NATIONAL TRANSPORTATION SAFETY BOARD
Investigative Hearing

Washington Metropolitan Area Transit Authority Metrorail train 302 that encountered heavy smoke in the tunnel between the L'Enfant Plaza Station and the Potomac River Bridge on January 12, 2015

GROUP	C
EXHIBIT	
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Agency / Organization

WMATA

Title

Summary Report For PSRS Adjustments at One Judiciary Square

Docket ID: **DCA 15 FR 004**

WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
TIES/CENI/Communication

Summary Report

For

PSRS Adjustments at One Judiciary Square

Written by: David Rampersad - Sr. Communication Engineer (WMATA)

Approved by: Marshall Epler - Deputy Chief Communications & Network System

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Signature Date

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1. OBJECTIVE

The main objective is to test the uplink noise floor and Signal-to-Noise performance at the One Judiciary Square equipment for the underground system which is fed from Gallery

Place B01 Comm Room. The uplink was determined to be causing intermittent PSRS communications in Stations and inside the tunnels.

2. TASK

Task:	Test the uplink noise floor and Signal-to-Noise performance
Date:	01/14/2015
Time:	9:30 am – 1:00 pm
WMATA:	Matt Lang (SMNT), David Rampersad (CENI), Sid Krishnaswamy (CENI), James Noone (SMNT)
DC:	Steve Matthews (OUC), Mike (Wireless Communications Contractor)

3. EQUIPMENT

1 x Anritsu Site Master S412E Spectrum Analyzer.
1x Fiber-Optic Test unit (Noyes SMLP-5-5 SC)
2x (800MHz) Portable Radios
2x (490 MHz) Portable Radios
Safety Equipment to include:

- Flash Light
- WMATA Issued Vest

4. SUMMARY

TEST 1: WMATA measured the light levels on the fiber ports at the fiber optic transceiver at One Judiciary Square COMM room

RESULTS: All fiber levels at 1550 nm were within spec and showed no failures.

TEST 2: Measured the RF Noise floor at output of the Uplink fiber transceiver port

RESULTS: Noise floor measured to be within range of the original drawings (2009)

TEST 3: Traced Uplink RF path from the output of the fiber transceiver to the existing 4.1 system and into the new P 25 core equipment.

RESULTS: Original Configuration and path for the below ground UL signal have been modified (OUC contractors) after the 20 dB coupler to incorporate P25 Prime site equipment and continue cut-over support on the existing 4.1 equipment at One Judiciary Square

TEST 4: WMATA determined that the UPLINK levels into the new configuration may be at or close to the threshold of operation for both the 4.1 equipment and the P25 site equipment. The existing drawings show a total of 35 dB attenuation at point B on Drawing 1. It then gets added to the off-Air feed antenna (<1 dB via coupler) to radio systems.

RESULTS: WMATA removed a total of 18 dB of attenuation both the 10 dB and 5 dB attenuators (shown) and an additional 3 dB (not shown) before heading out to conduct radio checks.

TEST 5: WMATA and OUC personnel performed radio checks along Yellow/ Green line between F01 - F02 - F03

RESULTS: Radio Check performed over these stations and inside the tunnel all passed.

TEST 6: WMATA wanted to bring up the UL gain further by rotating the 20-dB directional coupler as it may have been installed opposite.

RESULTS: The one Judiciary site was temporarily placed in standby while the 20-dB directional coupler was reversed. Once all system went online again, radio test was conducted. Performance was much worse than before. After reviewing the signal flow and coupling loss with OUC's radio contractor, it was determined that the 20-dB directional coupler was originally installed in the correct direction. The site was then placed on standby again while the coupler was re-installed in its original direction. The system came online again, radio checks were performed across the same segment and all passed. The 20-dB directional coupler is left in its original position.

TEST 7: Measured any noise floor impact at P25 equipment created by WMATA increasing the noise floor by 18 dB fed from the below ground.

