November 2011 Cellular Device Test Report

(with January 26, 2012 Addendum)

Introduction

Following direction from various federal agencies and the DoD, the NTIA and EXCOMM requested additional testing of certain categories of GPS receivers in September 2011[1]. Relevant here, the NTIA and EXCOMM decided to have certain cellular devices from the FCC TWG test campaign re-tested in addition to ordering independent lab tests for several more devices which were deemed important based on current sales into the US market.

To ensure neutrality and objectivity, LightSquared, EXCOMM and NTIA mutually agreed to appoint an expert observer who is GPS knowledgeable, one familiar with the TWG testing, and who is a current industry executive, Greg Turetzky of CSR. To run the latest tests, NTIA and EXCOM decided to revisit the Cellular TWG labs to use their specialized base stations emulators, known as Spirent PLTS and ULTS instruments, to provide necessary assistance GPS data and extract measurements over each test trial.

These independent labs, InterTek (Lexington, KY) and ETS-Lindgren (Austin, TX) routinely perform compliance and certification tests of CDMA and UMTS cellular devices respectively, and have the racks of automated and calibrated A-GPS test equipment plus technical staff to support these industry standard tests. Two TWG Cellular team members, Rich Lee of Greenwood Telecommunications (which serves as an advisor to LightSquared) who headed the Cellular TWG group and Edward Harris, Manager, RF Engineering, LightSquared were also involved and present at the labs to observe, facilitate and review results in accordance with the NTIA's direction. This also involved obtaining the additional devices requested by the NTIA in a test-ready state. LightSquared provided funding for the independent test labs and certain test equipment rentals. Spirent, a GPS test equipment company that was directly involved in the Cellular TWG testing, was again involved to support to implement the original automated test software and re-open instrument software license keys.

The purpose of the NTIA testing was not limited to passive observation. There was an engaged and active schedule the week of November 8 at the labs that included assessing consistency with the previous TWG test results confirming that the TWG test procedures and methods were correctly applied and accurately determine downlink LTE interference susceptibility. The testing team participants worked first-hand with lab staff at the two independent labs, and confirmed that the physical testing process applied to each device actually follows the prescribed test "suites"; with certain procedures being corrected as noted in to the body of this report. Where devices were re-tested, results were compared with those from TWG tests in order to determine that the test process, not just individual devices themselves, were correct.

[1] Letter from L Strickland to Hon. William Lynn, Hon. John Porcari September 9, 2011.

Selected FCC TWG Cellular Test Suites

Based on experience gained in the TWG work and given the end of November deadline set by the NTIA , it was agreed that the NTIA tests would only draw from three of the seven TWG test suites (along with agreement to only test the Lower 10 MHz base station downlink LTE as the interferer in these suites). The three suites provide the more salient and meaningful results and skip redundant tests based on the results seen in the TWG work. .

Baseline tests were performed to directly compare performance of devices when no interfering LTE signal is present and to otherwise confirm the device meets industry standards prior to testing it with a downlink LTE signal present.

The NTIA chose the TWG cellular devices to be retested and requested three new devices for this round of test. One of the new smartphone devices requested, is still pending due to difficulty of obtaining one that is test-ready as the attempts to modify one off the shelf have been unsuccessful to date. Another sample has been requested through a company involved in the manufacture of the device to ensure it is AGPS test-ready. We ask that the NTIA either assist us if the latest attempt to secure a test-ready device fails, or waive testing this device.

The NTIA requested each of the CD-XX devices shown below in Table I be either retested or tested anew. The devices for retest remained in the custody of the labs since the TWG results were concluded in June 2011 and were readily available for retest.

The three TWG suites selected[2] and agreed by the parties[3] were:

- *2.4.1.1.* This test suite characterizes the base station downlink signal impact on industry standard (3GPP, 3GPP2) AGPS performance.
- *2.4.1.2.* This suite characterizes the interference impact at +1 dB above the actual AGPS threshold sensitivity for each device. This suite is analogous to measuring a 1 dB C/No degradation very close to the sensitivity threshold of the receiver. As the sensitivity of the device could be lower than that required to pass the standardized sensitivity test described by 2.4.1.1, thus this test is believed to be more stringent than 2.4.1.1. This receiver desensitization test also uses a set of comprehensive pass/fail 3GPP/3GPP2 criteria (time to fix, position error and secondary metrics) over a minimum number of consecutive trials.
- *2.4.1.4.* This tests for interference impact on position accuracy per 3GPP and 3GPP2 standards under the condition of eight uniform satellite signal power levels all set to -130 dBm.

