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July 5, 2005

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

RE: Docket ET 05-183

Dear Ms. Dortch:

Attached is a study that examines the interference caused by a Remington Eye Ball R1 to a nearby 802.11b LAN. Remington commissioned Alion Science and Technology to perform this study. Alion is well known for their expertise in wireless and EMC/EMI issues. Alion is the prime contractor for the Joint Spectrum Center for the Department of Defense.

Remington asked Alion to quantify the interference that an Eye Ball R1 would create in a nearby 802.11b wireless LAN.

Alion measured the impairments created by operation of an Eye Ball R1 to an 802.11b LAN that was operating with relatively little margin. Specifically, Alion arranged the LAN so that it was suffering from a 1% packet error rate before any impairment from the Eye Ball R1 was added. The effect of the Eye Ball R1 transmissions on the operation of the LAN were then measured as the distance between the Eye Ball R1 and the LAN was varied. Measurements were made both inside and outside.

The measuring process inside was problematic. At distances as short as 3 meters the Eye Ball R1 did not impair the operation of the LAN. This counter intuitive result probably reflected a complex multipath environment inside in which the signal from the Eye Ball R1 was in a fade but the LAN signal was not. But, the multiple indoor observations of the 802.11b LAN functioning well when the Eye Ball R1 was nearby and transmitting co channel shows that the interference created by the Eye Ball R1 can be relatively minor.

The outdoor measurements gave results that were much as one would expect. The packet error rate was high when the separation was short but declined as the Eye Ball R1 was moved farther away from the LAN. Table 7 of the report illustrates this well. When the Eye Ball R1 was 21 meters from the LAN, the LAN connection was unusable. At 23 meters the LAN connection was intermittently usable but the error rate was quite high 73%. At a separation of

30.5 meters, the error rate had fallen to 27%. Finally, at a separation of 37 meters, the error rate fell to 8% and the LAN connection was clearly usable.

The unit that Remington provided to Alion for testing had output power of 0.5 watt. The production units will be similar to the tested unit but will have output power of 1 watt. Thus, the distances at which interference occurs will be scaled up by 20 to 40% over those measured by Alion. This scaling is explained in the Alion report.

To put these numbers in context, the Eye Ball R1 is designed to permit law enforcement officers to observe conditions in a room without the need to enter the room. The Eye Ball R1 permits law enforcement to look into a space believed to be unsafe and make direct observations without risk of injury from an individual with a firearm or other weapon. We believe strongly that people who are a few meters from such a location have more urgent concerns than possible interference on their wireless LAN.

Sincerely,

Gregg P. Skall

cc: Service List

Service List

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5 July 2005

Gregg P. Skall
Womble Carlyle Sandridge & Rice, PLLC
1401 I Street, N.W.
Washington, DC 20005-2225

Dear Mr. Skall:

Alion has completed the measurements you requested on the Remington Eye Ball R1 device. Please find the report of our results attached.

It has been a pleasure doing business with you. Don't hesitate to contact me should you have any questions or similar tasking in the future.

Anthony Perotti
Division Manager, C2 Systems/Measurement
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PERFORMANCE DEGRADATION MEASUREMENTS OF AN 802.11B LAN IN THE PRESENCE OF AN EYE BALL R1 EMITTER

Prepared by

Alion Science and Technology

Anthony Perotti
Ricardo Perez
April Robinson

30 June 2005

BACKGROUND

The Eye Ball R1, like any other co-channel radio emitter, is expected to cause performance degradation to the normal operation of nearby 802.11b LANs when operated co-channel at short separation distances. In order to determine the level of performance degradation, measurements were performed indoors and outdoors to monitor the 802.11b LAN performance in the presence of Eye Ball R1. This report documents the measured test results.

MEASUREMENT APPROACH

The measurements were conducted in 4 steps:

1. Spectral emission measurements
2. Indoor radiated performance measurements
3. Outdoor radiated performance measurements
4. Reduce the data and document the results

The indoor and outdoor measurements were performed to quantify the link quality of an 802.11b LAN in the presence of an Eye Ball R1 emitter at various distances.