RESULTS: OUC's contractor verified that he saw no increase to the overall noise floor before and after the attenuators were removed. The below ground noise floor level may still be below the noise floor coming of the above ground feed point A on Drawing 1

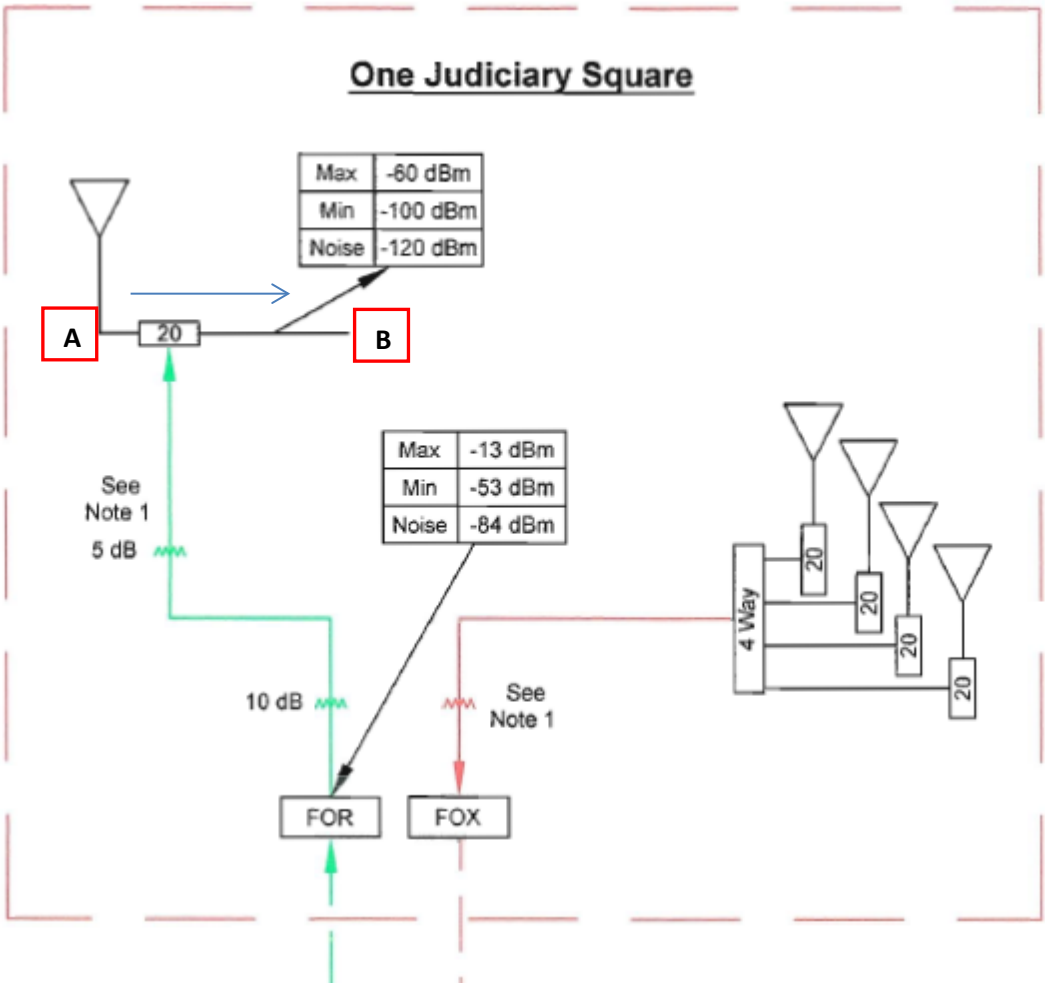
TEST 8: WMATA conducted SNR (Signal to Noise Ratio) testing on the Uplink at One Judiciary Square with an 800 MHz portable radio set to keyed up for 10-15 seconds on a test frequency (809 MHz)

RESULTS: Once the radio keyed up, SNR was measured on the analyzer. Levels were reporting around 30 dB SNR at D03/F03 (L'Enfant station). With a 30 dB SNR, radio communication should be loud and clear.