[2] These test suites are defined in the FCC TWG document, June 29, 2011
[3] Ed Drocella, NTIA, Email, November 3, 2011

TABLE I: Cellular Device Test Results (dBm)

Device	2.4.1.1 (TWG)	2.4.1.1 (NTIA)	2.4.1.2 (TWG)	2.4.1.2 (NTIA)	2.4.1.4 (TWG)	2.4.1.4 (NTIA)	Test Environment; Comments
UMTS Devices							
CD-37	-10	-10	-20	-10	-10	-10	Anechoic chamber tested
CD-38	-20	-10	-10	-15	-10	-10	"
CD-39	-10	-10	-10	-10	-10	-10	Conducted test
Device	**2.4.2.1 (TWG)**	**2.4.2.1 (NTIA)**	**2.4.2.2 (TWG)**	**2.4.2.2 (NTIA)**	**2.4.2.4 (TWG)**	**2.4.2.4 (NTIA)**	**Test Environment; Comments**
CDMA Devices							
CD-62	NA	0+	NA	0+	NA	0+	Conducted; NTIA requested this device be added.
CD-09	-15	-11	-15	-14	-15	-11	Conducted test
CD-10	-10	-8	-15	-10	-10	-8	"
CD-36	-30	-26	-30	-27	-30	-26	"

Notes to Table:

1. The values above represent the passing test values.
2. The anechoic chamber test limits the highest LTE signal (emulating the LightSquared base station signals) level to -10 dBm and the conducted test limit is limited to 0 dBm.
3. Green denotes a positive change; red denotes a negative change in interference impact compared to the TWG results.

Findings

1. There was no significant change in findings from the original TWG findings.
2. There was an incorrect calibration procedure at the ETS Lindgren test lab to determine the threshold for 2.4.1.2. However, once the error was corrected, there was no significant change in test results compared to the original findings.
3. Some minor differences in device performance between the TWG and NTIA cellular tests were observed
    a. For UMTS (the air interface primarily used by AT&T and T Mobile), test results improved for two devices in one or more of the three test suites by 5 dB, and were found in another case to be up to 5dB worse (Since 5dB step sizes were being used, this is the minimum change possible to measure in the anechoic chamber). The mechanism for improved results is unknown, but the degradation is believed due to the corrective action at the UMTS test lab in setting up the GPS satellite power settings correctly at baseline. For two tested devices, we observed 10 and 17 dB reported variation on ETS data sheets relative to the GPS receiver sensitivity threshold setting determined in the original TWG testing. Another confirmation test of 2.4.1.2 was performed on CD-44 which, of the remaining devices, had the most change in threshold. It too showed improved results compared to the earlier TWG test.
    b. For CDMA (used by Sprint, US Cellular, Verizon and others), interference threshold improved uniformly due to using a 1 versus 5 dB interferer step size, which reduced the

measurement uncertainty and improved accuracy, at least in conducted test environments.

4. The NTIA requested adding another device, CD-62, which passed above 0 dBm. This is the highest level LTE signal that the lab test system is capable of testing.
5. Test suite 2.4.1.2 had to have a corrective action taken due to the way the device baseline was set for GPS threshold sensitivity. This was true only at the ETS lab. None of the changes in test results for the UMTS devices tested at ETS were deemed meaningful in terms of the sample of devices tested or to overall results at ETS from earlier tests.

Other Points

Test of an additional smartphone sample: One carrier was originally contacted in October but was unable to fulfill our request and another carrier was not responsive our request for test ready devices. Separately, a smartphone was then obtained from LightSquared to at least see if it could be placed into test but that was unsuccessful. This was due to the carrier phone subsidy "lock" that prevents retail device operation unless it is authenticated over the air. After that attempt, the team reached out to the silicon provider whose technology is in that particular model smartphone.

