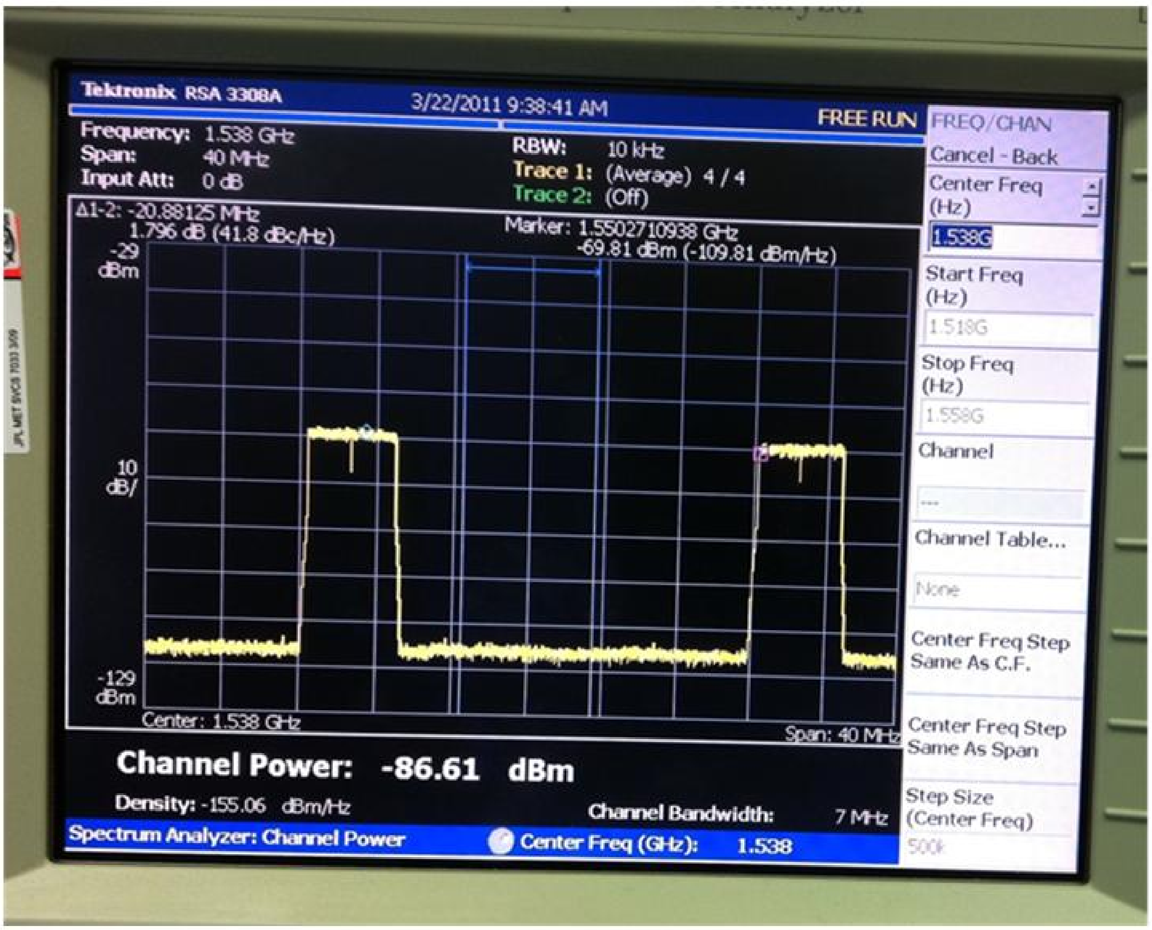
LightSquared Signal Power and Spectrum Measurement:

The *Antenna Output Simulator* port was connected to a calibrated **Tektronix RSA3308A** Spectrum Analyzer.
The function: **Measure -- Channel Power** was used with a channel BW set to **7 MHz** and a **Rectangular** integration Filter Shape.
In order to compensate for total losses due to **directional couplers, cables, filters, I/Q modulator sensitivity,** on each Signal Generator, the **Amplitude Offset** was adjusted until the measured powers for each LightSquared channel match the Amplitude read-off on the Signal Generators.

The final Amplitude offset values ended up being:

- Channel 1 – 1552.5 MHz – E4438C: **-12.02 dB**
- Channel 2 – 1528.7 MHz – SMBV100A: **-19.7 dB**

A picture of the final spectrum when both Channels are set to the same level:



Noise Power and Spectrum Measurement:

In a Space environment, an antenna pointed partially towards the Earth would pick-up 150K of Thermal Noise from the antenna, cable losses, wideband pre-select filter and LNA Noise Figure contribute another 150K giving a **Total System Noise Temperature of about 300K.**

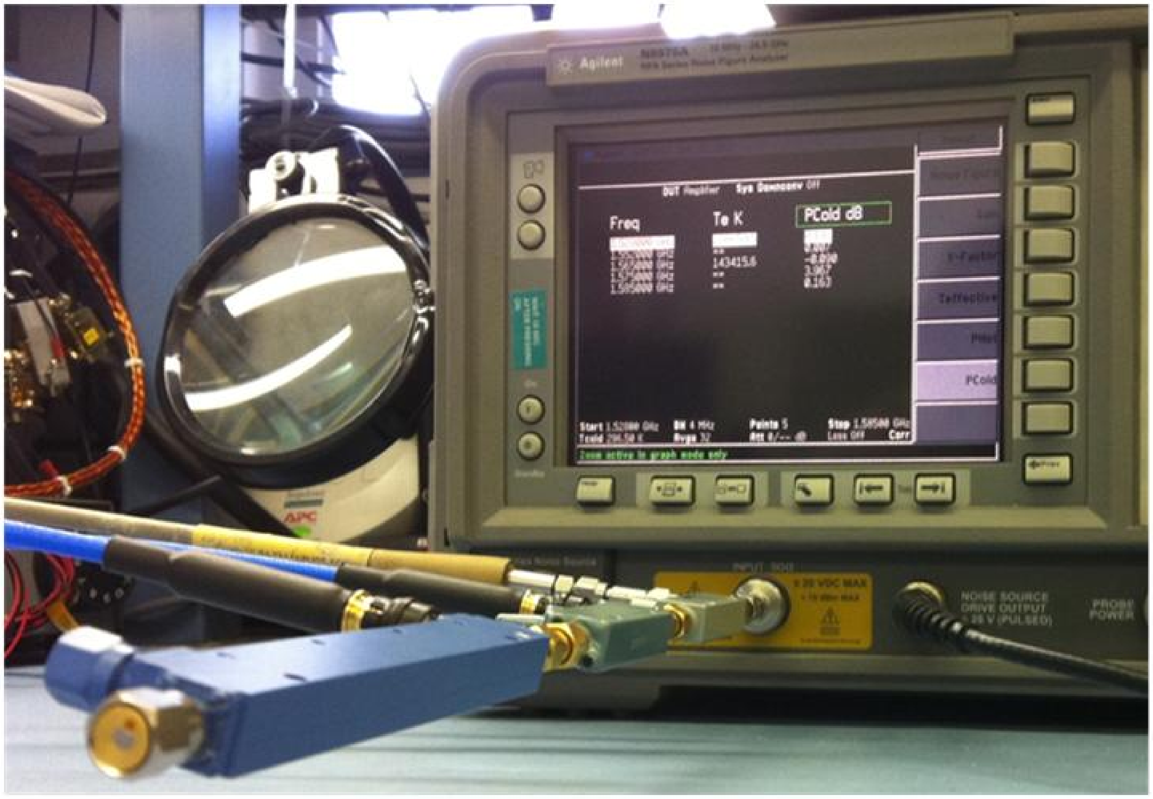
Therefore, in order for our ”Antenna Output Simulator” to output realistic power levels, the Total Equivalent Noise System Temperature has to be in the neighborhood of 300K or equivalent to a Noise Density of about -174 dBm/Hz.