The collected data, consisting of the signal level and the Packet Error Rate (PER) as a function of Eye Ball R1 distance, was analyzed to determine the level of degradation.

REMINGTON EYE BALL R1

The Remington Eye Ball R1 is a compact, physically-robust wireless 360° mobile camera system. The system comes equipped with a personal display unit (PDU) that can control two Eye Ball camera units. The PDU controls the rotation, transmission channel, and illumination of Eye Ball R1. The control signals are transmitted over the 902 to 928 MHz frequency band. Eye Ball R1 transmits an FM signal at 2.4 GHz carrying multiplexed audio and video.

EYE BALL R1 EMISSION SPECTRUM

The emission spectrum was measured with a HP8566B spectrum analyzer and a DRG SAS-200/571 calibrated horn that has an average gain of 10 dBi near 2.4 GHz and 6 dBi near 900 MHz. The horn was separated from Eye Ball R1 by one meter. The in-band emissions are shown in Figure 1. The 802.11b Direct Sequence Spread Spectrum (DSSS) channels and transmit frequencies along with Eye Ball R1 transmit frequencies are shown in Table 1. The table shows that R1 is co-channel (on-tune) with DSSS on channels 5 and 12 and off-tune by 2 MHz from channels 1 and 9. The Eye Ball R1 emission spectrum at 2450 MHz (Figure 1) shows a high level, the low-side side-band. The transmit power level at 2414 MHz is approximately 4 dB lower than the other transmit frequencies.

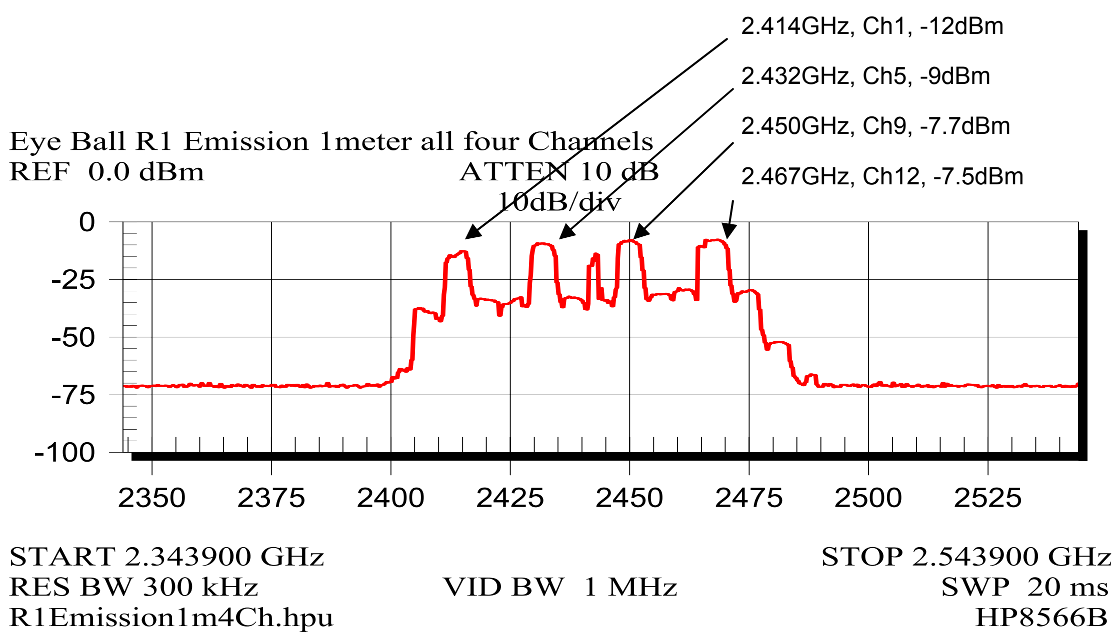

Figure 1. In-band Emission Spectrum of Eye Ball R1

Table 1. Channel and Frequency Pairing between DSSS and Eye Ball R1

DSSS (LAN) Channel	1	5	9	12
DSSS Frequency (MHz)	2412	2432	2452	2467
Eye Ball R1 (MHz)	2414	2432	2450	2467

