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March 8, 2012

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

Re: *Amendment of Part 27 of the Commission's Rules to Govern the Operation of Wireless Communications Services in the 2.3 GHz Band (WT Docket No. 07-293) WRITTEN EX PARTE PRESENTATION*

Dear Ms. Dortch:

At a time when the Commission is finding it increasingly difficult to achieve the National Broadband Plan's goal of expanding the amount of spectrum available for mobile broadband, it is imperative that the Commission eliminate unnecessary rules that effectively preclude use of the 2.3 GHz band Wireless Communications Service ("WCS") for mobile broadband. Among other things, that means the Commission must reconsider and reverse its May 2010 adoption of a 50 mW/MHz power spectral density ("PSD") limit on WCS mobile devices.

On December 1, 2011, a report, "Simulation of TD-LTE User Equipment Transmissions in the WCS Band" by Jim O'Connor and Kurt Schaubach, was submitted by the WCS Coalition in support of its proposal for elimination of the 50 mW/MHz PSD limit (the "Report").[1] Most significantly, the Report presents the result of simulations which demonstrate that, although LTE transmissions may on rare occasion exceed the 50 mW/MHz PSD limit, power from a given mobile device tends to be evenly distributed across the WCS band when viewed over an appropriate period of time. These simulations establish that under real world operating conditions, the 50 mW/MHz PSD limit is not necessary to prevent harmful interference to Sirius XM subscribers.[2]

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[1] *See* Letter from Paul J. Sinderbrand, Counsel to the WCS Coalition, to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 07-293, Attachment (dated Dec. 1, 2011).

[2] To supplement the Report, on January 26, 2012, the WCS Coalition filed a presentation by Mr. O'Connor which addresses in detail the manner in which the simulations underlying the Report were conducted utilizing software developed for use in cellularized network planning. *See* Letter from Paul J.

To confirm that the simulation presented in the Report fairly reflects LTE performance, the WCS Coalition enlisted Mr. O'Connor and ATECS, LLC ("ATECS") to collect empirical data, characterize and report upon the uplink resource allocation and uplink transmit power of a commercial LTE system operating at 700 MHz in a major U.S. city. Attached hereto is a further report by Mr. O'Connor, which along with the annexed ATECS study, presents the results of that effort. Mr. O'Connor concludes that the "[r]esults from the ATECS field data collection on a commercial LTE network show that LTE PRB allocations are spread uniformly across the channel bandwidth over short periods of time relevant to the muting mechanisms in an SDARS receiver, and that the typical power levels of an LTE mobile device will be well below the 50 mW/MHz PSD limit in the vast majority of instances." Thus, while LTE may exceed the PSD limit of 50 mW/MHz "in rare instances when the mobile device is operating at the cell edge with full transmit buffer (high uplink data rate) conditions," such excursions are benign because they "occurred for a mere fraction of the SDARS receive buffer time period of 4 seconds."

Pursuant to Sections 1.1206(b)(2) and 1.49(f) of the Commission's Rules, this letter is being filed electronically with the Commission via the Electronic Comment Filing System. Should you have any questions regarding this presentation, please contact the undersigned.

Respectfully submitted,

Paul J. Sinderbrand

Counsel to the WCS Coalition

Attachment

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LTE Uplink Transmit Power Spectral Density Field Data Collection Report

WCS Coalition

March 7, 2012

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Introduction

In a December 1, 2011 filing,[1] the WCS Coalition provided the FCC with results of a simulation of LTE system performance in the 2.3 GHz WCS band with regard to uplink transmit power from mobile devices and nearly-uniform resource block assignments across the channel bandwidth (White Paper). This simulation supports WCS Coalition arguments to remove the new power spectral density (PSD) limit[2] of 50 mW/MHz adopted by the FCC for WCS mobile devices. As described in the White Paper, the PSD limit unnecessarily impairs the ability of WCS spectrum to be used for mobile broadband services using LTE and other advanced air interface technologies.

In response to questions regarding the simulation results, the WCS Coalition provided additional information on the simulation methodology on January 26, 2012.[3] In addition, the WCS Coalition engaged an independent engineering consulting firm to collect mobile device transmission data from a commercial LTE network. Attached as Appendix A is a report from that engineering firm containing empirical evidence that LTE mobile devices do perform in practice as predicted in the simulation that was the basis for the WCS Coalition's December 2011 filing.

Data collection background information

The WCS Coalition engaged the services of ATECS, LLC, a wireless engineering consulting firm with over 10 years of experience in 3G and 4G system design and testing. ATECS conducted air interface statistics data collection on a commercial 700 MHz FDD LTE network, using an off-the-shelf Sierra Wireless AirCard 313U modem (USB modem),[4] shown in Figure 1 below, connected to a laptop. Data was collected without prior coordination with the system operator as to the time and location.

Figure 1 Sierra Wireless 313U LTE modem

[1] *See* Letter from Paul J. Sinderbrand, Counsel to the WCS Coalition, to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 07-293, Attachment (dated Dec. 1, 2011)("White Paper").
[2] 47 C.F.R. § 27.50 (a)(3).
[3] *See* Letter from Paul J. Sinderbrand, Counsel to the WCS Coalition, to Marlene H. Dortch, Secretary, Federal Communications Commission, WT Docket No. 07-293, (dated Jan. 26, 2011).
[4] FCC ID: N7NAC313U.

The USB modem was configured for test mode to enable collection of detailed air interface statistics, including transmit power level and resource block allocation statistics, with a time granularity of 1 ms (i.e. an LTE sub-frame). During the data capture window for each operational environment tested, uplink data was generated and logged on the laptop hard drive. Data capture windows of 30-60 seconds were typical.

To characterize LTE transmit power and resource block allocation statistics in a diverse set of environments, ATECS collected uplink statistics under the following conditions:

- Stationary (no mobility) in a parking lot, good coverage;
- Pedestrian mobility in a hotel parking lot, edge of cell coverage;
- Vehicular mobility in an urban setting.

These environments were selected to sample the range of RF conditions where a WCS mobile device and an SDARS receiver could be in close proximity. These diverse environments allow observation of the dynamic power control and resource block allocation mechanisms employed in LTE to maximize system capacity. The empirical data collection results are presented in Appendix A as a series of six graphs for each of the three test environments for a total of 18 graphs. The results are grouped into three sections: transmit power statistics (9 graphs), resource block allocation statistics (6 graphs) and throughput (3 graphs). The throughput graphs are not necessary for demonstrating non-interfering behavior, but are provided as confirmation that significant uplink data transfer occurred during the data collection.

Transmit Power Statistics

The graphs included in Appendix A present for each test environment the following transmit power statistics:

- Average power per resource block for each 4 second window in a test file
- Power per MHz with 100 mS averaging versus time during the collection window;
- CDF of transmit power per MHz during duration of test.

Table 1 below provides a reference to the graph information for each of the transmit power Figures in Appendix A. The Figure numbers listed below correspond to the figure numbers in the report.

Graph type	Y axis	X axis	Series	Stationary	Pedestrian	Vehicular
1	mW	PRB ID	ave. power each 4 S of data	Figure 1	Figure 4	Figure 7
2	mW	time	ave. power in 100 ms for each 1 MHz	Figure 2	Figure 5	Figure 8
3	Probability	mW	100 mS power per MHz for entire data file	Figure 3	Figure 6	Figure 9

Table 1 Description of Transmit Power Graphs in Appendix A

The transmit power graphs shown in Figures 1 – 9 of Appendix A confirm that the simulation results[5] presented by the WCS Coalition in its December 1, 2011 filing are representative of commercial LTE system performance. The per MHz transmit power levels of mobile devices generally are substantially below 50 mW/MHz. In fact, per-PRB power levels below 1 mW are typical in the stationary and vehicular mobility conditions.

As mentioned in the WCS Coalition White Paper,[6] and as shown in the pedestrian and mobility environment data collection results in Appendix A, despite the fact that per-PRB power levels of less than 1 mW are typical, there are rare occasions when an LTE terminal may exceed 50 mW/MHz. It was observed that the transmit power exceeded 50 mW/MHz during 48 separate 100 ms/1 MHz samples collected in cell edge conditions in the pedestrian environment. This represents 1.78% of the pedestrian environment samples (270 data points for each 1 MHz of bandwidth, 2700 data points in total). None of these events were of sufficient duration to cause muting in an SDARS receiver.

Resource Allocation Statistics

The graphs included in Appendix A present for each test environment the following resource allocation statistics:

- PRB allocation count per 4 second window in drive test; and
- PRB allocation count for busiest 4 second window in drive test.

Table 2 below provides a reference to the graph information for each of the resource allocation Figures in Appendix A. The Figure numbers listed below correspond to the Figure numbers in the report.

Graph type	Y axis	X axis	Series	Stationary	Pedestrian	Vehicular
4	Count	PRB ID	each 4 second window in test file	Figure 10	Figure 12	Figure 14
5	Count	PRB ID	busiest 4 second window	Figure 11	Figure 13	Figure 15

Table 2 Description of Resource Allocation Graphs in Appendix A

Figures 10 – 15 in the Appendix document the near uniformity of LTE PRB allocations across the channel bandwidth, as predicted in the WCS Coalition simulation.[7] It is assumed that the PRB allocation statistics shown in the Appendix were influenced in part by: 1) the presence of few customers on the system at the time of data collection; 2) a full transmit buffer on the USB modem; and 3) a less than fully mature resource scheduler implementation on the system. Together, these factors result in larger blocks of resources being assigned to a given user device than would occur on a typical commercial system. In a more loaded, mature system with typical uplink throughput resulting from Internet page request, acknowledgement, overhead and VOIP traffic, fewer allocations would be expected than what was experienced on this system.