In order to measure the Total Noise Temperature of our ”Antenna Output Simulator”, an **Agilent N8975A Noise Figure Analyzer (NFA)** is used together with an **HP 346A Noise Source** for calibration.

The NFA Cold Noise Power measurement result is used. The Cold Noise Power Pcold reading is in units of dB referenced to the Noise Power generated by a resistor at a temperature of 296.5K. After calibration, connecting the HP 346A to the NFA yields a Pcold of 0.0dB as expected (In Pcold mode, the HP 346A is turned OFF and is acting as a perfect 50 Ohm resistor).

When we connect our ”Antenna Output Simulator” output port, we measure a Noise Power that is very close to 0.1dB, at all measured frequencies except at 1575 MHz (@4 MHz BW) where we measure close to +4dB. The reason for the higher power at 1575 MHz is because of the main C/A lobe being above the noise floor.

We conclude that the Noise Power coming out of our Antenna Simulator output port is very close to 303K or -173.8 dBm/Hz.



In order to verify the spectrum of our broadband noise floor for flatness, we use a combination of an LNA and a Tektronix RSA3308A Spectrum Analyzer.

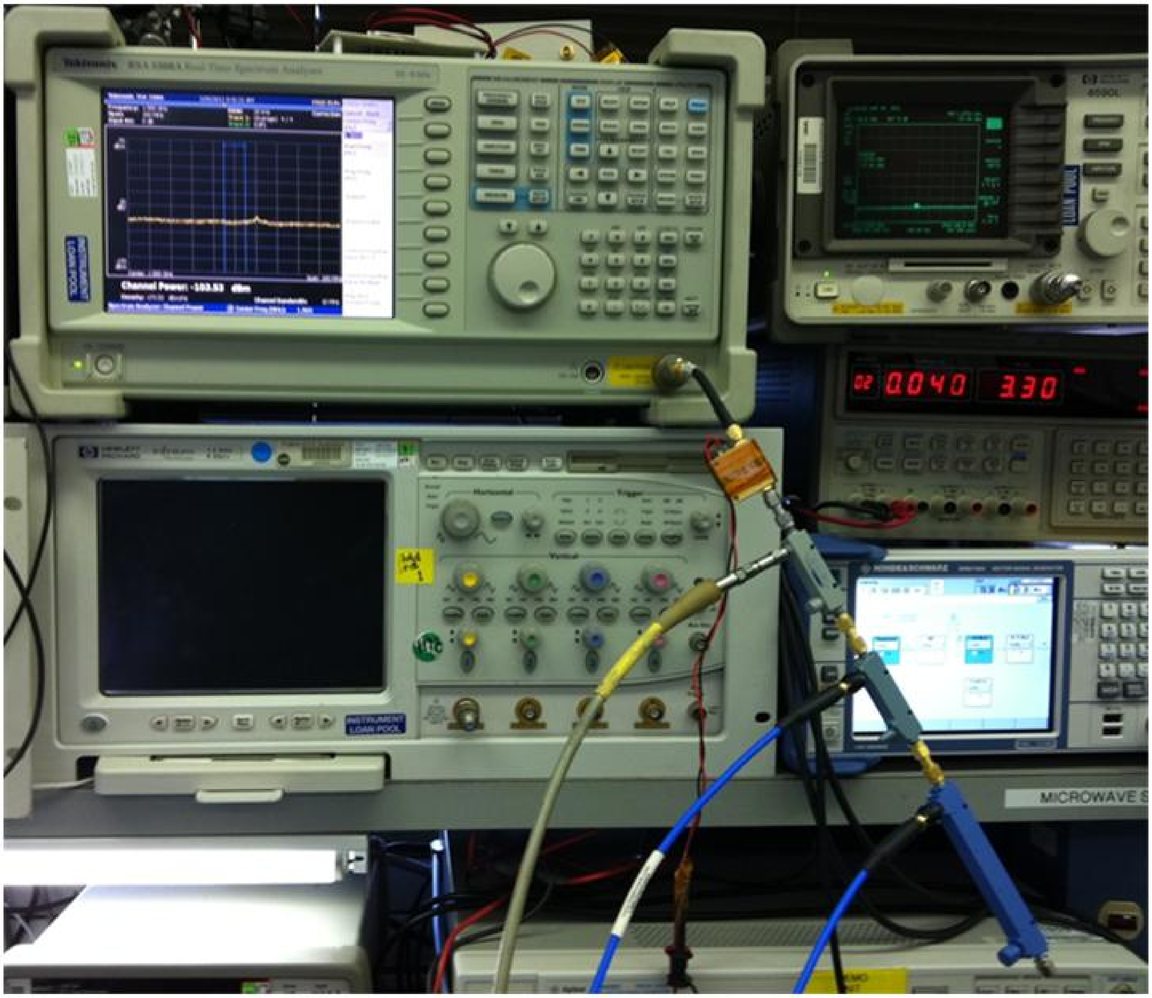
The LNA is first characterized on an **Agilent N8975A** Noise Figure Meter