Reliability of (only) Cellular Device C/N_o measurements: In a radiated environment, the power levels vary significantly and in particular, near the tracking threshold. Therefore, C/N_o measurements alone, especially at low signals, are not a reliable indicator of interference impact.

References:

1. FCC TWG Report and Appendix, both submitted 6/29/2011

Conclusions

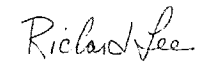
These latest tests show no material change and reinforce the results obtained in the TWG testing performed earlier this year. Consistent with the TWG Report findings, the impact of LTE transmit power at the lower 10Mhz band, 1526-1536 MHz, on GPS operation in cellular devices is minimal or nonexistent if LTE power by site design and EIRP is managed to not exceed -30dBm on the ground. An error in the baseline test for Suite 2.4.1.2, the +1 dB desensitization test, was discovered at the anechoic test lab, ETS Lindgren. This was subsequently corrected for the UMTS devices tested, but reveals no other systematic or material differences once corrected.

Overall, the test results are largely unchanged for the UMTS devices as seen in Table I above. For CDMA devices that were 100% conducted tests, finer granularity was obtained simply by decreasing the step size of the interference signal to obtain finer test results than using the original and somewhat coarse 5 dB step size between pass and fail consecutive test trial sets. Based on the finer measurement granularity the average improvement was just over 3 dB in reported susceptibility for the selected CDMA devices using the finer 1 dB step size.

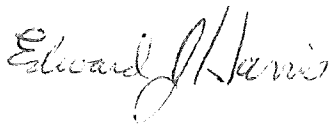
Signed:
November 29, 2011

Greg Turetzky

Rich Lee

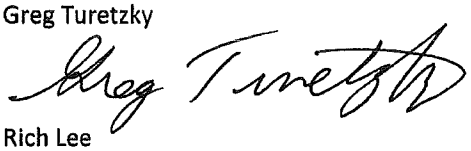


Edward Harris

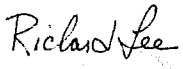


Signed:
November 29, 2011

Greg Turetzky



Rich Lee



Edward Harris

ADDENDUM

On Tuesday, January 24, 2012 the Smartphone device referenced in the original report that was delayed beyond the original test deadline was finally secured in a lab test-ready state from the OEM device maker and was finally provided to Sprint during the week of January 16 and under terms with the OEM had to be personally brought to the test facility by Sprint technical management employee, Kevin Butler. As with all the previous TWG and submitted devices since, there was no knowledge of the adjacent band test results.

The Smartphone device was promptly tested after calibrating the assisted GPS simulator, interference generator and CDMA network emulator was performed. Test results for that device, designated as **CD-66**, have been added to the original Table I and is shown below as "UPDATED" and other that the new CD-66 results is the identical table that was submitted to the NTIA on November 29, 2011.

UPDATED TABLE I: Cellular Device Test Results (dBm)

Device	2.4.1.1 (TWG)	2.4.1.1 (NTIA)	2.4.1.2 (TWG)	2.4.1.2 (NTIA)	2.4.1.4 (TWG)	2.4.1.4 (NTIA)	Test Environment; Comments
UMTS Devices							
CD-37	-10	-10	-20	-10	-10	-10	Anechoic chamber tested
CD-38	-20	-10	-10	-15	-10	-10	"
CD-39	-10	-10	-10	-10	-10	-10	Conducted test
Device	**2.4.2.1 (TWG)**	**2.4.2.1 (NTIA)**	**2.4.2.2 (TWG)**	**2.4.2.2 (NTIA)**	**2.4.2.4 (TWG)**	**2.4.2.4 (NTIA)**	**Test Environment; Comments**
CDMA Devices							
CD-62	NA	0+	NA	0+	NA	0+	Conducted; NTIA requested this device be added.
CD-66	NA	0+	NA	0+	NA	0+	Conducted; NTIA requested this device be added.
CD-09	-15	-11	-15	-14	-15	-11	Conducted test
CD-10	-10	-8	-15	-10	-10	-8	"
CD-36	-30	-26	-30	-27	-30	-26	"