[5] See White paper at Figures 1 and 2.
[6] White Paper at 14.
[7] White Paper at Figures 3 and 4.

Throughput Statistics

The graph included in Appendix A for the throughput statistics presents:

- Throughput for based on 100 ms averages.

Table 3 below provides a reference to the graph information for each of the throughput Figures in Appendix A. The Figure numbers listed below correspond to the Figure numbers in the report.

Graph type	Y axis	X axis	Series	Stationary	Pedestrian	Vehicular
6	Kbps	time	100 ms average throughput	Figure 16	Figure 17	Figure 18

Table 3 Description of Throughput graphs in Appendix A

Figures 16 – 18 in Appendix A show the high throughput values observed on the LTE system. These peak levels of 16 and 18 Mbps in the stationary and vehicular mobility environments (both with very good coverage) approach the peak values for LTE using 16QAM modulation in a 10 MHz channel bandwidth and serve to validate the earlier statement that the system was lightly loaded by other customer traffic during the test period. Lower device throughput would be expected with more typical uplink Internet traffic demands, as well as higher system loading due to the presence of other customers being served by the same cell site sector, would result in much lower throughput for the typical user device and this lower usage would require lower overall transmit power.

Conclusion

Results from the ATECS field data collection on a commercial LTE network show that LTE PRB allocations are spread uniformly across the channel bandwidth over short periods of time relevant to the muting mechanisms in an SDARS receiver, and that the typical power levels of an LTE mobile device will be well below the 50 mW/MHz PSD limit in the vast majority of instances. As shown in Appendix A, LTE can support high uplink data rates without exceeding PSD limit of 50 mW/MHz except in rare instances when the mobile device is operating at the cell edge with full transmit buffer (high uplink data rate) conditions. Even under these circumstances, however, the excursion above the 50 mW/MHz PSD limit occurred for a mere fraction of the SDARS receive buffer time period of 4 seconds.

Appendix A

LTE Power Spectral Study

February 28, 2012

Data collection of LTE UE power spectral density and physical resource block allocation statistics

Prepared for: WCS Coalition

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Executive Summary

ATECS, LLC has characterized for the WCS Coalition the uplink resource allocation and uplink transmit power operation of an operating 3GPP Long Term Evolution (LTE) system in the 700 MHz band to provide empirical confirmation of earlier simulation work submitted to the FCC in December, 2011 (the "White Paper"). The simulations showed that the uplink transmit power profile for a portable LTE user device (UE) with high transfer rate uplink traffic in three different RF environments generally is less than the newly adopted FCC WCS power spectral density limit of 50 mW/MHz, and that physical resource block (PRB, or RB for short) distribution is fairly uniform across the channel bandwidth, even over short periods of time. Our empirical results largely confirm the results of the earlier simulation.

Introduction

4G broadband wireless systems based on LTE technology are deployed commercially in the U.S. and elsewhere today. The LTE standard is comprised of both Frequency Division Duplex (FDD) and Time Division Duplex (TDD) versions and is generally deployed currently in channel bandwidths of 5 and 10 MHz with other bandwidths supported. LTE is deployed in multiple frequency bands around the world by leading wireless operators and is supported by all the major infrastructure, device, chipset and core network vendors. LTE technology is inherently optimized for carriage of Internet and other packetized traffic such as voice over IP (VOIP), file transfer protocol (FTP), and other user traffic.

Data Collection Details

All data was collected using a Sierra Wireless LTE USB modem, FCC ID N7NAC313U. The device supports LTE in the 700 and AWS bands. A Lenovo Thinkpad laptop had the LTE UE mounted to the top of the screen using the plastic clip that came with the device. The laptop was placed on the center console of the vehicle at least 18 inches from any obstructions. The data was collected using Anritsu's Link Master LML data collection tool. Post-processing of the data was done by exporting the raw data to text using Anritsu's Link Master LMA tool, and then processing the text files using software developed by ATECS, LLC.

The LTE system characterized in these test results is located in a large U.S. city (NFL market) and the network is commercial with live customer traffic. Testing was done between 2:30 pm and 4:30 pm on Wednesday, Feb. 1, 2012 (the timestamp on the data is local time minus nine hours). The system is using the 700 MHz band and configured as 10x10 MHz FDD LTE with N=1 reuse.

A large set of tests was conducted in various locations in the test market under various mobility conditions. Uplink TCP/IP traffic was generated using FireFTP on a laptop. The program was pushing files to an FTP server in Denver as fast as the wireless service would allow, *i.e.* a full buffer condition on the LTE UE at all times. When service was lost and then restored, the FTP session would automatically restart. The receiving FTP server was limited to 60 Mb/s transfer rate, therefore the LTE link was the limiting segment for overall data transfer speed.

Test Environment Descriptions

A dozen data log files were captured in various outdoor urban/suburban environments and terminal mobility conditions. The post-processed results from three different environments are presented below. These three were chosen because they represent stationary, pedestrian speeds and slow highway speeds. The also represent coverage ranging from excellent to cell edge conditions. A summary of the three selected test environments follows:

- Stationary – Vehicle in a parking lot. Not line of sight to cell, but excellent RSSI. Suburban environment in a strip mall parking lot, along a busy surface street. The UE stayed on the same cell sector throughout the test. Duration of the data capture is approximately 45 seconds.
- Pedestrian speed – Going from one side of hotel with weak LTE service to the parking lot on the backside where service is lost. Total drive distance 30 yards at walking speeds. The UE handed between two different sectors a couple of times. Duration of the data capture is approximately 27 seconds.
- Vehicular speed – Drive from convention center to restaurant/bar neighborhood in downtown. Dense urban environment with heavy traffic, at 4 pm. The UE stayed on the same cell throughout the test. Driving speeds were low with some time spent not moving. Duration of the data capture is approximately 43 seconds.

Results

The empirical data is post-processed to allow comparison to the simulation presented in the WCS Coalition White Paper, which described predicted uplink power statistics and expected PRB distribution statistics for a Monte Carlo distribution of cell edge LTE devices associated with the same base station, sourcing uplink data traffic. In keeping with the White Paper, which showed results in a short time window with statistics on a per-PRB basis, the individual PRB power profiles are shown for each 4 second segment of each test environment presented. In order to provide some indication of the conformance of these results to the FCC power spectral density limit for WCS mobile terminals of 50 mW/MHz, results are also shown with data binned into ten separate 1 MHz bandwidths (5 contiguous PRB's) with 100 ms granularity in the time domain. A

cumulative distribution function (CDF) graph is also provided for each of the 3 environments showing the statistical probability of transmit power in each 1 MHz bandwidth for the entire drive.

The PRB allocation frequency distribution for each of the 3 environments is presented in 4 second segments and also in snapshot form for the busiest segment of each drive. We also present the uplink throughput profile during the entire test for each of the three environments characterized here.

Transmit power profile results

The uplink Tx power per MHz is clearly well below the FCC requirement of 50 mW/MHz during the stationary and vehicular tests with a few short term excursions above the limit during the pedestrian test owing to the cell edge/full Tx buffer conditions. Only at the edge of coverage does the power go above 50 mW/MHz for brief periods as seen clearly in Figure 5.

Overall, the Tx power per MHz is quite low and well below maximum power. In the stationary and vehicular tests, the power per MHz averaged over 100 ms is always below 1 mW.

Graph Types for power results

For each test environment (stationary, pedestrian, vehicular mobility) we present 3 graphs showing the transmit power statistics in different time and frequency dimensions, and a cumulative distribution function format. The graphs types are explained below.

Average power per PRB for each 4 second window during test

The power in each PRB is averaged over each 4 second interval in the drive test and displayed in the graph.

- Y axis: mW
- X axis: PRB identity (from 0 to 49)
- Data series graphed: each 4 second window of data is a different line

Power per MHz with 100 ms averaging versus time during test

The power in each 5-PRB group is averaged over each 100 ms interval in the drive test and displayed in the graph.

- Y axis: mW
- X axis: time over the duration of the data capture file
- Data series graphed: average power for each 1 MHz bandwidth in the channel bandwidth averaged every 100 ms (10 LTE frames)

CDF of transmit power per MHz for entire capture file

A cumulative distribution function of the average power per MHz is calculated using the data from the above graph type. This graph shows the probability that the average power per MHz will be below any value on the X axis.

- Y axis: cumulative distribution function probability that the power will be below a value on the X axis
- X axis: range of power levels observed during test, starting at zero
- Data series graphed: each 1 MHz bandwidth in the channel bandwidth is graphed separately using all values from the duration of the drive test.