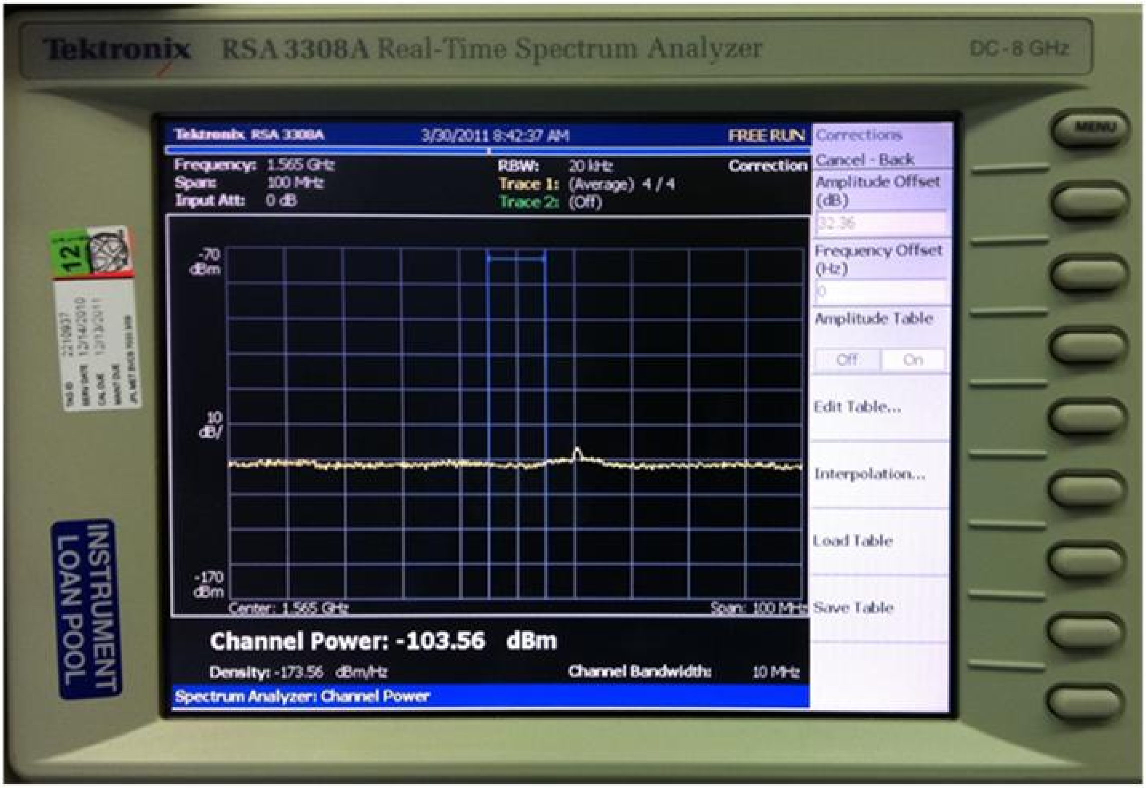
Brand: Richardson Electronics (RELL)
Model: 1216A
S/N: 070+0011
At **1565 MHz:**
Gain = 32.36dB NF = 0.54dB Te = 38.47K Pcold = 32.99 dB


Agilent
N8975A
NFA Series Noise Figure Analyzer
DUT Amplifier
Sys Downconv Off
Freq
Gain dB
NoiseFig dB
1.520000 GHz
32.383
0.551
1.575000 GHz
32.355
0.559
1.585000 GHz
32.336
0.556
Start 1.52000 GHz
BW 4 MHz
Points 5
Avgs 32
Loss Off
Corr
Zoom active in graph mode only
Result
Noise Figure
Gain
Y-Factor
Teffective
PHot
PCold
Help

We can now set-up an **Amplitude Correction** of **32.36dB** in the Spectrum Analyzer to compensate for the LNA gain**.**

Check 1: Upon connecting our ”Antenna Output Simulator” output to the input of this LNA, we should be reading a Noise Floor Power Density of 303K + 38.47K = 341K or **-173.3 dBm/Hz** anywhere **except around 1575MHz**. We measured a Noise Floor Power Density **-173.5 dBm/Hz** centered at 1565 MHz. We also remark that the noise floor is flat in the displayed 100MHz spectrum.





Check 2: We can also verify the power accuracy of weak LightSquared signals: Below is shown the output of the E4438C LightSquared Signal Generator output when set to -100 dBm.

GPS Signal Power Measurement:

- Power of total GPS signal out of Simulator at GPS L1 (7 satellites): -66.1dBm (in 20MHz integration BW)
- Measured loss due to -20dB directional coupler: -19.1dB
- Measured loss due to -20dB pad: -20.0dB
- Power of GPS signal coupled onto Antenna Simulator mainline (7 satellites): -105.2 dBm (in 20MHz BW)
- Power of GPS signal coupled onto Antenna Simulator mainline (per satellite): **-113.7 dBm** (in 20MHz BW)
- NOTE: This was the GPS simulator power used for tests of the IGOR, Ashtech, and JAVAD receivers. The simulator output power for each signal was reduced by 2 dB

for tests involving the TriG receiver. Because of its lower noise figure, less signal power was required to reach a C/No of 48 dB-Hz.

Intermodulation and Distortion-Free Dynamic Range:

In order to make meaningful susceptibility measurements of GPS receivers to LightSquared emissions, we need to make sure that **as we raise the power of LightSquared signals coming out of our Antenna Output Simulator, we are not raising the power in the GPS L1 pass-band.**