4. DRAWINGS

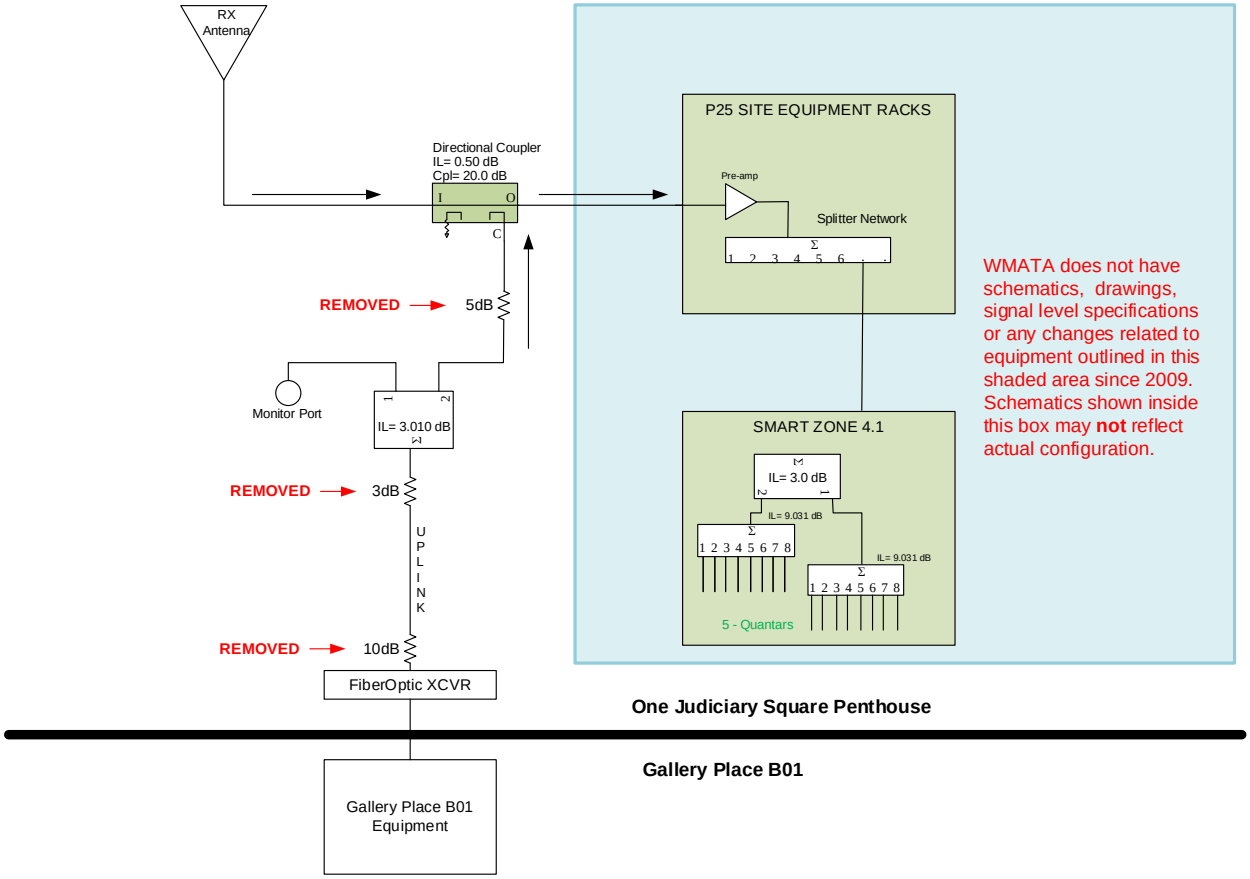
DRAWING 1

Original Configuration shown for UPLINK (snapshot from 2009 contract document)



DRAWING 2

Configuration sketched from One Judiciary Square visit for UPLINK (Jan 14, 2015)



WMATA does not have schematics, drawings, signal level specifications or any changes related to equipment outlined in this shaded area since 2009. Schematics shown inside this box may **not** reflect actual configuration.

5. CONCLUSION

Based on the measurements taken at One Judiciary Square for the PSRS system and the removal of 18 dB attenuation from the Uplink Signal fed from the below ground, the PSRS system performance increased significantly throughout the underground stations and tunnels. With the new settings in place, it was verified that it did not affect the above ground communications nor did it increase its overall noise floor. The Uplink also showed an increase in the Signal to Noise (SNR) ratio coming from the below ground. *See note 1 – detailed explanation & possible cause*

Radio Checks on the 800 MHz PSRS radio system were re-tested after the changes were made. Areas that had poor communications now show a significant increase in below ground radio communications. WMATA will continue to test the PSRS system across the below ground and identify and repair any issues should they exist.