Stationary location results

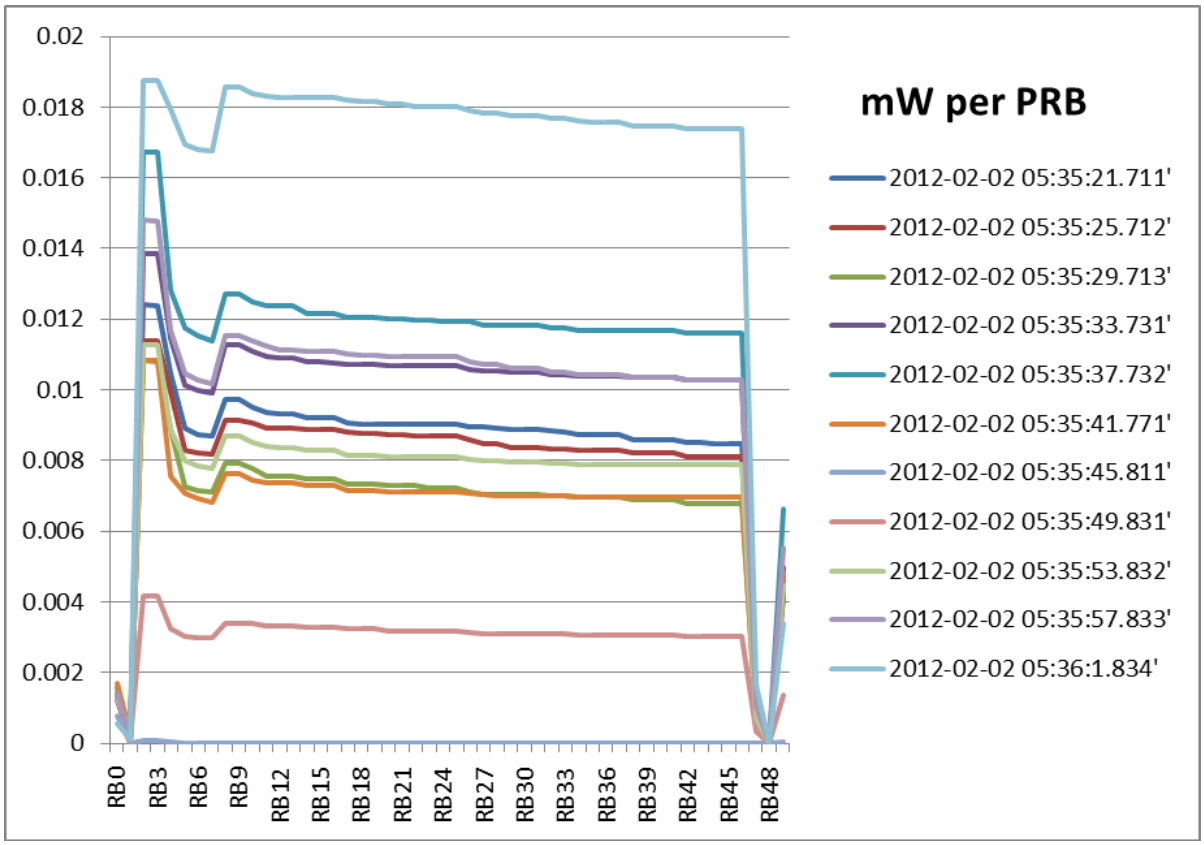

Figure 1 Stationary PRB average power in 4 seconds

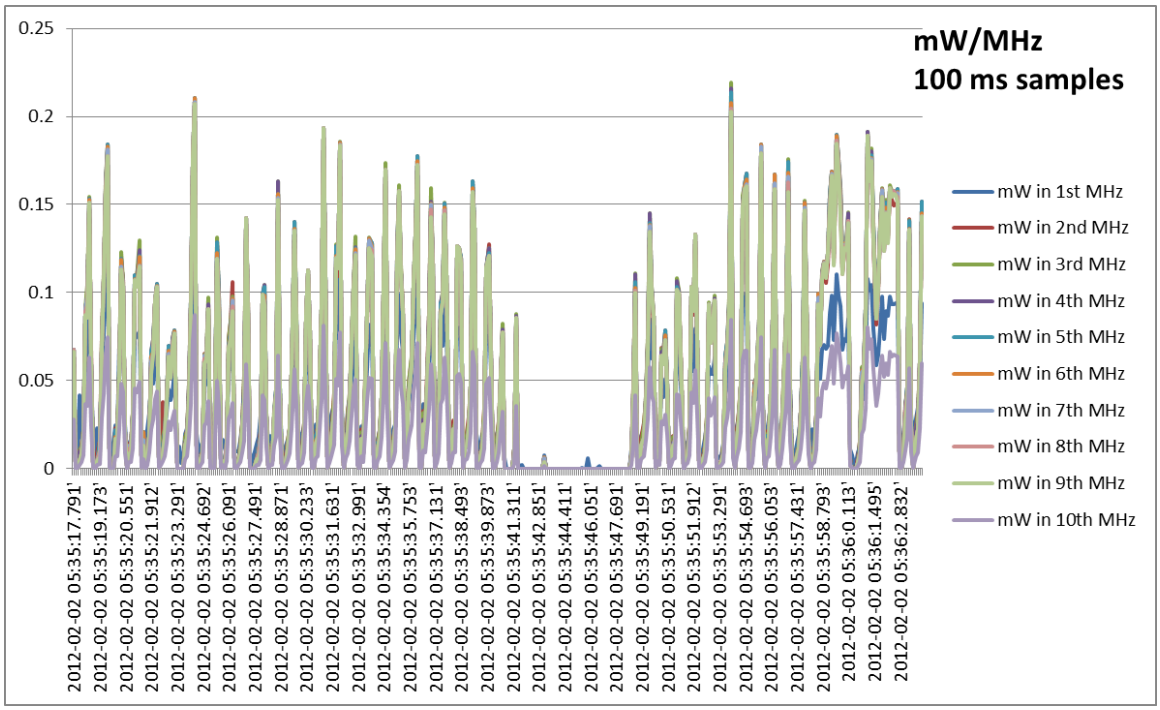

Figure 2 Stationary average power per 1 MHz in 100 ms

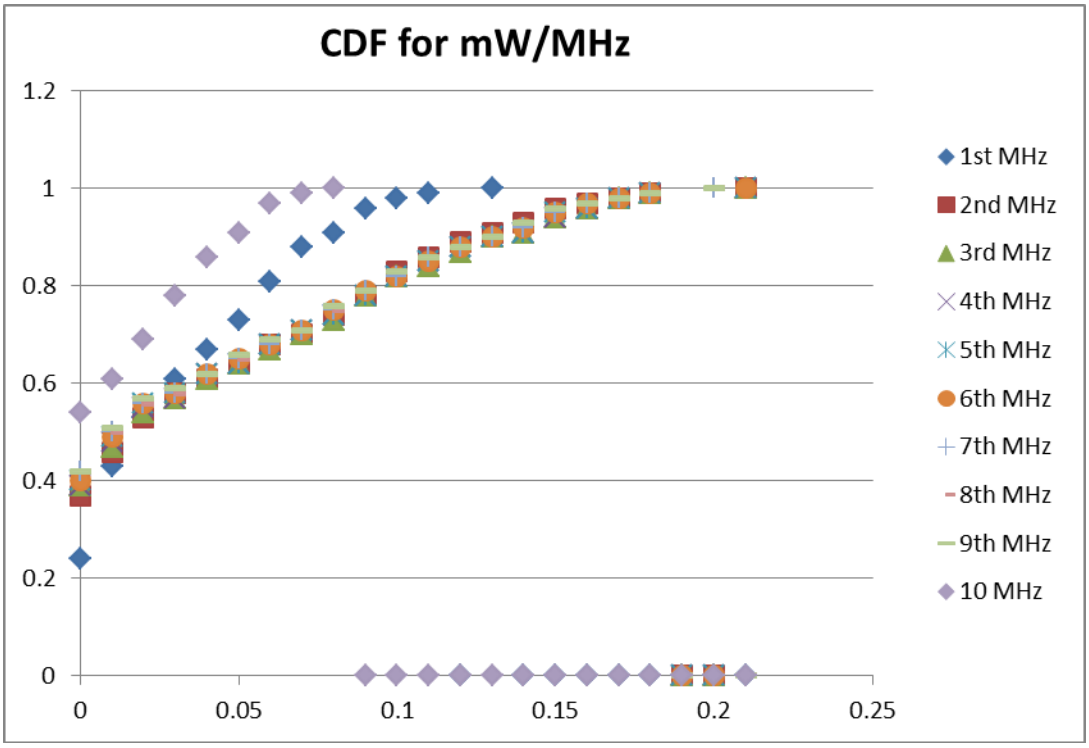

Figure 3 Stationary CDF of transmit power per MHz

Edge of cell pedestrian mobility results

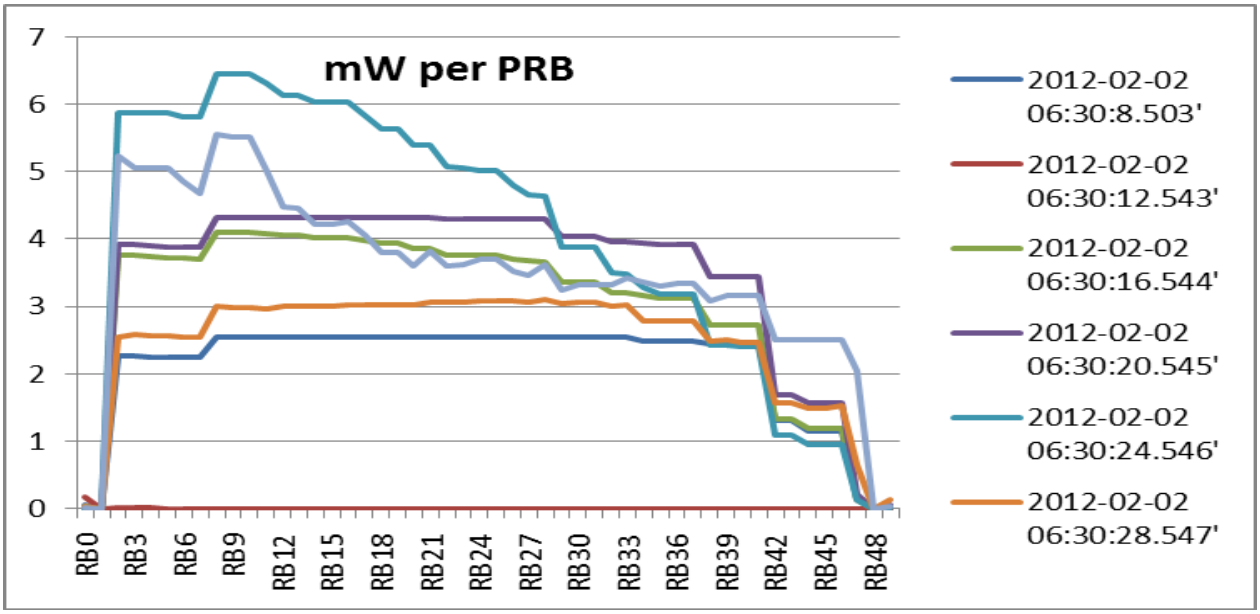

Figure 4 Pedestrian average power per PRB in 4 seconds

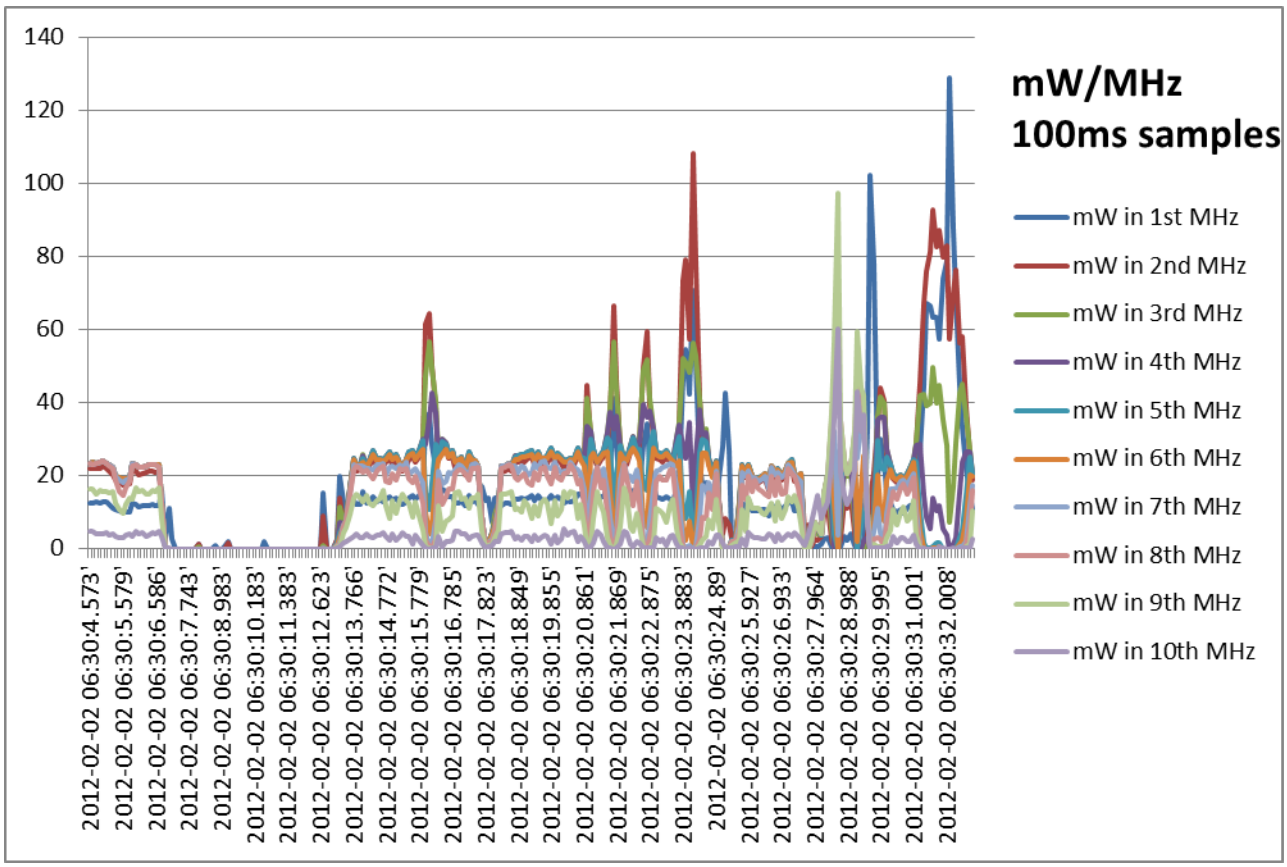