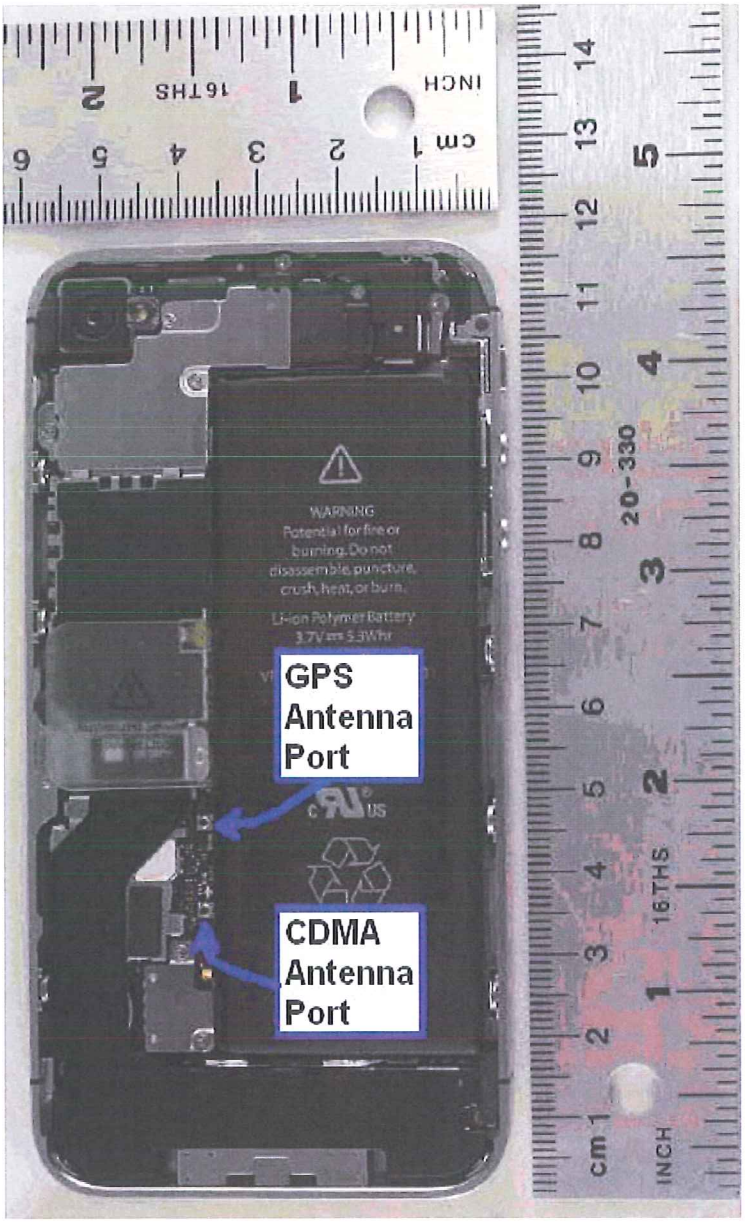
Notes to Table (same as original version):

1. The values above represent the passing test values.
2. The anechoic chamber test limits the highest LTE signal (emulating the LightSquared base station signals) level to -10 dBm and the conducted test limit is limited to 0 dBm.
3. Green denotes a positive change; red denotes a negative change in interference impact compared to the TWG results.

Since the new CD-66 device was not tested in the TWG test process there is no corresponding results to compare between this and a previous test, hence no color coding of results.

Of interest was the fact that CD-66 has both GLONASS and GPS capabilities. Since GLONASS satellite signals have frequencies above GPS (from 1590-1610 MHz), the adjacent band rejection characteristics were thought to be different than comparable narrowband cellular GPS receivers.

Downlink LTE between 1526-1536MHz was rejected at no less than most CDMA GPS-only receivers perform. Uplink signal tests showed -18 dBm susceptibility based on simulating the LTE uplink at 1626.5-1636.5MHz.



Signed:

K. L. B. _____ Kevin Butler, Sprint

Richard Lee _____ Rich Lee, Greenwood Telecommunications

January 26, 2012