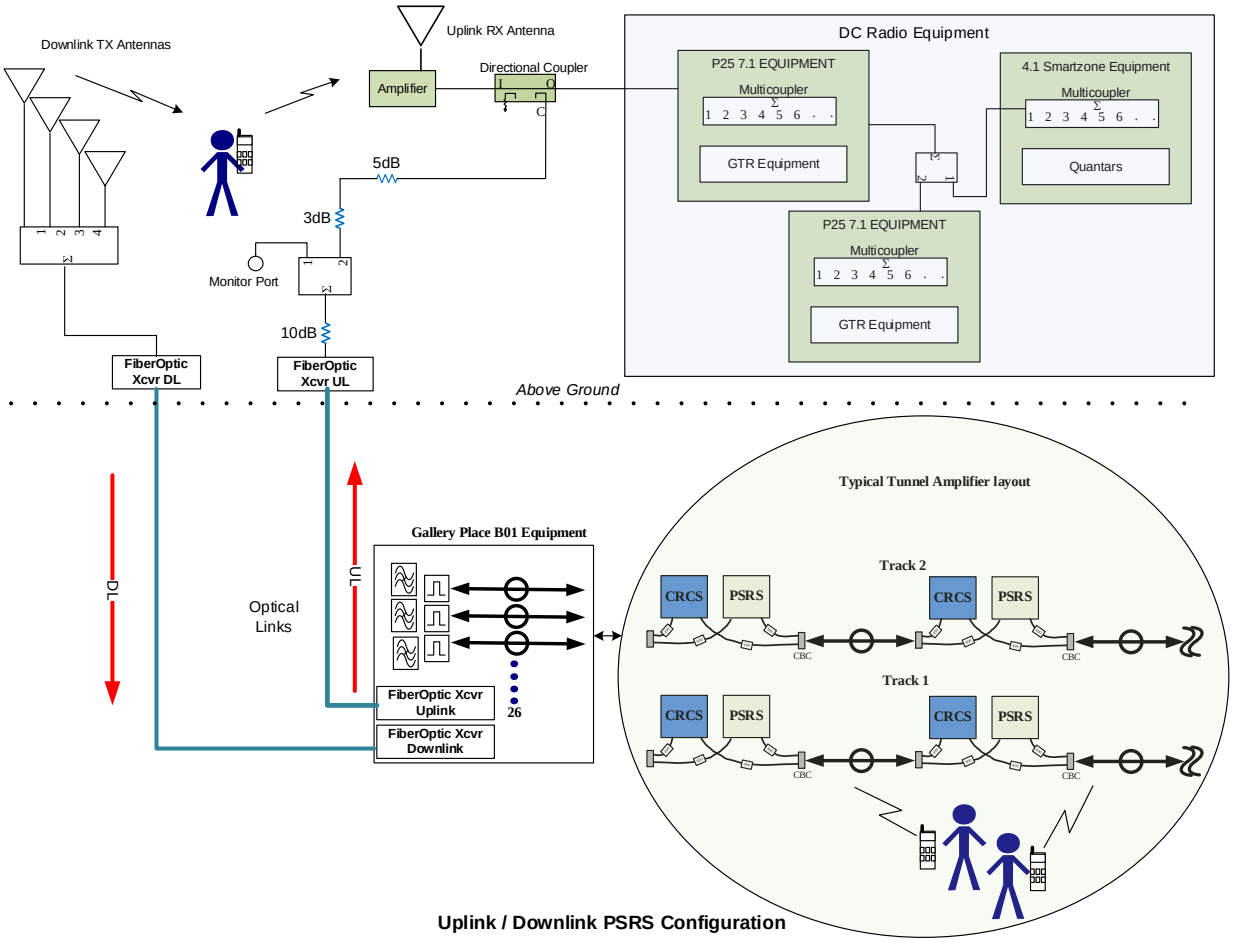
The Uplink levels coming into one Judiciary square from the below ground PSRS will need to be balanced relative to the levels coming from the above ground. WMATA and DC should work together in providing necessary documentation and coordinating testing when updates or hardware changes are planned and implemented.