Figure 5 Pedestrian average power per 1 MHz in 100 ms

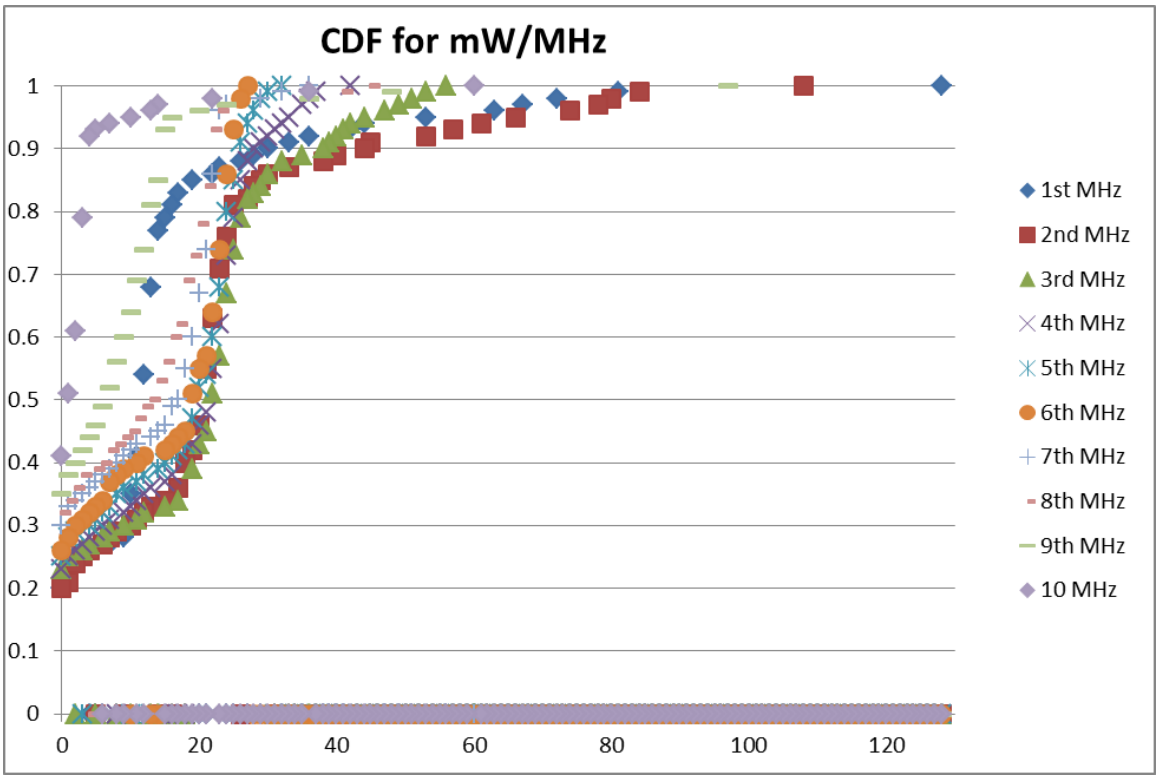

Figure 6 Pedestrian CDF of transmit power per MHz

Vehicular mobility results

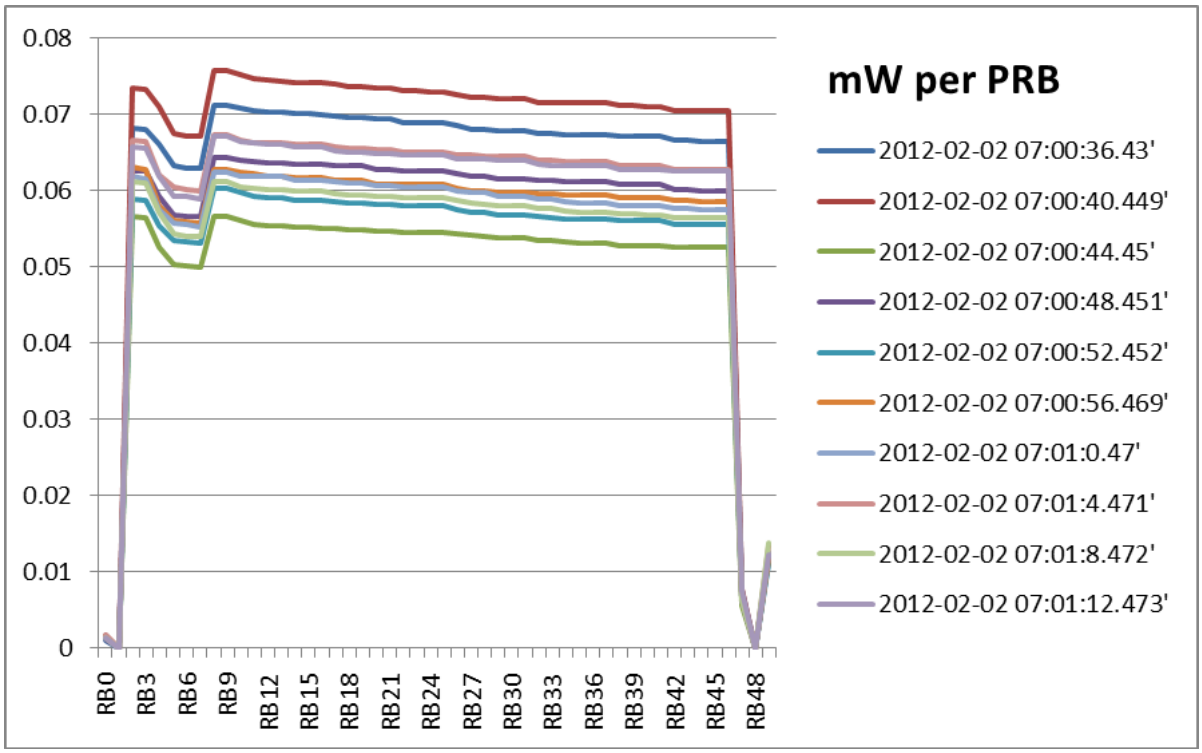

Figure 7 Vehicular average power per RB in 4 seconds

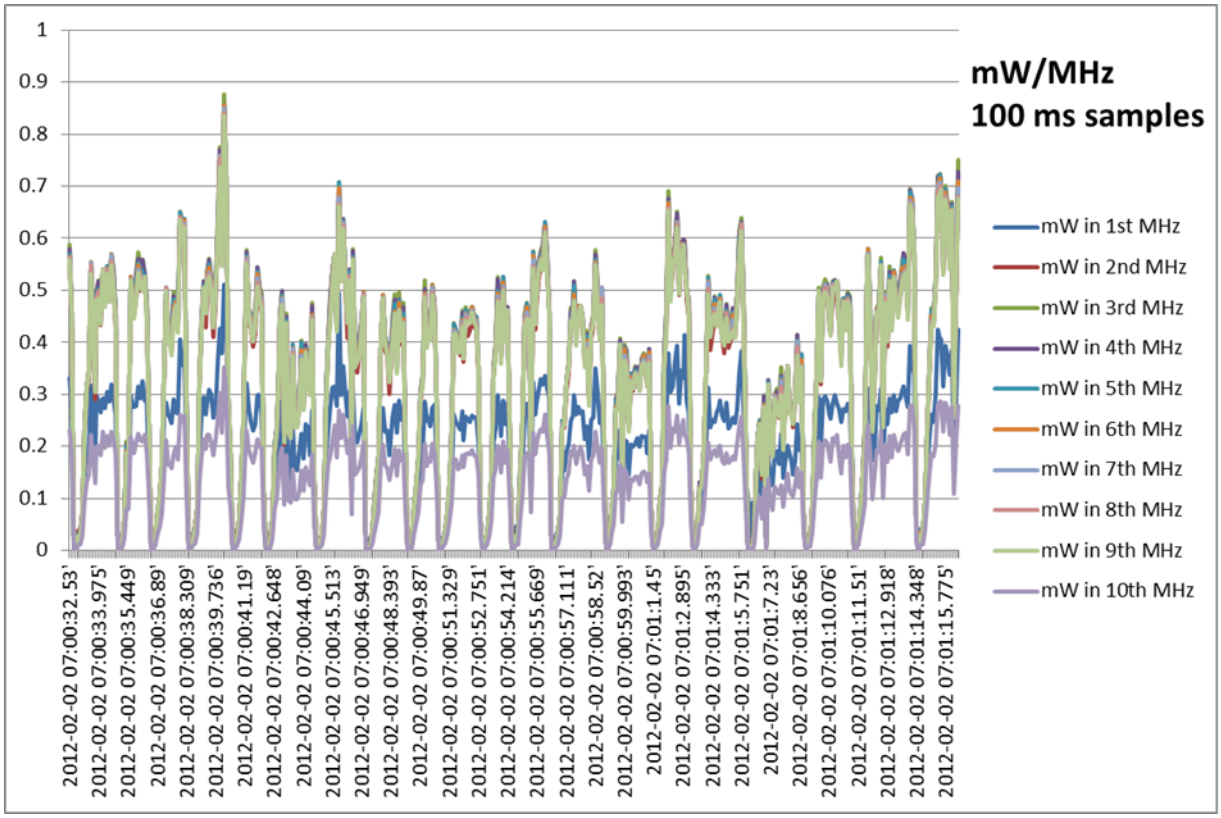

Figure 8 Vehicular average power per MHz in 100 ms

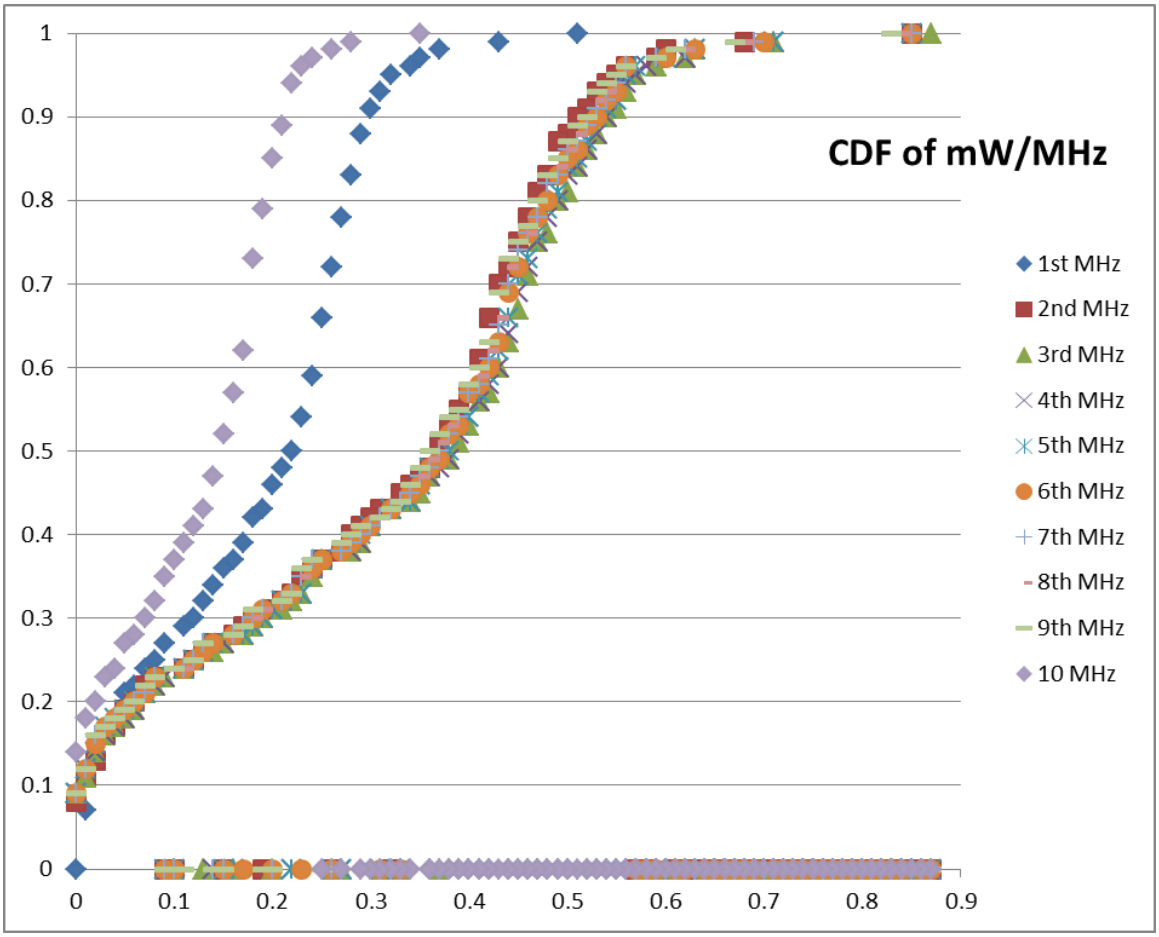

Figure 9 Vehicular CDF of transmit power per MHz

Resource Block allocation results

The LTE resource scheduler clearly is distributing the allocations rather uniformly across the 10 MHz of bandwidth. The physical resource block at the upper edge (PRB 49) is only being used for physical uplink control channel (PUCCH) messages. The two resource blocks at the lower edge of the band (PRB 0 and PRB 1) are also only being used for PUCCH control channel messages, while the rest of the PRB's are allocated for user data traffic.