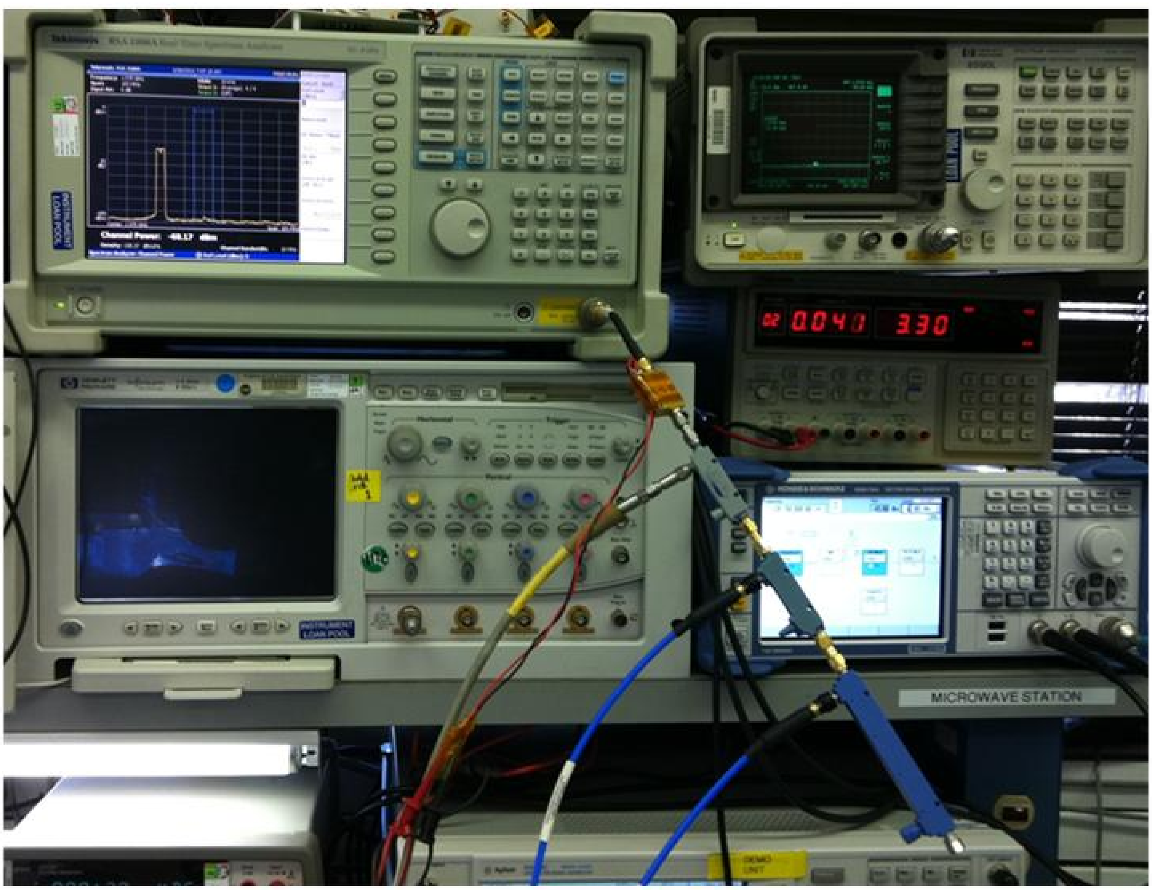
The dominant effect by which the Noise Power in the GPS L1 pass-band gets raised **is 3rd order Intermodulation Distortion** between the two LightSquared Channels:

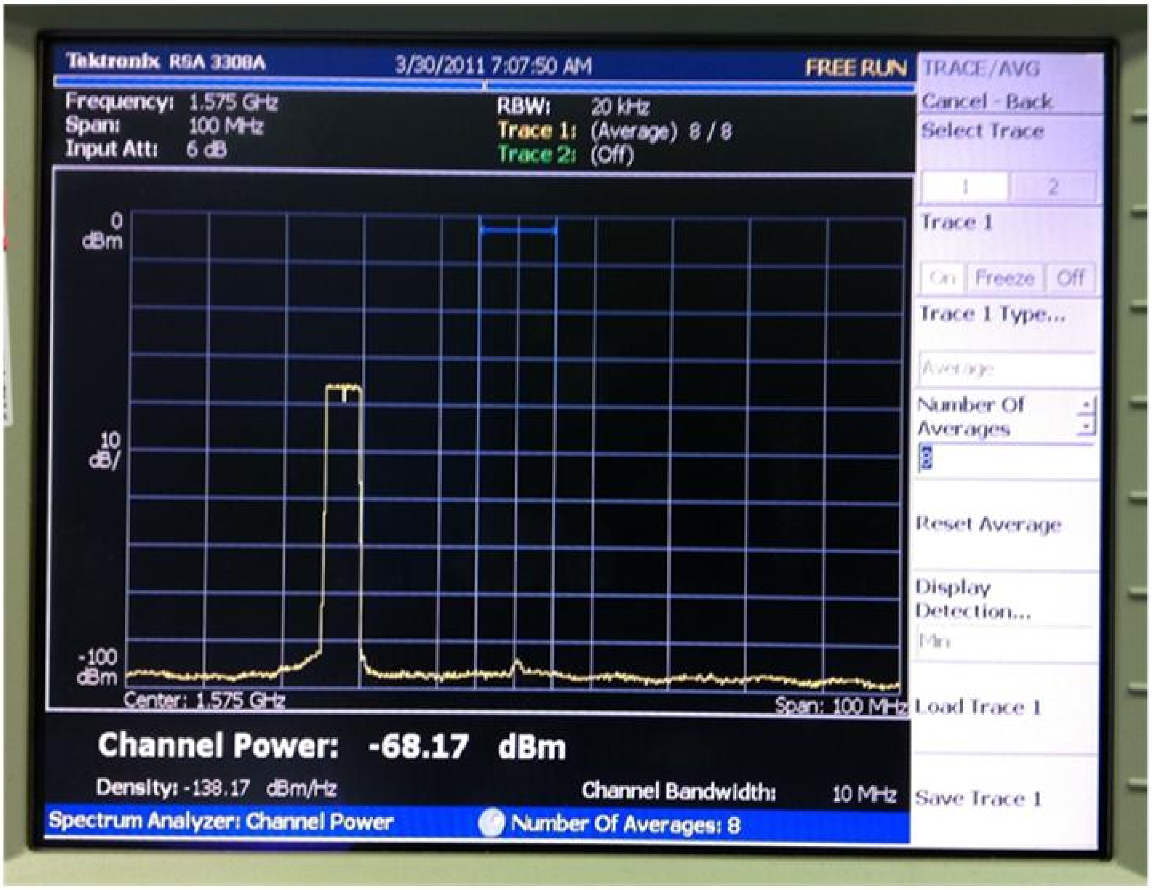
When the two LightSquared signals centered at 1552.5 MHz and 1528.7 MHz pass through an odd-order non-linearity, one set of Intermodulation Products is produced in the GPS L1 pass-band:

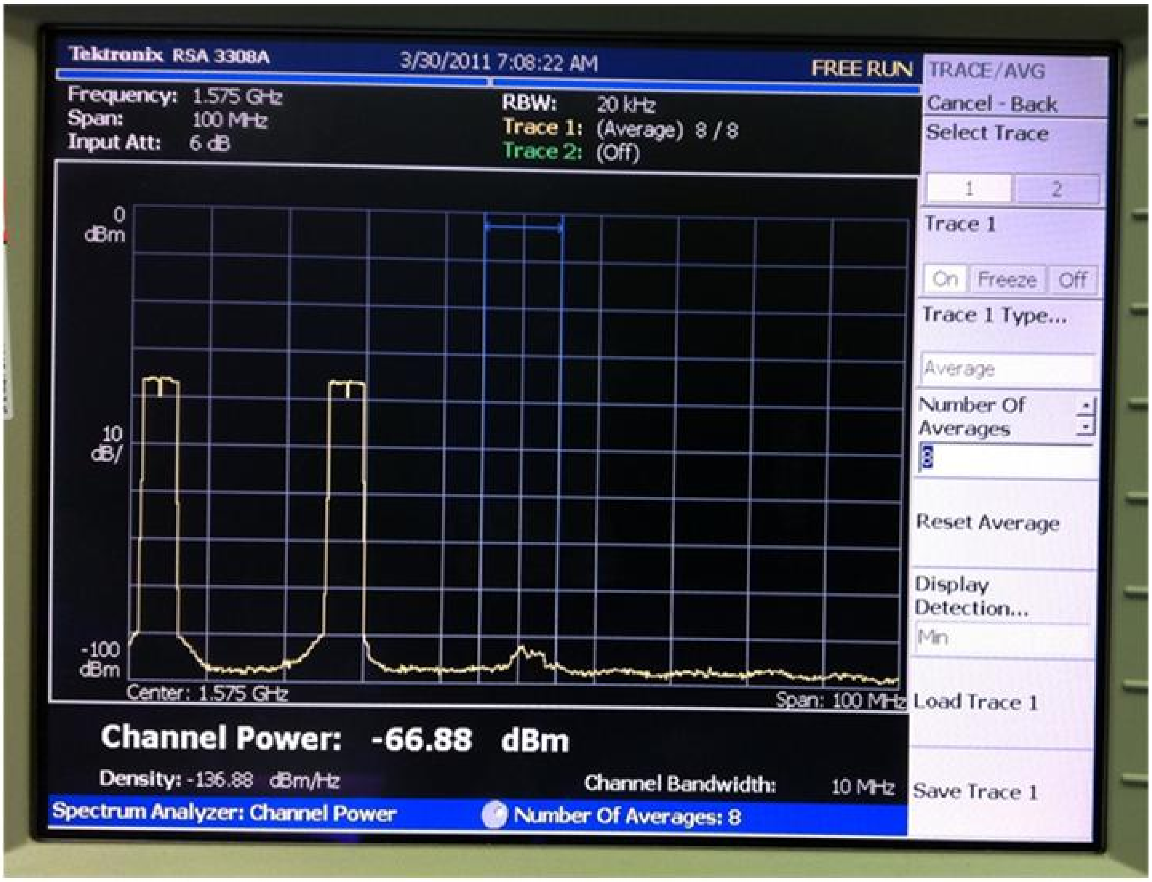
2 x 1552.7 MHz - 1528.8 MHz == 1576.6 MHz

In order to observe this IMD effect:

We connect our "Antenna Output Simulator" output to an LNA (Richardson Electronics Model 1216A, measured above) and monitor its output on a spectrum analyzer. With only one LightSquared signal turned ON at -45dBm, we do not observe any added power in the GPS L1 pass-band. With both LightSquared signals turned ON at -45dBm each we observe an Intermodulation Product appear in the GPS L1 pass-band. This is also shown to affect the receiver C/No in the GS receiver result section below.




Tektronix RSA 3308A
3/30/2011 7:07:50 AM
FREE RUN
Frequency: 1.575 GHz
Span: 100 MHz
Input Att: 6 dB
RBW: 20 kHz
Trace 1: (Average) 8 / 8
Trace 2: (Off)
0 dBm
10 dB/
-100 dBm
Center: 1.575 GHz
Span: 100 MHz
Channel Power: -68.17 dBm
Density: -138.17 dBm/Hz
Channel Bandwidth: 10 MHz
Spectrum Analyzer: Channel Power
Number Of Averages: 8
TRACE/AVG
Cancel - Back
Select Trace
1
2
Trace 1
On
Freeze
Off
Trace 1 Type...
Average
Number Of Averages
8
Reset Average
Display Detection...
Min
Load Trace 1
Save Trace 1



We use the following method to measure the Distortion-Free Dynamic Range of our ”Antenna Output Simulator” and to verify that no new power is being added to the GPS L1 pass-band **before** the output of our ”Antenna Output Simulator”, ie: that any Intermodulation products that we observe on a spectrum analyzer are being created **after** the ”Antenna Output Simulator” output port:

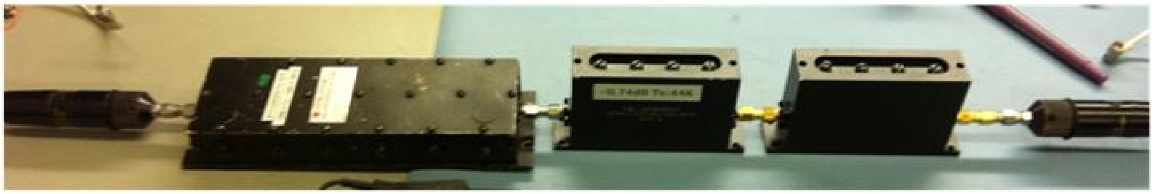
We insert a GPS L1 band-pass filter with a steep cutoff between the output of our Antenna Simulator and an LNA. We monitor the output of the LNA on a spectrum analyzer as we alternate turning ON and OFF the LightSquared signals. We increase the power of both signals until we start noticing an increase in power in the GPS L1 pass-band.