6. DETAILED EXPLANATION & POSSIBLE CAUSE

Back Ground:

The DC Public Safety Radio System (PSRS) operates in the below ground at 800 MHz to support EMS and DC fire. In the current mode of operation, all communication from the bellow Ground segments are combined at galley Place Station (room B01). Signals are converted from RF to optical and linked to DC's COMM room at One Judiciary square. At the penthouse COMM room, DC's radio equipment is installed and operated. This is also an antenna site for subscriber units operating above ground. See diagram below

Typical PSRS configuration



Uplink / Downlink PSRS Configuration

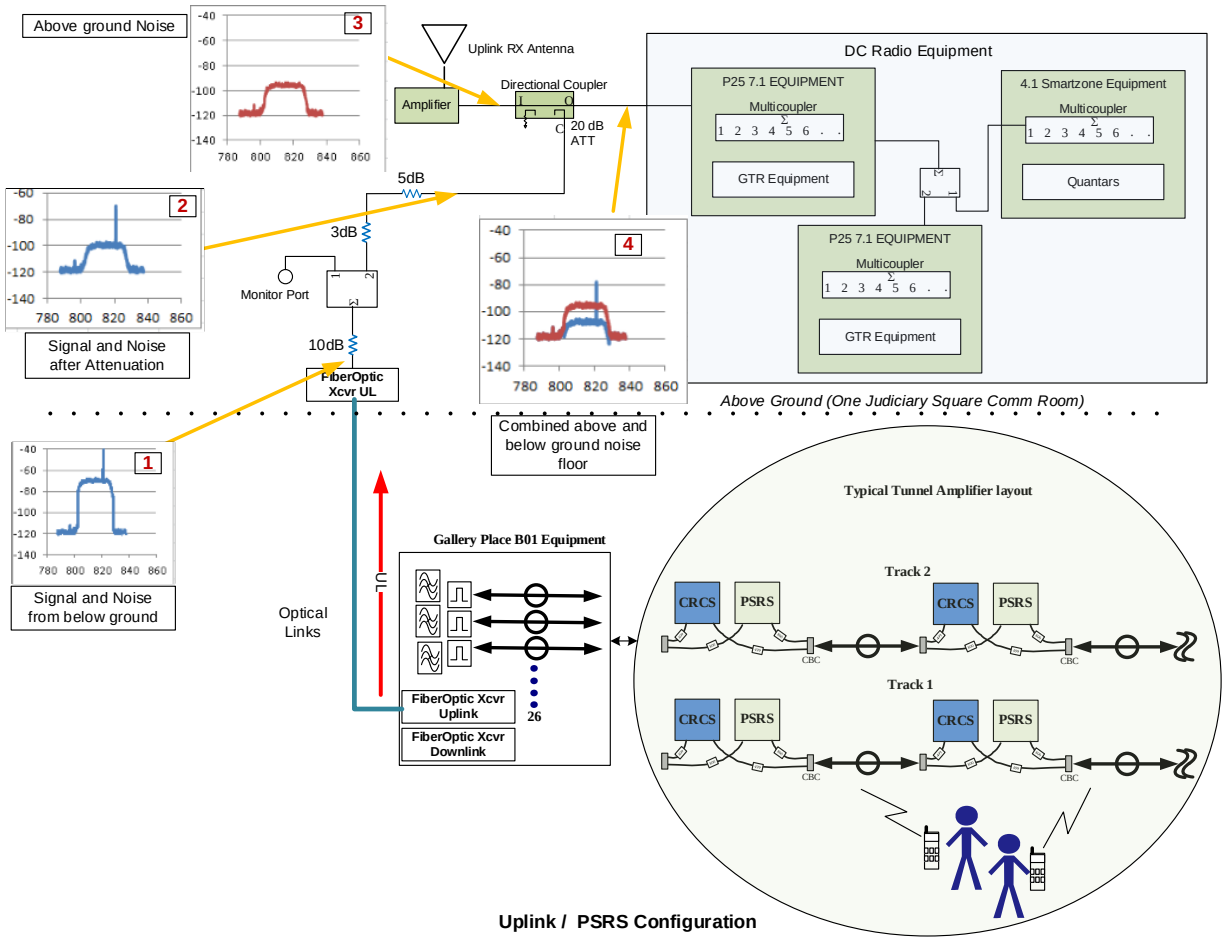
DC Radio communication issue:

Poor radio communication inside the tunnel for the 800 MHz radio system was diagnosed as having issues only on the Uplink side. The Downlink signal did not have an impact on poor communication. The following steps and diagrams will explain what may have happened to cause the poor performance across the below ground.