Resource block allocation graph types

Below we describe the graphs types used to show the physical resource block allocation statistics in each test file.

PRB count per 4 second window in test file

The graph shows the number of times each PRB was allocated in each 4 second window. Allocations are scheduled on a subframe (1 ms) basis, therefore a PRB could be allocated to the test UE up to 4000 times in each 4 second window.

- Y axis: count (number of times PRB was allocated)
- X axis: PRB identifier (0 to 49)
- Data series graphed: the PRB count for each PRB during a different 4 second window during the test

PRB count for busiest 4 second window in the test file

This graph shows in more detail the PRB allocation statistics for the busiest 4 seconds during the data capture.

- Y axis: count (number of times PRB was allocated)
- X axis: PRB identifier (0 to 49)
- Data series graphed: the PRB count during the busiest (most allocations) 4 second window during the test

Stationary location results

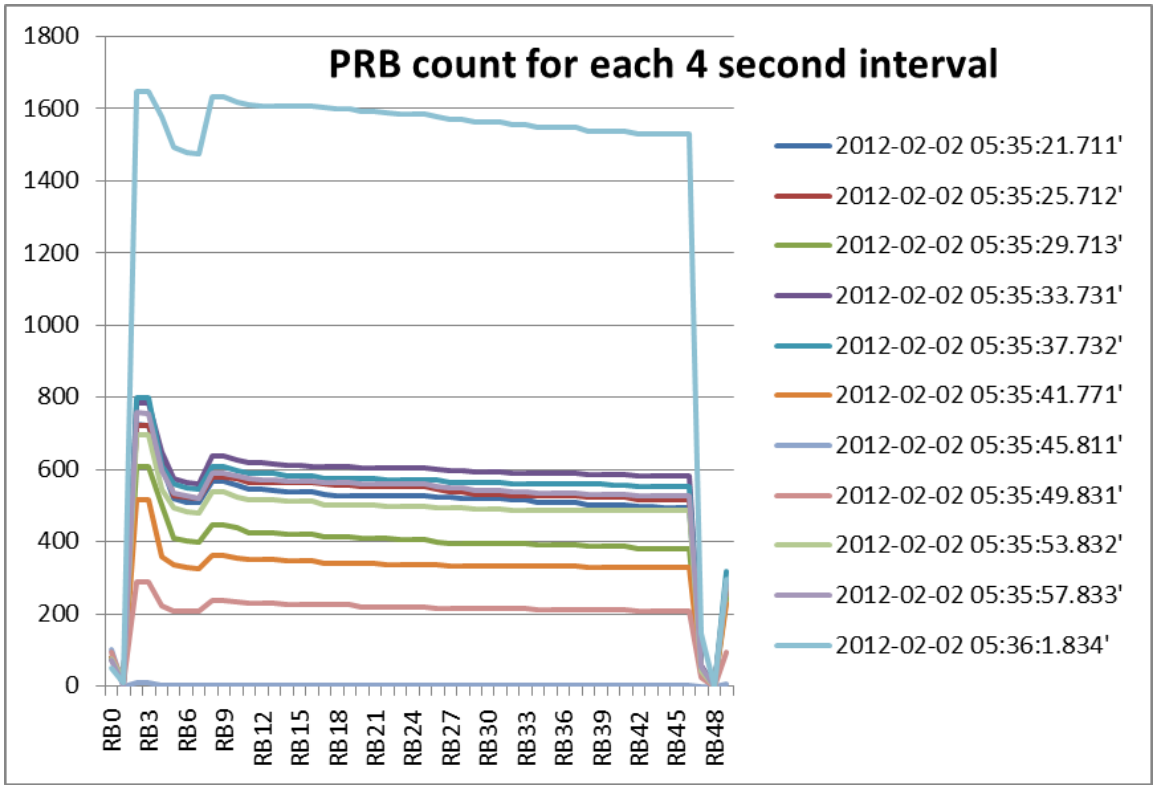

Figure 10 Stationary PRB count per 4 seconds

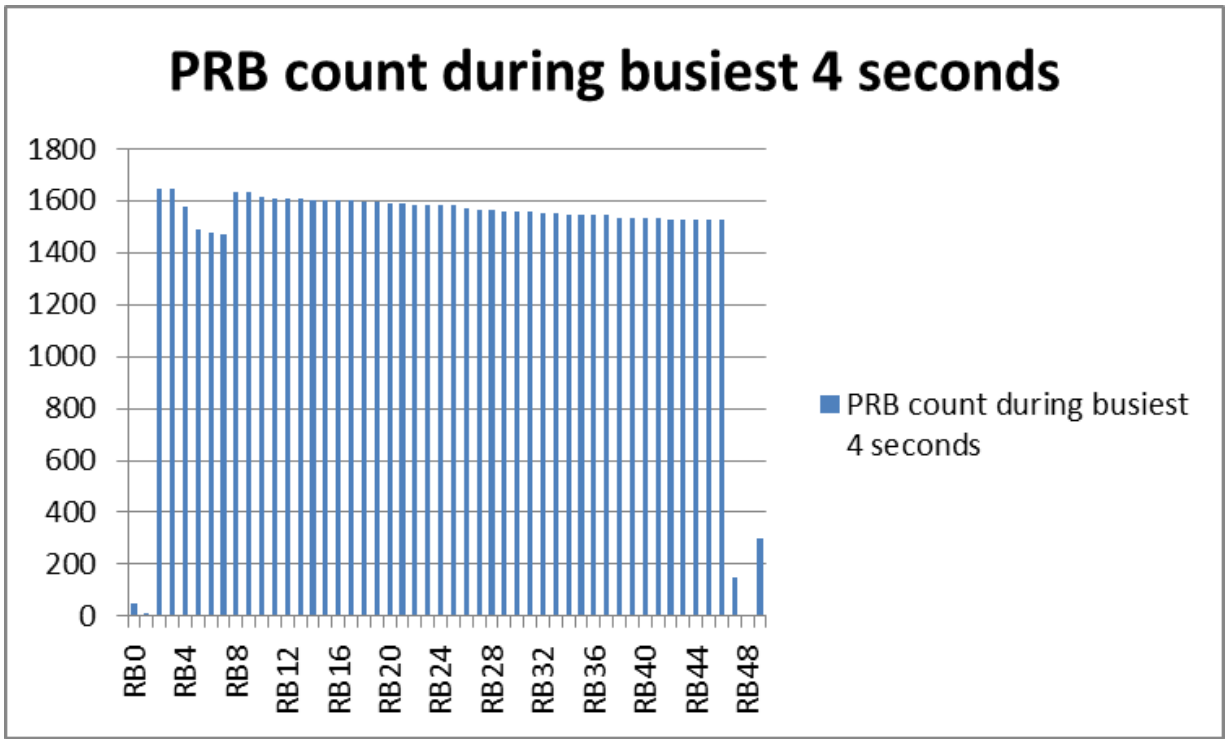

Figure 11 Stationary PRB count busiest 4 seconds

Edge of cell with pedestrian mobility results

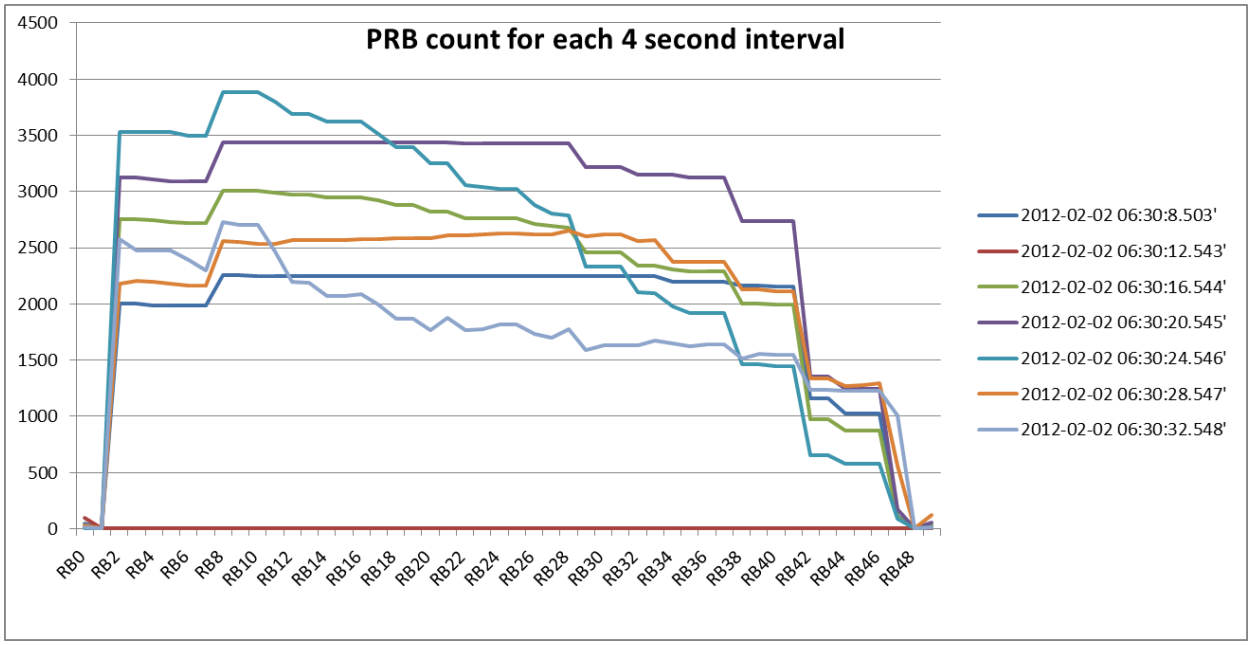

Figure 12 Pedestrian PRB count per 4 seconds

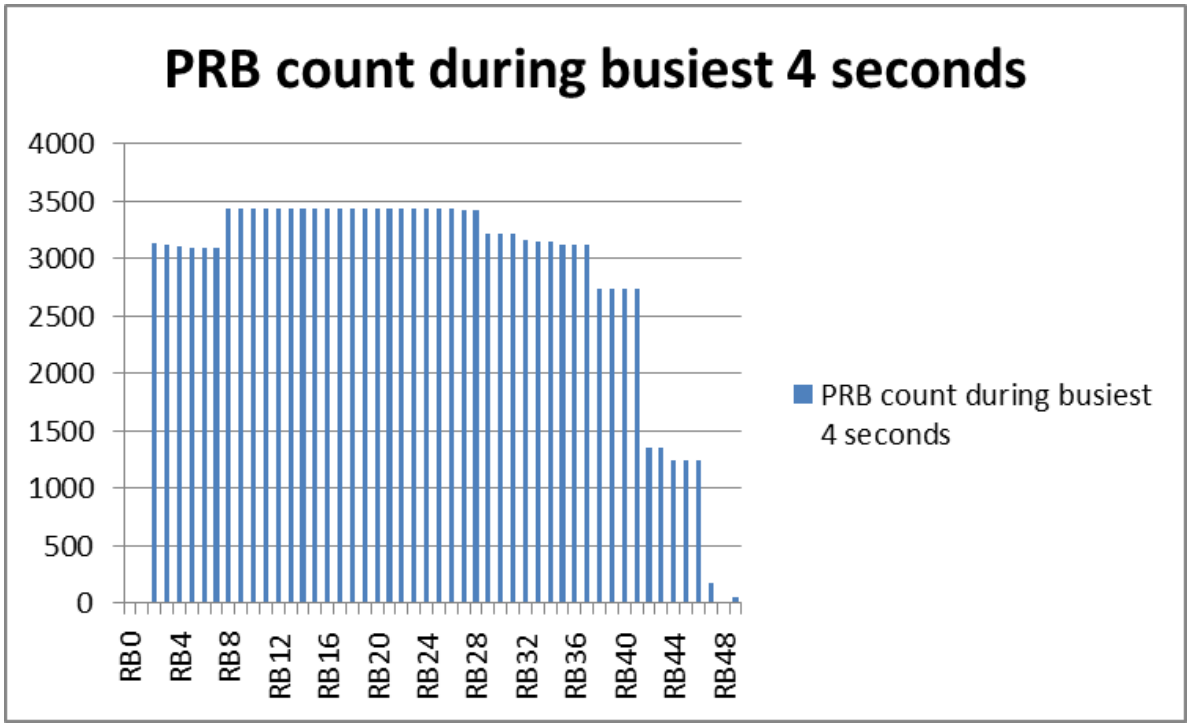

Figure 13 Pedestrian PRB count busiest 4 seconds

Vehicular mobility results

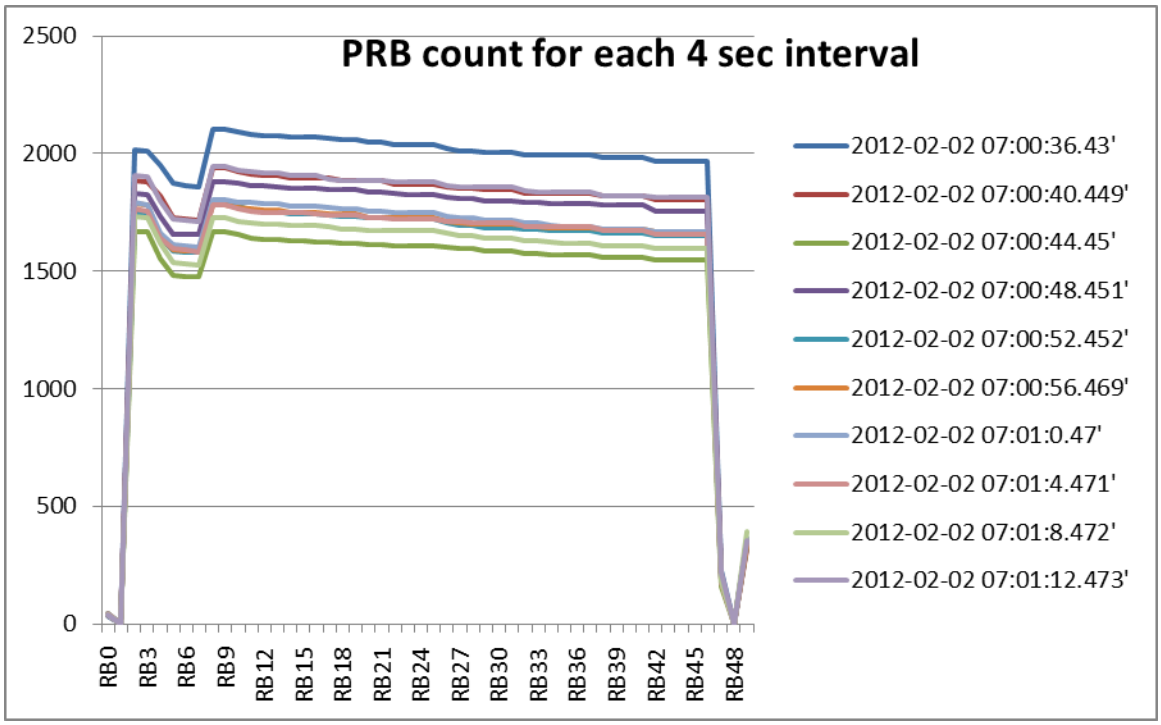

Figure 14 Vehicular PRB count per 4 seconds

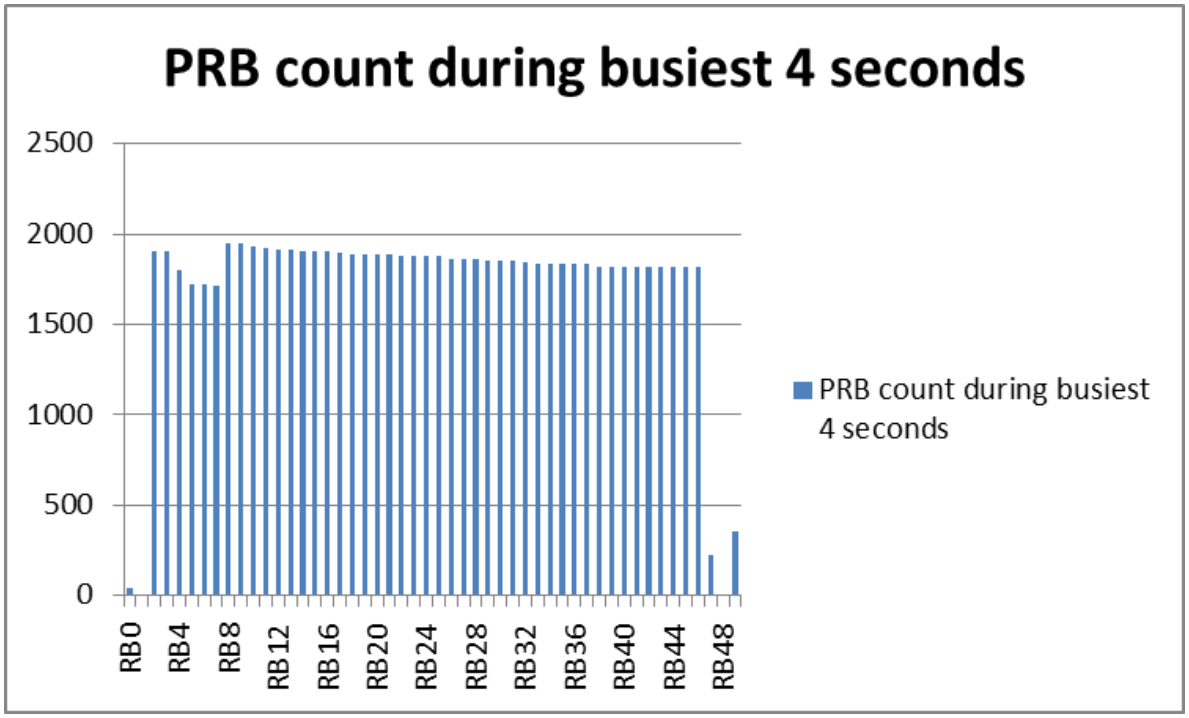

Figure 15 Vehicular PRB count busiest 4 seconds

Throughput results

The following graphs show the throughput for each of the three test environments. Each data point represents the average throughput during a 100 ms (10 LTE frames) segment of the data file. We notice by inspection that the activity levels in graphs 16, 17 and 18 is consistent with the mW/MHz/100 ms data shown in graphs 2, 5 and 8 respectively.