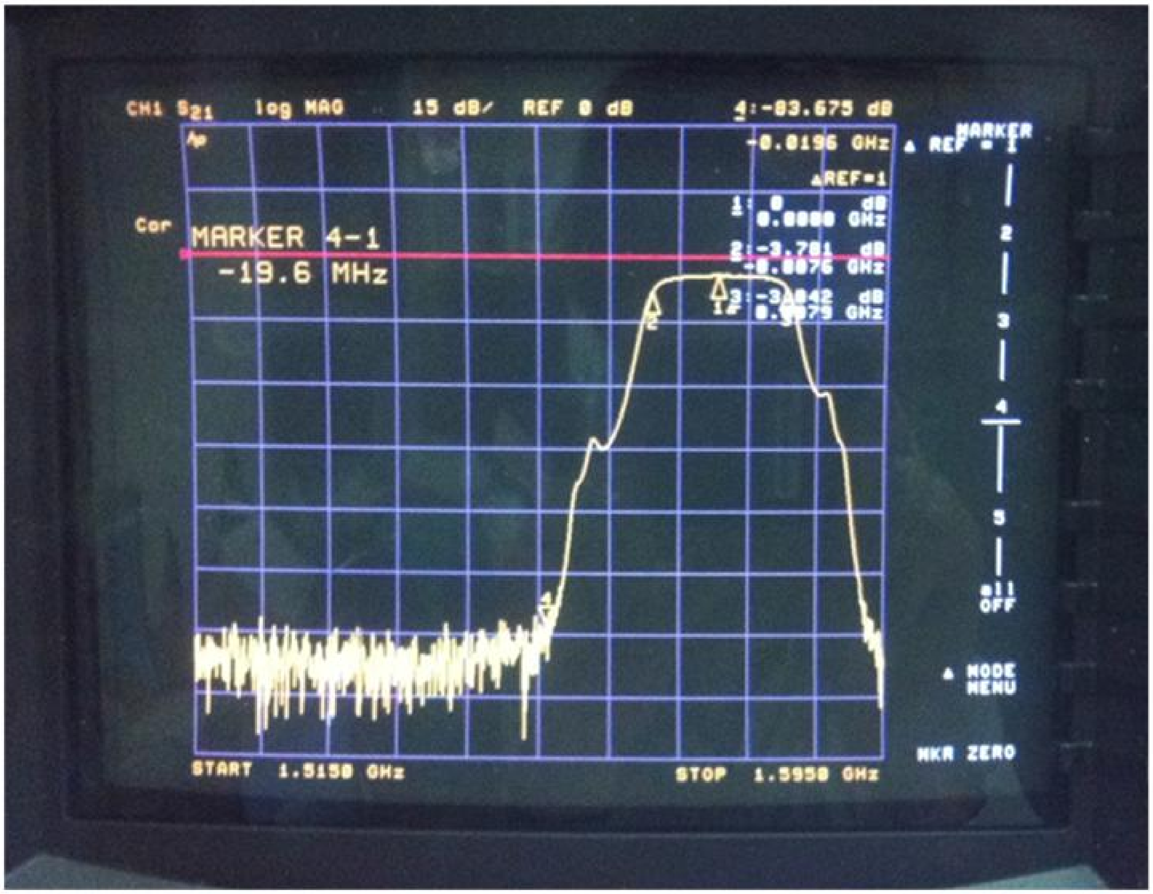
We make such a filter by connecting in succession **three microwave cavity filters**. Measuring this filter on a **HP 8722C** Network Analyzer we get:

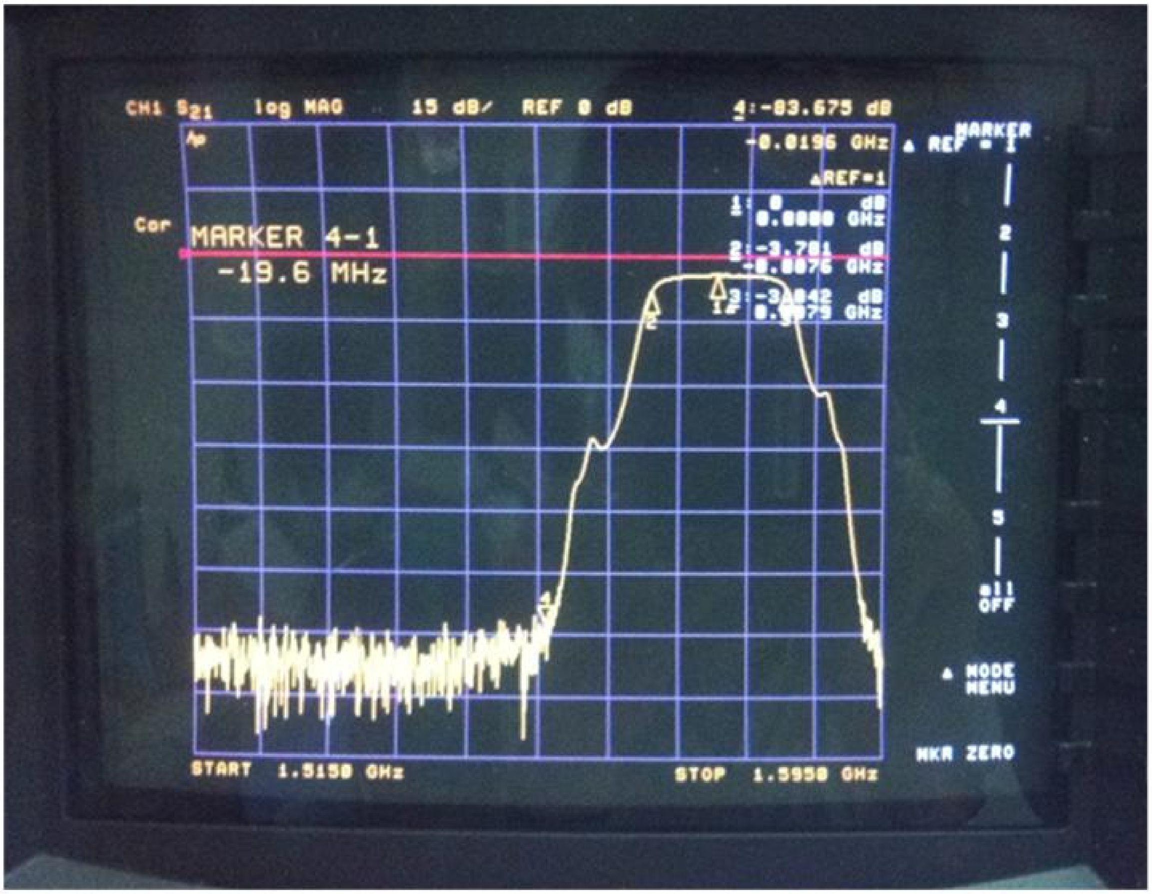
- **S21 at 1575 MHz = -4.3 dB**
- **S21 at 1555 MHz = -83 dB**