What we know:

1. DC performed Radio checks on Dec 8th throughout the below ground stations and tunnels. There were no major communication problems found.
2. DC Commissioned 7 new channels on their system on Dec 22nd 2014 as part of migration over to full P25. WMATA was never notified.
3. All Fire and EMS should have had these new channels enabled.
4. No indication if radio check were performed by DC after these channels was added.
5. WMATA discovered poor communication across the below ground tunnels and stations where DC's PSRS radio system extended. This occurred around the last week in December.
6. WMATA started work on troubleshooting the issue across the system which includes 26 segments on Tracks 1 and 2 consisting of approx. five hundred 800 MHz Bi-Directional Tunnel Amplifiers (BDAs).

Description of Uplink :



Waveform 1:

This waveform show a typical signal and noise coming from the combined output of the below ground that is fed from one Gallery Place B01 equipment room. The Signal is usually higher than the noise floor in order to be detected and processed.

Waveform 2:

Waveform 2 is identical to waveform 1 but at a reduced level. Both the signal and noise are equally attenuated through a 10-dB pad, 3-dB splitter, 3-dB pad and another 5-dB pad prior to entering the 20-dB coupler. A total of 21-dB attenuation drop in level.

Waveform 3:

Waveform 3 illustrates what the above ground noise floor would look like after it enters the antenna and amplified through the Tower Top Amplifier (TTA).

Waveform 4:

Waveform 4 illustrates the combined signals of the above and below ground. This combination of signals gets done using a directional coupler. In this case the below ground signal it is further attenuated by 20 dB on the coupled port since the coupler used is 20 dB. The above ground path passes through the coupler with less than < 2 dB attenuation.

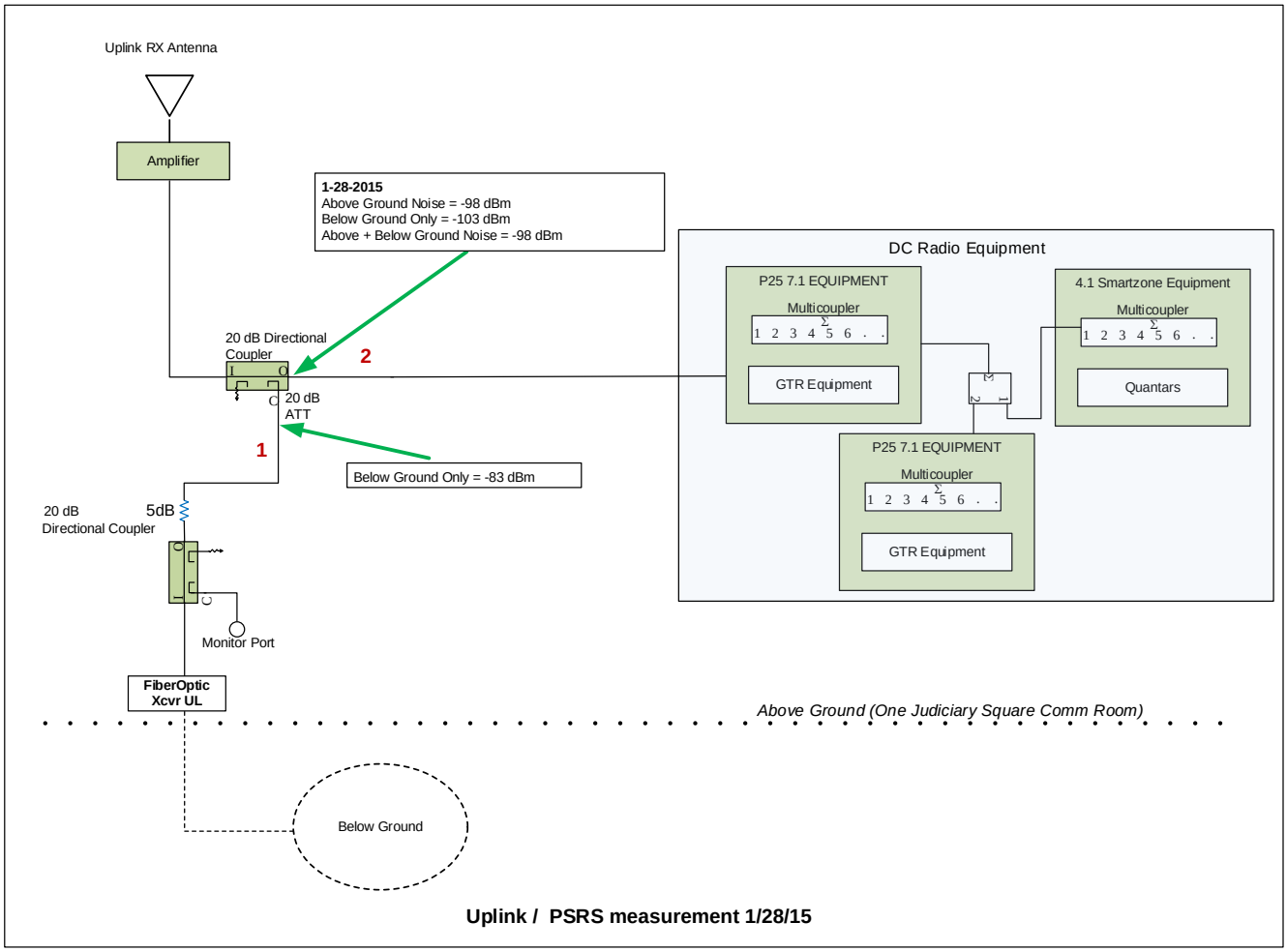
At the output port leaving the coupler, if the above ground noise is much higher than the below ground noise, signals on the below ground must now need to exceed the dominant noise floor before it gets detected and processed. WMATA suspects that this may have been the case where the above ground signal increased and overshadowed the below ground signal and noise therefore causing poor radio communications. Further test and measurements are required to make a better determination.