LAN PERFORMANCE MEASUREMENT SETUP

Radiated measurements were performed indoors and outdoors. For each case, co-channel and adjacent channel radiated measurements were performed. Figure 2 shows a block diagram of the test setup. The 802.11b LAN link was setup by positioning two laptop computers in ad hoc-mode (peer-to-peer) separated by 30 ft. The link performance was monitored with a Berkeley Varitronics Systems Yellow Jacket 802.11b Analyzer. The Yellow Jacket receiver signal strength indicator (RSSI) and PER parameters were monitored. The ad hoc LAN was configured to maintain a baseline performance of 1% (PER) and -55 dBm (RSSI). This represented a fair to good signal quality.

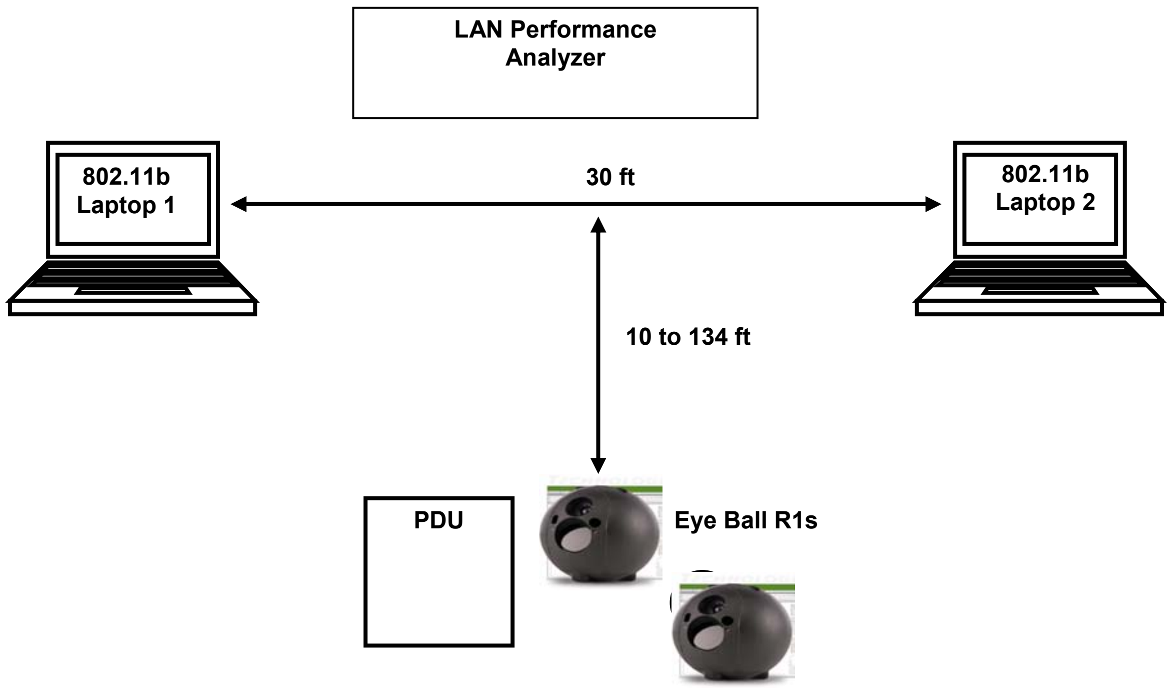

Figure 2. Test setup used to monitor 802.11b LAN performance

The indoor measurements were performed in a 54-by-41 ft room. Outdoor measurements provided for greater separation distances and reduced multipath effects. For both measurement sets, the white Eye Ball R1 was positioned at various distances from the 802.11b LAN while the black Eye Ball R1 and the PDU remained 10 ft from the middle of the two wireless LANs.