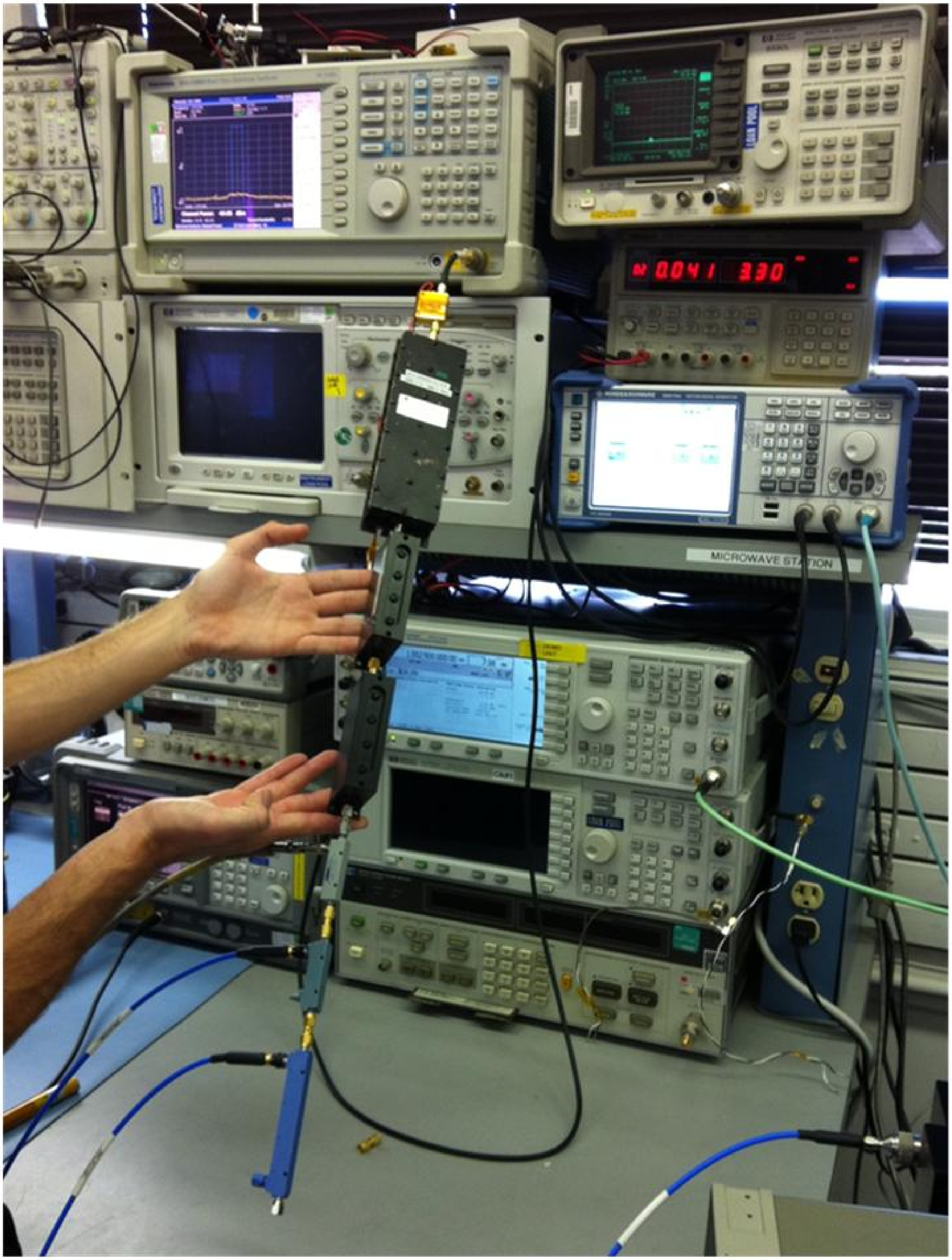
We notice no added power in GPS L1 pass-band even when both VSG are set to maximum output (+10.3dBm and +7.98dBm for 1528.7 and 1552.5 signals respectively).

From this experiment we conclude that there are no IMD products coming out of our ”Antenna Output Simulator” output port, and that our Distortion-Free Dynamic Range is at least as wide as the output power ranges of our Signal Generators.