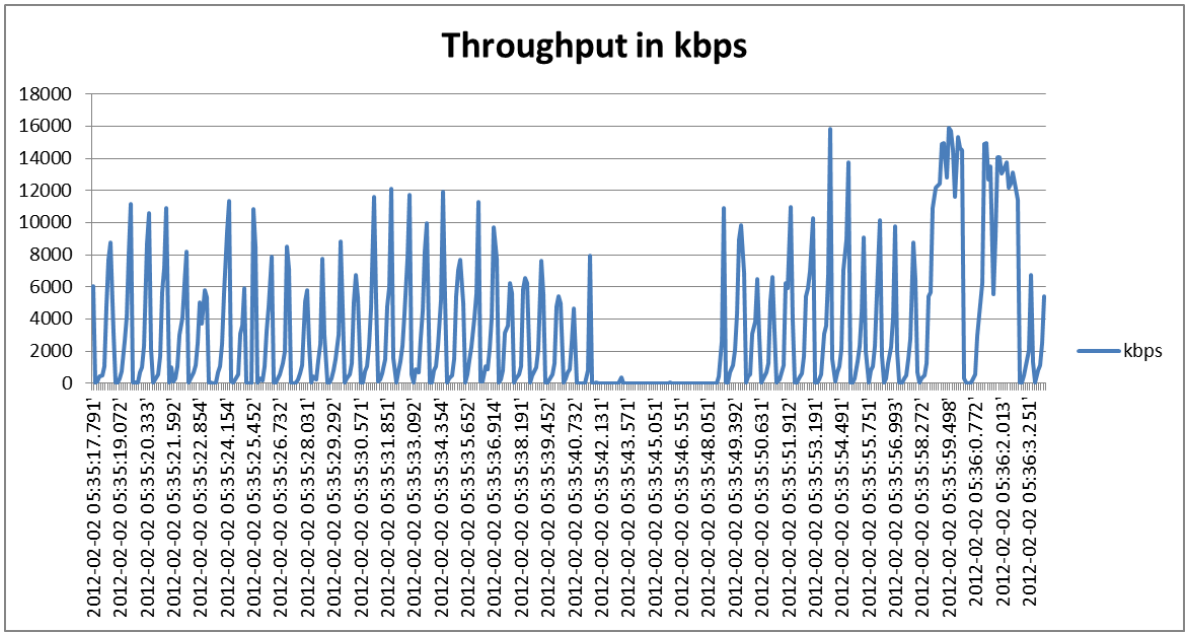

Figure 16 Stationary throughput entire test period

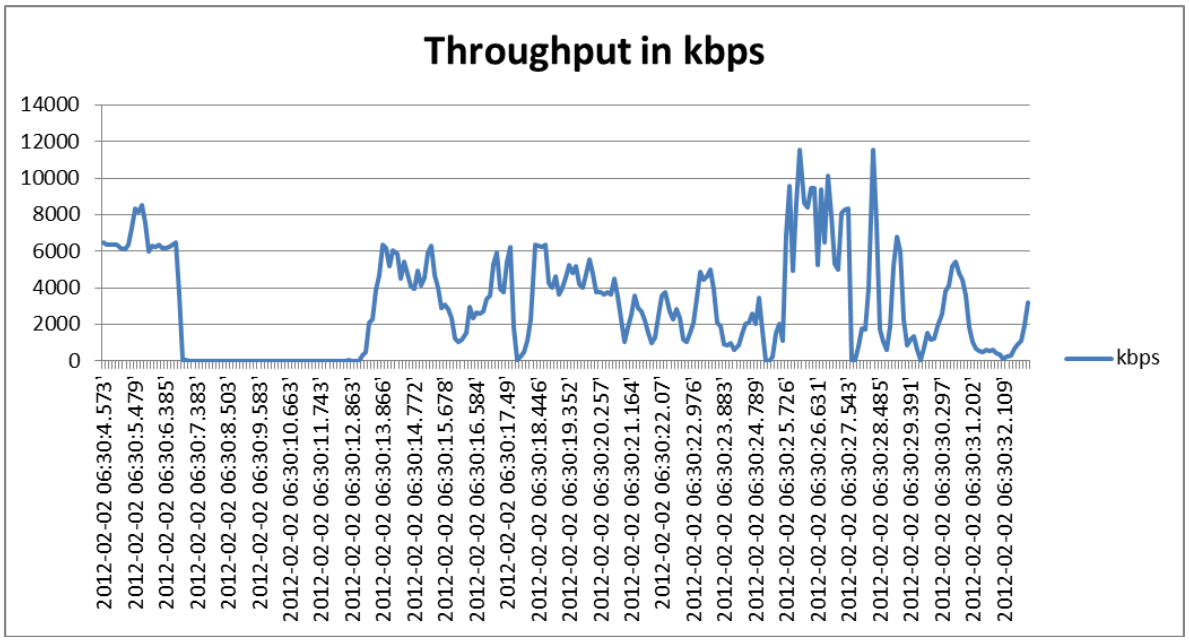

Figure 17 Pedestrian throughput entire test period

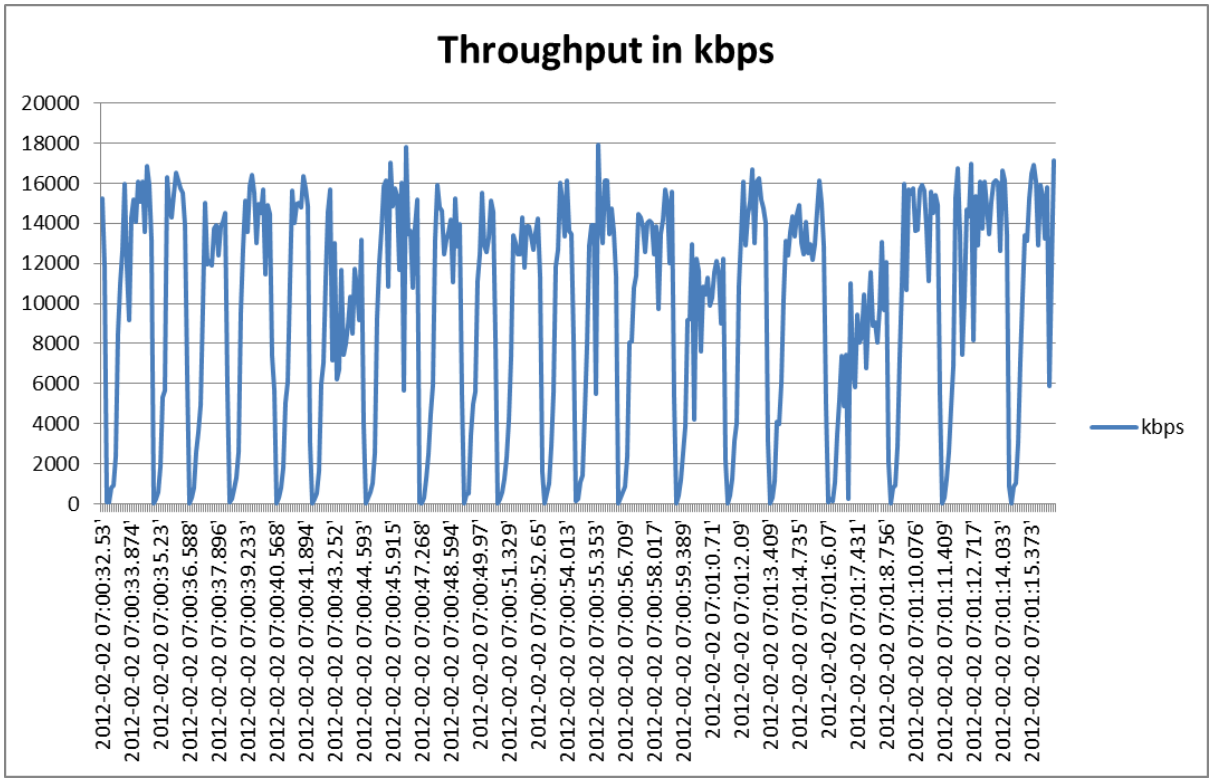

Figure 18 Vehicular throughput entire test period

Conclusions

Data capture and post-processing of LTE UE performance statistics on a commercial LTE network has resulted in the performance graphs shown above. The data collection effort was intended to show the basic operation of the resource scheduling and adaptive power control mechanism in a commercial LTE network. The resulting effect on PRB power and PRB allocation statistics was verified to be consistent with that shown in the WCS Coalition White Paper from December, 2011.

References

1: WCS Coalition ex parte_12-1-2011

Limited Warranty

ATECS LLC warrants that this analysis was performed in good faith using the methodologies and assumptions covered in this report and that data used for the analysis and report were obtained by ATECS LLC employees or representatives via drive testing or research of available information. In the event that specific third party details were not available, best efforts were made to use assumptions that are based on industry experience of various carriers' standards without violating any confidential information obtained under non-disclosure terms.

ATECS LLC also warrants that this analysis was performed in accordance with industry acceptable standards and methods.

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