Measurements were performed to determine the LAN's performance in the presence of Eye Ball R1 in the following order:

1. Two laptop computers, equipped with 802.11b capabilities, were setup to establish a reliable ad hoc link. For each measurement, the Yellow Jacket accumulated data for several minutes or until the display settled.

2. The link quality, RSSI and PER, was measured by the Yellow Jacket when the Eye Ball R1 was turned off. This provided a baseline measurement.

3. Eye Ball R1, was configured to transmit at the same frequency as the established 802.11b LAN. The performance of the LAN was measured as the separation distance of Eye Ball R1 and the LAN varied between 10 and 130 ft.

4. Eye Ball R1, was configured to transmit on an adjacent-channel with the established 802.11b LAN. The performance of the LAN was measured as the separation distance of Eye Ball R1 and the LAN varied between 10 and 130 ft.

MEASURED RESULTS

Tables 2 through 5 provide the indoor measured test results, and Tables 6 through 8 provide the outdoor measured test results. The tables are divided into three categories. Tables 2 and 8 provide the measured test results when Eye Ball R1 and the 802.11b LANs are transmitting cochannel. Table 2 also shows the results of one measurement in which the Eye Ball frequency is well separated from the LAN frequency. Tables 4 and 6 provide the measured test results when Eye Ball R1 frequency is offset from the LAN frequency by 5 MHz but the Eye Ball signal is within the LAN channel bandwidth. Thus, these cases might be called modified cochannel cases. Table 4 also shows the results for one measurement in which the Eye Ball frequency was well separated from the LAN frequency. Tables 3 and 5 provide the measured test results when Eye Ball R1 and the 802.11b LANs are on adjacent channels with the Eye Ball R1 signal just at the edge of the 802.11 channel. In each table, columns 4 and 5 represent the measured data, RSSI and PER, with respect to the distance between Eye Ball R1 and the 802.11b LANs, column 3.

Indoor Measurements

Table 2. Indoor 802.11b LAN Performance on Channel 5

Eye Ball R1 CH	LAN CH	DIST., m/ft	RSSI, dBm	PER, %
5	5	3/10	-52	0.0
5	5	10/33	-58	1.0
12	5	3/10	-52	0.0

Table 3. Indoor 802.11b LAN Performance on Channel 4

Eye Ball R1 CH	LAN CH	DIST., m/ft	RSSI, dBm	PER, %
1	4	3/10	-45	13.0
1	4	3/10	-40	25.0
1	4	10/33	-45	5.0
1	4	12/40	-43	25.0
1	4	12/40	-48	32.0

Table 4. Indoor 802.11b LAN Performance on Channel 4

Eye Ball R1 CH	LAN CH	DIST., m/ft	RSSI, dBm	PER, %
5	4	3/10	-52	42.0
5	4	10/33	-47	70.0-100.0
5	4	10/33	-50	77.0
12	4	12/40	-53	0.0

Table 5. Indoor 802.11b LAN Performance on Channel 4

Eye Ball R1 CH	LAN CH	DIST., m/ft	RSSI, dBm	PER, %
1	4	3/10	-38	15.0
1	4	10/33	-40	0.0-5.0

Outdoor Measurements

Table 6. Outdoor 802.11b LAN Performance on Channel 4

Eye Ball R1 CH	LAN CH	DIST., m/ft	RSSI, dBm	PER, %	Comments
5	4	14/47	-41	0.0	Connection fades in and out
5	4	14/47	-46	0.0	Connection fades in and out
5	4	18/60	-48	-	No connection
5	4	20/65	-46	0.0	Connection fades in and out
5	4	20/65	-40	0.0-16.0	Connection fades in and out
5	4	21/70	-45	1.0	Connected
5	4	21/70	-52	66.0	Connected
5	4	23/75	-54	100.0	Connected
5	4	24/80	-58	3.0-100.0	Connected
5	4	27/88	-51	0.0	Stable Connection