7. TESTING PERFORMED AT ONE JUDICIARY SQUARE ON 1/28/15

Final results are indicated on the drawing below. The measurements taken on Jan 28th 2015 shows that the below ground noise had no impact to the above ground floor after exiting the directional coupler. The above ground noise floor is the dominant of the two, averaging around -98 dBm with the below ground coming in around -103 dBm. In order to achieve a -103 dBm on the below ground noise floor, WMATA was able to bring the signal up an additional 4 dB by re-

configuring the coupler at the monitor port. This brought the level up for a total of 22 dB (18 dB increase on 1-14-15 and additional 4 dB on 1-28-15) to balance the above and below ground floor.
The wide difference seen between the levels on the above and below ground floors on 1-14-15 is still left unknown. It can only be explained with an increase in the above ground side. Since above ground floor noise floor measurements are not available from OUC since 2009, WMATA cannot determine how much it increased.

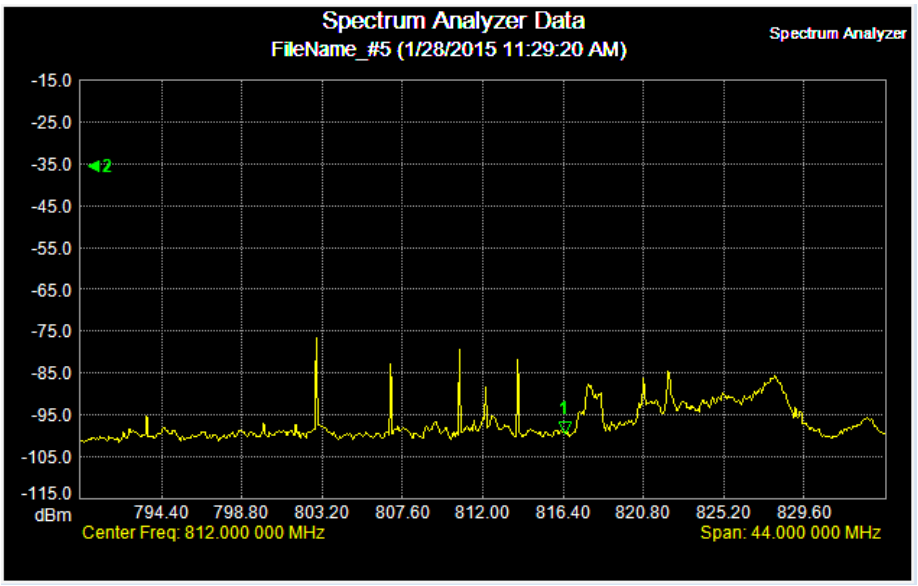
Measurement on 1/28/15 after final adjustments