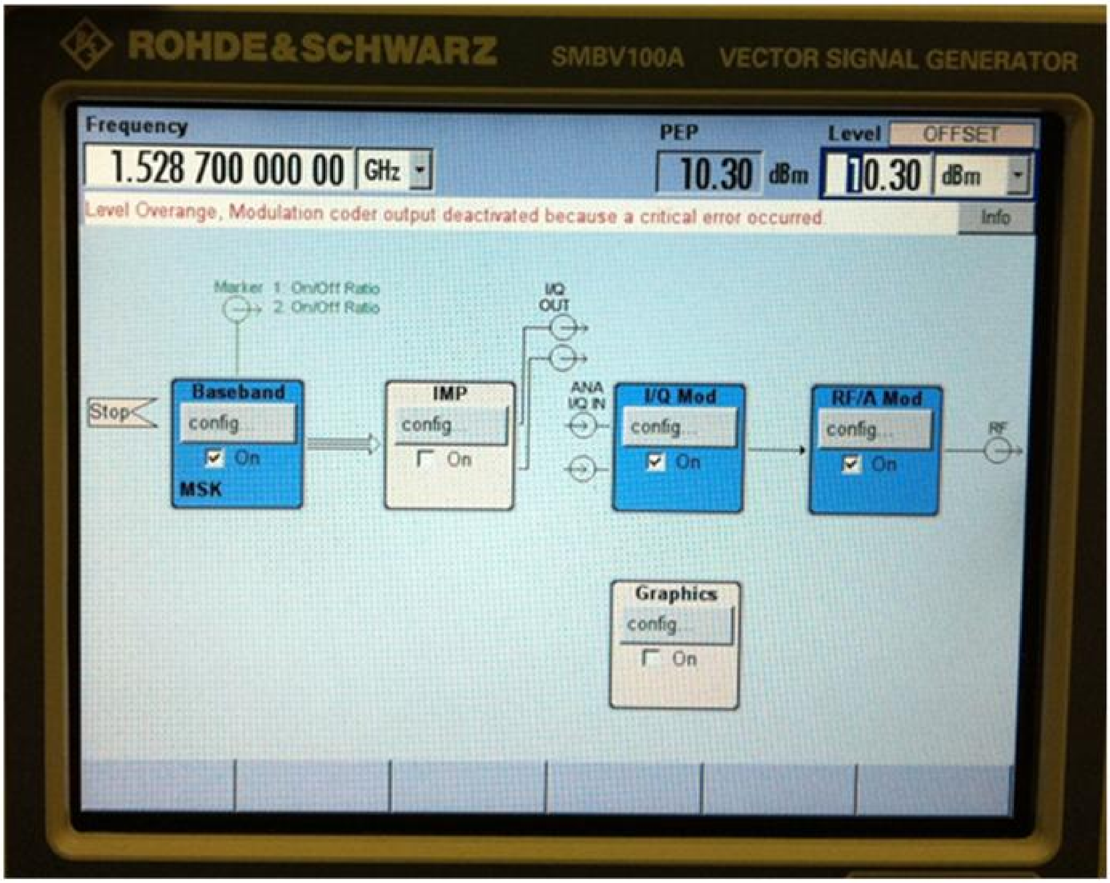


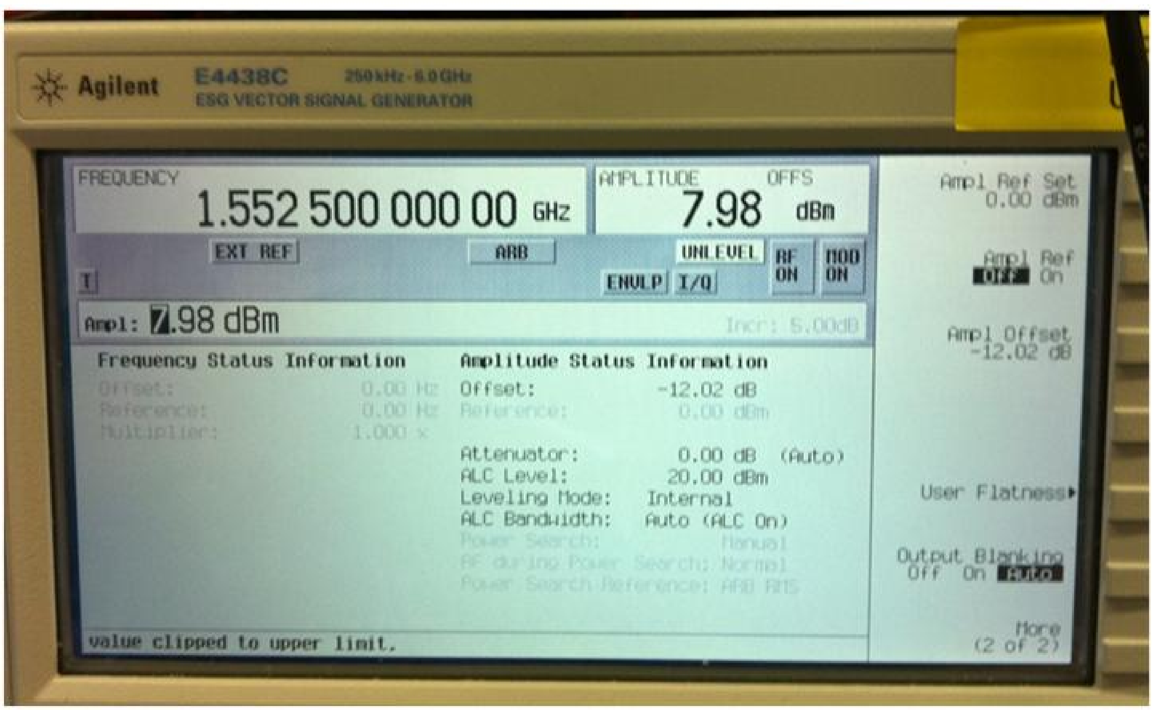

CH1 S21 log MAG 15 dB/ REF 0 dB 4:-83.675 dB
-0.0196 GHz
▲REF=1
1: 0 dB
0.0000 GHz
2:-3.701 dB
-0.0076 GHz
Cor
MARKER 4-1
-19.6 MHz
MARKER
▲ REF = 1
2
3
4
5
all
OFF
▲ MODE
MENU
MKR ZERO
START 1.5150 GHz
STOP 1.5950 GHz


CH1 S21 log MAG 15 dB/ REF 0 dB 4:-83.675 dB
-0.0196 GHz
▲REF=1
MARKER 4-1
-19.6 MHz
START 1.5158 GHz
STOP 1.5958 GHz
MARKER
MKR ZERO


0.041 330
MICROWAVE STATION


Tektronix RSA 3308A
3/30/2011 7:20:17 AM
FREE RUN
Frequency: 1.575 GHz
Span: 100 MHz
Input Att: 6 dB
RBW: 20 kHz
Trace 1: (Average) 4 / 4
Trace 2: (Off)
-10 dBm
10 dB/
-110 dBm
Center: 1.575 GHz
Span: 100 MHz
Channel Power: -69.85 dBm
Density: -139.85 dBm/Hz
Channel Bandwidth: 10 MHz
Spectrum Analyzer: Channel Power
Ref Level (dBm): -10
AMPLITUDE
Cancel - Back
Ref Level (dBm)
-10
Auto Level
RF Atten / Mixer
Auto
RFAtt
Mixer
RF Att (dB)
6
Vertical Scale (dB/div)
10
Vertical Units
dBm
dBµV
V
µV
W
Corrections...


ROHDE&SCHWARZ
SMBV100A VECTOR SIGNAL GENERATOR
Frequency
1.528 700 000 00 GHz
PEP
10.30 dBm
Level OFFSET
10.30 dBm
Level Overange, Modulation coder output deactivated because a critical error occurred.
Info
Marker 1: On/Off Ratio
2: On/Off Ratio
I/Q OUT
ANA I/Q IN
Stop
Baseband
config...
On
MSK
IMP
config...
On
I/Q Mod
config...
On
RF/A Mod
config...
On
RF
Graphics
config...
On


Agilent
E4438C 250 kHz - 6.0 GHz
ESG VECTOR SIGNAL GENERATOR
FREQUENCY
1.552 500 000 00 GHz
AMPLITUDE OFFS
7.98 dBm
EXT REF
ARB
UNLEVEL
ENVLP I/Q
RF ON
MOD ON
Ampl: 7.98 dBm
Incr: 5.00dB
Frequency Status Information
Offset: 0.00 Hz
Reference: 0.00 Hz
Multiplier: 1.000 x
Amplitude Status Information
Offset: -12.02 dB
Reference: 0.00 dBm
Attenuator: 0.00 dB (Auto)
ALC Level: 20.00 dBm
Leveling Mode: Internal
ALC Bandwidth: Auto (ALC On)
value clipped to upper limit.
Ampl Ref Set 0.00 dBm
Ampl Ref Off On
Ampl Offset -12.02 dB
User Flatness
Output Blanking Off On Auto
More (2 of 2)