Table 7. Outdoor 802.11b LAN Performance on Channel 1

Eye Ball R1 CH	LAN CH	DIST., m/ft	RSSI, dBm	PER, %	Comments
1	1	21/70	-48	-	Connection Lost
1	1	23/75	-46	73.0	Connection fades in and out
1	1	24/80	-46	55.0	Connection fades in and out
1	1	26/85	-49	100.0	Connection fades in and out
1	1	27/90	-48	57.0	Connection fades in and out
1	1	29/95	-45	86.0	Connection fades in and out
1	1	30.5/100	-52	27.0	Connection fades in and out
1	1	32/105	-52	25.0	Connection fades in and out
1	1	34/113	-53	15.0	Connection fades in and out
1	1	37/122	-53	8.0	Stable Connection

Table 8. Outdoor 802.11b LAN Performance on Channel 5

Eye Ball R1 CH	LAN CH	DIST., m/ft	RSSI, dBm	PER, %	Comments
5	5	30.5/100	-46	7.0	Connection fades in and out
5	5	37/122	-53	18.0	Connection fades in and out
5	5	38.7/127	-52	0.0	Stable Connection
5	5	40.8/134	-49	0.0	Stable Connection

SUMMARY OF RESULTS AND OBSERVATIONS

Table 9 provides a summary of the 802.11b LAN performance in the presence of a single Eye Ball R1 emitter. When possible, the criteria used to arrive at a separation distance between the LAN and Eye Ball R1 was a PER measurement of 1% i.e., the baseline condition.

For the indoor measurements, the size of the room restricted the separation distance that could be achieved. Additionally, the effects of indoor multipath made it difficult to obtain the monotonically decreasing PER performance that is consistent with increasing propagation losses with distance. For example, Table 2 shows no indoor interference at a separation of 3 meters (10 feet) or 10 meters (33 feet) in a co-channel configuration. This lack of interference may have occurred due to a multipath null on the signal from Eye Ball R1 to the wireless LAN receiver.

Table 9. LAN Performance in the Presence of Eye Ball R1

Table	In/Out Door	Eye Ball R1 Channel	LAN Channel	Stable LAN distance, m/ft
2	Indoor	5 12	5 5	Inconclusive Inconclusive
3	Indoor	1	4	Inconclusive
4	Indoor	5 12	4 4	Inconclusive 12/40
5	Indoor	1	4	>10/33
6	Outdoor	5	4	>27/88
7	Outdoor	1	1	>37/122
8	Outdoor	5	5	>38.7/127

The outdoor measurements provided more consistent results. The measured test results, shown in Table 7, indicate that there was no co-channel interference from Eye Ball R1 to the 802.11b LANs at a separation distance of 37 meters (122 ft) or greater. Table 6 indicates that when the Eye Ball R1 was not directly on the 802.11b frequency but was within the channel, the 802.11b LAN performance was unaffected by Eye Ball R1 at a separation distance of approximately 27 meters (88 ft). Table 7 shows that the PER decreased as the separation distance between Eye Ball R1 and the LAN increased. At a separation distance of 30 meters (100 feet), the PER dropped below 30%. At a separation distance of 37 meters (122 feet), the wireless LAN connection was stable.

OUTPUT POWER AND SEPARATION DISTANCE

The manufacturer has stated that the Eye Ball R1 that was tested had a maximum output power of 0.5 watts, but the production units will be capable of outputting 1.0 watts of power. Therefore, interference from the production units would occur at greater distances from a LAN than those report here. Although not measured, from RF propagation theory in circumstances where free-space propagation occurs, e.g., outside on land with irregular surfaces, interference would occur at distances about 40% greater than we measured or at about 52 meters in the cochannel case.[1] In circumstances in which there is an excess loss beyond free-space loss, interference would occur at distances shorter than that free space distance but greater than the distances we measured. For example, if we assume that propagation follows an inverse fourth power law (a propagation law often used for modeling urban wireless), then interference would extend about 20% farther or 44 meters in the cochannel case.[2]

[1] An increase by 40% is an increase by a factor of 1.4. Because $1.4^2 = 1.96$ the added free space attenuation (proportional to the square of the distance increase) matches the power increase.

[2] Note that $1.2^4 = 2.07$.