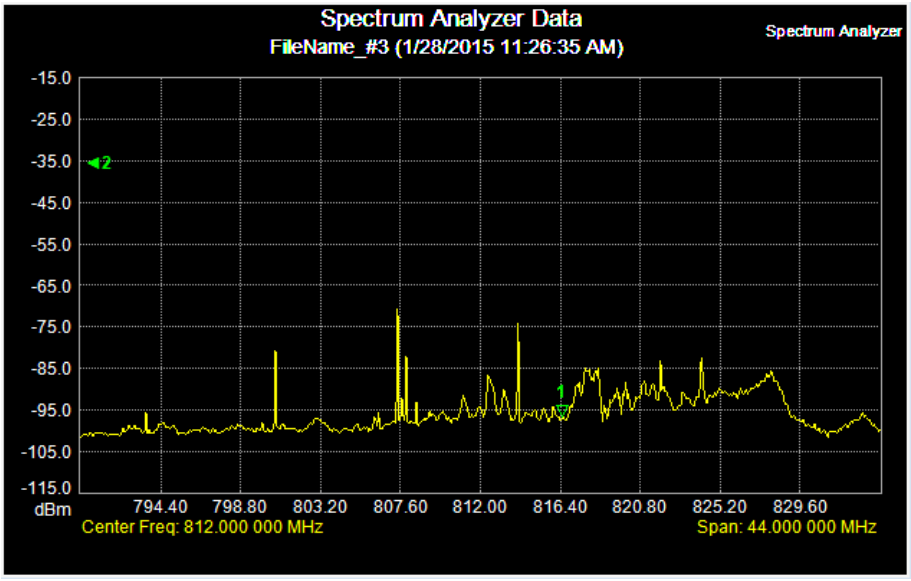
Uplink / PSRS measurement 1/28/15

Spectrum Analyzer plots

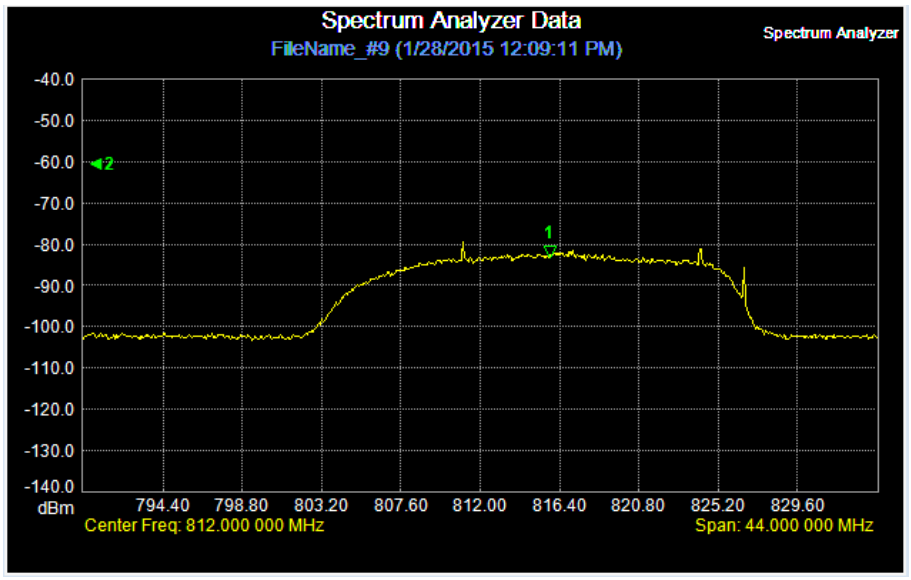
Above Ground Only - Output of Coupler



Above and Below Ground Combined - Output of Coupler



Below Ground Only – Coupled Port Before 20 dB loss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Center Freq: 812.000 000 MHz
Span: 44.000 000 MHz